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Meeting Abstracts

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Abstracts

Numerical Analysis of a Ruffled Fin type Automotive Car Radiator Operating with Different Particle-shaped Optimized Ternary Nanofluid

Doga Kavaz[1*] and Humphrey Adun[2]

[1]Department of Engineering, Bioengineering, Cyprus International University, Turkey
[2]Operational Research Center in Healthcare, Near East University, Turkey

Abstract

Nanofluids provide significantly higher heat transfer characteristic as compared to conventional automobile engine fluids. However, there is still room for improvements in the performance of nanofluids based on hybridization and particle shape effects. The numerical investigation in this work examines the performance of a ruffled fin-type radiator employing ternary nanofluids as coolants. On the basis of the different nanocomposites and volume fractions of ZnO, Al_2O_3, TiO_2, MWCNT, graphene, Fe, Cu, and Ag nanoparticles, the performance of radiators was analysed. The aim of this study is to cover the gap in literature relating to high performance radiators using more novel fluids, which can substitute for conventional fluids. Depending on the nanofluid types and shapes, the Nusselt number and overall heat transfer coefficient exhibited distinct trends in terms of radiator performance. As the volume fraction of tertiary fluids 2, 3, and 5 increased, the Nusselt number increased, indicating enhanced convective heat transfer efficacy. With increasing volume fraction, the outlet temperature of the coolants decreased, indicating enhanced cooling performance. The result show that a temperature drops of 44.6% from the engine is observed when using optimal nanofluid. The performance index of a radiator with ternary hybrid nanofluid coolant decreases by 5.8%, 11.15%, 9.3%, 11.6%, 7.9%, 8.3%, 9.8%, and 11.7%, for the ternary 1, 2, 3, 4, 5, 6, 7 and 8 nanofluids.

The Use of Nanomaterials in Batteries

Valencia De La Vega[*]

Solid Energies, Inc., Nestpoint Group, USA

Abstract

The use of nanomaterials and super materials is becoming more poignant in the development and system architecture for the batteries of the future. Achieving the right nanoscale for materials to support the right electrochemistry is what is required from industry to support a growing demand for power delivery both modular and portable. The most critical aspects being the ability to achieve energy efficiency, comprehensive safety and overall sustainability.

Microfluidic Sensing Textile for Continuous Monitoring of Sweat Glucose at Rest

He Zhao* and Ling Zhang

East China University of Science and Technology, Shanghai, China

Abstract

Wearable sweat sensors have received considerable attention due to their great potential for non-invasive continuous monitoring of an individual's health status applications. However, the low secretion rate and fast evaporation of sweat pose challenges in collecting sweat from sedentary individuals for non-invasive analysis of body physiology. Here, we demonstrate wearable textiles for continuous monitoring of sweat at rest using the combination of a heating element and a microfluidic channel to increase localized skin sweat secretion rates and combat sweat evaporation, enabling accurate and stable monitoring of trace amounts of sweat. The Janus sensing yarns with a glucose sensing sensitivity of 36.57 mA cm^{-2} mm^{-1} are embroidered into the superhydrophobic heated textile to collect sweat directionally, resulting in improved sweat collection efficiency of up to 96 and 75% retention. The device also maintains a highly durable sensing performance, even in dynamic deformation, recycling, and washing. The microfluidic sensing textile can be further designed into a wireless sensing system that enables sedentary-compatible sweat analysis for the continuous, real- time monitoring of body glucose levels at rest.

Green Loading of PdO Nanoparticles on to Activated Carbon and its Antibacterial Activities against *Staphylococcus aureus* and *Escherichia coli*

Aisha Mohammed Al Musharraf , Elsaid EL Shafey and Nallusamy Sivakumar

Sultan Qaboos University, Muscat, Sultanate of Oman, Oman

Abstract

Infections by waterborne bacteria are one of the main reasons for human mortality and, thus, water disinfection is inevitable for human health. In the disinfection process, pathogenic microorganisms are destroyed or inactivated. Among the different methods of disinfection, Irradiation, ozonation, chlorination, and antibiotics are common methods of water disinfection. One of the most promising methods may come from metallic nanoparticles, since bacteria may not develop a resistance to these nanostructures as they do for antibiotics. In this study, activated carbon loaded with Pdo nanoparticles was tested for its antibacterial properties of *Staphylococcus aureus* and *Escherichia coli*. Activated carbon (AC) was prepared from black cumin seeds using KOH activation at 700 °C. Produced AC possesses a very high surface area of 1060 m^2/g. Surface characterization of AC involves XRD, SEM, FTIR, and TGA. AC acts as a reducing agent converting Pd^{2+} to Pd metal in the form of nano particles on the AC surface. This is accompanied by surface oxidation. The size of the nanoparticles was influenced by contact time and Pd (II) concentration. Pdo was confirmed using XRD, SEM, and XPS. The antibacterial activities of Pdo-loaded AC were tested for Staphylococcus aureus (gram-positive bacteria) and Escherichia coli (gram-negative bacteria) in terms of well diffusion assay. All AC/Pd prepared exhibited effective antibacterial activities with smaller sizes of Pdo nanoparticles.

Interfacial Engineering to Enhance Electrochemical Windows

Ming Chen[1,2*] and Guang Feng[1]

[1]State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology (HUST), Wuhan, China
[2]Department of Chemistry, Faculty of Natural Sciences, Imperial College London, Molecular Sciences Research Hub, White City Campus, London, UK

Abstract

Room temperature ionic liquids (ILs), with unique properties including excellent thermal stability, nonflammability and especially wide electrochemical windows, are an emerging class of candidates for electrochemical energy storage devices, such as supercapacitors, batteries and solar cells. However, owing to their hygroscopic nature, ILs can spontaneously adsorb water from the humid environment. It is an unaddressed issue that, hydrophobic ILs would become humid when exposed to the atmosphere, and unfortunately, their water much favours adsorption on both negatively and positively charged electrodes. To address such an issue, in this study, we performed molecular dynamics (MD) simulations to investigate the effect of adding Li-salt in humid hydrophobic ILs on the ion and water distributions near electrodes. Results disclose that, water is excluded from the electrode surface and the activity of water remaining in the interfacial region is reduced by adding salt, which could dramatically enhance the electrochemical window of humid ILs. This conclusion is verified by electrochemical cyclic voltammetry measurements on carbon electrodes in contact with humid ILs and salt-in-humid ILs. Both simulation and experiment show that such conclusion holds regardless of the molar salt-water ratio as well as different hydrophobic ionic liquids. Therefore, our findings reported with the concept of salt-in-humid ILs could extend the comprehension of the preferential species electro sorption and provide a guideline for minimizing water adsorption and altering the structure and property of adsorbed water.

Mechanical Properties of 3D Boron Nitride Foam

Yarden Mazal Jahn*, Liat Levavi, Anway Pradhan, Benny Bar-On and Assaf Yaakobovitz

Faculty of Engineering Sciences, Ben-Gurion University of the Negev, Israel

Abstract

Boron carbonitride (BCN) foam is a three-dimensional material with a hierarchical structure, which has promising potential due to its semiconducting properties and high surface area. However, the lack of understanding of its elastic properties impedes its large-scale integration into advanced applications. We grew BCN samples with different atomic compositions. We studied their microscopic- and macroscopic-scale mechanics, which revealed that samples with high concentrations of carbon have lower elastic resistance across different scales (i.e., lower Young's moduli). While the microscopic elasticity is dominated by interlayer interaction, the macroscopic elasticity is also strongly influenced by the buckling and fracturing of the three-dimensional structure of the BCN foam, and thus, the macroscopic Young's moduli are lower than the microscopic ones. Our findings shed light on the mechanism that underlies the multiscale mechanics of BCN foam and pave the path toward its integration into flexible electronic devices and resonators.

Ultra-long Afterglow of 2D Transition Metal Dichalcogenides

Assaf Yaakobovitz*, Guy Alboteanu and Yarden Mazal Jahn

Ben-Gurion University of the Negev, Israel

Abstract

Phosphorescence materials typically emit light long after their illumination has stopped and therefore, they hold promising potential to revolutionize illumination instruments and optochemical sensors. We show the first ever ultra-long, room-temperature two-dimensional phosphorescence devices. These devices consist of transition metal dichalcogenide (TMDs) monolayers, with WS2 exhibiting an afterglow time exceeding an hour, while other monolayered TMDs showed an afterglow of several minutes. The ultra-long afterglow of these devices was achieved due to the relatively large atoms of the TMD metal layers combined with sulfur atoms that encourage afterglow and lattice mismatch with an amorphous silicon-dioxide layer underneath, which restricts non-radiative quenching. Therefore, this work reveals the light-matter interactions of TMDs, and thus, it opens the path toward the integration of monolayer TMDs into advanced optical applications.

Magnetic Aerogels from FePt and CoPt3 Synthesized in Organic Media

Larissa Schoske[1,2,3*], Franziska Lubkemann Warwas[4], Irene Morales[5,6], Christoph Wesemann[4], Jan Gerrit Eckert[4], Rebecca Tatjana Graf[4,5] and Nadja-Carola Bigall[1,2,3]

[1]Institute of Physical Chemistry, University Hamburg, Germany
[2]The Hamburg Centre of Ultrafast Imaging, Hamburg, Germany
[3]Cluster of Excellence CUI: Advanced Imaging of Matter, Hamburg, Germany
[4]Institute of Physical Chemistry and Electrochemistry, Leibniz University Hannover, Germany
[5]Cluster of Excellence PhoenixD (Photonics, Optics and Engineering- Innovation Across Disciplines), Leibniz University Hannover, Germany
[6]Institute of Inorganic Chemistry, Leibniz University Hannover, Germany

Abstract

Superparamagnetism can occur for particles smaller than a single domain. The particles can follow the magnetic field with negligible remanence and therefore heat up through application of an external magnetic field. This behavior makes them interesting for application in magnetic hyperthermia and inductive heating. The particle properties are highly dependent on the size and shape of the particles. Therefore, a precise control during synthesis is needed, which can be provided by use of colloidal synthesis routes. To the present day mostly non connected magnetic particles are used, even though a combination of the magnetic properties of these nanoparticles with the high specific surface area of aerogels can give place to new functional materials with improved and tailored properties. Within this work magnetic particles were synthesized through colloidal synthesis routes in organic media, followed by a gelation process directly in organic media. The resulting nanoparticle assemblies were characterized through transmission electron microscopy and scanning electron microscopy. Additionally, hysteresis cycles, zero field cooled and field cooled measurements were performed on the building blocks and the nanoparticle assemblies to investigate the influence of the gelation procedure on the magnetic properties.

Biomacromolecules/Halloysite Hybrids for Biomedical Applications

Giuseppe Cavallaro*, Martina Maria Calvino, Giuseppe Lazzara and Stefana Milioto

Dipartimento di Fisica e Chimica "E. Segre", Universita degli Studi di Palermo, Viale delle Scienze, Pad. 17, 90128 Palermo, Italy

Abstract

Composite materials based on halloysite clay nanotubes (HNTs) and biomacromolecules are powerful for numerous pharmaceutical and medical applications. In this work, we investigated the surface functionalization of halloysite nanotubes by keratin and therapeutic oligonucleotides (TOs) in aqueous media at variable pH and ionic strength conditions to control the specific supramolecular interactions occurring between the biological molecules and HNTs. The HNTs functionalization was optimized by studying the surface charge, the colloidal properties, and the structure of the composite nanomaterials. Further useful insights were obtained by the determination of the thermodynamic parameters of the HNTs/macromolecules interactions. We detected that the functionalization efficiency is improved at pH larger than the corresponding isoelectric points of the biomolecules because of an enhancement of the attractive interactions with the halloysite inner surface, which is positively charged. Opposite effects were observed by increasing the ionic strength due to the screening effect of the electrolytes. Then, the functionalized nanotubes were immobilized within a biopolymeric network obtained by the crosslinking of alginate with calcium chloride. The actual formation of the hydrogel was demonstrated by rheology through flow and frequency sweep experiments. Due to their specific functionalities, the functionalized HNTs and hybrid hydrogels were tested for coating of sutures and photoprotective reinforcement of human hair. The reinforcing and protective actions of the functional hydrogels were proved by dynamic mechanical analysis and FTIR spectroscopy through the determination of the cysteine oxidation index. This research was funded by European Union-Next Generation EU (PRIN 2022 PNRR-NANOEURO project-Cod. B53D23025300001).

Multi-functional Green Copper Mesh for Sustainable Membrane-based Water Treatment Technology

Hala Al-Jawhari*

Department of Physics, King Abdulaziz University, Jeddah, Saudi Arabia

Abstract

In this work, we aim to fabricate a green, sustainable, and recyclable copper mesh with multi-functional properties for water treatment technology. Specifically, we introduce an environmental and sustainable approach to grow free standing heterogeneous Cu_2O-$Cu(OH)_2$ nanocomposites on a Cu mesh using spinach leaf extract and glycerol. Such green synthesized catalyst membrane showed high photocatalytic activity for degradation of a cationic dye methylene blue (MB), an anionic dye methyl orange (MO), and a mixture of both dyes. The mesh also exhibited high uniformity and stability in both acid and alkali mediums. Moreover, the versatility of the Cu_2O-$Cu(OH)_2$@ Cu mesh was evaluated for oil/ water separation, and a high capability for removing engine oil from the water was revealed. Nevertheless, as a functional membrane for water treatment, the safety issues of employing this coated mesh should be considered. Promisingly, the Cu_2O-$Cu(OH)_2$@Cu mesh proved to have appropriate antimicrobial activities against a wide range of microorganisms in dark. However, upon visible-light irradiation the bactericidal properties were enhanced. Such encouraging outcomes indicate the potential of our green composites to degrade dyes, remove oil, and kill some microorganisms from wastewater.

Muti-stimuli Controlled Properties of Shape Memory Polymer Composites from Biobased Benzoxazine-epoxy Copolymers Filled with Magnetic Nanoparticles

Sarawut Rimdusit*, Lunjakorn Amornkitbamrung, Krittapas Charoensuk, Panyawutthi Rimdusit and Sitanan Leungpuangkaew

Center of Excellence in Polymeric Materials for Medical Practice Devices, Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

Abstract

Thermosetting bio-based shape memory polymer composites were prepared from vanillin based benzoxazine (V-fa) and epoxidized castor oil (ECO) with iron oxide nanoparticles (NPs) as magnetic filler. Shape memory characteristics had resulted from copolymerization of suitable composition between the biobased flexible epoxy segments and the rigid benzoxazine chain structures. Thermomechanical and shape memory properties of the V-fa/ECO copolymers were investigated. In addition, the obtained iron oxide filled V-fa/ECO nanocomposite can be effectively softened via NIR laser irradiation in addition to heat and can be deformed under magnetic attraction. Once the laser is removed and allowed to cool down, the actuated shape can be fixed. The incorporation of magnetic filler helps facilitate the shape recovery by converting electromagnetic energy to joule heating. The shape memory performance was also improved with the filler addition with reported shape fixity and shape recovery as high as 93% and 95%. Moreover, functionalization of the copolymers with acid anhydride can grant self-healing capabilities. The obtained SMPs based on bio-based benzoxazine, and epoxy is a promising multifunctional thermoset for various engineering applications.

Electrochemical Determination of Capsaicin at Platinum Electrode Modified by CuO Nanoparticle Functionalized with Multiwalled Carbon Nanotubes

Pooe O[1,2] and Omolola Esther Fayemi[1,2*]

[1]Department of Chemistry, School of Physical and Chemical Sciences, Faculty of Natural and Agricultural Sciences, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho, South Africa
[2]Material Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Natural and Agricultural Sciences, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho, South Africa

Abstract

Capsaicin (CAP) and dihydrocapsaicin are the most abundant capsaicinoids found in chili peppers. This work reports the electrochemical detection of capsaicin in sauce and rub using the platinum electrode (Pt) fabricated with copper oxide nanoparticle (CuO NPs) incorporated with functionalized multi-walled carbon nanotubes (fMWCNTs) to form nanocomposite electrode (CuO/fMWCNTs). From all the fabricated electrodes, the nanocomposite fabricated electrodes showed an enhanced electron transfer and a better electrocatalytic reaction towards CAP with current response of the nanocomposite fabricated electrode being almost 43 times bigger than that of the bare electrode. The limit of detection (LOD) at the nanocomposite fabricated electrode was 0.0881 µm, with the linear range of 0.357 - 2.73 µm and a regression (R2) value of 0.995, using the square wave voltammetry (SWV) for the CAP detection. The proposed sensor out-performed other CAP sensors reported in literature. The fabricated electrode showed great applicability with excellent recoveries ranging from 100 to 116% with mean relative standard deviation (RSD) value of 8.24 (n = 3) for the sauce while the recovery percentages ranging from 98.31 to 105% with and RSD value of 3.36 (n = 3) for the rub.

Biosynthesis, Characterization and Potential Antimicrobial Studies of Ag-MgO Nanocomposite Mediated from *Talinum fructicosum* Leaf Extract

Fonye Nyuyfoni Gildas[1*], Paboudam Gbambie Awawou[2] and Eya'ane Meva Francis[3]

[1]*Applied Physical and Analytical Chemistry Laboratory*
[2]*Coordination Chemistry Laboratory*

Abstract

Nanocomposites are materials that combine different materials at the nano scale to create new properties. They typically consist of nano sized materials embedded in a matrix of ceramic, metal, or polymer, connected by weak interactions like electrostatic bonds or covalent bonds. These nanocomposites are highly valued for their ability to enhance optical, electronic, magnetic, and mechanical properties by combining the unique features of various nano scale systems. Among the inorganic nanoparticles, silver nanoparticles are widely used for their applications in sensitive biomolecular detection and antibacterial activities. On the other hand, Magnesium Oxide (MgO) nanoparticles have gained attention for their versatile applications in biomedical materials, catalysis, and absorption processes. In this study, nanocomposites were developed by decorating silver nanoparticles on magnesium oxide using an eco-friendly synthesis technique involving Talinum triangulare extract as a reducing and stabilizing agent. The process involved synthesizing silver nanoparticles from an aqueous extract through infusion and then preparing Ag-MgO nanocomposites using the sol-gel method. The presence of silver nanoparticles was confirmed by changes in color and the appearance of Surface Plasmonic Resonance in the UV/visible spectrum. Characterization of the nanocomposites revealed specific vibrational peaks corresponding to Ag-O and Mg-O stretching, as well as the presence of magnesium and oxygen atoms in the matrix. Dynamic light scattering (DLS) analysis showed agglomerate sizes of 295 nm for Ag-MgO nanocomposites and 225 nm for Ag nanoparticles. Overall, this study focused on fabricating and characterizing Ag-MgO nanocomposites with a particular emphasis on their antimicrobial properties.

Quantum Dots-hydrogel Composite for Drug Delivery and Cell Imaging Approaches

Nurten Asina[1,2*] and Doga Kavaz[1,2]

[1]*Department of Bioengineering, Faculty of Engineering, Cyprus International University, Via Mersin 10, Nicosia 98258, Northern Cyprus, Turkey*

[2]*Biotechnology Research Centre, Cyprus International University, Via Mersin 10, Nicosia 99258, Northern Cyprus, Turkey*

Abstract

Hydrogels have become increasingly popular in drug delivery systems due to their biocompatibility, durability,

enhanced drug loading capacity, and low cytotoxicity. The discovery of carbon quantum dots (CQDs) has sparked interest among materials scientists due to their exceptional photo-physical characteristics and long-lasting colloidal stability. CQDs confined polymeric hydrogel nanocomposites are innovative materials that combine the features of their distinct components, making them highly valuable in the field of soft nanomaterials. Embedding CQDs within hydrogels has been demonstrated as an effective strategy to monitor drug delivery efficiency by the luminescence characteristics of quantum dots. This approach allows for precise control over hydrogel properties and introduces novel traits on targeted delivery of paclitaxel (PTX) and doxorubicin (DOX). This work illustrates the photopolymerization of poly(ethylene glycol) dimetacrylate (PEGDMA)/methylcellulose (MC) hydrogel with four different concentrations and CQD and drug loaded state. The properties of hydrogels and CQDs loaded hydrogels were studied using various techniques, including fourier-transform infrared (FTIR), scanning electron microscopy (SEM), differential scanning calorimetry (DSC), swelling, and degradation tests. The ability of cancer cells to grow and proliferate on PEGDMA hydrogels was examined in terms of their viability as a drug carrier in tissue engineering. The results suggest that the synthesized F4/CQDs hydrogels provide a novel all-round means for cell culture and drug delivery, allowing for target drug delivery and non-toxic behavior.

Seasonal and Daily Variations in Lung-deposited Surface Area of Ambient Fine PM in Los Angeles

Constantinos Sioutas*, Yashar Aghaei, Mohammad Mahdi Badami, Mohammad Aldekheel and Ramin Tohidi

University of Southern California, Department of Civil and Environmental Engineering, Los Angeles, California, USA

Abstract

The aim of this study was to measure particle number concentration (PNC), as well as concentrations of lung-deposited surface area (LDSA), organic carbon (OC), and elemental carbon (EC) in ambient fine particulate matter (PM). The sampling campaigns were conducted during cold and warm periods at the particle instrumentation unit of the University of Southern California in Los Angeles. Hourly measurements of PNC and LDSA data were collected employing discmini and scanning mobility particle sizer (SMPS), while OC, OC volatility fractions (OC1-OC4), and EC concentrations were measured by the sunset lab monitor. The diurnal profiles of PNC and EC throughout the campaigns indicated peaks in the early morning hours and evening, which both were consistent with higher traffic flux, supporting prior studies linking a significant fraction of EC with ultrafine PM. Comparing LDSA hourly readings, the levels reported by discmini were consistently higher than those from SMPS, indicating a significant presence of irregularly shaped ultrafine particles, especially during high loads of traffic. It should be noted that the LDSA ratio was relatively lower during the colder periods, a trend attributable to the effect of higher relative humidity, which tends to increase water adsorption on particles. In the warmer periods, PNC levels also increased around midday, likely due to photochemical reactions triggered by the sunlight. This trend was similarly recorded in OC levels, particularly for OC4 as a tracer of secondary reactions. On the other hand, during the colder months, a nighttime peak was observed in PNC, attributing to the aqueous phase formation of secondary aerosols leading to higher OC4 levels, which is prevalent during the nighttime period of the cold seasons. This study offers a better insight into more effective air pollution regulation and associated health impacts.

Cellular Uptake of Spherical Gold Nanoparticles in PC-3 Cells: Dual-phase Kinetic Uptake and Modelling

Gabriela Traplin[1*], Raffi Karshafian[1,2,3] and Ana Pejovic-Milic[1]

[1]Department of Physics, Toronto Metropolitan University, Toronto, Ontario, Canada
[2]Institute for Biomedical Engineering, Science and Technology (iBEST), A Partnership Between Toronto Metropolitan University and St. Michael's Hospital, Toronto, Ontario, Canada
[3]Keenan Research Centre for Biomedical Science of St. Michael's Hospital, Toronto, Ontario, Canada

Abstract

Research into the cellular uptake of gold nanoparticles (AuNP) is an established area of study; however, the current literature is limited in long-term kinetic study. Here, the uptake of AuNPs of diameters 5, 10, and 20 nm at extracellular gold concentrations of 10 and 40 μm was measured from 0 to 48 h in prostate adenocarcinoma PC-3 cells. Total reflection X-ray fluorescence (TXRF) spectroscopy was used for simplified sample preparation, low detection limits, and high accuracy. Uptake was observed to have inverse- size dependency, and to increase with higher extracellular gold concentration. The kinetics of uptake were fundamentally similar across all conditions, with an initial rapid internalization, a plateau at ~2-4 h, a subsequent period of linear increase, and a second plateau at ~24 h. This second phase of uptake and plateau was the most novel kinetic feature observed, showing a significant increase in internalized AuNPs compared to the first plateau. A kinetic model was proposed, based on a two-phase process of langmuir adsorption, and fit the data well, with R2 values ranging from 0.8298-0.9876. Rate constants of uptake decreased with increasing AuNP size. The second phase of uptake showed larger uptake rate constants by an order of magnitude and had an observed onset time of 16.46 - 19.98 h. This second phase reveals the importance of considering longer exposure times in cellular uptake studies and may help reveal an underlying biological mechanism. It may be exploited to optimize AuNP cellular uptake and overcome the biomedical limitations due to the current observations of a low delivery fraction to tumors. Future work aims to investigate this second phase as well as expand the kinetic model by exploring different cell lines and AuNP features.

Phage-loaded Nanofibers: A Promising Nanobiopesticide Coating for Packaging Against Food Pathogens

Fernanda Coelho[1,2*], Pedro Miguel Silva[2], Victor Gomes Lauriano De Souza[2], Sanna Sillankorva[2] and Valtencir Zucolloto[1]

[1]Nanomedicine and Nanotoxicology Group (Gnano), Sao Carlos Institute of Physics, University of Sao Paulo, Sao Carlos, Sao Paulo, Brazil
[2]International Iberian Nanotechnology Laboratory, Portugal

Abstract

The increasing prevalence of antibiotic-resistant bacteria in food and packaging materials presents a serious public health challenge, necessitating innovative approaches to enhance food safety. Bacteriophages, viruses that specifically target and lyse bacteria, represent a promising alternative to conventional antimicrobials. Nanofiber coatings offer a dual advantage: their high surface area due to the nanoscale fiber size and the controlled release of active agents through diffusion in the polymer matrix. In this study, we developed nano biopesticide coatings using zein, hydroxypropyl methylcellulose (HPMC), and alginate through electrohydrodynamic processing (EHDP). Bacteriophages were embedded within zein-HPMC and alginate- HPMC matrices and electrospun onto two substrates, parchment paper and polystyrene, and characterized for their physical, chemical, and mechanical properties using techniques such as SEM, Cobb tests, FTIR, and water vapor permeability measurements. The resulting fibers, both unloaded and phage-loaded, exhibited an average diameter of 100 nm, as determined by SEM. Transmission electron microscopy (TEM) analysis of the *Salmonella*-specific bacteriophages revealed a particle size of approximately 80 nm. Microbiological evaluations showed a concentration of approximately 4 × 10^7 PFU/ml per substrate, with stability maintained over 7 days. The phage-coated parchment paper and polystyrene remained stable at a concentration of 10^7 PFU/ml throughout this period. These findings suggest that nanofiber-based coatings on polystyrene could enhance the antimicrobial properties of food packaging, offering a novel strategy to combat *Salmonella* and other foodborne pathogens.

Development of Biomimetic Doxorubicin-loaded Magnetic Nanoparticles for Targeted Breast Cancer Therapy

Maria Julia Bistaffa[1,2*], Prajakta Tambe[2], Ana Ribeiro[2], Valtencir Zucolotto[1] and Manuel Banobre-Lopez[2]

[1]Nanomedicine and Nanotoxicology Group (GNano), University of Sao Paulo (USP), Brazil
[2]Advanced (magnetic) Theranostic Nanostructures Lab, International Iberian Nanotechnology Laboratory (INL), Portugal

Abstract

Iron-oxide magnetic nanoparticles (MNPs) are promising candidates for drug delivery in the cancer treatment due to their unique properties, such as biocompatibility and tunable magnetic properties. This study aims to develop biomimetic doxorubicin (Dox)-loaded MNPs coated with triple-negative breast cancer cell membranes (CM) for targeted delivery to breast tumor cells. MNPs were synthesized via hydrothermal method and conjugated with Dox through electrostatic bonding. The CM coating was performed using high-power ultrasounds. Both coated and uncoated with MNPs-Dox were characterized by dynamic light scattering (DLS), X-Ray diffraction (XRD), transmission electron microscopy (TEM), and AC magnetometry for magnetic hyperthermia capacity evaluation. XRD confirmed the magnetite phase and the cubic inverse spinel structure of MNPs. MNPs exhibited a hydrodynamic diameter of 21 ± 3 nm and a surface charge of -48 ± 1 mv. Magnetic measurements showed superparamagnetic behavior with a specific absorption rate (SAR) of 292.6 w/g (668 kHz and 20 mt). Dox loading efficiency was 89±3 %. Post-Dox loading did not significantly affect the hydrodynamic size but reduced the surface charge to -35 ± 1 mV. After CM coating, the diameter increased to 80 ± 21 nm, and the charge shifted to -24 ± 1 mv, like the isolated CM. TEM confirmed CM coating and the circular shape of MNPs, whereas magnetic characterization showed that MNPs preserve their magnetic properties and SAR after CM coating. These results suggest that the homotypic targeting approach provided by the CM coating could enhance the specificity of drug delivery, supporting the potential of this strategy in breast cancer therapy.

Synthesis of Nano Superabsorbent Polymers for Harvesting Atmospheric Water for Human Consumption

Valquiria De Campos[1*], Isaac Jamil Sayeg[2] and Diego Gouveia Marques[1]

[1]UNESP-Sao Paulo State University, Science and Technology Institute of Sorocaba (ICTS), Brazil
[2]USP-University of Sao Paulo, Institute of Geosciences, Brazil

Abstract

The goal of this work is to produce drinking water using atmospheric air as a reservoir. Atmospheric humidity and droplets are a significant source of fresh water, especially at low levels of relative humidity typical of arid environments. Synthetic superabsorbent polymers (SAP) are hydrophilic three-dimensionally cross-linked materials characterized by considerable durability and significant water absorption capacity. In this study, nano SAP was synthesized from polyacrylonitrile and a device was built for the absorption/desorption of atmospheric water. The major advantages of this device containing SAP are the easy extraction of water from the air, unlike systems that use metal-organic frameworks (MOFs) and zeolite, and its low cost compared to that of the latter materials.

Metal Bionanoparticles: Optimization of Mycosynthesis, Characteristics and Antimicrobial Activities Against Crop Pathogens

Patrycja Golinska*, Julia Nadrowska, Joanna Trzcinska-Wencel and Aniketkumar Gade

Department of Microbiology, Nicolaus Copernicus University in Torun, Poland

Abstract

The aim of the study was optimization mycosynthesis of zinc oxide (ZnONPs), magnesium oxide (MgO), copper

oxide (Cu) and iron oxide (FeO) NPs, determination of physicochemical properties of NPs and evaluation of their antimicrobial activity against plant pathogens. Fungal extracts from Fusarium strains and appropriate salts ($ZnSO_4 \times 7H_20$, $MgNO_3 \times 6H_20$, $CuSO_4 \times 5H_2O$ and $FeSO_4 \times 7H_20$) were used for the synthesis of NPs. Synthesis conditions were optimized by adjusting salt concentrations, pH or temperature of the reaction mixture. The biosynthesis was confirmed by visual observations and UV-visible spectroscopy. Physico-chemical properties of NPs were determined using transmission electron microscopy (TEM), fourier transform infrared spectroscopy (FTIR) and X-ray diffraction analysis (XRD). Antibacterial activity of selected NPs was evaluated by determination of minimum inhibitory and biocidal concentrations (MICs and MBCs, respectively) against set of bacterial and fungal plant pathogens. The highest-yielding strains for the NPs synthesis were *F. solani* IOR825 (ZnONPs), *F. tricinctum* (MgONPs), and *F. graminearum* (CuNPs, FeONPs). The NPs showed an absorbance peak at 356, 331, 524, 290nm, respectively. TEM analysis showed spherical and irregularly shaped NPs while NTA size of NPs from 34 to 189 nm. The results from XRD confirmed crystalline structure of bioNPs, while from FTIR presence of biomolecules responsible for reducing the metal salts and stabilization of NPs. ZnONPs and CuNPs showed antimicrobial activity against all tested bacterial strains except *P. carotovorum* and inhibited fungal spore development in dose-depended manner, with highest efficiency of ZnONPs against *F. oxysporum* IOR342 and CuNPs against *Penicillum* sp. Fungi of the genus *Fusarium* showed ability for the synthesis of all nanoparticles. ZnONPs and CuNPs exhibited antimicrobial activity that indicate that they have potential to control microbial plant pathogens that cause serious losses to agricultural crops.

Biosynthesized Metal Nanoparticles with Antimicrobial Activity for Stimulation of Plant Growth

Joanna Trzcinska-Wencel[1*], Mucha Natalia[2], Tyburski Jaroslaw[2] and Golinska Patrycja[1]

[1]Department of Microbiology, Nicolaus Copernicus University in Torun, Torun, Poland
[2]Department of Plant Physiology and Biotechnology, Nicolaus Copernicus University in Torun, Torun, Poland

Abstract

Nanotechnology applications in agriculture aim to reduce excessive use of chemical-containing plant protection products and would become more efficient and less hazard to environment. Therefore, the effect of biologically synthesized zinc oxide (ZnONPs) and silver (AgNPs) nanoparticles on Zea mays seeds germination and seedlings growth was evaluated. The properties of NPs were determined by transmission electron microscopy (TEM), X-ray powder diffraction (XRD), fourier transform infrared spectroscopy (FTIR) and nanoparticle tracking analysis (NTA). The maize seeds were treated with NPs at concentrations of 32, 128 and 512 $\mu g ml^{-1}$ prior to sowing. The germination parameters, seedling vigour and total chlorophyll content were evaluated after 14 days. Antibacterial activity of bio-NPs was evaluated by determination of minimal inhibitory and minimal biocidal concentration (MIC and MBC) against plant pathogens. The AgNPs at all tested concentrations revealed sterilization effect on seeds. The increase of fresh and dry biomass of seedlings, and higher values of vigour indexes I and II were noted after the treatment with both bio-NPs at the concentration of 32 and 128 $\mu g\ ml^{-1}$ (ZnONPs) and 512 $\mu g\ ml^{-1}$ (AgNPs), respectively. The reduced chlorophyll content was observed in seedlings treated with ZnONPs and AgNPs at concentration of 512 $\mu g\ ml^{-1}$. The highest antibacterial activity was observed for AgNPs against *Pseudomonas syringae* IOR2188 and for ZnONPs against *Xanthomonas camperstris* IOR512. The application of low concentrations of bio-NPs revealed no adverse effect on seeds germination, seedling condition or chlorophyll content, indicates their potential for use in agriculture as nano-agrochemicals to provide nutrients and protection against pathogens.

Preparation, Structural Characterization, Optical, Photoluminescence, AC Electrical Conductivity and Broadband Dielectric Properties of WO 3 Reinforced PEG/CS Blend for Futuristic Optoelectronic and Energy Storage Devices

Maha Abdullah A Alqarni[*]

University of Jeddah, College of Science, Department of Physical Sciences, Jeddah, Saudi Arabia

Abstract

In the current study, solution cast procedure is used to prepare polymer nanocomposites (PNCs) based on polyethylene glycol (PEG)/chitosan (CS) blend and varying concentrations of tungsten trioxide nanoparticles (WO3 NPs), as a nanofiller. TEM micrograph shows that WO3 NPs have particle sizes of 5 - 32 nm their shapes are cubic and spherical. The XRD results reveal the semicrystalline of PEG/CS blend through showing three distinct diffraction peaks at 2θ = 7.42°, 19.47° and 23.62° and the degree of crystallinity is decreased after the incorporation of WO3 NPs due to the formation of polymer-nanoparticle interactions as indicated by FTIR spectra. The values of optical energy bandgap (direct and indirect) reduce while the Urbach energy increases with raising the concentration of WO3 NPs in the PEG/CS matrix. The PEG/CS-WO3 films' PL spectra show a photoemission peak at about 387 nm, where this peak loses intensity and becomes broader due to the induced defects and increase of disordering within the nanocomposite films. Additionally, the results of the dielectric investigation show an increase in the dielectric constant, dielectric loss, and AC electrical conductivity, which may be a sign of an increase of charge carriers and the content of amorphous regions that assists the movement of charge carriers. Argand plot shows a half semicircle implying the Debye-type relaxation mechanism. The experimental results suggest the use of PEG/CS-WO_3 nanocomposites as a possible contender for futuristic energy storage and optoelectronic applications.

Comparison of Induction of Fibrosis on 2D Cell Culture and 3D Bioprinted Scaffolds Using Methotrexate

Mrunmayi Ashish Gadre*

Manipal Centre for Biotherapeutics Research, India

Abstract

Recent trends in the field of life sciences is turning over from 2D culture to 3D culture to carry out various *in vitro* experiments. The results from 3D model is proven to be more reliable than 2D models, this study is carried out to establish liver fibrotic *in vitro* model which shows better results than the conventional 2D models. To make 3D bio printed *in vitro* diseased liver model, bioink was synthesized which composes of GelMA, rat liver dECM and HepG2 cells. Decellularization is a process where cellular content is completely removed from the tissue of interest while retaining the extra cellular matrix (ECM) components containing proteins. The presence of the proteins in the ECM aids in the cell fate process and thus, the retention of ECM is important to develop scaffold. The aim of decellularization is to remove all the cellular components and at the same to retain all the 3D extra cellular matrix proteins that can be used as a component for ink. The 3D bio printed models are constructed in a layer by layer 1 cm scaffold which was used for comparing with 2D culture that contained only the cells. In this work we attempted to use the drug methotrexate to induce fibrosis for making it as an *in vitro* liver diseased model. The study included the comparison of the expression of fibrosis on 2D and 3D models and prove that the 3D bioprinted *in vitro* liver disease model is better than the conventional 2D model.

Surface Enhanced Raman Scattering for Low Concentration Molecular Detection Applications

Arthur McClelland[1*], Caroline Song[2], Tom Huang[2], Sidarth Krishna[2], Christina Quinn[2] and Helen Zeng[2]

[1]*Center for Nanoscale Systems, Harvard University, USA*
[2]*Academy for Advanced Research and Development, USA*

Abstract

Raman scattering is the inelastic scattering of light upon light-matter interaction, which provides molecular information about the sample under investigation by probing the vibrational energy levels. Unfortunately, Raman scattering is a very inefficient process, only ~1 in 108 excitation photons undergo Raman scattering. surface enhanced raman scattering (SERS) uses a rough metal substrate or metal nanoparticles to enhance the probability of Raman

scattering occurring by several orders of magnitude. Since the effect was discovered in the late 1970's by Richard Van Duyne, many different applications have made use of the effect to lower the limit of detection of molecules of interest in a sample. Many applications require very low limit of detection for the molecules of interest. In this presentation several different projects making use of SERS with silver nanoparticles will be covered including pesticide detection on produce, "forever chemical" detection in drinking water, and biomarkers for disease detection.

Altering the Mechanical Properties of Self-assembled Bacterial Filaments Through Protein Engineering

Neta Sal-Man*, Moran Elias-Mordechai, May Morhaim, Maya Georgia Pelah, Irina Rostovsky, May Nogaoker, Jurgen Jopp, Raz Zarivach and Ronen Berkovich

Ben-Gurion University of the Negev, Beer Sheva, Israel

Abstract

Protein-based biomaterials are in high demand due to their high biocompatibility, non-toxicity, and biodegradability. Here, we explored a bacterial protein that spontaneously self-assembles to form long extracellular filamentous structures (~1 µm in length) called *E. coli* secreted protein A (EspA). We studied the morphological and mechanical properties of the filamentous structures EspA forms and how protein engineering can alter these properties. To this end, we studied the natural EspA filaments and recombinant filaments. We observed that the two recombinant EspA proteins spontaneously assembled to form curly, thin filaments, different from the linear, thicker natural EspA filaments. Image analysis of the filaments disclosed that the longitudinal elasticity of the recombinant filaments was considerably higher than the natural filaments with a persistence length smaller by two orders of magnitude. Nanoindentation force spectroscopy measurements revealed that the recombinant filaments measured a radial elastic modulus by about an order of magnitude lower than the natural filaments. Yet the radial elastic modulus of the truncated recombinant filaments was higher than the full-length recombinant filaments. These differences underscore the potential to modulate the mechanical properties of EspA filaments by introducing mutations into the protein sequence. Our findings suggest the candidacy of EspA as a fundamental building block for developing a potentially new biomaterial with a unique three-level hierarchical architecture. This structure would encompass the prospective fabrication of the self-assembled EspA-modulated filaments into a macroscopic substance.

Au Nanodyes as Enhanced Contrast Agents in Wide Field Near Infrared Fluorescence Lifetime Imaging

Neelima Chacko[1*], Rinat Ankri[1], Menachem Motiei[2], Jadhav Suchita Suryakant[1] and Michael Firer[1]

[1]*Ariel University, Israel*
[2]*Bar-Ilan University, Ramat Gan , Israel*

Abstract

The near-infrared (NIR) range of the electromagnetic (EM) spectrum offers a nearly transparent window for imaging tissue. Despite the significant potential of NIR fluorescence-based imaging, its establishment in basic research and clinical applications remains limited due to the scarcity of fluorescent molecules with absorption and emission properties in the NIR region, especially those suitable for biological applications. In my presentation, I will present a novel approach for enhanced NIR florescence imaging by combining the widely used IRdye 800 fluorophore with gold nanospheres (GNSs) and gold nanorods (GNRs) to create Au nano dyes, with improved quantum yield (QY) and distinct lifetimes, which are also biocompatible. These nano dyes exhibit varying photophysical properties due to the differences in the separation distance between the dye and the gold nanoparticles (GNP). I will also show a rapid and highly sensitive wide- field fluorescence lifetime imaging (FLI) macroscopic setup, along with phasor-based analysis, we introduce multiplexing capabilities for the Au nano dyes.

Condensation-assisted Hazardous Vapor Detection on 3D Gold Nanoparticle Surface-enhanced Raman Spectroscopy

Pratiksha P. Mandrekar[1*], Jeong Hee Kim[2], Seungman Park[3] and Daejong Yang[1]

[1]Kongju National University, Republic of Korea
[2]Johns Hopkins University, Baltimore, USA
[3]University of Nevada, Las Vegas, USA

Abstract

Detection and identification of toxic vapours are crucial for ensuring environmental, industrial and biomedical safety as exposure to these vapours can pose significant health risks and environmental hazards. Surface- enhanced raman spectroscopy (SERS) offers a powerful approach due to its exceptional sensitivity, selectivity, and rapid analysis capabilities. While SERS is well-established for analysing solid and liquid samples, vapor detection presents challenges due to the limited interaction between vapor molecules and SERS substrate. To overcome this drawback and enhance sensitivity, a method has been proposed that involves converting vapours into liquids through a controlled condensation process. This conversion process greatly improves the interaction between the analytes and the substrate, thereby boosting Raman signal detection. Gold nanoparticles (AuNPs) are incorporated into SERS substrates for the detection of both individual and mixed vapors. The substrate was fabricated using liquid phase deposition (LPD) of AuNPs on a silicone (Si) base and tested with hazardous vapors such as ethanol, methanol, toluene, and ethylbenzene. The experimental results demonstrate that the AuNP-based SERS substrate effectively distinguishes between specific vapors and complex mixtures, including challenging vapor sets like ethanol-methanol and toluene-ethylbenzene. SERS exhibits potential for rapid and sensitive vapor detection, particularly in biomedical contexts where trace-level sensing is crucial. These findings advance the application of SERS as a reliable analytical tool, leveraging the unique properties of AuNPs to improve vapor detection across various fields, including chemical and biomedical safety monitoring.

Improved pDNA-loading in Lipid Nanoparticles Through Microfluidics: Optimization and *in vitro* Trials

Jason Thomas Duskey[1*], Ilaria Ottonelli[1], Elisa Adani[2], Sabrina Cuoghi[1], Riccardo Caraffi[1,3], Francesca Roda[1,3], Alessandro Anderlini[1], Valeria Marigo[2], Maria Angela Vandelli[1], Giovanni Tosi[1] and Barbara Ruozi[1]

[1]Nanotech Lab, University of Modena and Reggio Emilia, Modena, Italy
[2]Department of Biology, University of Modena and Reggio Emilia, Modena, Italy
[3]Clinical and Experimental Medicine PhD Program, Department of Biomedical, Metabolic, and Neural Sciences, University of Modena and Reggio Emilia, Modena, Italy

Abstract

Nanoparticle-based gene therapy has been increasingly growing in recent years for both genetic and non- genetic diseases, especially given the success of the lipid nanoparticle (LNP) based COVID-19 vaccine. Microfluidic technology has become the new paradigm to produce LNPs, but most aspects of this novel technique need to be more deeply investigated. Therefore, fluorescent cationic LNPs were optimized (amount of lipids and fluorescence) to load pDNA using microfluidics and characterized for size, polydispersity, surface charge, morphology, fluorescent intensity, and storage stability. LNPs were then tested to bind (post-adsorption) or encapsulate (DNA present during formation) pDNA over a range of plasmid concentrations. Post absorption showed critical limitations, as the LNPs showed aggregation with concentrations of pDNA > 15ug/ml, while encapsulation allowed for larger amounts of pDNA up to 100 μg/ml, with a wider range of N:Ps (25:1-1:1), with almost 100% loading efficiency without affecting the LNP physical characteristics. The importance of the cationic lipid was also evaluated. Without DOTAP, the classical method led to LNPs that loaded < 2% pDNA due to lack of electrostatic interactions while when the pDNA was solubilized in the aqueous phase during formulation, almost 40% of the DNA was loaded. These formulations represent a great advantage in gene therapy to load higher amounts of pDNA and offer the ability to load without the cytoxic cationic lipid. The toxicity and transfection efficacy of the most promising formulations

are now under investigation using *in vitro* models to assess the optimal balance between reduced cationic lipid and transfection efficiency.

Improving Cancer Diagnosis via Nanofabricated Colorimetric Histology Platforms

Brian Abbey[1,2*], Kristian Caracciolo[1,2], Erinna F. Lee[2,3,4,5], W. Douglas Fairlie[2,3,4,5] and Eugeniu Balaur[1,3]

[1]*Department of Mathematical and Physical Sciences, School of Engineering, Computing and Mathematical Sciences, Bundoora, Victoria, Australia*
[2]*La Trobe Institute for Molecular Science, La Trobe University, Bundoora, Victoria, Australia*
[3]*Department of Biochemistry and Chemistry, School of Agriculture, Biomedicine and Environment, Bundoora, Victoria, Australia*
[4]*Olivia Newton John Cancer Research Institute, Victoria, Australia*
[5]*School of Cancer Medicine, Bundoora, Victoria, Australia*

Abstract

Early-stage cancer detection typically involves visually examining tissues under a microscope, often employing nuclear and cytoplasmic stains such as hematoxylin and eosin (H&E) in conjunction with conventional optical microscopy. While H&E staining effectively reveals the structure of normal tissues and cells, it often needs to be combined with more intricate methodologies. These may involve supplementary immunohistochemistry (IHC) staining or the application of gene targets through fluorescence *in situ* hybridisation (FISH). Unfortunately, a consistently reliable biomarker distinguishing early-stage cancer from non-cancerous conditions remains scarce, further complicated by biological variations among and within patients. Furthermore, these techniques are resource-intensive, demanding specialized technicians and equipment, posing challenges in locations without access to advanced biochemistry tools. Over the past 8 years we have been working to develop new nanotechnology-based histology platforms that can rapidly and reliably achieve label-free detection of cancer cells without the need for any specialised equipment or training. Our approach exploits localised surface plasmons (LSPs) to detect minute changes in cancer versus healthy cells. Based on the specific optical properties of cancer cells, which are determined by cell intrinsic/extrinsic factors, cancer cells may be detected by monitoring variations in LSP resonances using nanostructured thin films resulting in a colour change-termed "colorimetric histology". Here we describe our recent work applying colourimetric histology for the detection and visualization of cancer cells. Furthermore, we compare our results in terms of their sensitivity and selectivity to different kinds of cancer biomarker and optical imaging tools.

Hyaluronic Acid: Development and Application in Drug Delivery Systems

Carla Serri*, Giovanna Rassu, Paolo Giunchedi and Elisabetta Gavini

Department of Medicine, Surgery and Pharmacy, University of Sassari, Italy

Abstract

Hyaluronic acid (HA) has sparked significant interest in drug delivery research due to its biocompatibility and ability to bind to CD44 and RHAMM receptors, which are commonly overexpressed in inflammation and cancer. Herein, we aimed to develop hyaluronic acid (HA)-coated biodegradable nanoparticles (NPs) and HA-hybrid nanoparticles (H-NPs). NPs were composed of polymeric blends and coated with HA using a modified double emulsion technique. H-NPs were prepared via nanoprecipitation technique using lipids and polymeric materials (HA). The characterizations including morphology, size, zeta potential (ZP), differential scanning calorimetry (DSC), isothermal titration calorimetry (ITC), encapsulation efficiency, drug content, *in vitro* drug release, and permeation were investigated. The HA content in or on the NPs was quantified using an HA ELISA kit. Additionally, cellular uptake studies and cytotoxicity assays were conducted using cell lines overexpressing CD44. The morphology proved that all formulations showed spherical shape. Only H-NPs had irregular surfaces; the mean size was approximately 110-290 nm (NPs/H-NPs). The ZP was affected by HA addition for all formulations decreasing about-4 at -40 mv. DSC and ITC revealed the presence of HA on the NPs and H-NP surface. The ELISA kit results confirmed the presence of HA on the NPs surface. *in vitro* tests demonstrated the ability of the NPs/H-NP to sustain the release

and permeation of drugs: the influence of HA was assessed. The tumor-targeting ligand HA enhanced intracellular uptake of NPs in cell lines overexpressing the CD44 receptor. The results indicate that HA-based NPs/H-NPs can be a promising candidate for targeted drug delivery.

Comparision of Induction of Fibrosis on 2D Cell Culture and 3D Bioprinted Scaffolds Using Methotrexate

Mrunmayi Ashish Gadre*

Manipal Centre for Biotheraputic Research, India

Abstract

Recent trends in the field of life sciences is turning over from 2D culture to 3D culture to carry out various *in vitro* experiments. The results from 3D model is proven to be more reliable than 2D models, this study is carried out to establish liver fibrotic *in vitro* model which shows better results than the conventional 2D models. To make 3D bioprinted *in vitro* diseased liver model, bioink was synthesized which composes of GelMA, rat liver dECM and HepG2 cells. Decellularization is a process where cellular content is completely removed from the tissue of interest while retaining the extra cellular matrix (ECM) components containing proteins. The presence of the proteins in the ECM aids in the cell fate process and thus, the retention of ECM is important to develop scaffold. The aim of decellularization is to remove all the cellular components and at the same to retain all the 3D extra cellular matrix proteins that can be used as a component for ink. The 3D bioprinted models are constructed in a layer by layer 1 cm scaffold which was used for comparing with 2D culture that contained only the cells. In this work we attempted to use the drug methotrexate to induce fibrosis for making it as an *in vitro* liver diseased model. The study included the comparison of the expression of fibrosis on 2D and 3D models and prove that the 3D bioprinted *in vitro* liver disease model is better than the conventional 2D model.

Enhancing Charge Transfer on Graphene Surface-enhanced Raman Spectroscopy by Adjusting Graphene's Fermi Energy

Samar A. Ghopry[1*], Bo Liu[2], Andrew Shultz[2] and Judy Z. Wu[2]

[1]Department of Physics, Jazan University, Jazan, Saudi Arabia
[2]Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas, USA

Abstract

Surface enhanced raman spectroscopy (SERS) is a useful spectroscopic method for accurately and sensitively detecting molecules adsorbed on nanostructures or rough metal surfaces. SERS relies on chemical (CM) and electromagnetic (EM) mechanisms. Because the CM depends on an effective charge transfer between the probe molecules and SERS substrates, optimizing the CM enhancement requires engineering the molecule attachment and the energy level alignment at the molecule/substrate interface. At this paper, a review of the recent progress made to increase CM of Rhodamine 6G (R6G) on graphene SERS substrates by using a combination of atomic layer deposition (ALD) decorating of Pt nanoparticles (Pt-NPs) and C-band ultraviolet (UVC) irradiation. Both techniques lead to high enhancement, which is justified by the activation of the graphene surface, p-doping for better attachment of R6G molecules and charge transfer, and the downshift of the Fermi energy (p-doping) following UVC exposure. The Pt-NPs decoration leads to further p-doping graphene, which modifies the graphene's Fermi energy to encourage charge (hole) transfer at the R6G/graphene interface.

Seed Priming with Zinc Oxide Nanoparticles: An Innovative Approach to Alleviate Cobalt-induced Stress and Enhance Maize Growth

Yinbo Gan*, Abdul Salam and Muhammad Umair Yasin

Department of Agronomy, College of Agriculture and Biotechnology, Zhejiang University, Hangzhou, China

Abstract

Cobalt (Co) stress adversely impacts plant growth and biomass, posing a significant threat to global crop production and food security. Nanotechnology is an emerging field in crop sciences for its potential in improving crop production and mitigating various stresses. Although there have been several studies reporting the toxic effects of zinc oxide nanoparticles (ZnO NPs) on different crops, their role in ameliorating heavy metal toxicity are still poorly understood. This study aims to explore the positive effects of seed priming with ZnO NPs in alleviating phytotoxicity induced by cobalt (Co) stress. Our results demonstrated that ZnO NPs significantly improved the plant growth, biomass, and photosynthetic machinery in maize under Co stress. The NPs priming reduced ROS and MDA accumulations in maize shoots. More importantly, ZnO NPs alleviated the toxic effects of Co by decreasing its uptake and conferred stability to plant ultra-cellular structures and photosynthetic apparatus. Moreover, increased levels of nutrient content and antioxidant enzymes were observed in seedlings primed with NPs. This study offers innovative evidence showcasing the mitigation of Co toxicity through ZnO NPs seed priming in maize. Our findings also provide the potential of ZnO NPs as a stress mitigation agent for crops cultivated in Co-contaminated areas, thereby enhancing both crop growth and yield.

Transcriptomics of Temperature-sensitive Gene-mediated Resistance Identifies a WAKL10 Protein Interaction Network

Henrik Stotz[1*], Katherine Noel[1,2], Ivan Wolf[3], David Hughes[4], Guilherme Valente[5], Aiming Qi[1], Yong-Ju Huang[1] and Bruce Fitt[1]

[1]Centre for Agriculture, Food and Environmental Management, University of Hertfordshire, Hatfield, UK
[2]LS Plant Breeding, North Barn, Manor Farm, Milton Road, Cambridge, UK
[3]Department of Biological Sciences, University of North Carolina, Charlotte, USA
[4]Intelligent Data Ecosystems, Rothamsted Research, Harpenden, United Kingdom
[5]School of Medicine, Sao Paulo State University-UNESP, Botocatu, Brazil

Abstract

Understanding temperature-sensitivity of resistance (R)-gene mediated immunity against extracellular phytopathogens is important for sustainable food production in face of global warming. Resistance off or oilseed rape (*Brassica napus*) crop against the phoma stem canker pathogen *Leptosphaeria maculans* is temperature-sensitive in introgression line Topas-Rlm7 but temperature insensitive in Topas-Rlm4. A total of 1,646 host genes were differentially expressed in Topas-Rlm4 and Topas-Rlm7 in response to temperature. Amongst these were three WAKL10 genes, including one gene representing Rlm4 and the temperature- sensitive Rlm7-1 allele. A WAKL10 protein interaction cluster specifically for Topas-Rlm7 was identified at 25oC. Further analysis of the Topas-Rlm4 network identified WRKY22 as a putative regulatory target of the ESCRT-III complex-associated protein VPS60.1, which belongs to the WAKL10 protein interaction community. Combined enrichment analysis of gene ontology terms considering gene expression and network data linked vesicle-mediated transport to defence. Further research has identified extracellular vehicles (EVs) that have the size nanoparticles in axenic culture filtrates of the fungal pathogen *L. maculans*, suggesting that pathogenicity factors are delivered to the host via such EVs.

Synthesis and Functionalization of Silica Nanoparticles with Silver Ions as a Hydrophobic and Antibacterial Fabric Coating

Alexis Alejandro Salazar Navarro[1*] and Valdez-Salas, Benjaminan[2]

[1]*Instituto de Ciencias Agricolas, Universidad Autonoma de Baja California, Carretera a Delta, Ejido Nuevo Leon s/n, Baja California, Mexico*
[2]*Instituto de Ingenieria, Universidad Autonoma de Baja California, Mexicali, Baja California, Mexico*

Abstract

An ecofriendly, safe, and low-cost method to synthetize and functionalize hydrophobic silica nanoparticles with antimicrobial activity tested against *Escherichia coli* and *Staphylococcus aureus* is proposed. The silica nanoparticles were synthetized by Sol-Gel method from sodium metasilicate in alkaline conditions with a silicon ethoxylated surfactant, in a water/ethanol system to promote condensation reactions, these particles show a 1.66 nm diameter with spherical morphology. Oleic acid, silver ions and octadecyldimethyl(3-trimethoxysilylpropyl) ammonium were used in ethanol to functionalize silica nanoparticles with a final diameter of 34.6 nm. The final coating shows a contact angle of 90.62° with a water aliquot and antibiogram inhibition diameters of 8.5 mm and 9 mm against *E. coli* and *S. aureus* at 24 and 48 h.

Piezo-phototronic Effect in Multi-layer Structured Optoelectronic: Bilateral Piezoelectric Charge Modulation

Fangpei Li[1,2] and Wenbo Peng[1,2*]

[1]*School of Microelectronics, Xi'an Jiaotong University, Xi'an, Shaanxi, China*
[2]*The Key Lab of Micro-Nano Electronics and System Integration of Xi'an City, Xi'an, Shaanxi, China*

Abstract

Piezo-phototronic effect utilizes the strain induced piezoelectric charges inside the piezoelectric semiconductors to modulate the local energy band diagram at the interface of junctions, thus controlling the photo-generated carriers' behaviors and the performance of optoelectronic devices. Since its invention in 2010, piezo-phototronic effect is vastly demonstrated in photodetectors, light-emitting diodes, and solar cells, where only one interface is modulated by piezoelectric charges. In 2018, we first propose to construct multi-layered structure for efficient utilization of piezoelectric charges with both polarities and obtain better performance optimization by piezo-phototronic effect, which we recently name as bilateral piezoelectric charge modulation. Here, we summarize the recent progresses of our research on bilateral piezoelectric charge modulation, including both experimental results and analytical theories. An n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is designed, and the regulation of bilateral piezoelectric charges on bipolar phototransistor's performances is studied from the perspectives of theoretical derivation and experimental research simultaneously. A theoretical model of n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is established, and the influence of four polar combinations of piezoelectric charges induced by different strains formed at the interface of two heterojunctions on the characteristics of phototransistor is carefully studied. The theoretical calculation results show that, when positive piezoelectric charges are generated at both two interfaces, the regulation of strain on the phototransistor is a superposition of two positive effects, which can significantly improve the performances of phototransistor. Then an n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is experimentally prepared. By rationally designing the device structure, positive piezoelectric charges could be simultaneously generated at the two heterojunction interfaces when an external compressive strain is applied. The saturation current of phototransistor is significantly improved, and the photoresponsivity is also improved to a certain extent by the applied compressive strain. To further optimize the performances, the effects of interdigitated electrode's size, substrate and ZnO layer on the strain regulation of device performance are carefully studied. The experimental results show that when the p-Si substrate is used, the size of interdigitated electrodes is chosen as channel width W0 = 80 μm, the channel length L = 5 μm, and the number of electrodes N = 14, and the ZnO nanowires layer prepared by low temperature hydrothermal growth method is used as both emitter and collector, the strain induced bilateral piezoelectric charges regulation of the

obtained bipolar phototransistor is the best. At a compressive strain of -1.37%, the photoresponsivity is enhanced about 2000%, indicating the significant modulation of applied strain on the performances of heterojunction bipolar phototransistor.

MoS_2-$ZnIn_2S_4$/Single Layer Graphene Oxide: A Noble Metal Free Photocatalyst for Enhanced Photocatalytic Hydrogen Evolution

Fizza Siddique[1,2*], Tongtong Liu[1], Sergio Gonzalez-Cortes[3], MA. Rafiq[2], Xiaoming Zhang[1] and Chuanbo Li[1]

[1]School of Science, Minzu University of China, Beijing, 100081, People's Republic of China
[2]Department of Physics and Applied Mathematics, Pakistan Institute of Engineering and Applied Sciences, Islamabad, Pakistan
[3]Kinetic and Catalysis Laboratory, University of Los Andes, Merida, Venezuela

Abstract

Efficient light harvesting plays a pivot role in photocatalytic water splitting. The introduction of co-catalyst onto catalyst surface is a popular technique to improve photocatalytic performance of a catalyst. In this work, hierarchical 3D-MoS2-ZIS/SLGO catalyst was successfully designed by subsequent hydrothermal method, while SLGO was photo-deposited onto the surface of MoS2-ZIS catalyst. MoS2-ZIS heterostructure was optimized by varying MoS2 loading concentration from 1wt.% to 15wt.%. The structural, morphological, optical features of as-prepared samples were studied in detail. It is interesting to note that with the increase in MoS2 loading percentage, the original flowerlike morphology of ZIS changed to nanoplates. Moreover, 3% loading of MoS2 showed a significant red shift in band gap (2.58eV) than as-prepared ZIS (2.67eV) and the incorporation of SLGO led to further decrease in bandgap to 2.44eV. Photocatalytic studies revealed that 3%MoS_2-ZIS exhibits the highest Hydrogen Evolution Reaction (HER) rate (2160.94 $\mu molg^{-1}h^{-1}$), 10.13 times higher than bare-ZIS. The incorporation of SLGO further increased HER performance to 2684.65 $\mu molg^{-1}h^{-1}$. Importantly, the 3%MoS_2-ZIS and 3%MoS_2-ZIS/SLGO photocatalysts showed excellent HER rate after several cycles of operation. Based on the results, it is suggested that increase in H_2 evolution kinetics of MoS_2-ZIS/SLGO catalyst is due to enhanced visible light harvesting as well as efficient separation and transfer of charge carriers. This work also demonstrates that photo-deposition is an effective method for the preparation of efficient MoS_2-ZIS/SLGO composite. Moreover, it is an important study to exploit the use of cost effective, noble-metal free and non-toxic photocatalysts for efficient visible light hydrogen evolution.

Glycyrrhizic Acid/Carbon Nanozyme Injectable Hydrogel Promotes Wound Healing of Multiple Bacterial Infections

Chen Xu* , Chenhao Zhang, Tianyu Zhu, Shuwen Sun, Xiaoyu Fang and Kai Dong

Jilin Agricultural University, China

Abstract

The slow healing or non-healing of skin wounds caused by polymicrobial infections has become a serious problem in clinical wound treatment. Herein, we have developed an NIR-activating glycyrrhizic acid/carbon nanozyme injectable hydrogel (CGA hydrogel) for the synergistic treatment of polymicrobial infected wound. The CGA hydrogel can undergo phase transition at a specific temperature and facilitate administration at the wound site. Additionally, under near-infrared light irradiation, the CGA hydrogel can generate heat and promote the release of glycyrrhizic acid (GA) for achieving photothermal-drug synergistic treatment of various bacteria. Furthermore, the carbon nanozyme within the composite hydrogel can mimic the activity of superoxide dismutase and catalase enzyme, enabling the removal of reactive oxygen species, effectively alleviating inflammation and promoting wound healing caused by polymicrobial infections. *In vitro* antibacterial tests demonstrated the excellent antibacterial effect of CGA hydrogel on methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*. *In vivo* experiments also confirmed that the hydrogel significantly reduced inflammatory responses and accelerated angiogenesis in polymicrobial infected wounds. The CGA hydrogel exhibited excellent antibacterial and anti-inflammatory properties, offering a novel strategy for developing new treatments for polymicrobial infections.

Structural Dynamics Analysis of E3 Ubiquitin Ligase, E6AP HECT Domain, Revealed by High-speed Atomic Force Microscopy

Hiroki Konno*

WPI Nano Life Science Institute (WPI-NanoLSI), Kanazawa University, Kakuma-Machi, Kanazawa, Japan

Abstract

Ubiquitin (Ub) ligases E3 are an important factor in selecting target proteins for ubiquitination and determining the type of polyubiquitin chains on the target proteins. In the HECT (homologous to E6AP C-terminus)-type E3 ligases, the HECT domain is composed of an N-lobe and a C-lobe that are connected by a flexible hinge loop. The large conformational rearrangement of the HECT domain via the flexible hinge loop is essential for HECT-type E3-mediated Ub transfer from E2 to a target protein. However, detailed insights into the structural dynamics of HECT domain remain unclear. Here, we provide the first direct demonstration of structural dynamics of the HECT domain using high-speed atomic force microscopy at the nanoscale. We also found that flexibility of the hinge loop has a great impact not only on its structural dynamics but also on the formation mechanism of free Ub chains.

Novel Photothermal Magnetic Membranes for Solar-driven Desalination

Norhan Nady[1*], Nourhan Rashad[2], Marwa Showman[3], Noha Salem[1,2] and Sherif. H. Kandil[2]

[1]Polymeric Materials Research Department, Advanced Technology and New Materials Research Institute (ATNMRI), City of Scientific Research and Technological Applications (SRTA-City), New Borg El-Arab City, Egypt
[2]Department of Materials Science, Institute of Graduate Studies and Research, Alexandria University, Egypt
[3]Fabrication Technologies Research Department, Advanced Technology and New Materials Research Institute (ATNMRI), City of Scientific Research and Technological Applications (SRTA-City), New Borg El-Arab City, Egypt

Abstract

The integration of desalination with renewable energy sources like solar or wind power is a crucial aspect of climate change adaptation. It addresses both water scarcity and clean energy requirements. Solar water evaporation presents a promising alternative for desalination, as it solely relies on renewable and eco-friendly solar energy, eliminating concerns about brine disposal. However, conventional solar evaporation suffers from low efficiency due to the placement of the solar absorber at the bottom of the water body. A noteworthy advancement in solar-driven desalination systems is the development of novel photothermal magnetic (Janus) membranes. These membranes represent a significant breakthrough, as they enable solar-thermal energy conversion at the air/liquid interface. By utilizing photothermal membranes, this approach offers benefits over conventional bulk heating-based evaporation, including reduced thermal losses and improved energy conversion efficiency. The use of photothermal magnetic Janus membranes in solar-driven desalination systems holds great promise for achieving higher energy efficiency, increased freshwater production, and improved sustainability. This development represents an important step forward in advancing solar-driven desalination technologies, bringing us closer to realizing the goals of the green desalination economy.

Bioinspired Synthesis of Magnetic Nanoparticles Based on Iron Oxides Using Orange Waste and Their Application as Photo-activated Antibacterial Agents

David Giancarlo Garcia[1], Cristina Garzon-Romero[2], Mateo Alejandro Salazar[2], Karina J. Lagos[1], Kleber Orlando Campana[1], Alexis Debut[3], Karla Vizuete[3], Miryan Rosita Rivera[2], Dario Niebieskikwiat[4], Maria J. Benitez[5] and Maria Paulina Romero[1*]

[1]Department of Materials, Escuela Politecnica Nacional (EPN), Quito, Ecuador
[2]Laboratorio De Investigacion en Citogenetica y Biomoleculas De Anfibios (LICBA), Centro de Investigación Para La Salud En America Latina (CISeAL), Facultad De Ciencias Exactas y Naturales, Pontificia Universidad Catolica del Ecuador (PUCE), Quito, Ecuador
[3]Centro de Nanociencia y Nanotecnologia, Universidad De Las Fuerzas Armadas ESPE, Sangolqui, Ecuador

[4]Departamento De Física, Colegio De Ciencias E Ingenierías, Universidad San Francisco De Quito, Quito, Ecuador
[5]Departamento De Fisica, Escuela Politecnica Nacional (EPN), Quito, Ecuador

Abstract

In order to combat the widespread health issue of multidrug-resistant bacterial infections, magnetic nanoparticles based on iron oxides (MNPs-Fe) have been proposed as photothermal agents (PTAs) inside antibacterial photothermal treatment (PTT). We report on a rapid and simple green synthesis (GS) to synthesize MNPs-Fe utilizing trash. Orange peel extract (organic compounds) was utilized in the GS, which used microwave (MW) irradiation to shorten the synthesis time as a reducing, capping, and stabilizing agent. The weight produced, the MNPs-Fe's physical-chemical characteristics and magnetic properties were examined. Additionally, their antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* was evaluated, as well as their cytotoxicity in the animal cell line ATCC RAW 264.7. We found that the 50GS-MNPs-Fe sample (prepared by GS, with 50% v/v of NH4OH and 50% v/v of orange peel extract) had an excellent mass yield. Its particle size was ~50 nm with an organic coating (terpenes or aldehydes). We believe that this coating improved the cell viability in extended periods (8 days) of cell culture with concentrations lower than 250 $\mu g \cdot ml^{-1}$, concerning the MNPs-Fe obtained by CO and single MW, but it did not influence the antibacterial effect. The bacteria inhibition was attributed to the plasmonic of 50GS-MNPs-Fe (photothermal effect) by irradiation with red light (630 nm, 65.5 $mW \cdot cm^{-2}$, 30 min). We highlight the superparamagnetism of the 50GS-MNPs-Fe over 60 K in a broader temperature range than the MNPs-Fe obtained by CO (160.09 K) and MW (211.1K). Therefore, 50GS-MNPs-Fe could be excellent candidates as broad-spectrum PTAs in antibacterial PTT. Furthermore, they might be employed in magnetic hyperthermia, magnetic resonance imaging, oncological treatments, etc.

The Impact of Nanomedicine: 30,000 Orthopedic Nano Implants with No Failures and Still Counting

Thomas J. Webster[1,2,3,4*]

[1]School of Health Sciences and Biomedical Engineering, Hebei University of Technology, Tianjin, China
[2]School of Engineering, Saveetha University, Chennai, India
[3]Division of Pre-College and Undergraduate Studies, Brown University, Providence, USA
[4]CSO of Over a Dozen Companies, Mansfield Bioincubator, Mansfield, USA

Abstract

Nanomedicine is the use of nanomaterials to improve disease prevention, detection, and treatment which has resulted in hundreds of FDA approved medical products. While nanomedicine has been around for several decades, new technological advances are pushing its boundaries. For example, this presentation will present an over 25-year journey of commercializing nano orthopedic implants now in over 30,000 patients to date showing no signs of failure. Current orthopedic implants face a failure rate of 5-10% and sometimes as high as 60% for bone cancer patients. Further, artificial intelligence (AI) has revolutionized numerous industries to date. However, its use in nanomedicine has remained few and far between. One area that AI has significantly improved nanomedicine is through implantable sensors. This talk will present research in which implantable sensors, using AI, can learn from a patient's response to implants and predict future outcomes. Such implantable sensors not only incorporate AI, but also communicate to a handheld device, and can reverse AI predicted adverse events. Examples will be given in which AI implantable sensors have been used in orthopedics to inhibit implant infection and promote prolonged bone growth. *In vitro* and *in vivo* experiments will be provided that demonstrate how AI can be used towards our advantage in nanomedicine, especially implantable sensors. Lastly, this talk will summarize recent advances in nanomedicine to both help human health and save the environment.

Impact of Temperature and External Field Driving Rate on Disordered Antiferromagnetic-ferromagnetic Bilayers

Svetislav Mijatovic[1*], Stefan Graovac[1], Djordje Spasojevic[1] and Bosiljka Tadic[2,3]

[1]*Faculty of Physics, University of Belgrade, Belgrade, Serbia*
[2]*Department for Theoretical Physics, Jozef Stefan Institute, Ljubljana, Slovenia*
[3]*Complexity Science Hub, Vienna, Austria*

Abstract

This study employs numerical simulations based on the random field Ising model to investigate the magnetic behavior of antiferromagnetic-ferromagnetic bilayers. The study focuses on the hysteresis loop and coercive field, revealing nuanced dependencies on temperature and the driving rate of the external magnetic field. The hysteresis loop exhibits a distinctive staircase-like behavior, with the number of steps diminishing as both temperature and driving rate increase. Notably, the loop becomes smoother with elevated temperature and driving rates, highlighting the profound impact of thermal and dynamic factors on the magnetic response of the bilayer system. The coercive field demonstrates a systematic dependency on the driving rate, characterized by a power-law relationship with an exponent of 1/2. This suggests a clear connection between the coercive field and the external magnetic field driving rate. Additionally, the coercive field exhibits an exponential decrease with temperature, providing insights into the thermally induced variations in magnetic properties. These numerical predictions align with known experimental results from earlier studies, validating the model's predictive power. The observed changes in the hysteresis loop and the power-law dependence of the coercive field with temperature and driving rate offer valuable insights into the intricate dynamics of antiferromagnetic-ferromagnetic bilayers.

Broad-spectrum Antimicrobial ZnMintPc Encapsulated in Magnetic - nanocomposites with Graphene Oxide/MWCNTs Based on Bimodal Action of Photodynamic and Photo thermal Effects

Coralia Fabiola Cuadrado[1*], Antonio Diaz-Barrios[2], Kleber Orlando Campana[1], Eric Cardona Romani[3], Francisco Quiroz[4], Stefania Nardecchia[5], Alexis Debut[6], Karla Vizuete[6], Dario Niebieskikwiat[7], Camilo Ernesto Avila[8], Mateo Alejandro Salazar[8], Cristina Garzon-Romero[8], Ailin Blasco-Zuniga[8], Miryan Rosita Rivera[8*] and Maria Paulina Romero[1]

[1]*Laboratorio De Nuevos Materiales, Departamento De Materiales, Facultad De IngenierIa Mecanica, Escuela Politecnica Nacional, Quito, Ecuador*
[2]*School of Chemical Sciences and Engineering, Yachay Tech University, Urcuqui, Ecuador*
[3]*Instituto SENAI de Inovacao, Servico Nacional de Aprendizagem Industrial (Firjan SENAI), Rio De Janeiro, Brazil*
[4]*Departamento De Ciencia De Alimentos Y Biotecnologia DECAB, Escuela Politecnica Nacional, Quito, Ecuador*
[5]*Magnetic Soft Matter Group, Department of Applied Physics, Faculty of Sciences, University of Granada, Granada, Spain*
[6]*Centro De Nanociencia Y Nanotecnología, Universidad De Las Fuerzas Armadas ESPE, Sangolqui, Ecuador*
[7]*Departamento De Física, Colegio De Ciencias e Ingenierias, Universidad San Francisco De Quito, Quito, Ecuador*
[8]*Laboratorio De Investigacion en Citogenetica y Biomoleculas de Anfibios (LICBA), Centro de Investigacion para la Salud en America Latina-CISeAL, Facultad de Ciencias Exactas Y Naturales, Pontificia Universidad Catolica Del Ecuador, Quito, Ecuador*

Abstract

Since microbial illnesses are now considered one of the biggest risks to humanity, there has been a lot of interest in creating antimicrobial nanocomposites in recent years. This work investigated two magnetic nanocomposites based on multiwall carbon nanotubes (MWCNTs) and graphene oxide (GO). These magnetic nanocomposites were created in three steps: first, iron magnetic nanoparticles (MNPs) were synthesized; second, the photosensitizer menthol-zinc phthalocyanine (ZnMintPc) was adsorbed into MWCNTs and GO; and third, the polymer VCL/PEGDA, a biocompatible hydrogel, was encapsulated to create the magnetic nanocomposites VCL/PEGDA-MNPs-MWCNTs-ZnMintPc and VCL/PEGDA-MNPs-GO-ZnMintPc. This process was carried out in three stages. Based on the findings of *in vitro* experiments, *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans* yeast were used in the photodynamic/photothermal (PTT/ PDT) effect. This research describes the nanocomposites'

optical, morphological, magnetic, and photophysical characteristics and their application as antimicrobial agents. The antimicrobial effect of magnetics nanocomposites was evaluated based on the PDT/PTT effect. For this purpose, 65 $mW \cdot cm^{-2}$ doses with 630 nm light were used. The VCL/PEGDA-MNPs-GO-ZnMintPc nanocomposite eliminated *E. coli* and *S. aureus* colonies, while the VCL/PEGDA-MNPs-MWCNTs-ZnMintPc nanocomposite was able to kill the three types of microorganisms. Consequently, the latter is considered a broad-spectrum antimicrobial agent in PDT and PTT.

The Use of Graphene for Asymmetric Diodes and the Role of Defectiveness Degree for Energy Harvesting Applications

Emiliano Laudadio*, Elaheh Mohebbi, Eleonora Pavoni and Pierluigi Stipa

Department of Life and Environmental Science, Polytechnic University of Marche, Ancona, Italy

Abstract

Graphene is attracting high attention in energy harvesting applications at low received signal levels. In this study, we investigated three different geometries of asymmetric diodes with the aim to modulate the electron transport properties of the systems. We adopted an *in silico* approach based on Density Functional Tight Binding, to model three different nanodevices named GrapheneN8, Graphene-N6, and Graphene-N4, since they had different necks, i.e. 8 nm, 6 nm, and 4 nm, respectively. The three devices have been studied under a simulated voltage range from 0 to 1 V, and a source and drain have been also included in the simulations. More, zero gate voltage and a simulated gate voltage of +20 V have been also considered. The obtained results remark strong asymmetric intensity-voltage (IV) characteristic curves for each device investigated. Anyway, since both current values and asymmetry ratio are crucial for energy harvesting, the performance of the device are strictly correlated to the status of the graphene, which could be high quality of defective. For this reason, the most prominent graphene system has been chosen, and starting from this, three different types of graphene diodes have been modelled, including two defective systems (reduced graphene oxides) with two different defect levels, and one high quality graphene. Our results shed light on phenomena that are difficult to interpret with a purely experimental approach, opening unprecedented prospects for the design and the production of tailored geometric diodes based on graphene.

The Multiscale Architecture of Biomembranes and Vesicles

Reinhard Lipowsky*

Max Planck Institute of Colloids and Interfaces, Science Park Golm, Potsdam, Germany

Abstract

Biomembranes and vesicles attain a large variety of distinct morphologies, with frequent transitions between different shapes, domain patterns, and topologies. These remodeling processes can be studied in a systematic manner using synthetic membrane systems. The resulting insights are important for the engineering of synthetic organelles, a key challenge for bottom-up synthetic biology. So far, synthetic organelles have been typically based on spherical membrane compartments. Many intracellular organelles within our body are, however, far from spherical and exhibit rather complex architectures. A particularly fascinating example is provided by the endoplasmic reticulum (ER), which extends throughout each cell by forming a continuous network of membrane nanotubes connected by three-way junctions. The nanotubes are based on lipid bilayers with a thickness of 4 nm, have a diameter of 50 - 100 nm, and form irregular polygons with a mesh size of several hundred nanometers. The formation of these junctions and the maintenance of the network requires the presence of a membrane protein that hydrolyzes GTP. It has been recently demonstrated that these proteins can be incorporated into the membranes of giant vesicles. This reconstitution should be very useful because one can now apply the large and powerful toolbox of biophysical methods, which have been developed for giant vesicles.

Silicon Nanoneedles for Sustained Treatment of Ocular Angiogenesis

Yannis M. Paulus[1,2*], Van Phuc Nguyen[1], Jinheon Jeong[3], Junsang Lee[3] and Chi Hwan Lee[3,4,5]

[1]Department of Ophthalmology and Visual Sciences, University of Michigan, Ann Arbor, USA
[2]Department of Biomedical Engineering, University of Michigan, Ann Arbor, USA
[3]School of Mechanical Engineering, Purdue University, West Lafayette, USA
[4]Weldon School of Biomedical Engineering, Purdue University, West Lafayette, USA
[5]Department of Materials Engineering, Purdue University, West Lafayette, USA

Abstract

Purpose: Choroidal neovascularization (CNV) is a major cause of vision loss and blindness in wet macular degeneration. Intravitreal bevacizumab (BEV) is used to treat CNV, but this requires frequent (monthly) invasive eye injections. To improve treatment efficiency, reduce treatment burden, and reduce side-effects and invasiveness, this study describes a novel treatment of CNV using miniature biodegradable silicon nanoneedles (SiNNs) fabricated on a tear-soluble contact lens.

Methods: The SiNNs were encapsulated with BEV (BEV@SiNNs) as drug carriers for long-term, sustained drug delivery. BEV@SiNNs were evaluated on a New Zealand rabbit CNV model (n = 7) after approval from the University of Michigan IACUC. To generate CNV, subretinal injection of Matrigel (20 µl) and VEGF (7.5 µL, 100 µg/ml) was performed. A contact lens was inserted subconjunctivally 3 days after CNV creation and monitored by color fundus photography, OCT, and Fluorescein Angiography (FA) before and at 1, 3, 7, 14, and 28 days and monthly for up to 12 months post-treatment.

Results: BEV@SiNNs resulted in long-term, sustained reduction in mean FA CNV leakage intensity for at least 1 year. There was a rapid 45% reduction in CNV within 1 week. CNV continued to gradually reduce further to an 80% reduction in CNV by 4 months that was persistent to 1 year. Control CNV did not have a significant change in CNV over 1 year. Rabbits were comfortable, and no complications occurred with treatment.

Conclusions: SiNNs are an efficient drug delivery platform technology for long-term sustained treatment of CNV in this rabbit model.

Early Detection of Lung Cancer via miR-155 and Surface Enhanced Raman Spectroscopy (SERS)

Christina Quin[1*], Arthur McClelland[2] and Tingying Helen Zeng[3]

[1]Lincoln-Sudbury Regional High School, Sudbury, MA
[2]The Center for Nanoscale Systems (CNS) at Harvard University, Cambridge, MA
[3]Advanced Academy of Research and Development, Cambridge, MA

Abstract

Lung cancer remains the leading cause of cancer-associated deaths globally. Early detection is pivotal for improving patient outcomes, yet current diagnostic methods like CT scans and sputum cytology are limited by high false-positive rates. This study explores the utilization of miR-155, a microRNA associated with lung cancer, as a novel biomarker for early detection in conjunction with surface enhanced raman spectroscopy (SERS). Utilizing silver nanoparticles to enhance the detection sensitivity of miR-155, this research presents a non-invasive, accurate, and cost-effective method for early lung cancer diagnosis. Through meticulous experimental design and analysis, this study demonstrates the potential of SERS combined with miR-155 as a powerful diagnostic tool, offering the possibility of improving early detection rates and thereby patient survival rates significantly.

Transition Metal Dichalcogenide Nanoribbons with Atomic Adsorbates as Elements of Nanospintronics

Frank Hagelberg* and Joshua O. Aggrey

East Tennessee State University, TN, USA

Abstract

Novel nanomaterials with tailored spin properties are essential for advancing devices that exploit the spin of electrons in addition to their charge, and thus are of high relevance for spintronics. Specifically, transition metal dichalcogenides (TMDCs) hold potential for spintronic applications due to their unique electronic and magnetic properties. In this work, we explore functionalization of zigzag TMDC nanoribbon (zTMDCNR) edges with adatoms as a strategy to achieve optimum efficiency of these units as spin filters in nanospintronics networks. Emphasis is placed on Janus TMDCs, asymmetric structures comprising a transition metal layer sandwiched by two different chalcogen layers. We (1) establish atomic adsorption at the TM ribbon edge as a means to open spin gaps in the Fermi energy regime of zTMDCNR systems and (2) outline protocols for adsorbate addition to the ribbon edges, involving the nature, the concentration, and the adsorption geometry of the added atoms. From our results, edge functionalization of the ribbons with non-metal atomic species provides a tool for manipulating the magnetic phase of the device and to enhance the spin filtering capacity of the nanoribbon. Conditions for half-metallicity, associated with transport of one spin orientation only, are specified. zTMDCNR systems with TM = Cr, Mo, W and DC = S, Se, were investigated as transmission elements between semi-infinite electrodes. Density functional theory (DFT) in conjunction with the non-equilibrium green's function (NEGF) approach was used throughout. An accurate representation of the electrode band structure in the fermi energy regime turned out to be crucial for this work.

Patterning Optimization for Device Realization of Patterned GaAsSbN Nanowire Photo Detectors

Sean Johnson*

Department of Electrical and Computer Engineering, High Point University, High Point, North Carolina, USA

Abstract

This study presents the effects of process and design parameters on self-catalyzed GaAsSbN NWs grown by plasma-assisted molecular beam epitaxy on patterned silicon substrates using electron beam lithography. Vertical alignment of the patterned NWs examined via scanning electron microscopy show the sensitivity of patterned NW growth to the parameters of NW diameter, pitch, dose time, etching techniques and growth plan. Diameters range from 90 nm to 250 nm. Pitch lengths of 200 nm, 400 nm, 600 nm, 800 nm, 1000 nm, and 1200 nm were examined. Dry etching of the oxide layer of the silicon substrate and PMMA coating is performed using reactive ion etching (RIE) for 20 s and 120 s respectively. Comparisons of different HF etch durations performed pre and post PMMA removal are presented. Additionally, the report of an observed surfactant effect in dilute nitride GaAsSbN NWs in comparison to non-nitride GaAsSb is presented. Optimizations to patterning, RIE, and HF etching are presented to obtain higher vertical yield of patterned GaAsSbN NWs, achieving ~80% of the expected NW μm2. Room temperature and 4K photoluminescence results show the effect of nitride incorporation for further bandgap tuning, and patterned pitch on the optical characteristics of the NWs which gives insights to the compositional homogeneity for NWs grown at each pitch length. Pitch-dependent axial and radial growth rates show a logistic sigmoidal growth trend different from those commonly observed in other patterned non-nitride III–V NWs. Sigmoidal fitting provides further insight into the PL spectral shift arising from differences in Sb and N incorporation from pitch induced variation in secondary fluxes.

Biochemical Responses of *Coffea arabica* Var. Borbon to Foliar Exposure of Copper Doped Silica Chitosan Oligosaccharides Nanoparticles

Alexis Alejandro Salazar Navarro[1*], Ruiz-Valdiviezo Victor M[2], Joya-Davila Jose G[3] and Gonzalez-Mendoza Daniel[1]

[1]*Instituto de Ciencias Agricolas, Universidad Autonoma de Baja California, Carretera a Delta, Baja California, Mexico*
[2]*Laboratorio de Biología Molecular, Tecnológico Nacional de Mexico campus Tuxtla Gutierrez (TecNM), Tuxtla Gutierrez, Chiapas, Mexico*
[3]*Facultad de Ciencias Agronómicas Campus V, Universidad Autónoma de Chiapas (UNACH), Villaflores, Chiapas, Mexico*

Abstract

Coffea arabica Var. Borbon biochemical responses was evaluated after foliar exposure of copper doped silica chitosan oligosaccharides nanoparticles. Silica nanoparticles (SiNPs) were synthetized by Sol-Gel method from sodium metasilicate and modified with synthetized chitosan oligosaccharides (Si-COS) by microwave assisted methodology. The Si-COS nanoparticles were doped with different concentration of copper from copper sulfate to obtain the final system of Si-COS@Cu NPs. The experiments were carried out following a factorial experimental design AxB in the form of 2x3 with 7 treatments (T1-T7) 4 replicates and α=0.05. The factor A was designed to two levels of COS and the factor B to three levels of copper. The objective of the experiments was to evaluate the stimulation of defense mechanisms and phytotoxicity of foliar exposure of Si-COS NPs and Si-COS@Cu NPs to *Coffea arabica* Var. Borbon. Changes in photochemical potential yield (Fv/Fm) of photosystems II (PSII) was evaluated by chlorophyll fluorescence. Also, soluble protein concentration changes and specific enzymatic activities of phenylalanine ammonium lyase (PAL), chitinase, β-1,3-glucanase, peroxidase and catalase were evaluated. The Fv/Fm results only shown a significant decrement (α = 0.05) in the foliar application of T2 composed by Si-COS NPs. Meanwhile T1-T2 composed by Si-COS NPs presented higher (α = 0.05) stimulation in soluble protein content related to pathogenesis- related (PR) proteins as chitinases and β-1,3-glucanases, also T1-T2 shown a higher activity of PAL (α = 0.05). The application of Si-COS NPs and Si-COS@Cu NPs suggest a safety alternative in the control of *C. arabica* Var. Borbon phytopathogens.

Chemically Modified Liposomal siRNA Formulation Targeting SOD1 for Chemo Sensitization of Platinum-resistant Ovarian Cancer

Attila Szenasi[1*], Sonia Rocha[2] and Mu Wang[3]

[1]*Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, USA*
[2]*Department of Molecular Physiology and Cell Signaling, Institute of Systems, Molecular and Integrative Biology, University of Liverpool, United Kingdom*
[3]*Academy of Pharmacy, Xi'an Jiaotong-Liverpool University, Suzhou, Jiangsu, China*

Abstract

Platinum resistance remains a significant obstacle in the treatment of advanced-stage ovarian cancer, frequently leading to therapeutic failure. Our previous research identified superoxide dismutase 1 (SOD1) as a key antioxidant target for re-sensitizing platinum-resistant ovarian cancer cells to platinum-based therapies through both enzymatic inhibition and RNA interference (RNAi) utilizing a graphene-based siRNA delivery platform. Building on these findings, we have now developed a liposomal formulation of chemically modified siRNA targeting SOD1, which demonstrates potent knockdown efficiency and significantly enhances the sensitivity of resistant ovarian cancer cells to cisplatin *in vivo*. While SOD1 inhibition or knockdown via RNAi effectively re-sensitizes resistant cells to cisplatin, the underlying redox-sensitive signalling pathways remain largely unexplored in ovarian cancer. Our current study reveals that SOD1 knockdown acts as a redox switch, triggering cellular reprogramming in drug-resistant cells through post-translational cysteine modifications. This reprogramming leads to the rewiring of critical cancer hallmarks, culminating in the restoration of a cisplatin-sensitive phenotype. These findings suggest that a liposomal, chemically modified SOD1 siRNA formulation could serve as a promising therapeutic approach for reversing platinum resistance in ovarian cancer by exploiting redox-mediated reprogramming of cancer hallmarks. This study

not only underscores the therapeutic potential of targeting SOD1 but also highlights the broader implications of redox signalling in the etiology of platinum resistance, providing a novel avenue for therapeutic intervention.

Bioinspired Nanocomposite for Passive Cooling

Hong Li*

Nanyang Technological University, Singapore

Abstract

Passive radiative cooling in tropical climate (e.g., in Singapore, 1.3477N 103.6816E) is the most challenging due to the high humidity (84% on average), abundant rainfall (~167 days annually), intense solar radiation, and strong downward atmospheric radiation, which halve the radiative cooling potential; and thus, there is no report of outdoor sub-ambient radiative cooling under one-Sun radiation in tropical climate. Inspired by various bio-species in nature, we integrate various passive cooling strategies in a rationally designed nanocomposite named meta gel to achieve stable sub-ambient (4-6 ˚C) passive cooling in all tropic climate conditions in sunny, cloudy, and rainy days (both outdoor and indoor). The metagel cooler adaptively adjusts the contributions of the integrated passive cooling strategies according to ambient conditions, resulting in a stable sub-ambient temperature regardless of the fluctuating ambient conditions. Such a metagel could find wide application in energy-saving cooling in tropical regions or summer season of temperate regions.

Liposomal Drug Delivery to Target Hypoxic Tumor Environment

Vidhi M. Shah[1,2,3], Craig Dorrel[1,2], Adel Al-Fatease[1,4], Brittany L. Allen-Petersen[3], Yeonhee Woo[1], Yuliya Bortnyak[1], Rohi Gheewala[5], Brett C. Sheppard[2,6,7], Rosalie C. Sears[2,3,7] and Adam WG. Alani[1,7*]

[1]Department of Pharmaceutical Sciences, College of Pharmacy, Oregon State University, South Moody Avenue, Portland, USA
[2]Brenden-Colson Center for Pancreatic Care, Oregon Health and Science University, Southwest Sam Jackson Park Road, Portland, USA
[3]Department of Molecular and Medical Genetics, Oregon Health and Science University, Southwest Sam Jackson Park Road, Portland, USA
[4]Department of Pharmaceutics, College of Pharmacy, King Khalid University, Guraiger, Abha, Saudi Arabia
[5]School of Medicine, Oregon Health and Science University, Portland, USA
[6]Department of Surgery, Oregon Health and Science University, Portland, USA
[7]Knight Cancer Institute, Oregon Health and Science University, Portland, USA

Abstract

Pancreatic tumors present a unique challenge for drug delivery due to hypoxic regions. Vinblastine-N-Oxide (CPD100) is a hypoxia-activated prodrug (HAP) that selectively converts to its parent compound, vinblastine, a potent cytotoxic agent, under hypoxic conditions. To date, the FDA has no approved HAP agents, which may be attributed to unfavourable patient inclusion criteria in clinical trials. The study evaluates the efficacy of microfluidics-formulated liposomal CPD100 (CPD100Li) in Pancreatic Adenocarcinoma Cells (PDAC). The liposomes are around 100 nm in size with a polydispersity index of 0.2 and are stable for 18 months when freeze-dried at a concentration of 3.65 mg/ml. CPD100 and CPD100Li are selectively activated in 2D cancer cell lines at low oxygen levels. CPD100Li displayed higher penetration and disruption of the 3D spheroid model than CPD100. In patient-derived 3D organoids, CPD100Li exhibited higher cell inhibition in the organoids that expressed higher levels of hypoxia-inducible factor 1 alpha (HIF1A) compared to CPD100. In an orthotopic animal model, the combination of CPD100Li with gemcitabine (standard of care for PDAC) showed significantly higher efficacy than CPD100Li alone for 90 days, demonstrating the potential of this treatment. In summary, the evaluation of CPD100Li in multiple cellular models, including 2D and 3D cancer cell lines, patient-derived 3D organoids, and an orthotopic animal model, provides a robust and reliable foundation for its clinical application and the selective activity as a function of HIF1A levels, is a promising aspect for it to be explored for personalized treatment of PDAC.

Control of Dynamic Percolation Kinetics in Electrically Conductive Pastes Containing Multi-walled Carbon Nanotubes Using Chemical Factors

Masahiro Inoue*, Subaru Tsujimura and Jinseok Won

Graduate School of Science and Technology, Gunma University, Japan

Abstract

Electrically conductive pastes containing carbon nanotubes are expected to prepare wires and electrodes for advanced microsystems using printed electronics technology. Although the electrical conductivity of the pastes is usually discussed using static models in the percolation theory, it varies dynamically during curing and annealing (dynamic percolation). This work examines the kinetics of the dynamic percolation transition of the multi-walled carbon nanotube (MWCNT)-filled pastes during curing to enhance electrical conductivity. The binder chemistry of the pastes influences the kinetics of the percolation transition, which relates to variation in interfacial electrical resistance between MWCNTs. The binder chemistry of the pastes can control the change in interfacial electrical resistance. This implies the design of the binder composition will be a key for developing advanced CNT-filled electrically conductive pastes.

Oral Administration of pH-responsive Polymeric Nanoparticles Based on Zein and their Therapeutic Potential on Cancer

Bruno Alejandro Valades-Aguilar*, Jose Raul Rangel-Lopez, Jennifer Citlally Leos-Rivera, Moises Armides Franco-Molina, María Cristina Rodriguez-Padilla and Diana Ginette Zarate- Trivino

Universidad Autonoma De Nuevo Leon, Facultad De Ciencias Biologicas, Laboratorio De Inmunologia Y Virologia, Mexico

Abstract

Zein is a water-insoluble protein from corn seed; this polymer is an attractive matrix to encapsulate compounds because of its high proportion of hydrophobic amino acids. Nanoparticles have been used as drug delivery systems for the improvement of oral bioavailability. In this study, a modified method to obtain zein nanoparticles (ZNps) was optimized without the use of stabilizers by the implementation of heat treatment. This allowed the obtention of ph-dependant nanoparticles with an average size from 125 to 150 nm, it might be due to the increment of protonation levels and intermolecular forces during antisolvent precipitation. ZNps showed stability for 30 days. The wavelength splits shown on FT-IR analysis could indicate a rearrangement from tertiary to secondary structure. Additionally, the encapsulation efficiency was at 70%, improving over other methodologies by 20%. The release profile of ZNps on a gastrointestinal *in vitro* model showed their capability as an oral drug delivery system, with a maximum point at 240 min in acid conditions and 120 min on a basic environment. ZNps highly decreased the viability on HT29 colon cancer cells in comparison to HUVEC endothelial cells. Pure zein affects the cell viability in a minor proportion compared to ZNps; ZNps showed a major cytotoxicity percentage in HT29 than in Huvec, which suggests a potential therapeutic effect as a drug delivery vehicle against cancer. Finally, this system has the potential to be a novel strategy for an alternative to oral drug delivery and should be further studied on a wide variety of treatments.

Exploring Hollow Gold Nanoparticles as Multifunctional Therapeutic Platforms for the Treatment of Breast Cancer

Zeljka Krpetic*, Pouria Rafati and Yara Atto

University of Salford, School of Science Engineering and Environment, Biomedical Research and Innovation Centre, United Kingdom

Abstract

Using nanoparticles as chemotherapeutics has shown great potential in providing selective treatments, targeted

therapies, and personalised medicine approaches. Gold nanoparticles represent a preferred choice for advanced theranostic design and applications due to their unique properties, remarkable stability and high tuneability towards generating ordered anisotropic structures, and nanoparticle shape and surface chemistry libraries. This interdisciplinary study showcases a systematic approach to the design of high-quality nanoparticles and development of a therapeutic library of hollow gold nanoparticles, and functionalisation strategies with a selection of anticancer drugs for the evaluation of anticancer properties of shaped nanoparticles *in vitro*. This contribution will outline the impact of the particle shape on the drug delivery and effects towards cancer cells highlighting potential for the future breast cancer treatment therapeutics. Moreover, a full overview of complex characterization steps towards the clinical trials will be included, outlining the importance of the assessment of the biomolecular corona of the hollow gold nanostructures, and a systematic nanoparticle characterisation using key physico-chemical methods including the use of differential centrifugal sedimentation (DCS) and nanoparticle tracking analysis (NTA) and for stability *in situ* study in biological fluids, use of high performance liquid chromatography (HPLC) for the assessment of the drug loading and intracellular fate of hollow particles using transmission electron microscopy.

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