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Meeting Abstracts

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Small is Big: Magic Nano Droplets

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Abstract

Droplets of nano-/subnano-liter are useful in a wide range of applications, particularly when their size is uniform and controllable. Examples include biochemistry, biomedical engineering, food industry, pharmaceuticals, and material sciences. One example of their many fundamental medical applications is the therapeutic delivery system for delivering site-specific therapy to targeted organs in the body andas the carriers for newer therapeutic options. The size, size distribution, generation rate, structure, and manipulation at nano-/subnano-liter scales are critical in all these applications. Prof. Wang will show the big impact of small microfluidic droplets with an overview of their generation, manipulation, and application. Their precision generation counts on system geometries, fluid properties and flow rates; their effective manipulation is magically enabled with the phase separation, microfluidic channels, droplet overlay, and fiber or light touch; their beautiful application includes embolic particles, smart colloidosome drug delivery, super thermal conductors, and super anti-pathogenic coatings.

Free-standing Polymer Thin Films for Loading of Drugs or Stem Cells as Immobilizable Devices

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Abstract

The free-standing polymer thin films of biodegradable and biocompatible polymers with a thickness of tens to hundreds of nanometers have unique physical and chemical properties. We are evaluating the effects of loading antibiotics and stem cells onto thin films on wounds of infected mouse models and diabetes models. I will present the design of polymer thin film devices for drug loading and release,and stable loading of stem cells with high density as well as the results of evaluation.

Local Reprogramming of Tumor-associated Macrophages with Nano-in-cryogel Biomaterials

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Abstract

Tumor-associated macrophages (TAMs) represent more than 50% of the immune cells in breast tumors, even in immune dysregulated, 'cold' tumors. TAMs that express an M2- like phenotype promote tumor growth and create an immunosuppressive tumor microenvironment (TME). Macrophages that express an M1-like phenotype are inflammatory and can induce anti-tumor immunity. Administration of pro- inflammatory cytokines reprogram M2 TAMs toward an M1-like phenotype that can reduce tumor growth and stimulate an inflammatory response within the TME. However, systemic delivery of these inflammatory cytokines generates toxic, dose-limiting off target effects. This work seeks to develop a localized delivery approach that enables TAM polarization toward M1 programs while abrogating systemic toxicities. We have developed an injectable alginate cryogel (hydrogel fabricated at -20 C) to act as localized delivery depot for inflammatory cytokines and macrophage-specific chemokines to repolarize TAMs. Peritumoral injection of the cryogel system into FVB female mice with orthotopic mammary tumors resulted in significantly suppressed tumor growth, an increase in T cell infiltration, and an increase in the M1:M2 ratio of TAMs. This activated immune response and elevated presence of T cells suggests that localized chemokine/cytokine treatment 'primes' the TME, potentially making it more susceptible to immunotherapies that rely on T cells, such as immune checkpoint blockade. Our first-generation gel demonstrates the potential of priming the TME to slow tumor growth. To delay the release of repolarizing cytokines relative to the chemoattractant, we are developing a second generation cryogel, loaded with free chemokines and poly(lactic-co- glycolic acid) (PLGA) nanoparticles encapsulated with cytokines.

Magnetic-actuated 'Capillary Container' for Versatile Three-dimensional Fluid Interface Manipulation

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Abstract

Fluid interfaces are omnipresent in nature. Engineering the fluid interface is essential to study interfacial processes for basic research and industrial applications. However, it remains challenging to precisely control the fluid inter-face because of its fluidity and instability. Here, we proposed a magnetic-actuated "capillary container" to realize three-dimensional (3D) fluid interface creation and programmable dynamic manipulation. By wettability modification, 3D fluid interfaces with predesigned sizes and geometries can be constructed in air, water, and oils. Multiple motion modes were realized by adjusting the container's structure and magnetic field. Besides, we demonstrated its feasibility in various fluids by performing selective fluid collection and chemical reaction manipulations. The container can also be encapsulated with an interfacial gelation reaction. Using this process, diverse free-standing 3D membranes were produced, and the dynamic release of riboflavin (vitamin B 2) was studied. This versatile capillary container will provide a promising platform for open microfluidics, interfacial chemistry, and biomedical engineering.

Poly(glycerol)-based Biomedical Nanodevices Constructed by Functional Programming on Inorganic Nanoparticles for Cancer Nanomedicine

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Abstract

Nanomedicine is promising to improve conventional cancer medicine by making diagnosis and therapymore accurate and more effective in a more personalized manner. A key of the cancer nanomedicine isconstruction of medical nanodevices by programming most of the following functions to nanoparticles(NPs); A) high dispersibility in a physiological environment, B) high stealth efficiency to slip through the trap by liver and spleen, C) high targeting efficiency to cancer tissue, D) clear visualization of cancerfor diagnosis, and E) high anticancer activity for treatment (Figure 1a) [1].

In our approach, poly(glycerol) (PG), containing a hydroxy group at every monomer unit, was found as a better alternative to poly(ethylene glycol) (PEG), the most commonly used hydrophilic polymer, giving A) high dispersibility to inorganic NPs [2]. Although most of the inorganic NPs are not dense infunctional groups, the hyperbranched structure with many hydroxy groups in PG turns the lessfunctional surface into highly functional one, imparting not only good hydrophilicity, but also B) highstealth efficiency we reported recently [3]. In addition, a number of hydroxy groups in PG afford the structural or functional extensibility to introduce the additional layer or function. This enables us to design and construct a three-layer architecture consisting of core inorganic NP, hydrophilic and stealthyPG layer, and functional molecule layer (Figure 1b). Owing to the versatility of the three-layer model, the rest of the above functions C) – E) can be programed to the NP core and/or the outmost layer in nanodevices [4,5].

In this invited talk, I will present functional programming of inorganic NPs and their application to cancer nanomedicine [1].

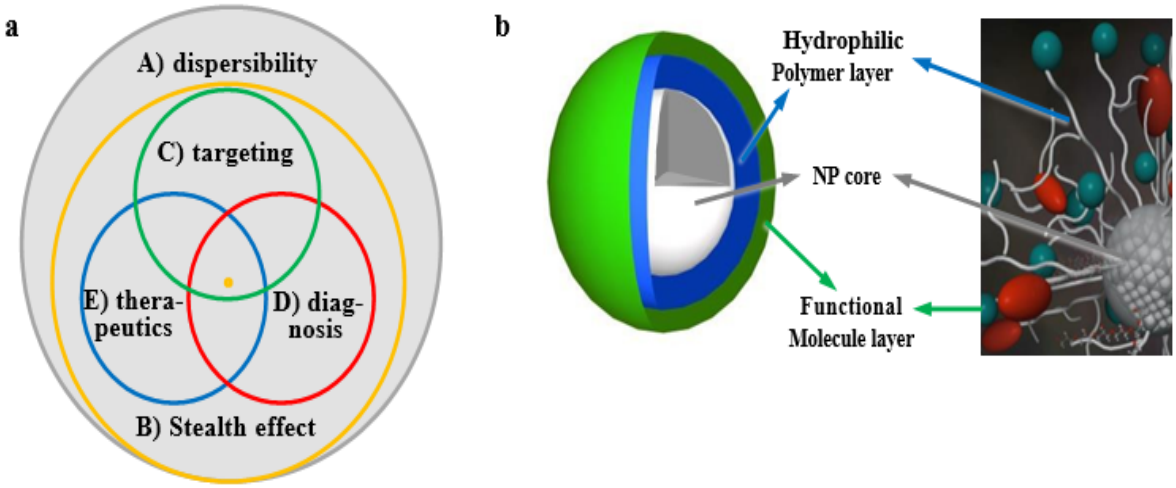

Figure 1: (a) Schematic illustrations of three-layer construction in and (b) requisite functions for a biomedical nanodevice.

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Dually Targeted Brain and GBM Specific Nanomedicines

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Abstract

Nanoparticles (NPs) are taking the spotlight in Glioblastoma multiforme (GBM) treatments. They have the capacity to improve brain delivery of therapeutics, but the therapeutic success of NPs against GBM is directly correlated to their ability to selectively accumulate in the cancerous cells without causing toxic effects to healthy cells nearby. In this study, NPs based on the FDA approved polymer poly(lactic- co-glycolic) acid were surface modified with 4 ligands for potentially upregulated receptors in GBM cells: Adenoassociated coat peptide AAVF, the glycopeptide g7, and two monoclonal antibodies against Cell Surface Vimentin (M08 and M08J). NPs were optimized based on a full chemico- physical and morphological characterization. Then, the uptake and toxicity of the NPs at different concentrations and incubation times were analysed *in vitro* on GBM cells. To further demonstrate the GBM specificity, co-culture assays with GBM (C6) and healthy astrocytes (DITNC1) were performed showing not only a significantly higher uptake by GBM cells over healthy astrocytes for NPs conjugated with M08, but also a shift to an increased presence of healthy astrocytes on the plate, especially for M08-NPs. Thus, M08-NPs were tested for their ability to selectively transport Paclitaxel with improved effects *in vitro*. Lastly, these NPs were demonstrated to be able to cross the BBB *in vivo*. These results demonstrate the ability of optimized NPs to enhance specific targeting not only to the brain but specifically to GBM which will help increase the pharmaceutical effectiveness while limiting off-target effects.

Chitosan Covalently Functionalized with Peptides Mapped on Vitronectin and BMP-2 for BoneTissue Engineering

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Abstract

Chitosan is a natural polysaccharide produced by the deacetylation of chitin. It has been employed for various biomedical applications since it is biocompatible and biodegradable. Moreover, it can be prepared as 3D sponges, nanofiber matrices, or nanospheres. In this work, two synthetic peptides were covalently grafted to chitosan in order to improve polymer capacity to enhance cellular events. The first sequence, the nonapeptide (351 - 359) of human vitronectin (HVP), was demonstrated to enhance osteoblast adhesion and migration. The second peptide, a 22mer sequence reproducing the fragment (48 - 69) of BMP-2, was able to increase the osteogenic differentiation of

mesenchymal stem cells. The anchoring chemistry consists of Schiff base formation, successively reduced, between chitosan amino groups and aldehyde groups appositely inserted in the peptide backbone. One of the advantages of this method is the specific anchoring of a bioactive sequence in a single-step reaction carried out in an aqueous solution and mild conditions. Six different 3D-porous scaffolds were obtained by various combinations of both functionalized chitosan or using chitosan simultaneously functionalized with the two above-reported peptides. The characterization of the matrices includes biomechanical tests, analysis by scanning electron microscope (SEM), x-ray photoelectron spectroscopy (XPS), and *in vitro* biological assays with human jaw-derived osteoblasts. Eventually, scaffolds were implanted *in vivo* in the ectopic site of a murine model, to assess the cytotoxicity and osteoinduction capacity of the scaffolds.

3D Printed Nanocomposite Contact Lenses

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Abstract

In this study we present the fabrication of tinted contact lenses for color blindness, and several issues related to their mechanical properties and toxicity were reported. Gold nanoparticles were integrated into the soft hydrogel material-based contact lenses, thus forming nanocomposite contact lenses targeted for red-green CVD application. The integration of nanomaterials into hydrogels is a prominent research challenge for a myriad of healthcare applications, such as bio-sensing, cancer therapy, and bone tissue engineering. Practical contact lenses functionalized with metallic nanoparticles are of interest for therapeutics and targeted therapy. Several types of nanoparticles were synthesized, characterized, and incorporated within the pHEMA hydrogel material. The materials were utilized along with Vat Photopolymerization based 3D printer for printing soft contact lenses, and their resulting optical, mechanical, hydration and material properties were assessed. The optical transmission properties of the 3D printed nanocomposite lenses were found to be analogous to those of the commercial CVD glasses, and their water content and wettability properties were better in comparison to some of the commercially available contact lenses used for cosmetic/vision correction purposes. Hence, this work demonstrates the potential of 3D printing multi-functional, and nanocomposite contact lenses for ocular health management and, more generally, color filtering applications.

Hydrophilic Nanostructures in Nanomedicine and Biotechnology: The Role of Surface and Interface Properties for Efficient Bioactivity

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Abstract

In the field of nanomedicine and biotechnology, hydrophilic nanostructures are being extensively studied to design and develop diagnostic, monitoring, and therapeutic devices [1,2]. Up to now, a wide range of engineered nanomaterials and nanoplatforms with different shapes, sizes, and compositions has been developed for various biomedical and biotechnological applications [3-5]. Herein, functionalized metal nanoparticles (MNPs) are presented as promising nanocarriers for drug delivery with bioactive properties. Hydrophilic functionalized gold (AuNPs) and silver nanoparticles (AgNPs) within size range of 5 - 50 nm were successfully synthesized via wet chemical reduction methods in aqueous environment starting from commercially available precursors. Exploring different hard and soft surface chemistry, different stabilizing agents - commercial or synthetic – were used to functionalize MNPs surface, also tuning their interfacial properties. Different surface functionalities were achieved using negatively and positively charged ligands to obtain MNPs with single or mixed functionalities. The presence of surface functional groups (sulfonate and amine moieties) allowed a non-covalent immobilization of hydrophobic drugs, antibodies or to exploit novel antibacterial properties via a synergistic combination of metal/metal oxide hybrid nanostructures. Extensive

physicochemical characterizations were carried out to determine the nanoparticles characteristics including their size, shape, surface morphology, surface charge, structure, stability, and optical properties for applicative purposes. To qualify nanoparticles for their use in nanomedicine and biotechnological applications, *in vitro* cytotoxicity and antibacterial studies were conducted on different cell lines or bacteria strains to assess their cytocompatibility and antibacterial behavior in complex environments.

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Cyclodextrins in Drug Delivery: An Updated Overview

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Abstract

Cyclodextrins (CDs) are versatile excipients able to interact with several drugs forming non-covalently bonded inclusion complexes. These multifunctional excipients are able to increase solubility, dissolution rate, chemical stability, permeation and bioavailability of different drugs playing an essential role in drug delivery. Since 1960 they can and have been employed to formulate a variety of both conventional and innovative drug delivery systems designed for several administration routes by virtue of their great formulation versatility and safety. In the last 5 years great strides have been made: CDs have been chemically modified to assemble directly as nanovectors, linked to polymers able to form nanoaggregates or successfully combined with nanovectors with any modification. Several examples of applications of combined strategies simultaneously exploiting the use of CD complexation and of a suitable nano-carrier have been reported in literature, highlighting the possible advantages achievable by such a dual strategy, depending on the CD-nanocarrier combination, and mainly resulting in enhanced performance of the delivery system and improved biopharmaceutical properties and therapeutic efficacy of drugs. CD applied to nanotechnologies aimed for drug delivery results able to combine the advantage of both: improving drug solubility and permeability, drug loading in nanodevices but also the stability not only of the drug but also of the nanocarrier confirming the successfulness of the proposed approach. New CD-based drug delivery systems prove the great and continuous interest towards these excipients that amply proven to be a very useful and versatile tool for improving the drug formulation performance.

Magnetic Nanoparticle Engineered Red Blood Cells as Novel Theranostic Agents

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Abstract

Due to their inducible magnetic properties, superparamagnetic iron oxide nanoparticles (SPIONs) have long been used for drug delivery, magnetic resonance imaging, cell tracking, and hyperthermia. However, SPIONs continue to be quickly removed from the circulation by the reticuloendothelial system (RES) or mononuclear phagocyte system, with uptake being influenced by several variables including the hydrodynamic diameter, electrical charge, and surface coating, limiting the medical applications of these nanoparticles. This study suggests a method to produce SPIONs biocompatible by encapsulating them inside red blood cells (RBCs). The multi-step chemical synthesis of magnetic nanoparticles (MNPs), specifically iron oxide nanoparticles (IONPs) and zinc manganese-ferrite nanoparticles (Zn/Mn FNPs), for encapsulation in human and murine RBCs, has been the main focus of this research. High-quality nanoparticles in terms of chemical properties, morphology, stability, and biocompatibility were obtained and tested for effective encapsulation in RBCs. Following the achievement of this objective, *in vitro* experiments were carried out using specific nanomaterials to examine the potential of engineered MNP-RBC constructs in theranostic approaches.

Bio-templated Nanomaterials for Sensing, Imaging and Therapeutic Applications

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Abstract

Inspired by Natural biomineralization processes, our research focuses on the rational design of peptide- and nucleic acid-based biomolecular templates for the synthesis of multifunctional metallic and carbon- based nanomaterials with tunable optical properties and biofunctionalities for sensing, imaging, drug/gene delivery and therapy. Such bio-templated nanomaterials exhibit synergistic combination of biological functions and chemical properties resulting from the hard nanocore and soft biomolecular shell. For example, we have developed a series of metallic nanobiosensors with target specific bio-shell to detect wide range of analytes in solution from small molecule drugs, protein biomarkers to cancer and bacteria cells. Recently, we have exploited the use of designer DNA and peptide templates to synthesize a palette of photoluminescent metal nanoclusters (NCs <2nm) which could be used as multi- color probes for bioimaging, image-guided photodynamic therapy and multiplexed sensing. We also take this biomimetic approach to 'turn' the native protein into bioactive fluorescent nanosensor for rapid drug screening without tedious genetic engineering. To enable greener synthesis with good biocompatibility and sustainability, pure organic resources and biomass wastes were utilized to synthesize carbon dots from biomolecules (biodots) and metal-enhanced fluorescent nanodots with tailored functionalities for a range of biomedical applications. For instance, bioinspired antimicrobial biodots has been successfully developed for ultrasensitive pathogen detection (1 cfu/ml in <0.5 hour) as well as to combat broad spectrum multi-drug resistant bacteria. With further understanding in biotemplates design, we expect a far more extensive applications of bio-templated nanomaterials for the advanced biomedical diagnostic and treatment towards personalized nanomedicine in future.

Camouflaged Nanocarriers for Targeted Drug Delivery

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Abstract

Targeted therapy approaches are the core of modern translational science and biomimicking carriers are demonstrating stealth features, improved biodistribution and cell specific targeting, resulting in a powerful tool for personalized therapies. Camouflaged nanocarriers consist in a drug loaded core surrounded by cell derived membranes or lipids mixture biomimicking cell surfaces. This contribution will cover the camouflaged approaches investigated at the Department of Pharmacy, University of Pisa, for improving targeted drug delivery to selected tissues, i.e., brain by blood brain barrier crossing and metastatic melanoma. The purpose of the work is to exploit the homoselective recognition between adhesion cell proteins of epithelial cell lines as well as the stealth features of circulating blood

cells. Either polymeric nanoparticles or self-emulsifying drug delivery systems (SEDDS) were applied as nanocarrier core, demonstrating good cell biocompatibility and effective internalization in targeted cell lines. Fluorescently labelled nanocarriers were applied for trafficking evaluations.

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Fluorescent and Magnetic Mn, Gd or Fe-doped Ag-In-Zn-S QDs: Aqueous Synthesis andCharacterization

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Abstract

Ternary quantum dots (QDs) such as AgInS2 (AIS) have been demonstrated to be very attractive for biomedical applications due to their small size, composition tunable optical and electrical properties, and low toxicity. To improve their photoluminescence properties, shelling with ZnS is well developed,which led to quaternary Ag-In-Zn-S (AIZS) QDs. The synthesis of AIZS QDs in aqueous media is developing because the obtained nanocrystals do not require a post-preparative step for their water dispersion. Furthermore, aqueous synthesis is of low-cost, environmental-friendly, and mild synthesis conditions allow large-scale synthesis. The synthesis of highly fluorescent AIZS and Mn^{2+}, Gd^{3+} or Fe^{3+}-doped AIZS QDs was carried out in aqueous media using reduced L-glutathione (GSH) as a capping ligand. Folic acid (FA) was used asthe surface targeting ligand to adapt AIZS QDs for biomedical applications. For this purpose, PEI-FA conjugate was first prepared, then, the positively charged PEI-FA conjugate was associated to negatively charged carboxylate groups of GSH-capped QDs.

AIZS and Mn, Gd or Fe-doped AIZS QDs exhibit a cubic ZnS blende structure and average diametersare in the range of 2.2 to 2.5 nm. The doped QDs show superparamagnetic and paramagnetic properties.MTT assay results indicate that synthesized QDs showed no toxicity towards KB cells when incubatedfor one day at a concentration of 1 mg/ml. Moreover, GSH-PEI-FA-capped QDs were used for *in vitro* bioimaging tests. The efficient labeling of cells using these QDs indicates that the FA-conjugation hasbeen successful and facilitates specific intracellular uptake, which occurs mainly through receptor- mediated endocytosis.

Production of Foams for Drug Delivery

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Abstract

Drug carriers have the function of transporting drugs while protecting them from degradation and improving bioavailability to target tissues. Depending on the geometry and shapes of carrier devices, it is possible to tune drug delivery according to specific applications. Carriers' properties can be improved by choosing the most efficient production process and biomaterials, which can positively affect drug release kinetics, reducing patients' side effects.

Polycaprolactone (PCL) is a semicrystalline nonhazardous, relatively cheap, and biodegradable polymer, generally used in tissue engineering, but also in drug delivery systems. As a possible application, PCL foams have been produced in order to create biomaterials loaded with antioxidants and antibiotic compounds.

PCL foams were produced through a supercritical assisted batch process, using carbon dioxide as a blowing agent. The effect of mould geometry, sorption time, pressure, temperature, and drug to polymer ratio has been investigated. Foams were characterized in terms of shape and pore dimensions using scanning electron microscope. Tape-like

foams were also created in order to compare them with commercial products, in terms of drug delivery but also of mechanical properties and adaptability to the human skin.

A Portable Paper-based Viscometer for Measurement of Plasma Viscosity

Neha Gautam* and Arnab Sarkar

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Abstract

The development of microfluidic paper-based point-of-care devices for the estimation of blood related pathological parameters is the need of the hour especially in the remote locations where sophisticated health care diagnostic facilities are really scarce. However, in spite of the promising advantages, many such devices either use sophisticated instrumentation or suffer from accuracy. Herein, we have reported a portable paper-based viscometer which measures plasma viscosity from whole blood. Plasma viscosity is an important biomarker for non-specific identification of diseases which has the true potential to replace ESR. However, traditional measurement of plasma viscosity with sophisticated gold standard equipment cannot be deployed in the field. In sharp contrast with reported findings, our paper- based device measures plasma viscosity with the help of a simple stopwatch and uses only 50 µl of blood plasma sample. Our measurement of plasma viscosity shows excellent agreement with gold standard device and covers the clinical range from 1-3 cP. We envisage a paper based microfluidic device as viscometer which has the potential in the truest sense for its deployment as a point-of-care device among underserved population in resource limited settings with the engagement of minimally trained human resources instead of highly skilled technicians.

Polysaccharide Nanohydrogels and Drug Delivery: An Effective Combination

Pietro Matricardi

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Abstract

In the biomedical and pharmaceutical field, polysaccharide hydrogels are gaining an increasing interest due to a favorable combination of two items: the generally accepted biocompatibility of this class of polymers and the high amount of water content. This combination, resembling the extracellular matrix, is very well accepted by different kinds of human cells, and, as a consequence, polysaccharide hydrogels can be used in internal administrations without interfering with the metabolism and the normal human physiology, thus representing a valuable tool for applications in tissue engineering and drug delivery. The hydrogels can be shaped and used in the form of bulk materials or in the particulate form - from micro to nano dimensions -, thus fulfilling different needs. In particular, nanohydrogels (NHs) are very promising as they can combine the favorable properties of nanotechnologies and the features of the hydrogels. In this contest, the preparation of a new nanoparticulate hydrogel carriers based on the polysaccharides gellan (Ge) and hyaluronic acid (HA), obtained by self-assembly of polysaccharide chains, previously derivatized with hydrophobic moieties, represent an important step onward for some pharmaceutical applications.

Analytical Characterization of LNP-RNA based Therapeutics

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Abstract

The development of highly effective vaccines against COVID-19 based on lipid nanoparticle/mRNA technology has revolutionized the medical field and, nowadays, RNA-based therapeutics are considered one of the most promising

technologies for the prevention and treatment of multiple diseases. However, their characterization is challenging due to the intrinsic complexity and requires the use of multidisciplinary techniques and competencies. It can be conceptualized as a combination of physicochemical, immunological, and toxicological assays. Given the complexity and the potential of RNA therapeutics, international collaboration is essential in the development of measurements and standards for LNP-RNA systems, in line with similar requests coming from both regulators and policymakers. This work addresses some identified needs and presents JRC contribution to the adaptation, development, and optimization of methods for the analytical characterization of LNP-RNA based therapeutics.

High Performance Sustainable Food Packaging: Efficacy of Bio-nanocomposite Coating Systems

Nattakan Soykeabkaew

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Abstract

The growing demand for ready-made foods pushes the need for using plastic food packaging beyond a substantial scale. With a huge negative impact of non-degradable plastic wastes on the environment, a new generation of food packaging should be more sustainable (reusable/recyclable/biodegradable) and at the same time being as effective barrier materials to save food quality. In this talk, new sustainable food packaging systems with high recyclability and high performance via nanocomposite coating based on biopolymers (e.g., cellulose derivatives and biopolyesters) and nanocelluloses (i.e., nanofibrillated cellulose and cellulose nanocrystal) will be introduced. The different approaches in nanocellulose modification (i.e., sonication and microwave-assisted process), nanocellulose type and its loading content, and biopolymer type were found to play a vital role in altering properties of the current sustainable packaging. Gas barrier properties (i.e., oxygen and water vapor transmission), water and oil contact angle, Kit value (grease resistance) as well as thermal and mechanical properties of the prepared packaging samples with different nanocomposite coatings were investigated. Their oxygen transmission rate and water vapor transmission rate were measured in a range comparable to those of conventional food packaging materials. These new sustainable food packaging showed a great potential to replace current commercial multi-layer products and could also be recycled as an end-of-life option.

Ultra-small Non-magnetic Iron Oxide Nanoparticles: Uptake and DNA Damage Response *In Vitro* and *In Vivo*

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Abstract

The ultra-small, non-magnetic iron oxide (III) nanoparticles, covered with tartaric and adipic acid (FeAT-NPs), have potential biomedical applications, as an anemia treatment or cancer drug nanocarriers. However, the presence of these nanoparticles in the cell cytosol might trigger the production reactive oxygen species (ROS), which is a possible cause of DNA damage. Thus, DNA damage response on the effects of FeAT-NPs should be evaluated. In this work, we use several human cell lines to analyze FeAT-NPs cellular internalization, by transmission electron microscopy (TEM) and inductively couple plasma mass spectrometry (ICP- MS); DNA damage response analysis included cell viability and proliferation, ROS induction and analysis of DNA strand breaks induction. Moreover, the effects of these nanoparticles *in vivo* were studied with the eye w/w+ SMART assay of Drosophila melanogaster. The results of these experiments show that FeAT-NPs were efficiently internalized by all cell lines, and caused minimum cell toxicity and genotoxicity *in vitro*, since little effects were found on cell viability and ROS production, no effect on cell proliferation, and not inductions of relevant levels of DNA strand breaks. Furthermore, *in vivo* results revealed that FeAT-NPs were not toxic nor genotoxic in Drosophila larvae. With these data, we can conclude that these nanoparticles could be used as a safe anemia treatment.

Bioapplications of Electrosprayed Coatings based on Chitosan, Bioglass and Zinc Oxide on Ti-Zr-Ta-Ag

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Abstract

New coatings based on chitosan, bioglass and ZnO were designed and deposited on Ti-Zr-Ta-Ag aiming for improving the alloys' properties for use in bioapplications. The suspension used for the coating was composed of chitosan dissolved in acetic acid and various ratios of bioglass and ZnO. Prior to the coating process, the alloy samples were etched in an acid mixture which produced complex oxides on the surface. The deposition of the suspension on the alloy surface was carried out by electro-spraying deposition applying a voltage of 20 kV. The morphology of the samples was analyzed by Scanning Electron Microscopy (SEM) correlated with roughness and wettability evaluation. The qualitative characterization of the coating was investigated with Fourier transform infrared spectroscopy (FT-IR) and Energy Dispersive X-ray (EDX) spectroscopy. Antibacterial activity was tested against Gram positive and Gram-negative bacteria. All investigations show the coatings as good candidates for further bio-applications.

Upconversion Nanoparticles as Multimodal Nanomarkers for Non-invasive Bioimaging, Monitoring and Tissue Engineering

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Abstract

Upconversion nanoparticles (UCNPs) are widely used for non-invasive imaging and monitoring oftissue- engineered structures behavior in a living organism. The upconversion nanoparticles are inorganic fluoride nanocrystals doped with lanthanide ions. The UCNPs perform unique upconversion emission under excitation at 970–980 nm with narrow emission bands, large anti-Stokes shift, non-photoblinking, and photostability. We synthesized and studied UCNP-loaded scaffolds based on polymers of natural and synthetic origin using different fabrication techniques: electrospinning, extrusion and antisolvent 3D printing. For our purposes, we used β-NaYF4:Yb3+:Er3+ nanoparticles with an inert NaYF4 shell and an average size of 21 ± 6 nm. These nanoparticles have two main photoluminescence bands at wavelengths of 544 and 658 nm. We studied the scaffold degradation *in vitro* and *in vivo* with the simultaneous release of UCNPs and analysis of their photoluminescent properties. Cellular experiments had shown that scaffolds were not cytotoxic and provided excellent adhesion surfaces. Subcutaneous implantation of the obtained scaffolds in BALB/c mice and their intravital visualization was carried out. The scaffolds' integral photoluminescence intensity monotonously decreased, indicating their gradual biodegradation inside the body. Surrounding tissues had a moderate inflammatory response. Thus, we demonstrated the viability of the developed approach of bioimaging various polymer scaffolds loaded with the β- NaYF4:Yb3+:Er3+/NaYF4 upconversion nanoparticles and simultaneously monitoring their photoluminescent properties. The study was funded by RFBR according to the research project No: 20-32- 90218.

Core-Shell DNA-Cholesterol Nanoparticles Exert Lysosomolytic Activity in African Trypanosomes

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Abstract

Trypanosoma brucei is a protist parasite, the causal infectious agent of human African trypanosomiasis and Nagana in livestock. Both diseases are currently treated with a small number of chemotherapeutics such as eflornithine, fexinidazole or melarsoprol. All three were developed in the second half of the last century and suffer from a variety of limitations reaching from acute toxicity to growing resistance of the parasite. However, they are all on the World Health Organization's list of essential medicines highlighting the need for the development of new trypanocide drugs. Here, we explore the forward design of a new class of synthetic trypanocides based on nanostructured, core-shell DNA-lipid particles. The nano particles self- assemble in aqueous solution into micelle-type structures consisting of a hydrophobic lipid core surrounded by a solvent-exposed, hydrophilic DNA shell. DNA-lipid nanoparticles have membrane-adhesive qualities and can permeabilize lipid membranes. We report the synthesis of DNA-cholesterol nanoparticles, which specifically impair the membrane integrity of the T. brucei lysosome, killing the parasite with nanomolar potencies. Furthermore, we provide an example of the programmability of the nanoparticles. Every mature mRNA in T. brucei is characterized by a constant 5'-end, the so-called spliced leader (SL). By functionalizing the DNA shell with a (SL)-RNA-specific DNAzyme, we target a second trypanosome-specific pathway (dual-target approach). The DNAzyme provides a backup to counteract the recovery of compromised parasites, which reduces the risk of developing drug resistance. However, different, or multiple functionalization of the DNA-shell can be envisaged.

Simulation and Fabrication of Nanostructured Device for Image Enhancement of fNIRS System

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Abstract

Nowadays, photonic fields are the most interesting field in optics, biology, and other various fields. Many researchers studied about plasmonic nanostructure which have a lot of optical properties such as enhancing the electric field in hot spot, modulating the optical pathway, second harmonic generation (SHG) for enhancing the resolution and detect small signal. Surface plasmons are coupled oscillations that arise from the interaction between light and charge electrons. Spatial variation of the charge density along the conductive surface can cause surface plasmon effects. In this proposal, we designed plasmonic nanostructure based on FEM analysis and fabricated these structures using nanoimprint lithography with subsequent metal evaporation for enhancing optical signal. Designed plasmonic nanostructure have different surface plasmon effect according to change of the gap between patterns and therefore we especially studied the structures and gap of patterns which could be adaptive to NIR wavelength for fNIRS system applications. These structures which have plasmonic characteristics can gather the optical and electric field in one place and enhance transmittance of signals and so it can be enhance the signals. And through NIL process and metal evaporation, designed structure was transferred into polymeric surface, and formability and accuracy of fabricated structure was evaluated by SEM images. Also designed structures enhanced small optical signal 76 times than original signal applied in fNIRS system and also can detect the small signal which cannot detect in original system due to similar with noise signal.

The Influence of pH and Molar Ratio in Wet Chemical Synthesis of Hydrothermally Obtained MoS_2

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Abstract

Molybdenum disulfide (MoS2) is a two-dimensional (2D) material with unique electronic properties, making it a promising material for various applications in electronics and energy [1]. One way to obtain MoS2 is by hydrothermal synthesis in neutral or acidic medium, which includes reacting molybdenum precursors with sulfur sources at high pressures and temperatures in order to control the crystal size and structure. Compared to other synthesis techniques, this method can generate MoS2 of excellent quality, with a well-defined shape and increased stability [2]. In this work, we highlight the morphological changes between the as-prepared MoS2 samples in weakly acidic (i.e., pH - 6.5) and strongly acidic (i.e., pH - 2) medium, as well as the differences in crystallinity induced by varying the molar ratio of Mo and S precursors. X-ray diffraction, scanning electron microscopy, Raman spectroscopy, Brunauer-Emmet-Teller (BET) analysis and Electrical Impedance Spectroscopy (EIS) measurements were conducted with the purpose of characterizing the as-prepared MoS2 samples and determining their potential as an electrode material in future energy storage applications.

X-ray diffractograms recorded to determine the crystalline phase of MoS2 samples, present a major peak at 9°, attributed to (002) plane, which has shifted to a lower angle value (i.e., 2θ - 9°) and an additional peak at 18°, corresponding to (004) plane, both peaks confirming the metallic 1T crystalline phase of MoS2 [2, 3]. Moreover, the crystallinity of MoS2 samples increases as the sulfur precursor concentration is increased. Consequently, the promising crystallinity and the presence of the 1T metallic phase in hydrothermally synthesized MoS2 samples have generated interest in their potential as electrode materials for future energy storage applications.

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Morpho-structural and Electrical Characteristics of Hydrothermally Synthesized MoS_2 Using Various Precursor Combinations

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Abstract

Over the past few years, two-dimensional (2D) nanostructured materials have drawn a lot of interest. Recently, the scientific world has become very interested in molybdenum disulfide (MoS2), a 2D, graphene- like nanostructure with various potential uses including energy storage, hydrogen, and oxygen evolution process, and photocatalysis [1]. In our work, we are trying to understand the changes in structure, morphology and electrical properties that occur when using different precursors in the hydrothermal synthesis of MoS2 [2]. X-ray diffraction and Raman spectroscopy were used to elucidate the crystalline structure of MoS2 nanostructures and to evaluate their metallic or semiconductor nature. Electrical Impedance Spectroscopy (EIS) measurements were also performed to determine the electrical properties of the synthesized nanostructures in order to establish the potential of MoS2 for the fabrication of efficient supercapacitors. In this regard, we are employing various precursors [1,2] to create a 3D MoS2 network resembling a flower-like morphology as revealed by scanning electron microscopy.

In the Raman spectra of as-prepared samples recorded by using the 632 nm laser line an additional peak around 228 cm-1 was obtained. This band is not present in the commercial sample spectrum and is associated with the existence of the conducting metallic 1T crystalline phase of MoS2. The presence of this phase was also confirmed by X-ray diffraction, where a shift of (002) plane to lower angle values (i.e., 2θ - 9°) and an additional peak attributed to (004) plane around 2θ = 18° were observed [3,4] Therefore, the synthesized metallic phase presents an interest in the potential of MoS2 as a promising electrode material.

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Multifunctional Nano-coatings by MAPLE Deposition on Titanium Alloy for Bioapplications

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Abstract

New multifunctional formulations based on chitosan (Ch), bioglass (BG), titanium oxide (TiO2), zinc oxide (ZnO), and graphene oxide (GO) were obtained by Matrix Assisted Pulsed Laser Evaporation (MAPLE). The deposition was carried out on a titanium alloy support.

The MAPLE deposition technique is presented as a method for producing uniform films, composed of species with different molecular weights, with unique morphologies using the advantages of vacuum deposition. The process of deposition of polymeric films by MAPLE involves the absorption of light with a certain wavelength produced by a laser by a diluted and frozen mixture of polymer (substance of interest) with a concentration of less than 5% and relatively volatile solvent (matrix), so that the substance of interest is protected by a large amount of solvent. During the deposition process, ideally, most of the laser energy should be absorbed by the solvent molecules, thus minimizing, or completely avoiding the photochemical degradation of the polymer.

Deposition tests were carried out using discs of 2 cm diameter and 1 mm thickness of 73Ti-20Zr-5Ta-2Ag. The deposition was optimized depending on the laser fluence and the pressure inside the working chamber. The best combination of deposition parameters will be presented.

The characterization of the substrates obtained through surface analysis coupled with compositional techniques was carried out: SEM and EDX, FT-IR, contact angle, roughness measurements. The obtained data are in good agreement with the purpose of using this method of deposition for bio-applications.

Keywords: Nanomaterials, Polymer, MAPLE, Titanium alloys, Bio-applications.

Nanocoatings Prepared by MAPLE Deposition Based on Chitosan (Ch), Bioactive Glass (BG), Titanium Dioxide (TiO_2), and Zinc Oxide Nanoparticles (ZnO)

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Abstract

The purpose of this research is to obtain new multifunctional formulations based on chitosan (Ch), bioglass (BG), titanium oxide (TiO2) and zinc oxide (ZnO) by Matrix Assisted Pulsed Laser Evaporation (MAPLE), for biomedical applications. MAPLE depositions are compatible with different types of substrates, like metals, ceramics, polymers, or semiconductors. In this study, the deposition is carried out on a titanium alloy substrate (73Ti-20Zr-5Ta-2Ag).

To prepare the suspensions for MAPLE deposition, several samples containing Ch, BG, TiO2, and ZnO were produced in various mass ratios which were subsequently characterized. The surface morphologies of the 73Ti-20Zr-5Ta-2Ag samples coated and uncoated with Ch + BG + TiO2 + ZnO films deposited from mixtures solution were investigated by a scanning electron microscope (SEM) equipped with an EDX detector-analyzer. The FTIR method was used to confirm the qualitative detection of functional groups specific to the Ch + BG + TiO2+ ZnO coating.

The studies of the coatings were also evaluated by atomic force microscopy measurements and by wettability determinations. The surface roughness is correlated with SEM morphology, proving that the coatings containing larger particles lead to surfaces with higher roughness. All the investigations show a good response of the coatings for further biocompatibility applications in medicine.

Keywords: MAPLE, Nano-coatings, Nanoparticles, Wettability, Functionalization.

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Fire Resistant and Thermal Insulator Monolithic Cellulosic Materials Obtained from Wood Sawdust Waste

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Abstract

The increase of the sustainability and technical performance of materials obtained from recycled and renewable waste materials is a priority of our days.

In this study, wood waste (e.g., sawdust of wood) is used to obtain porous monolithic materials with lower density, improved fire resistance and increased thermal insulation properties. The raw material is subjected to a delignification process (using NaOH/CH3COOH/H2O2), a modification with phosphorous groups (using H3PO4 as a fire protective agent, [1]), a mixing step with epoxy resin (using SU8 photoresist as an adhesive agent, [2]) and nanocarbons (using nanohorns as structural stabilizer). The obtained composite materials were investigated by microscopic (optical, SEM), spectroscopic (FT-IR and Raman spectroscopy), X-ray diffraction (XRD) and thermal (microscale combustion calorimetry-MCC and vertical flame burning) analyses.

A monolithic cellulosic composite material with an improved fire resistance (about 27% mass lost in vertical burning test against total burning of raw material) was obtained. Moreover, a decrease of 33% for density of the monolithic composite sample (i.e., 0.24 g/cm3) prepared with cellulosic material against that obtained using raw material was achieved. These properties support the interesting potential of this type of composites to be further investigated and tested as fire-resistant thermal-insulation materials.

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Structural Characterization and Flame Retardancy Properties Evaluation of GO functionalized based Composites

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Abstract

Graphene oxide (GO) nanosheets have been used as constituent of different flame retardant compounds due to their properties as strong barrier effect, chemical stability, high thermal resistance and large specific surface area [1,2] Moreover, it was reported about the synergistic effect of P-N-Si-containing compounds on improving flame retardancy of various polymeric materials [3, 4], by ensuring an enhanced flame and heat protective char layer generated by the presence of phosphorus, which is foamed up by the action of nitrogen and thermally stabilized by the presence of silicon.

In the present work the structural, morphological, and surface properties of GO and a composite obtained by grafting a novel nitrogen-containing polyhedral oligomeric silsesquioxane (HAK) and 9,10-dihydro-9- oxa-10-phosphaphenanthrene-10-oxide (DOPO) on the surface of GO nanosheet were investigated by means of different techniques such as XRD, TEM-EDX, FT-IR, Raman and zeta potential. The performed analyses evidenced the successful functionalization of the GO and the changes induced on the GO structure. Moreover, microscale combustion calorimetry (MCC) and TG measurements were performed, and it was found that the obtained residual weight for GO-DOPO-HAK compound is the highest one as compared to the other investigated samples suggesting thus the great potential of the GO-DOPO-HAK as flame retardant material and opening new perspectives for getting building materials with improved fire-retardant properties.

Acknowledgements: This work was supported by a grant from the Ministry of Research, Innovation and Digitization, CNCS/CCCDI–UEFISCDI, project number PN-III-P2-2.1-PED-2021-3156, within PNCDI III.

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ZnO NR/Au NP Nanocomposites for Antibacterial Applications

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Abstract

The use of nanoparticles as antimicrobial agents may be a strategy to overcome the tendency of microbes to become resistant to antibiotics' action. We propose different ZnO NR /AuNP nanocomposites, synthesized by simple aqueous solution route, that can serve as an alternative antimicrobial product. The structure and morphology of nanocomposites were analyzed by standard structural and morphological characterization techniques and the antimicrobial properties against *Escherichia coli* and *Staphylococcus aureus* were investigated through disc diffusion and tetrazolium/formazan assays. Proposed nanomaterialsexhibited significant antibacterial effects. Samples containing ZnO nanorods with less than 50 nm in diameter showed better antibacterial activity. The antibacterial efficiency improved considerably by adding small quantities of nanogold - 0.2% (w/w) Au to ZnO nanorods. The results indicated the new materials' potential for antibacterial applications.

Non-invasive and Selective Neuromodulation of Deeper Structures in the CNS

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Abstract

The main objective of this project is to develop a minimally invasive method to stimulate selective neuropathways located within the Central Nervous System (CNS). We intend to use a non-electrical, non-electromagnetic, and non-electrode-based implantation approach to depolarize or hyperpolarize targeted neurons. Our aim is to replace a conventional approach to emit visible light by stimulating dye sensitized upconversion nanoparticles (UCNPs) using Near Infrared (NIR) light. The optimized visible light emission of UCNPs will activate light sensitive ion channels, Channelrhodopsin-2 (ChR2), in transfected neuropathways. These endocytosed UCNPs will also be in much closer proximity to the membrane bound ChR2s, which enhances energy transfer efficiency between the UCNPs and ChR2s. Hence, less NIR irradiation power is sufficient to drive the neural activities. We investigated the biocompatibility of the UCNPs and the efficacy of the system to activate specific ChR2-transfected neurons with spatiotemporal precision in *in vivo* models. This new system will provide scientists with a powerful tool to non-invasively modulate deeper neural pathways, enabling functional recovery post-neurotrauma as well as neuromodulation of the peripheral and visceral nervous systems. The application of UCNPs-NIR will enable safer access to regions beyond conventional intervention such as invasive electrode implantation, paving the way for scientists and physicians in diverse fields of Neuroscience and Neuromodulation.

The PDZ Motif Peptide of ZO-1 Attenuates *Pseudomonas aeruginosa* LPS-induced Airway Inflammation

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Abstract

Pseudomonas aeruginosa is known to play a role in many human diseases. Therefore, examining the negative control mechanisms of tight junction protein ZO-1 on the exotoxin LPS of *P. aeruginosa*-induceddiseases could be critical in the development of novel therapeutics. We found that ZO-1 expression dramatically decreased in inflammatory human lung tissues. Interestingly, PDZ1 deletion of the PDZ domain in the ZO-1 protein dramatically decreased LPS-induced F-actin formation and increased the expression of genes for pro-inflammatory cytokines, but not PDZ2 and PDZ3 of the ZO-1 protein. We alsofound that the consensus PDZ peptide (based on PDZ1) of ZO-1 down-regulates the expression of pro-inflammatory cytokine genes and F-actin formation; in contrast, the GG24,25AA mutant PDZ peptide cannot control these genes. LPS activates IL-8 secretion extracellularly in a time-dependent manner, while the secretion is inhibited by PDZ peptide. Whereas increased IL-8 secretion by LPS activates the CXCR2 receptor, overexpressed RGS12 negatively regulates LPS-induced CXCR2/IL-8 signaling. The PDZ

peptide also decreases LPS-induced inflammatory cell populations, pro-inflammatory cytokine gene expression, and TEER in bronchoalveolar lavage fluid and cultured alveolar macrophages. Collectively, wesuggest that the PDZ peptide may be a potential therapeutic for bacteria-induced respiratory diseases.

Donepezil-loaded Liposomes as Innovative Strategy to Overcome P-gp Dependent Resistance in Neurodegeneration

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Abstract

The blood-brain barrier (BBB) controls the traffic of substances in the central nervous system, protecting neurons against toxic compounds. In neurodegenerative pathologies, like Alzheimer's disease, the crucial function of the BBB assumes a negative role, impeding the drug influx. Besides the presence of thigh junctions between endothelial cells, BBB function is strongly regulated by active efflux transporters, including P-glycoprotein (P-gp) [1].

P-gp is a 170 kD transmembrane glycoprotein whose function consists in actively transporting xenobiotics/chemotherapeutics outside the plasma membrane, consuming two ATP molecules. P-gp is normally expressed in different tissues, particularly on the apical side of BBB and gastrointestinal wall. P-gp actively extrudes many structurally heterogeneous substrates, including Donepezil, an acetylcholinesterase inhibitor used in AD therapy [2]. Thus, inhibition of brain P-gp could result in an increased Donepezil brain uptake.

Aiming to overcome P-gp dependent resistance in AD, we designed new Donepezil-loaded liposomes containing in the external lipidic membrane SG44, a P-gp inhibitor with IC_{50} in the nanomolar range (compound 10 in Nesi et al. [3]). Three liposomal formulations composed by different lipids ratio: 1. DPPC:DOPC:Chol (6:3:1 w/w), 2. HSPC:DMG-PEG:Chol (3:1:1 w/w) and 3. DPPC:DOPC:DMG-PEG:Chol (5:2:2:1 w/w) were prepared by film rehydration and extrusion sizing. Dual drug loading was performed, obtaining liposomes of average diameter in the range 100 - 160 nm. Biological andbiopharmaceutical evaluations on BBB cell model are ongoing.

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Numerical Study of Early Oxidation Effect on Wettability of Laser-treated Surface

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Abstract

Surface texturing by direct laser ablation creates micro- and nano-scale roughness on materials, resulting in increased

surface area and improved surface energy. In particular, micro- and nano-textured surfaces findnumerous applications in virus and bacterial repulsion, including the osseo-intergration process in biomedical implants. Laser treatment is one of the most efficient tools for surface texturing, but it can introduce surface oxidation or chemical modifications that cause changes in wettability over time. Despitethe significance of these changes, the underlying reasons are not yet fully understood. To gain further insights into these effects, we performed reactive molecular dynamics (RMD) simulations to understand the effect of early oxidation on laser-treated titanium at different temperatures. The obtained results demonstrate that oxide thickness increases with time. Hence, the TiO_X layer grows more quickly in the earlystages (0 - 130 ps) than it does in the later stages (130 - 300 ps). This condition is brought on by an increase in the TiO_X layer and a decrease in O_2 diffusion. The obtained results are then used in a series of wetting simulations showing that the presence of oxide makes the droplet behavior less hydrophobic in agreementwith experimental observations. Interestingly, because oxide layer thickness rises with time, the contact angle drops down with time, thus the calculated early dynamics of titanium surface oxidation correlates well with the early time-evolution of laser-treated surface wettability.

Multifunction Optoelectronic Fiber Device by Integrating Graphene/MoS_2 Heterostructures

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Abstract

Two-dimensional (2D) materials exhibit fascinating and outstanding optoelectronic properties, laying the foundation for the development of novel optoelectronic devices. However, ultra-weak light absorption of 2D materials limits the performance of optoelectronic devices. Here, a structure of MoS_2/Graphene/Auintegrated onto the side- polished fiber (SPF) is proposed to achieve a high-performance fiber-integrated multifunction-in-one optoelectronic device. It is found that the device can absorb the TM mode guided in the SPF and generate photocurrents as a polarization-sensitive photodetector, while the TE mode passes with low loss through the device, making the device simultaneously a polarizer. In the device, the MoS_2 film and the Au finger electrode can enhance the TM absorption by 1.75 times and 24.8 times, respectively,thus allowing to achieve high performance: a high photoresponsivity of 2.2 x 10^5 $A.W^{-1}$ at 1550 nm; the external quantum efficiency (*EQE*) of 1.76 x 10^7%; a high photocurrent polarization ratio of 0.686 and a polarization efficiency of 3.9 dB/mm at C-band. The integration of 2D materials on SPF paves the way to enhance the light-2D material interaction and achieve high performance multifunction-in-one fiber-integrated optoelectronic devices.

Keywords: Graphene/MoS_2 heterostructures, Side-polished fiber, Multifunctional device, Photodetector, Polarizer

The Efficiency of Silver Iodide Nanoparticle as a Novel Suppression Agent for Grown, Migrated, and Invasive Papillary Thyroid Cancer Cells

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Abstract

A simple chemical precipitation method synthesized uniform and well-dispersed silver nanoparticles (AgNPs) and silver iodide nanoparticles (AgI NPs). UV-visible spectroscopy, Field Emission Scanning Electron Microscopy (FE-SEM), Transmission Electron Microscopy (TEM), Dynamic Light Scattering (DLS), and Thermogravimetric

Analysis (TGA) have all been used to explore the characterization of NPs.Remarkably, the cytotoxic evaluation of AgNPs and AgI NPs revealed profoundly effective cytotoxicity against papillary thyroid cancer (PTC) (MDA-T22) in a dose-dependent manner with recorded IC_{50} valuesof 71.35 µg/ml and 192.6 µg/ml for AgNPs and AgI NPs, respectively. Concurrently, the AgNPs and AgI NPs had no cytotoxic impact on normal cells (WRL-68) at low concentrations and very minor cytotoxicityat higher doses of 200 - 400 µg/ml, with a dramatically raised IC_{50} value that reached 215.8 µg/ml for AgNPsand 230 µg/ml for AgI NPs. Cellular uptake results indicate that AgNPs were taken up by PTC cells more than AgI NPs in a time- and concentration-dependent manner. The Western blot analysis illustrated that AgNPs inhibited the migratory ability of PTC cells down to 75% while AgI NPs to 70%. Moreover, the invasive cell rate significantly decreased in PTC cells down to 55% for AgNPs and 40% for AgI NPs. Collectively, these data have shed light on the potential application of these NPs in PTC target therapy.

Keywords: Silver nanoparticles, Papillary thyroid cancer, Chemical participation, Silver iodide nanoparticle, Cytotoxicity, Cellular uptake, Cell viability

Comparative Evaluation of Standard Quercetin versus Nanoparticles Formulation on Kidney Fibrosis

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Abstract

Background: Renal fibrosis is the final stage of chronic kidney injury characterized by glomerulosclerosis and tubulointerstitial fibrosis with parenchymal destruction. Quercetin belongs to the most studied flavonoids with antioxidant, anti-inflammatory, antifibrogenic, and antitumor activity. It modifies the TGF-β/Smad signaling pathway, decreasing profibrogenic expression molecules and inducing the expression of antioxidant, anti-inflammatory, and antifibrogenic molecules. However, quercetin exhibits poor water solubility and low absorption and bioavailability. This limitation is solved by the production of nanoparticle formulation that has been demonstrated to improve the solubility and bioavailability of several bioactive compounds.

Aim: This investigation aimed to prove in an animal model the antifibrogenic effect of a quercetin nanoparticles formulation and compare it with standard quercetin.

Methods: Male C57BL/6 mice were induced into chronic renal failure with 50 mg/kg of adenine for four weeks. The animals were randomly grouped and treated at the same time with 25, 50, or 100 mg/kg of quercetin, either standard or nanoparticle formulation. We analyzed several parameters associated with renal damage, such as histological, biochemical, and molecular analysis.

Results: We found a better effect on preventing fibrosis using quercetin nanoparticles than using standard quercetin at similar doses. Serum levels of creatinine and uric acid are almost normal with 100 mg/kg of nanoparticle formulation treatment. Quercetin nanoparticles more effectively inhibited the TGF-β/Smad signaling pathway by promoting the expression of antifibrogenic genes.

Conclusion: Our results suggest that nanoparticles formulation of quercetin increases the bio disponibility facilitating its entry into the cells and activating antifibrogenic and anti-inflammatory signaling pathways.

Future Directions of Materials

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Abstract

For millennia, thousands of materials have been sourced | synthesized | developed and employed in the service of humans. Scholars grouped them to denote their historical significance, and to provide cumulative knowledge of enabling scientific principles and advances. Poly-disciplinary approach, which draws upon advances in diverse scientific fields, sets the stage for imagining future directions of materials, i.e., Intelligent Materials and Sustainable Materials.

Sustainable materials foster a healthy living environment via circular economy and elimination or reduction of associated greenhouse gas (GHG) emissions, wastage, and resources depletion. They are purposely designed | selected with lower environmental footprint and social costs, and higher circularity while satisfying the cost as well as functional requirements. In other words, sustainable materials are friendly to the Earth's ecosystem and human health with high circularity performance. Intelligent materials are capable of sensing and processing external signals as well as internally generated signals and produce optimized responses | behaviors. Shape memory materials, piezoelectric materials, photoelectric materials, protein and lipid-based biomaterials, and thermoelectric materials are rudimentary examples of intelligent materials. They are often interchangeably referred to as smart materials.

This lecture seeks to describe and discuss the principles of sustainable materials as well as intelligent materials while sitting case studies and examples.

Nanostructured Interfacial Energy Materials for Sustainable Photovoltaics and Solid-state Lithium Batteries

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Abstract

We plan to provide an overview of our research in the area of sustainable energy materials spanning from nanostructured photo-electrodes for photovoltaic cells to advanced hybrid (ceramic@polymer) electrolytes for solid-state Li-ion batteries. Building on our previous solar energy material research featuring Cu_2ZnSnS_4 (kesterite) as light absorber [Nano Energy, 53 (2018), 130-134], we have sought to address the hysteresis problem in hybrid perovskite solar cells (PSCs) via interfacial engineering ofthe two charge extraction films, the ETL [Nanoscale, 2023, 15, 2152-2161] and HTL. In the formerstudy, two electron transport layer (ETL) nanostructures were evaluated: (a) rutile titania nanorods grown over anatase titania (AR) and (b) anatase titania deposited on the rutile titania nanorods (RA).PSCs based on ETL with RA structure found to attain higher short-circuit current density (JSC) and open-circuit voltage (VOC) attributed according to our EIS analysis to variable charge transfer resistance across perovskite interfaces and the appearance of inductance due to ionic accumulation atthe ETL interface. A major part of our presentation though will discuss some exciting recent advances we have made in developing highly conducting and robust hybrid solid-state electrolytes (HSE) (garnet@PEO-LiTFSI) that show remarkable stability in symmetric Li-HSE-Li cells. The HSE is made of a novel mesoporous ceramic film built from near nanosized garnet (Al-stabilized $Li_7La_3Zr_2O_{12}$) particles [https://doi.org/10.1007/978-3-031-17425-4_36] and molecular bonding of PEO enabling theattainment of Li-ion conductivity 200% higher than that of the best dense garnet film conductivity. Indeveloping these new energy nanoengineered structures, our research puts equal emphasis on electrochemical device performance as well as on ionic material processing, searching to understandand control/optimize the intricate nanoscale governing relationships.

Activation of the Micron-aluminum-water System Using Aluminum Nanoparticles for the Steady Generation of Hydrogen

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Abstract

The development of methods for H_2 production is motivated by a vision to move away from fossil fuels due to their finite availability and the environmental damage caused by their combustion. There are multiple ways to generate H_2 including water electrolysis, chemical reactions, steam reforming of hydrocarbons, and from biological sources. These methods are not amenable to portable use systems,as they are either too expensive or initiated under extreme conditions. Transporting pure H_2 has challenges with low volumetric energy density and high flammability. Thus, it is necessary to developsafe and economically feasible H_2 delivery systems that can be utilized on-demand. Aluminum is deemed as a possible source of energy storage for direct H_2 generation if its surface is passivated efficiently, effectively, and safely.

A method is described for activation of the reaction of ambient temperature water with micron-scale aluminum particles (μAl) by the addition of epoxyhexane-capped aluminum nanoparticles (Al NPs). By themselves, Al NPs react vigorously and completely with water at to produce H_2. While pure μAlparticles are unreactive toward water, mixtures of the μAl particles comprising 10 % to 90 % (by mass) of Al NPs, demonstrated appreciable hydrolytic activation. Speciation modelling, pH studies, and powder X-ray diffraction analysis of the hydrolysis product confirm that the pH change is the key driver for the activation of μAl rather than residual heat from the exothermicity of the Al NPs hydrolysis.

Janus Organic Semiconductor Nanoparticles Prepared by Simple Nanoprecipitation for Organic Photovoltaics

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Abstract

A new way to think organic photovoltaics (OPV) was investigated a few years ago, in which the active materials are no more solubilized in organic solvents, often toxic, but dispersed as nanoparticles in a friendly solvent, such as ethanol or water. After a few years of research and optimization, the very symbolic power conversion efficiency (PCE) of 10% was surpassed in 2022, from water dispersions. The nanoparticle internal morphology (linked to the preparation technique, i.e., nanoprecipitation or miniemulsion), the nanoparticle size, the use of friendly additives, or the influence of surfactant molecules (mandatory for dispersion stability) are under the scope of several research teams. In this invited talk, the effect of these parameters on the particle size will be discussed. Then, our recent published results showing a Janus morphology never described before with conjugated materials will be presented. This morphology was obtained with the P3HT:PCBM couple reference system, using the nanoprecipitation technique, It has been theoretically confirmed and demonstrated with other donor/acceptor couples, using the same conditions. To further characterize the nanoparticle dispersions, Dynamic Light Scattering, Cryo-TEM, STXM, UV-Visible spectroscopy, Photoluminescence and Atomic Force Microscopy were used. After several optimizations, water-based solar cells reached 85% of efficiency of their chlorobenzene-based counterparts.

Nanocomposite based on "Silicon Nanowires-conducting Polymer" for Flexible an Ultra-stable All Solid Supercapacitor

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Abstract

With an exponential consumption of electronic components and their almost constant presence in our daily lives, little progress is needed to make them really stick to our skin. Indeed, the use of on-board portable technologies has stimulated research on flexible electronics with flexible systems at all scales such as scrolling screens, touch screens, IoT, integrated sensors and textiles. Based on EDLC, pseudo- capacitive storage, or an asymmetric system, flexible all-solid supercapacitors have gained considerable attention in recent years with their many advantages and ease of use, including the ability to have systems that are small in size, light in weight, easy to handle and usable over wide temperature ranges.

In this context, we realized high-performance electrochemical energy storage microdevices based on nanocomposites electrodes (silicon nanostructures - nanometric dielectric - conductive polymer or transition metal oxide) with aqueous electrolyte and all-solid electrolyte. This processed nanocomposite electrode is a major improvement in terms of energy density and durability of devices: that becomes possible thanks to the Atomic Layer Deposition (ALD) technique and the homogeneous growth of Alumina layers. For our all-solid component, we use a polymer electrolyte. Our solid-state electrolyte was obtained by bifunctionalization on polysiloxane with trimethylammonium and methyldiallylammonium groups, with crosslinking. Crosslinking is done by heating the sandwich device at 80 °C. for 48 hours. Very good cycling stability for a cell potential of 3 V was observed with galvanostatic cycling of the device.

Water Disinfection and Pathogens Detection via Thermoplasmonic Responsive and Bioactivated Gold Nanorods Array

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Abstract

Water treatment and pathogens detection deserve particular attention because of the risks associated with human and animal health, such as pathogenic illnesses, infectious diseases, and antibiotic resistance. Modern technologies that rely on chemical disinfection (water treatment) and analytical methods for water monitoring have significantly contributed to realizing new methodologies and innovative tools that help control and monitor water quality. However, several drawbacks still need to be addressed, such as excess chemical agents in potable water and the long waiting time for lab test results, requiring complex procedures. To this end, we have developed a nanotechnology-assisted platform that exploits the physical and chemical properties of an array of gold nanorods (Au NRs) suitably immobilized on a rigid platform. The Au NRs array is bioactivated using a specific antibody that selectively recognizes (colorimetric detection) the presence of Escherichia coli cells dispersed in potable water. In addition, the thermoplasmonic properties of the Au NRs array are exploited for realizing a physical disinfection methodology of drinkable water using the light-to-heat conversion capability of the realized platforms. A very low detection limit (8.4 CFU/ml) and high photo-thermal efficiency (0.9) allow the realized nano-platforms to work as a new multifunctional technological device that simultaneously offers the capability to monitor the water quality (biosensing capability) and enables light-triggered thermal disinfection (disinfection capability).

Sustainable Synthesis of Coconut Shell-based Magnetic Activated Carbon: Application on the Removal of Contaminants from Wastewater

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Abstract

Coconut shell magnetic activated carbon (CSMAC) was prepared from coconut shell wastes through pyrolysis and co-precipitation and employed as an adsorbent in diesel-contaminated water. The effectiveness of the CSMAC was compared against that of commercial activated carbon-based adsorbents—both magnetic and non-magnetic—for chemical oxygen demand (COD) removal from oily wastewater. Fourier-transform infrared spectroscopy, X-ray diffraction, and scanning electron microscopy were used to characterize the adsorbents. The characterization analyses revealed that the prepared magnetic nanocomposites had sufficient magnetic saturation for quick and easy recovery, interconnected pores, and different functional groups. The CSMAC nanocomposite removed 93% of COD under optimal conditions—temperature of 35 °C, adsorbent dosage of 0.5 g, pH of 7.0, and contact duration of 3 h. The COD removal mechanism followed the Langmuir isotherm, and thermodynamic analyses revealed that the removal process is exothermic and occurs spontaneously with the increase in temperature. After seven use cycles, the COD removal efficiency of the CSMAC was 80%, which is significantly higher than that of commercial magnetic activated carbon.

Keywords: Oily wastewater, Iron oxide magnetic nanocomposite, Diesel-contaminated water, COD removal, Sustainable materials

Green Synthesis of Ni Doped ZnO Nanoparticles Using Dandelion Leaf Extract and its Solar Cell Applications

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Abstract

In designing sub-100nm nanoparticles (NPs), the "green synthesis" method has drawn considerable interest in recent years due to its sustainable, reliable, and eco-friendly in nature. The green synthesis method successfully eradicates the harmful and/or toxic effects usually associated with wet chemical methods. Different concentrations of Ni2+ ion doped ZnO NPs were synthesized by using dandelion leaf, an eco-friendly and green synthesis method at ~70 °C for 0.5 h and annealed the NPs at 600 °C for 3 h to grow the crystalline nature of the NPs. The Ni2+ ion doped ZnO NPs were surface modified to enhance the dispersion ability of the NPs in aqueous solvents. NPs with surface modifications are readily dispersed in water and further surface functionalization can be performed. NPs are characterized by XRD, SEM, EDX, FTIR, and UVVis. XRD confirms the high crystallinity and Ni2+ ion saturation limit ~5% in ZnO NPs with hexagonal-Wurtzite phase structure. Shifting of diffraction angle to higher angles clearly shows successful incorporation of Ni2+ ions in ZnO host. SEM images of the ZnO nanoparticles confirm the NPs are mostly spherical and sub-100 nm in size. EDX results confirm the elemental composition and purity of the NPs, and no impurity peaks were detected. FTIR confirms the band at 410 cm-1 is assigned to asymmetric stretching of the Zn-O tetrahedron. A slight shift in this peak ~10 - 20 cm-1 is observed by Ni2+ ion incorporation. Also, surface modified NPs show further surface vibrations, which supports high dispersibility of the

NPs. The UV-Vis absorption study confirms the decrease in bandgap of NPs from 3.1 to 2.54 eV. In addition, Ni2+ doped ZnO NPs incorporated in PVA thin films and coated on polycrystalline silicon solar cells sustain strong UV-Vis absorption, supporting their use as for the enhancement of light harvesting efficiency.

Keywords: ZnO NPs, Green synthesis of NPs, Dandelion leaf extract, Surface modification, Polycrystalline silicon solar cell

Efficient Power Density Amelioration Strategy for Capacitive Salinity-gradient and pH-gradient Energy Harvesting Systems

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Abstract

Osmotic energy released from the mixing of dilute and concentrated solutions is a new source of renewable energy. Our team developed an efficient capacitive energy harvesting system based on two inexpensive capacitive electrodes and one single selective membrane. These systems are a sustainable, environmental-friendly approach. However, the power obtained remains lower than that necessary to achieve economic profitability. In order to ameliorate power density performance, we developed a promising strategy, which is the use of an additional booster system in the circuit. The booster system generates an alternative electric voltage in phase with the period of flux reversal. The net power density output is calculated as the difference between gross power density dissipated and the power density generated by the booster system. Using salted solutions and a current collector covered with carbon particles, we measure a maximal power density of 5.26 W.m-2 (salinity difference of 0.17 mol.L-1 and 5.13 mol.L-1), which corresponds to a 59.8% increase compared with its power density of 3.29 W.m-2 without booster. Using solutions with different pH and a current collector covered with MnO2 nanoparticles, we generate a net power density of 3.2 W.m-2 (pH gradient of 2.4) compared with the experimental result of 1.7 W.m-2 reported in literature. The pH differences can be generated in nature by injecting CO2 into saline solutions. A maximum net power density of 4 W.m-2 is obtained for a higher pH difference. In both situations, the process is economically viable.

Hybrid Heterostructure Nanocomposite of Carbon Nanofibers in Hollow Sheet-like Tin Sulfide Nanotubes for Ultrafast Lithium Storage

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Abstract

Lithium-ion batteries (LIBs) are briskly used as the main power source of smartphones, tablets, laptops because of various advantages such as environmental friendliness, high energy density, and long cycle life. However, the LIBs have encountered some restrictions such as short mileage due to the low discharge capacity, slow charging speed, and deficient number of cycles to be applied in electrical vehicles (EVs). To improve the charging speed and capacity, developing the anode materials is key technology, because the anode materials are the main component embodying the capacity of LIBs. Among various anode materials, Zinc sulfide (ZnS) has been regarded as excellent anode materials due to its environmental friendliness, high natural abundance, and high theoretical capacity (962.0 mAh/g). However, the ZnS also has characteristics such as large volume change and poor electrical conductivity, leading to obstructed lithium storage capability. In particular, some studies including surface coating, morphology control, and composite with other materials have been reported to overcome these problems, but these processes have complicated and expansive synthesis process. In this study, therefore, we designed hybrid heterostructure nanocomposite of carbon nanofibers in hollow sheet-like tin sulfide nanotube for ultrafast lithium storage capability through one-pot process by carbonization with thiourea effect. This unique structure can improve electrochemical kinetics and cycling stability under ultrafast charge/discharge. These contents will be discussed in Nano Rome-2023.

Metalloid Group 11 Clusters: Novel Structures and Applications

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Abstract

Metalloid clusters of the general formula MnRm with n > m (M = Al, Au, Ag etc.; R = substituent) [1] are ideal model compounds to shed light onto the nanoscaled area between molecules and the solid state on an atomic level. In the case of gold, the structural characterization of the multishell metalloid gold cluster Au102(p-MBA)44 (p-MBA = para-mercaptobenzoic acid) [2] was a breakthrough in this field. Lately we could show that also other structural motives can be realized within nanoscale metalloid gold clusters whereby Au4S4 rings within Au108S24(PPh3)26 is only one example [3]. Additionally, alkyl phosphanes gave access to metalloid clusters of the formulae Au32(PR3)12Cl8 [4], showing novel optical and electrical properties in the solid state [5] and unusual film forming properties [6]. Here we describe further applications of this novel cluster in the field of nanotechnology as well as further examples of multi-shell metalloid gold clusters.

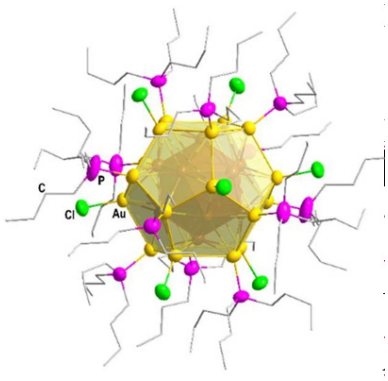

Figure 1: Molecular structure of the metalloid gold cluster Au32(PR3)12Cl8. The arrangement of the different shells is highlighted by a polyhedral presentation.

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Interlocking of Single-walled Carbon Nanotubes with Metal-tethered Tetragonal Nanobrackets to Enrich a Few Hundredths of Nanometer Range in their Diameters

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Abstract

We have separated CNTs through host-guest complexation using host molecules named "nanotweezers" [1] and "nanocalipers" [2]. In this work, a new host molecule named tetragonal "M- nanobrackets", consisting of a pair of dipyrrin nanocalipers corresponding to two square brackets "[" and "]" tethered by two metals (M), is designed, synthesized, and employed for separating SWNTs (Figure 1a) [3]. Three-step facile process, including one-pot Suzuki coupling, from a carbazole derivatives gave M-nanobrackets in 37% total yield (M = Cu). Upon extraction of SWNTs in the presence of the square nanobracket and Cu(II), in situ formed tetragonal M-nanobrackets is found to interlock SWNTs to disperse in 2-propanol. After concentrating the extract, the residual extracted SWNTs was washed several times with dichloromethane to remove the host molecules weakly bound to the SWNT surface. The resulting interlocked SWNTs (iSWNTs) were demetallized with dithiothreitol in dichloromethane, giving pristine SWNTs (p-SWNTs) as solid and the square nanobracket in the washings (Figure 1a). The interlocking is confirmed mainly by TEM observation (Figure 1b) and Raman spectra (Figure 1c). While Cu-nanobrackets are found to show inherent resonance Raman signals (green trace in Figure 1c), similar signals remain in i-SWNTs (blue trace) and disappear in p-SWNTs (red trace), supporting the interlocking structure. The facile unlocking enables.

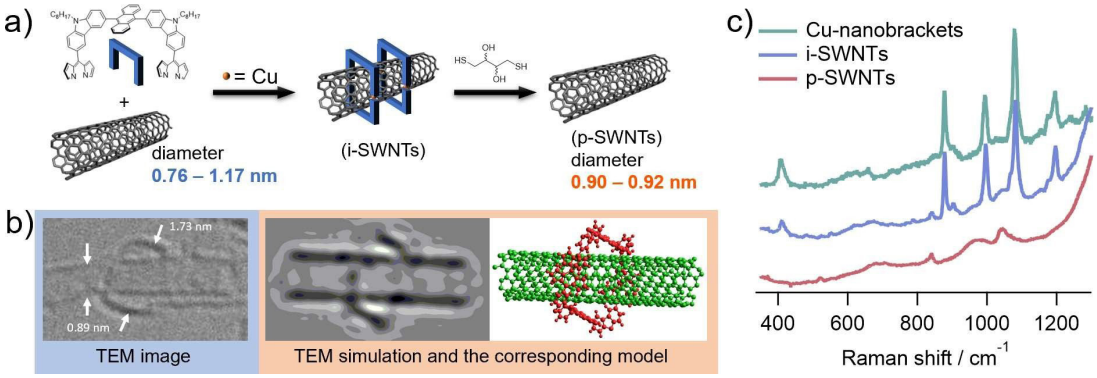

Figure 1: (a) Extraction of SWNTs with Cu-nanobrackets and their removal with dithiothreitol; **(b)** TEM image of the mechanically interlocked SWNT, TEM simulation and computer-generated model; and **(c)** Raman spectra of Cunanobrackets, i-SWNTs and p-SWNTs (λex = 488 nm). Raman intensities of all SWNTs are normalized at the G-band. precise evaluation of the diameter selectivity to SWNTs by Raman, photoluminescence, and absorption spectroscopies, revealing the diameter enrichment of only three kinds of SWNTs, (7,6), (9,4) and (8,5), in the 0.02 nm diameter range from 0.90 nm to 0.92 nm among ~20 kinds of SWNTs from 0.76 nm to 1.17 nm in their diameter range.

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Self-organization and Aggregation-induced Emission Behaviors of Coordinated Gold Nanoclusters

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Abstract

Self-organization is a ubiquitous phenomenon in nature and sometimes gives rise to unique properties arising from the synergetic effects among the components, offering promising strategies to construct novel nanomaterials. Atomically precise ligand-protected metal nanoclusters have recently emerged as a unique class of functional platforms because of their fascinating electronic, optical, and catalytic properties, so that they can be expected as promising candidates of building blocks of self-organization- based nanomaterials (Konishi et.al. Coord. Chem. Rev. 2022, 470, 214713). However, so far, examples of organized cluster assemblies have been still limited. In this talk, our recent studies on the self- organization of coordinated gold clusters will be shown, highlighting unique J-aggregate-like behaviors and aggregation-induced-emission (AIE) phenomena in optical response.

The clusters we used here are [core + exo]-type clusters having polyhedral core with extra gold atoms. Typically, monomeric Au8 cluster shows a visible emission at ~600 nm, but new emissions appear at ~700 nm when assembled to form ordered nanostructures (J. Am. Chem. Soc. 2017, 139, 17731). Lifetime measurements revealed the aggregation caused a drastic change of the dominant emission mode from fluorescence to phosphorescence, showing a unique type of AIE optical response. We also found that related [core + exo]-type Au6 cluster form ordered assemblies with particular orientation, which was characterized by XRD in solution, and display J-aggregate-like absorption spectral changes and AIE behaviors of the near-IR photoluminescence emission (J. Phys. Chem. C, 2020, 124, 16209). Some recent related topics will also be covered in this presentation.

Insights into Carbon Xerogel Composites with Bi and Fe Nanoparticles for the Development of Efficient Electrochemical Sensors

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Abstract

Nanocomposites based on carbon and metal/metal oxides have a wide range of interesting physical and chemical properties that can generate advances in various research areas like catalysis, electrochemical sensing, etc. To achieve high quality carbon based electrochemical sensors it is needed a system with large active surface area, but also possessing high resistance to thermal, mechanical and chemical stress, high electrical conductivity and interfacial charge transfer properties that directly impact the electrochemical (bio)sensor performances. Thus, efforts were made regarding the formation of graphitized nanostructures during the pyrolysis steps through heterogeneous graphitization in the presence of embedded transition metal nanoparticles.

Carbon xerogel composites containing Bi and Fe nanoparticles (C-Bi-Fe) represent an interesting model of carbon

nanostructures decorated with multifunctional nanoparticles to electrochemical sensor applications. To deeply understand the multifunctional electrode materials based on carbon xerogel and Bi and Fe nanoparticles, for heavy metal and H2O2 detection [1], we analyzed the Fe-assisted graphitization mechanism by involving particle tracking algorithms. The thermal evolution together with structural and morphological characterizations of the C-Bi-Fe nanocomposites were performed by means of the real-time in situ TEM heating, TG/DTG, XRD, TEM, and Raman measurements. Four stages were identified to properly define the thermal evolution of morphology and structure of the nanocomposite during pyrolysis [2]. The results suggested that, if constraints related to bismuth and oxygen interference and the shortages in gaseous feedstock are released, the graphitization yields will increase. This outcome leads to new strategies for selecting thermal treatments for carbon-based systems and nanocomposites with improved electrochemical sensing properties.

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Nano-spectroscopic Studies of Chemical Evolution

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Abstract

The origin of life, though it remains a mystery, is believed to have been chemical reactions at mineral surfaces on the earth during the Hadean period. Although there have been many proposals and preliminary experiments on this topic, no definitive origin has been reported yet because of a lack of nanoscopic studies. Herein, we present the first material surface observations intended to elucidate the origin of life at the molecular level. These observations were made using a combination of novel techniques, specifically, Raman spectroscopy and atomic force microscopy (AFM). Pyrite (FeS2) is known to be one of the most common minerals that can provide condensation and reaction surfaces for chemical evolution. However, this mineral has mostly been studied from a crystallographic viewpoint or in bulk systems, and such investigations cannot fully resolve the exact mechanisms of the specific interactions that occur on this mineral. Moreover, no direct experimental evidence has been reported regarding pyrite initiating chemical evolution at the nanoscale when it is used as a reaction surface. In this study, the quantitative force analysis performed by using AFM, in which the residue of a single amino acid was mounted on AFM tips, enabled us to locate the reaction sites and to study the interaction forces between the amino acid and the pyrite surface. Our Raman spectroscopy and AFM results revealed for the first time that defective areas, with the molecular composition FeS2-x, increase the adsorption probabilities of amino acid residues in chemical reactions on the surface of pyrite.

Low-cost CNT Synthesis with Rough Vacuum and Cold Walled CVD Reactor

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Abstract

Low-cost carbon nanotube synthesis methods promise higher availability of CNT's and CNT reinforced nanocomposite structures with increased strength at a relatively affordable price. A compact CVD reactor has been

developed which is capable of synthesizing MWCNT at rough vacuum levels using liquid carbon sources. At this study developed reactor has been tested for low vacuum levels of 1000 pa - 3000 pa. Samples were produced on a silicon hot surface covered with iron (III) nitrate solution, heated with a DC power source. Process duration is reduced to as low as 15 minutes with visible CNT products. Small reactor volume and cold walled design increases process safety by eliminating hazards of explosive carbon containing gases. Rough vacuum levels are also made possible by using a liquid carbon source. Design and manufacturing process of the reactor including FEM analysis is explained in detail. Patent application is made for the design.

Samples are examined using SEM and Raman Spectroscopy. Results show a diameter range of 100 to 200 nm at MWCNT's. Raman spectroscopy results show D, G and 2D bands. The geometry of the products is spaghetti like bundles grown on substrate. Correlation between pressure level and CNT structure is analyzed.

Photocatalytic Activity of M-ZnO Doped (M = Co, Cr, Fe, Mn, and Ni)

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Abstract

This work evaluates the effective use of zinc oxide nanoparticles doped with magnetic ions (Co, Cr, Fe, Mn, and Ni), in the photocatalytic degradation of polluting organic compounds. The contaminant used was Congo red. Co-doped samples show more than 50% higher effectiveness in degrading contaminants compared to undoped ZnO samples under the same conditions.

This has not been shown before and one of the possible causes is the reduction of the ZnO gap, by more than 14%, when Co is introduced into the ZnO matrix. Photoluminescence (PL) and Raman were the techniques that helped to evaluate the presence of defects in the materials crystalline structure, which may be associated with the reduction of the gap of doped samples or the introduction of energy levels in it. The gap was determined with UV-Vis measurements. Additionally, the smaller average crystal size of Co-doped ZnO samples, compared to that of ZnO, the non-variation of the local geometry of Co in the ZnO matrix, evaluated by Electron Paramagnetic Resonance (EPR), may be another cause of the improvement in the photocatalytic activity of ZnO-Co.

Precise Design and Synthesis of 2D Polymers Including Hetero Atoms

Michio Matsumoto

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Abstract

The on-surface covalent organic framework (COF) [1] synthesis, often using the Ullmann-coupling type carbon-carbon bond formation reaction on metal surfaces, connects aromatic planar monomers in two- dimensional (2D) geometry and affords π-conjugated 2D crystalline polymers in one atomic thickness [2] with the precise arrangement of heteroatoms in 2D polymers. We recently found that these atomic arrangements in the 2D π-conjugated polymer significantly affect the band structures of 2D polymers made from fused thiophenes. Benzotrithiophene (BTT) has two structural isomers, sym-BTT and assym- BTT (Figure), by the relative positions of its three sulfur atoms. Unlike the COF structure of sym-BTT shows flat band structures, the assym-BTT COF structure exhibited distorted band structures [3]. Based on this finding, we synthesized brominated assym-BTT (assym-BTT-Br3) and obtained 2D polymers made from assym-BTT on the Au (111) surface [4]. In this talk, I will discuss the importance of arranging heteroatoms in 2D polymers with atomic preciseness. Furthermore, our recent development arranging silicon atoms in 2D polymers by connecting aromatic monomers with 1,4-disilabenzene will be shared [5].

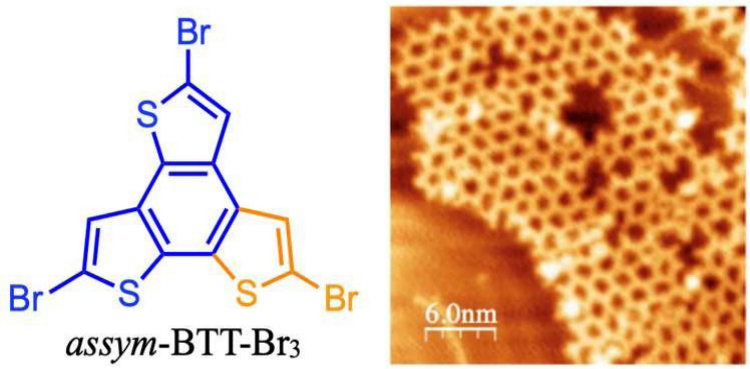

Figure 1: Chemical structure of assym-BTT-Br3 (right) and STM image of 2D polymer of assym-BTT (left).

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Electrically Switchable Intervalley Excitons with Strong Two-phonon Scattering in Bilayer WSe_2

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Abstract

We report the observation of QΓ intervalley exciton in bilayer WSe2 devices encapsulated by boron nitride. The QΓ exciton resides at ~18 meV below the QK exciton. The QΓ and QK excitons exhibit different Stark shifts under an out of plane electric field due to their different interlayer dipole moments. By controlling the electric field, we can switch their energy ordering and control which exciton dominates the luminescence of bilayer WSe2. Remarkably, both QΓ and QK excitons exhibit unusually strong two-phonon replicas, which are comparable to or even stronger than the one-phonon replicas. By detailed theoretical simulation, we reveal the existence of numerous (≥14) two-phonon scattering paths involving (nearly) resonant exciton–phonon scattering in bilayer WSe2. To our knowledge, such electric-field-switchable intervalley excitons with strong two-phonon replicas have not been found in any other two-dimensional semiconductors. These make bilayer WSe2 a distinctive valleytronic material with potential novel applications.

Short Oligomeric Molecules Demonstrate Behavior of Bistable Machines

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Abstract

The quest for creation and construction of two-state nanoscale devices motivates the search of small molecular systems whose dynamics resemble those of bistable mechanical systems, such as Euler archs or Duffing oscillators. Nano systems capable of spontaneous vibrations and stochastic resonance are of particular interest. Through atomistic molecular dynamics simulations, we explore several oligomeric molecules a few nanometers in size and identify short fragments of thermos-responsive polymers subject to external force load that demonstrate the bistable behavior similar to a Euler arch with spontaneous vibrations and stochastic resonance activated by conventional thermal noise. Also, we reveal that short pyridine-furan springs exhibit the bistable dynamics of a Duffing oscillator. Our findings suggest some reasons to believe that nano-sized oligomeric structures stabilized by short-range low-energy couplings can exhibit bi-stability with thermally activated spontaneous vibrations and stochastic resonance.

Photoluminescence Study of YVO4:Eu Nanoparticles Dispersed on Glass Slides

Eya Hergli*, Houssem Eddine Sekrafi, Stanislav Lazarov Ferdov, Paulo Coutinho, Anabela Gomes Rolo, Paulo José Gomes Coutinho and Luis Manuel Fernandes Rebouta

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Abstract

Ultrasonic atomization is a phenomenon by which a thin layer of liquid while spreading on a vibrating surface disintegrates into fine droplets [1,2]. In this work, the dispersion process of nanoparticles in aqueous solutions onto solid surfaces using an ultrasonic atomizer was performed. For this purpose, doped PL particles (YVO4:Eu) were synthesized by microwave reactor. Zeta potential measurements were used to check the stability of suspensions. The fluorescent properties of nanoparticles sprayed layers on glass slides were studied using photoluminescence measurements. The photoluminescence results showed that the amount of dispersed particles depends on the spraying time as well as the concentration of particles. In addition, the dispersion area was evaluated. These studies of the nanoparticle's dispersion process are useful for the traceability applications of the product of interest.

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Formation of Orthorhombic MAB Phase ($Mo_{1-x}Cr_xAlB$) Solid Solution Thin Films

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Abstract

(Mo1–xCrx)AlB thin films were deposited by combinatorial magnetron sputtering at temperatures between

450 °C and 700 °C. The composition-dependent phase formation has been studied by X-ray diffraction (XRD), Elastic recoil detection analysis (ERDA), transmission electron microscopy (TEM), and energy-dispersive X-ray spectroscopy (EDX). The orthorhombic MAB phase (Mo1–xCrx)AlB is formed between 0.38 ≤ x ≤ 0.76, consistent with previous ab initio predictions, which can hence be rationalized by composition-induced changes in chemical bonding impacting phase formation energetics.

3D Printed Carbon Nanotube Applications

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Abstract

SWCNT-based composite materials are interesting to the extent that they express the intrinsic properties of SWCNTs, are easy to fabricate, and can be integrated with conventional materials like metal electrodes. We have developed a 3D printing process for SWCNTs that addresses these metrics. Specifically, a surfactant based SWCNT ink is 3D printed and the surfactant is then removed, leaving pure SWCNT films with internal alignment that is governed by the printing process. This results in a thermal conductivity of 400 W.m–1.K–1, about the same as silver, in the alignment direction for films with densities of 0.6 g.cm-3. We are working both at increasing the film density as well as inducing direct SWCNT-SWCNT linkages to recover a higher level of intrinsic SWCNT properties. We have also found that these 3D printed SWCNT films exhibit outstanding electromagnetic shielding properties. Unlike a standard metal film, photons experience many internal reflection and absorption events when they enter the SWCNT films, leading to very little transmission. A potential drawback of SWCNT films is the difficulty of integration with other materials. Standard metal-metal bonding processes like soldering cannot be used. While clamping works, it is too bulky for most applications. We are developing, and will present the status of, a process to directly print SWCNTs into a metal mesh to create a strong SWCNT-metal bond without the use of an additional bonding agent. The novel, printed SWCNT films offer significant potential for practical applications in the aerospace, defense, precision components, and smart wearable electronics industries.

Quantum Defects in Semiconducting Carbon

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Abstract

Defects in a solid can act as atomic traps for electrons, excitons, ions, and their quantum coupling. This is particularly intriguing in semiconducting single-walled carbon nanotubes, in which covalent bonding of organic functional groups to the sp2 carbon lattice produces molecularly tunable sp3 quantum defects that fluoresce brightly in the shortwave infrared. Unlike native defects, which normally quench exciton photoluminescence, these synthetic defects fluoresce brightly, producing single photons at room temperature, and are molecularly tunable. These quantum defects, or "organic color-centers," have opened exciting opportunities for chemistry, physics, materials science, biomedical engineering, and quantum technologies. In this talk, I will discuss some of the recent progress in this emerging field and provide an outlook on the rapidly expanding research and applications of these synthetic defects.

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Large-scale and Integrated Metasurfaces for Active and Passive Light Modulation

Xingjie Ni

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Abstract

Metasurfaces, artificially engineered ultrathin subwavelength nanostructures with exceptional light control capabilities, have the potential to revolutionize conventional optics. In the past, our group has demonstrated a variety of novel metasurface devices, from the invisibility cloak to a space-time modulated one-way mirror. However, the traditional methods for creating these metasurfaces, such as electron beam lithography and focused ion beam milling, are slow, expensive, and have limited scalability. To address this, we have developed a cost-effective and scalable design and fabrication method for large-scale meta-optical devices. As an example, we have built a single-lens telescope using a wafer-scale metasurface lens. Another issue with current metasurfaces is their requirement for free space light excitation, making it difficult to integrate them on-chip. To overcome this challenge, we have designed a hybrid architecture that combines subwavelength metaphotonic structures with photonic integrated waveguide platforms. This results in a fully integrated platform with various functionalities, such as steering and focusing guided waves into free space, projecting holograms with controlled phase and amplitude, and generating laser emission with orbital angular momentum. Our findings offer a promising path towards complete control of light across integrated photonics and free- space platforms and open up new opportunities for creating multifunctional photonic integrated devices with agile access to free space.

Non-adiabatic Quantum Dynamics of Tribovoltaic Effects at Sliding Metal-semiconductor Interfaces

Wenjie Dou

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Abstract

Recent experiments observed electric current generation at sliding metal–semiconductor interfaces. Here, we present a detailed theoretical study on how electric voltage is generated at such a sliding interface. Our study is based on a two-band Anderson–Holstein model, where we solve the coupled electron–phonon dynamics using a surface hopping method. We show that the high local temperature induced by mechanical motion at the interfaces can lead to electron–hole pair generation through electron–phonon couplings. We quantify the efficiency of electron–hole generation as well as electric voltage as a function of local temperatures and semiconductor bandgaps. We find that increasing the local temperatures can lead to higher electron–hole generation and electric voltage. Furthermore, we find that there is a turnover for the electric voltage as a function of the bandgap. Such an observation is in agreement with the experimental results. Our study offers a theoretical framework to understand tribovoltaic effects from a quantum mechanical point of view, and our approach can be used to quantitatively simulate realistic sliding metal–semiconductor junctions.

CO-integrated Selective Multi-elements Organic Sensors: Towards Multi-selective Detection of Complex Gas Mixtures Using E-nose

Bilel Hafsi

Institute of Electronics, Microelectronics and Nanotechnology (IEMN), France

Abstract

Recent experiments observe electric current generation at sliding metal–semiconductor interfaces. Here, we present a detailed theoretical study on how electric voltage is generated at such a sliding interface. Our study is based on a two-band Anderson–Holstein model, where we solve the coupled electron–phonon dynamics using a surface hopping method. We show that the high local temperature induced by mechanical motion at the interfaces can lead to electron–hole pair generation through electron–phonon couplings. We quantify the efficiency of electron–hole generation as well as electric voltage as a function of local temperatures and semiconductor bandgaps. We find that increasing the local temperatures can lead to higher electron–hole generation and electric voltage. Furthermore, we find that there is a turnover for the electric voltage as a function of the bandgap. Such an observation is in agreement with the experimental results. Our study offers a theoretical framework to understand tribovoltaic effects from a quantum mechanical point of view, and our approach can be used to quantitatively simulate realistic sliding metal–semiconductor junctions.

Origin and Control of Molecular Orientation of Phosphorescent Dyes for Efficient and StableBlue OLEDs

Jang-Joo Kim

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Abstract

Organic light emitting diodes become mainstream in small and large size displays. Still increasing efficiency and lifetime especially in deep blue is important. Recently tetradentate Pt complexes are in active research for the purpose. Emitting dipole orientation (EDO) is an important issue of emitting materials in organic light-emitting diodes for an increase of outcoupling efficiency of light. In the presentation, I will discuss the origin and control of the phosphorescent emitters and resulting device performance enhancement. The origin of preferred orientation of emitting dipole of iridium- and Pt- based phosphorescent dyes doped in organic layers is revealed by simulation of vacuum deposition using molecular dynamics along with quantum mechanical characterization of the phosphors. Consideration of both the electronic transitions in a molecular frame and the orientation of the molecules at the vacuum/molecular film interface allows quantitative analyses of the EDO depending on host molecules and dopant structures. It turned out that interaction between the phosphor and nearest host molecules on the surface, minimizing the non-bonded van der Waals and electrostatic interaction energies determines the molecular alignment during the vacuum deposition. We will also present our recent development of highly oriented Pt complexes for efficient OLEDs based on the understanding.

The Ethical Concern about Nanotechnology

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Abstract

Some ethical issues have been associated with the development of nanotechnology. At first, this development has been accompanied by some 'great social visions', such as expressed for example in the famous US report entitled 'Converging Technologies for Improving Human Performance' from Roco and Bainbridge in 2003, where

nanotechnologies were associated with the transhumanist project of enhancement of the human species through technology. These problematic social projects, relayed and criticized by some philosophers, have given rise to a strong social mistrust towards nanotechnology, and even to a public opposition in some countries (the reluctance towards RNA vaccines due to the presence of nanoparticles being a recent example of it). In a more prosaic and realistic way, nanotechnologies, because of their incredible performance and their multitude of applications, have also a particular capacity to amplify some usual problems of sustainable development of technologies, which concern even their own applications for energy and for environment: problems of human toxicity and of ecotoxicity, problems of global environmental impact, materials end-of-life problems, social divide, social responsibility problems attached to their diverse applications (and related for example to medical ethics, bioethics, ethics of artificial intelligence, ethics of surveillance society, etc.). The 'nanosafety' approach must be generalized into a 'nanosustainability' approach including also the ethical concerns. We will discuss the best way to success in the upstream identification of the ethical issues of nanotechnology, and to involve researchers, industry, and civil society in ethical reflection to enable the harmonious development of nanotechnology.

Halloysite Clay Nanotubes for Restoration of Cultural Heritage

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Abstract

In recent years, halloysite clay nanotubes (HNTs) have been proposed for conservation of cultural heritages, including the consolidation/protection of lignocellulosic artworks as well as the protective coating/cleaning of solid surfaces. Among the nanoclays, halloysite nanotubes are appealing because of their hollow tubular shape, unable interface chemistry and high specific surface. Within Cultural Heritage, we investigated the efficiency of hybrid materials based on halloysite and biomacromolecules (wax and cellulose ethers) as protective consolidants of waterlogged archeological woods as well as cleaners for solid substrates. In particular, we proposed novel protocols based on wax/halloysite Pickering emulsions. The stability and the structure of the Pickering emulsions were characterized by microscopies and DSC experiments. Then, hydroxylpropylcellulose was added to enhance the colloidal stability of the emulsions preventing the coalescence of the wax droplets. The emulsions were successfully used for the consolidation of waterlogged archaeological woods by using an immersion procedure. Dynamic Mechanical Analysis revealed that the flexural performances of the wood were significantly improved by the filling of the wax droplets within the wooden channels. Moreover, the Pickering emulsions were employed for the surface coating of stone surfaces by spray and brushing applications. In conclusion, the combination of halloysite nanotubes and biological macromolecules can be a perspective for the development of sustainable protocols aimed at the conservation of Cultural Heritages.

Reduction of the Resistance to the Advance/growth of Lichens and Mosses in Lithic Elements Used in the Construction of Facades of Cusco Heritage Churches by Applying Air Nanobubbles

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Abstract

This research focuses on the application of air nano bubbles for cleaning chemical pathologies in the stone material of heritage churches. Specifically, the study explores the use of nanobubble technology for eliminating contaminants from the surfaces of stone structures. The nanobubbles, which are less than 100 nanometers in size, have the ability to penetrate the cracks and pores of the stone.

The primary objective of the research is to determine the effectiveness of air nanobubbles in removing chemical contaminants from the surfaces of stone structures found in heritage churches. To achieve this, a series of experiments were conducted using air nanobubbles on samples of stone that were contaminated with different types of chemical substances.

The results of the study indicate that air nanobubbles are highly effective in removing chemical contaminants from the surfaces of stone structures. This technology is capable of penetrating the cracks and pores of the stone, removing the contaminants while leaving the stone structure unharmed.

In conclusion, the research shows that the application of air nanobubbles is a promising and effective technique for cleaning chemical pathologies in stone material of heritage churches. This innovative method has the potential to contribute significantly to the conservation of cultural and architectural heritage.

Effect of Concentric Modes Formed by Nanograting Structured Ring Resonator on Biosensing Sensitivity

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Abstract

Dr. Prof. Wenbo Peng is now an Associate Professor at School of Microelectronics, Xi'an Jiaotong University. He received his PhD degree in major of Electronic Science and Technology at 2016 from Xi'an Jiaotong University. He has been a visiting scholar from Aug 2014 to Jul 2016, in Georgia Institute of Technology, working on the research field of piezotronics and piezo-phototronics under the supervision of Prof. Zhong Lin Wang.

His research direction is focused on advanced low dimensional piezoelectric semiconductor device physics and novel intelligent sensing integrated chips. He has authored and co-authored about 50 peer- reviewed papers published on high quality international journals, including Advanced Materials, Advanced Functional Materials, Nano Energy, ACS Nano, etc. He is the Fellow of International Association of Advanced Materials. His publications have been cited over 2000 times and google scholar h-index is 25.

Electrochemically Fabricated $SrGa_2S_4$:Eu/ZnO-vertical Nanowire Bilayer Scintillator for X-ray Imaging

Pei Loon Khoo

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Abstract

Scintillators play a crucial role in radiation detection for medical imaging, including X-ray computer tomography (X-ray CT) and positron emission tomography (PET). The effectiveness of these imaging techniques heavily relies on the properties of the scintillator material used. This study investigates the properties of SrGa2S4:Eu/ZnO vertical nanowires (ZnO-vnws) bilayer scintillators, which convert high-energy rays, such as X-rays and positrons, into visible and ultraviolet light. The scintillator was fabricated by depositing ZnO-vnws through electrodeposition, followed by electrophoresis deposition of SrGa2S4:Eu particles. The SrGa2S4:Eu/ZnO-vnws bilayer scintillator emitted visible light at a wavelength of 533 nm with a lifetime of 0.389 μs upon X-ray irradiation. The introduction of the ZnO-vnws layer resulted in an improvement in both the resolution and luminescence intensity of the scintillator compared to the ZnO-vnws-free-SrGa2S4:Eu layer. The SrGa2S4:Eu/ZnO-vnws bilayer scintillator demonstrated a spatial resolution of 6.8 μm, which was slightly larger than that of a ready- made LuAG single-crystal scintillator. Overall, this study highlights the potential of SrGa2S4:Eu/ZnO-vnws bilayer scintillators for use in medical imaging applications.

Urea Conversion Kinetics via Enzymes Immobilized on Microparticles

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Abstract

Ultrapure water is water from which ionic components such as minerals, particulates, and microorganisms have been removed to a certain level or less. In this sense, it is also expressed by the term deionized water. In order to supply high-quality ultrapure water that is essential for high-tech industries such as semiconductors, displays, solar power, pharmaceuticals, bio, and fine chemicals, related technologies must be raised to the world's best level. In the ultrapure water manufacturing process, particulate matter and dissolved matter are removed, but urea is still difficult to remove easily. In this study, the conversion of urea into biocarbonate anion by the enzyme immobilized on magnetic microparticles was measured and analyzed. The enzyme was immobilized on the particle through EDC-NHS chemistry. The reduction in the urea was qualitatively confirmed using UV-Vis spectrometer. Furthermore, the reduction was quantitatively measured using cyclic voltammetry. For the first, the calibration curve between the current and the concentration of the bicarbonate anion was established. This establishment suggested that the behaviour of the current was consistent with the Nernst equation - the relation between the concentration of the bicarbonate anion and the potential that was supplied linear with the current. The amount of the bicarbonate anion converted from the urea was estimated from the calibration curve. The production of the bicarbonate anion over time was analyzed with kinetic theory. The immobilized enzymes were collected and reused. As the reuse was repeated 8 times, the activity of the enzymes decreased up to 50%. The storage was also considered. After three months, the enzymes kept the capability for the conversion. These results may be a fundamental platform to design a reactor, one unit of ultrapure-water production system, to convert the urea into bicarbonate anion, which was removed through following process such as ion- exchange filtrations.

Acceleration of Interfacial Electrical Conductivity of Carbon-nanotube-filled Electrically Conductive Pastes by Binder Chemistry Control

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Abstract

Because carbon-nanotube-filled electrically conductive pastes are expected to be applied to packaging applications for novel microsystems such as sensors and energy devices, enhancing their electrical conductivity is a critical problem in developing advanced pastes. The electrical conductivity of the pastes is dynamically generated during curing (dynamic percolation), so the control of the kinetics in developing their electrical conductivity will be a key for enhancing the conductivity. This work investigated the effect of binder chemistry on the kinetics of the interfacial conductivity development between the fillers and between the filler and metal electrodes. Adding reactive diluents into an epoxy- based binder influenced interfacial conductivity development. Some diluents effectively enhance interfacial conductivity development, so binder chemistry control will be essential in developing advanced carbon-nanotube-filled conductive pastes.

Advanced ZnO based Piezo-phototronic Optoelectronics

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Abstract

Since its invention in 2010, piezo-phototronic effect has been widely used in piezoelectric semiconductor materials

and optoelectronic devices, e.g., solar cells, light-emitting diodes, and photodetectors, for both fundamentally physical research and potential applications. However, so far, the most related research is mainly focused on whether piezo-phototronic effect could modulate the devices' performance, and the reported piezo-phototronic effect induced enhancement is varying from a few dozen percent to thousands of percent. Why the piezo-phototronic effect could induce such different performance improvements in different optoelectronic devices? In some special cases, the piezo- phototronic effect even causes performance degradation. Therefore, it is of great significance to carefully investigate the role of the piezo-phototronic effect plays in different optoelectronic devices, which might possibly give us more clear understandings of the piezo-phototronic effect and further constructive suggestions of how to utilize it more effectively. In our recent works in the past a few years, we have systematically studied the piezo-phototronic effect in optoelectronic devices using ZnO as the piezoelectric semiconductor material, including photodiodes with different device structures, thin-film transistors with different charge carrier concentrations, and heterojunctions with different energy band diagram alignments, to reveal the underlying physics in piezo-phototronic effect. Our experimental and theoretical results indicate that: (1) the charge carrier concentration in ZnO is of great importance, should not being too small or too large; (2) compared to isotype photodiodes, anisotype photodiodes are preferred; (3) energy band diagram alignment is also preferred since misalignment would cause negative effects when introducing the piezo-phototronic effect. Finally, we give systematic instruction on how to utilize the piezo-phototronic effect more effectively.

Synthesis of Patchouli Biomass based Carbon Nanomaterial Using Two Different Double Pyrolysis Methods

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Abstract

Carbon nanomaterial (CNM) is a potential material for many applications such as adsorbent, catalyst, additive of ceramic, electrode, etc. due to its characteristics. However different pyrolysis methods can affect its properties which affect its performance in application. Therefore, the purpose of this research is to study the influence of the different double pyrolysis methods (reflux - microwave and hydrothermal - microwave) toward properties of the CNM. Patchouli biomass and ZnCl2 were used as the carbon precursor and chemical activator, respectively. The pyrolysis by reflux or hydrothermal method was conducted at 200 °C for 6 h, then, each was continued in microwave at 800 W for 40 minutes. The products were characterized with FTIR spectrometry, XRD, UV-Vis spectrophotometry, dispersion stability test to achieve main colloidal sol (1 - 100 nm), and SEM. Results of the research show that the hydrothermal – microwave method produced darker product, higher crystallinity index of cellulose, higher aromaticity, smaller irregular shape carbon particles (based on SEM), lower content of C-O functional group (based on FTIR spectra), more peaks of UV-Vis spectra, more stable CNM colloid with main content of the colloidal sol (more transparent qualitatively; higher TDS quantitatively) after keeping for 26.75 h, than the reflux – microwave one. However, the degree of graphitization of the carbons which were achieved by both methos were similar.

Au NPs/L-Cys/MWCNTs Modified Immunochip for the Detection of BaP

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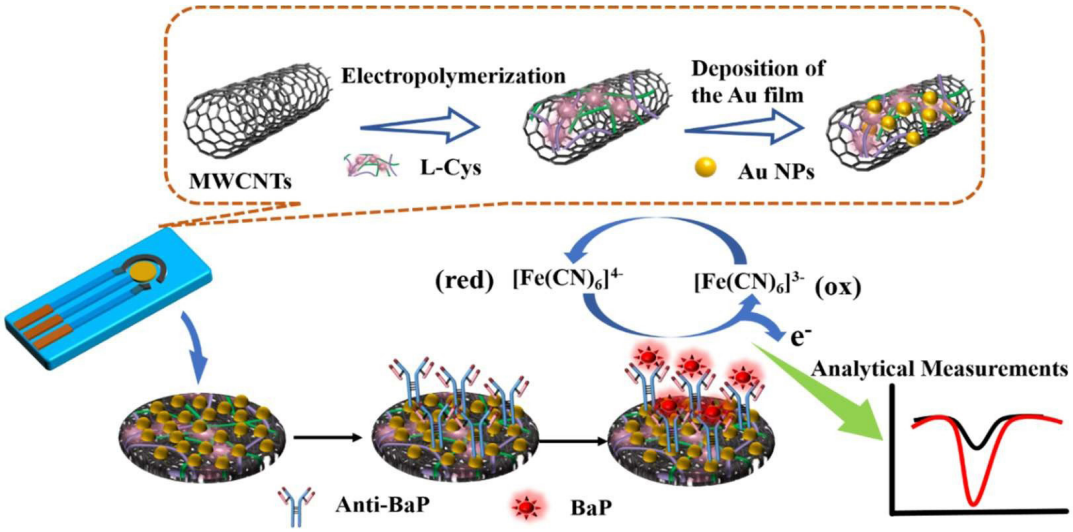
Abstract

An immunochip with a screen-printed electrode sensing platform for signal amplification was proposed for detecting benzo(a)pyrene in seawater with speed and flexibility. Immobilization of Anti-BaP wasachieved by electrodepositing gold nanoparticles on an L-cysteine polymeric membrane. Functionalized carbon nanotube electrodes have been improved for loading gold nanoparticles and forenhancing the electron transfer between the

electrode surface and electrolyte. The reduction current was observed to be inversely related to the concentration of benzo(a)pyrene in the range of 0.01 ng.L^{-1} to1000 ng.L^{-1} with a detection limit of 0.15 ng·L^{-1} under optimum experimental conditions. Using the current changes caused by blocking electron transfer after antibody binding to antigen as the basis of the immunochip, this device has highly anti-interference properties against the common seawater contaminants (i.e., naphthalene, fluoranthene, phenanthrene, fluorene, and anthracene). We examinedthe applicability of immunochip in determining benzo(a)pyrene in seawater samples. This leads to the conclusion that the developed immunochip had high sensitivity, easy functionality, and downsizing, making it a good candidate for environmental detection. The immunochip production process is depicted in Scheme 1.



Foam-surfactant Template Synthesis of Nanomaterials for Boosting the Electrochemical Energy Reactions

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Abstract

Engineering the electrocatalysts' nanoarchitectures, particularly the transition metal compounds with nanometer size, shape, facets, and composition, significantly boosts the electrocatalytic activity of the electrochemical energy reactions [1-5]. This work demonstrates a novel chemical approach for the synthesis of mesoporous nanoarchitectures (nanoflakes, nanosheets) of transition metal (nickel, cobalt, copper) hydroxides using double templates of surfactant self-assembled thin-film and foam of hydrogen bubbles (DTSF) concurrently produced by sodium borohydride reducing agent. The physicochemical characterizations show the nanomaterials exhibit high specific surface area and mesoporosity, various nanoarchitecture morphologies (nanoflakes and nanosheets), and compositions that can be varied in a controllable way through changes in the template compositions and deposition conditions. The electrocatalytic activity and stability of the new transition metal nanomaterials have shown significantly enhanced performance for the electrochemical energy and sensing reactions of methanol, urea, glycerol, and glucose oxidation as well as the water-splitting reactions of hydrogen and oxygen evolution. The electroactivity high-performance of the mesoporous transition metals nanoarchitectures is mainly derived from the high specific surface area and mesoporosity architecture that provide efficient charge transfer, as well as mass transport of the electroactive species. The double templates of the surfactant- foam (DTSF) approach have the advantages of a one-pot template applicable to the synthesis wide range of nanomaterials with various compositions and nanoarchitectures room temperature for application in electrochemical energy production and storage [1-5].

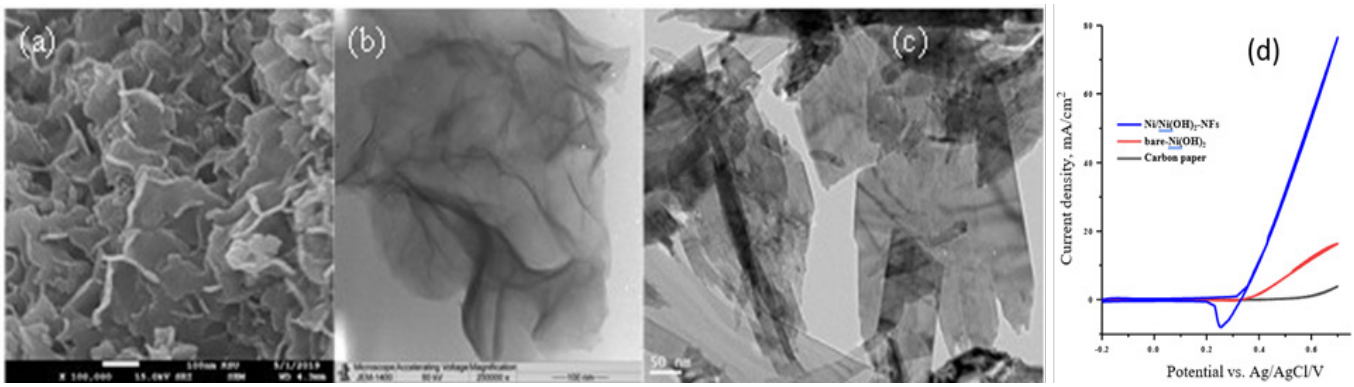

Figure 1: Scanning and transmission electron microscope of nanoarchitectures characterizations of (a) and (b) Ni/Ni(OH)2 nanoflakes and (c) CuO nanosheets, (d) CVs at 50 mV.s-1 of Ni/Ni(OH)2-NFs, in comparison to bulk-Ni(OH)2 catalysts, in 0.5 M methanol/2.0 M KOH.

Keywords: Surfactant double templates, Mesoporous nanomaterials, Electrochemical energy reactions

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Comparative Analysis of Properties of Coagulation-processed Nanocomposites: Polypropylene and Polyamide-6

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Abstract

Black nanocarbon developed from bamboo (Gigantochloa scortechinii) was utilized as reinforcement for two thermoplastic polymers. The nanocomposites of polypropylene and polyamide-6 were synthesized by applying a coagulation scheme. Methanol was used as a coagulant for the nanocomposite preparation. Comparative analysis was accomplished with three percent filler mixing. Structural interpretation of the nanocomposite was carried out using Fourier transform infrared spectroscopy. The investigation of the thermal and melting behavior of the nanocomposites was performed using thermogravimetric analysis and differential scanning calorimetry techniques. The obtained results of the nanocomposite were interrelated to the neat polypropylene. A comparative investigation was achieved on the effective role of filler in each of the two polymers. The thermal analysis revealed that nanocomposites were stable at higher weight loss temperatures compared with their neat composites. The two nanocomposites presented

a different change in thermal properties with the same amount of filler. DSC analysis disclosed the improvement in melting properties of the coagulation processed products.

A Novel Approach to Control *Botrytis cinerea* Fungal Infections: Uptake and Biological Activity of Antifungals Encapsulated in Nanoparticle-based Vectors

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Abstract

With the rapidly changing global climate, conventional agricultural systems are confronted with more unpredictable and harsh environmental conditions leading to compromised food production. Effective pathogen management is a major challenge in modern agriculture, nanotechnologies combined with agrochemicals and/or natural compounds could offer a smart solution for controlling crop diseases [1].

In this research, poly(lactic-co-glycolic acid) (PLGA) nanoparticles (NPs) were used for controlling fungal diseases. PLGA has been extensively studied, and its biocompatibility, its potential as a drug delivery system in plant organisms, and its activity against phytopathogenic fungi have been proved [2, 3, 4]. In this study, PLGA NPs were loaded with fluopyram, an antifungal widely used in agriculture, or pterostilbene, a bioactive natural compound [5]. The research was focused on a highly remunerative fresh-market variety of tomato (*Solanum lycopersicum L.*), variety ciliegino F1 and one of its fungal pathogens, i.e., *Botrytis cinerea*, an airborne plant pathogen with a necrotrophic lifestyle which is the causal agent of the grey mold, one of the most problematic diseases for tomato cultivation.

PLGA NPs uptake in the fungal cell of *B. cinerea* was recently confirmed by fluorescence microscopy observing fungal mycelium after the administration of PLGA NPs loaded with the fluorophore coumarin-6 [6].

The influence of empty or drug-loaded PLGA NPs on plants has been evaluated by 1H-NMR-based metabolomic analysis, quantitative profiling of fatty acids and oxylipins by LC-MS, chlorophyll, and carotenoids quantification by spectrophotometric analyses. Chlorophyll and carotenoids analysis showed empty, or drug loaded PLGA NPs do not cause variations in the parameters analyzed. Differently, the untargeted metabolomic analysis allowed us to highlight that PLGA NPs act as elicitors of plant defense response by stimulating the flavonoid pathway. Fatty acids and oxylipins quantitative profiling were also affected by PLGA-NPs administration.

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Zn-MOF Vaccine Controlled Release of Zinc Ions to Enhance Antitumor Immunotherapy

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Abstract

Vaccine is one of the most effective means to treat tumors. However, there are some problems in tumor vaccine, such as low efficiency of antigen presentation, insufficient induction of CD8+ T cells, and obstruction of tumor extracellular matrix (ECM). Our study found that Zn2+ not only plays a key role in activating the immune response, but also has the function of up regulating the activity of ECM degrading enzyme. We prepared zinc-based metal-organic framework vaccine (Zn-MOF) with controllable release of Zn2+. On the one hand, the vaccine actively targets dendritic cells (DC) to improve the efficiency of antigen uptake and presentation by DC; The vaccine enters DC lysosome to release Zn2+, induce lysosome swelling, promote antigen cross presentation, and regulate CD8+ T cell activation; On the other hand, the vaccine passively targets the tumor, releases Zn2+ in acid response, promotes ECM degradation, and enhances tumor invasion and killing of CD8+ T cells.

Our results showed that, compared with OVA-CpG group, the Zn-MOF nanovaccine group increased the uptake of antigen by DC by about 11 times. In addition, the Zn-MOF nanovaccine group has the strongest ability to promote the proliferation of T cells. The histological results showed that nano- vaccine mainly affected the formation and signal transduction of tumor ECM, and significantly down- regulated the multiple components of ECM. Zn-MOF nanovaccine group significantly increased the tumor inhibition rate of melanoma, which was 55.3% higher than OVA-CpG group. In conclusion, the Zn-MOF vaccine constructed by us is expected to comprehensively improve the efficacy of tumor vaccine.

Eight-channel Integrated Device for Electro-optic Modulation and Dense Wavelength Division Multiplexing based on Photonic Crystal

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Abstract

We propose an eight-channel integrated device for electro-optic modulation and dense wavelength division multiplexing (DWDM) using a photonic crystal Aubry–André–Harper (AAH) cavity. The device consists of electro-optic modulators and an eight-channel DWDM component. The electro- optic modulator is composed of an AAH cavity side coupled to a photonic crystal waveguide. Different voltages are applied to complete the on and off state modulation of a certain wavelength. Each channel of the DWDM component utilizes the download cavity and reflection cavity to realize filtering. The performance parameters of the integrated device are analyzed using the three-dimensional finite- difference time-domain method. The results show that the integrated device can simultaneously achieve the electro-optic modulation and DWDM of 8 wavelengths (1578.5, 1577.7, 1576.9, 1576.1, 1575.3, 1574.5, 1573.7 and 1572.9 nm), respectively. The channel spacing is 0.8 nm. The maximum insertion loss is 1.1 dB and the minimum is 0.2 dB. The maximum extinction ratio is 15.5 dB and the minimum is 9.6 dB. The maximum channel crosstalk is -19.5 dB and the minimum is -32.4 dB. The integrated device can be used in photonic integrated circuits and large capacity DWDM systems.

Functional Nanocomposites and their Potential Applications

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Abstract

Herein, the review aims to compile some reportable work of researchers carried out concerning the use of nanomaterials in polymeric composites for significant improvements in the properties and to report the application areas of such nanocomposites. Carbon nanotubes, cellulose nanoparticles, titanium dioxide, and other nanoparticles are used in the polymeric composites to enhance their mechanical, electrical, inter-laminar, optical, chemical, electrochemical, electromagnetic shielding, and ballistic properties. Nanocomposites have a wide range of applications in structural, biomedical, electronics, automobiles, aircraft, oil pipelines, gas pipeline construction, electromagnetic shielding, and protected areas. According to the reported results of researchers, the incorporation of nanomaterials into polymers significantly enhance their properties, which make them able to widen their application areas.

Thermal Conductivity of Screen-printed and Spray-coated Cotton Fabrics Coated with Phase-change Material

Gurumurthy. B. Ramaiah*, Metusal Meja, Daniel Asfaw, Robel legese, Senay Yacob Baraki and Kidist Tadesse Wolde

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Abstract

Phase change materials (PCMs) go through a process called phase transition. They can absorb or release heat in a unique way, which is called latent heat. However, phase-change materials depend on temperature ranges and applications. In this research, phase change material is used for producing thermo-regulated samples by coating cotton knitted and woven fabrics. Spray coating and screen- printing methods are used for the preparation of different samples. Box and Behnken (BBD) and Central Composite Design (CCD) are used for predicting the required response using independent variables under optimized conditions. The independent variables used in Box-Behnken for spray coating are viscosity (50 - 62 centistoke), distance between the coating surface and spray gun (5 - 10 cm), and nozzle size of the spray gun (1.8 - 2.6 mm). For screen-printing, a "Central Composite Design" is used. The independent variables were viscosity (56 - 62 centistoke) and number of strokes. The structure of spray deposits and the propensity of droplets to drift are influenced by gun-to-surface distance, droplet size, and the viscosity of the phase change material. In the process of screen printing, the number of strokes is a major parameter, along with the viscosity of the phase change solution. The test samples were cured and dried in an oven after coating. The thermal conductivity values of these samples were studied by utilizing Lee's disk test set-up. Graphs of FTIR spectra for coated and uncoated samples were used to determine the presence of chemical functional groups. The melting point of the sample is ascertained using DSC tests.

Advanced Concepts for Ultra-high Conversion Efficiency of Solar Photons into Photovoltaics and Solar Fuels based on Quantization Effects in Nanostructures and Molecular Singlet Fission

Arthur Nozik

University of Colorado, USA

Abstract

In order to utilize solar power for the production of solar electricity and solar fuels on a global scale, it will be necessary to develop solar photon conversion systems that have an appropriate combination of high efficiency (delivered watts/m2) and low capital cost ($/m2). One potential, long-term approach to attain high conversion efficiencies above (by a factor of 2) the well-known Shockley-Queisser thermodynamic limit of 33% is to utilize the unique properties of quantum dot/rod (QD/QR) nanostructures and Singlet Fission (SF) in molecular chromophores, to control the relaxation dynamics of photogenerated hot carriers and excited states in photoexcited molecules to produce

either enhanced photocurrent through efficient photogenerated electron-hole pair (ie, exciton) multiplication or enhanced photo-potential through hot electron transport and transfer processes. To achieve these desirable effects, it is necessary to understand and control the dynamics of SF and hot electron and hole cooling, charge transport, and interfacial charge transfer of the photogenerated carriers. These fundamental dynamics in various bulk and quantized nanoscale semiconductors and SF molecules have been studied for many years using various spectroscopies with fs to ns time resolution. The prediction that the generation of more than one electron-hole pair (which exist as excitons in size-quantized nanostructures and photoexcited molecules) per absorbed photon would be an efficient process in QDs, QRs and SF molecules, has been confirmed over the past years in different classes of materials, molecules, and in their device architectures. Very efficient and ultrafast multiple exciton generation (MEG), also called Carrier Multiplication (CM), and SF from absorbed single higher energy photons has been reported in many quantized semiconductors and molecules and associated solar photon conversion devices for solar electricity and solar fuels (e.g., H2) production. Selected aspects of this work will be summarized, and recent advances will be discussed, including the very remarkable and extremely large beneficial theoretical effects obtained when combining MEG with solar concentration. The analogous MEG effect in SF molecules and its use in molecular-based solar cells will also be discussed.

Application of Polymeric Nanocomposites in the Oil Industry: EVA: Clay Minerals Nanocomposites as Flow Assurance Improvers

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Abstract

During production, transport, and logistics activities of crude oil, it is necessary to use methods to prevent operational problems caused by waxes precipitation. To overcome this problem, polymeric additives can be used, and polymeric nanocomposites are a promising alternative. In this work, poly(ethylene-co-vinyl acetate) (EVA) containing 10 mol% vinyl acetate was used as a matrix of EVA:clay minerals nanocomposites. Different clay minerals were used as load: palygorkite (fibrillar), halloysite (tubular) and montmorillonite (lamellar). The nanometric dimensions and the structures of each clay mineral can influence their interaction with the polymer and, consequently, the nanocomposite interaction with the oil waxes. The produced materials were characterized by different techniques such as thermogravimetric analysis, x-ray diffractometry, scanning electron microscopy, and transmission electron microscopy. The performance of materials as flow improvers was evaluated by rheology, microcalorimetry and optical microscopy, in model oil and petroleum. Overall, it was observed that EVA:palygorskite nanocomposite was the most efficient, followed by the EVA:halloysite and then by EVA:montmorillonite. The EVA:palygorskite nanocomposite was able to reduce the pour point of model oil and petroleum from 21˚C to < -24 ˚C and 18 ˚C to < -24 ˚C, respectively.

Modeling of Nanomaterial Transportation within an Enclosure with Imposing External Magnetic Source

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Abstract

The ferrohydrodynamics (FHD) impact has been investigated in this study to improve the free convection of ferrofluid within the container by involving the magnetic wire close to the inner wall. Water containing iron oxide (with a volume fraction of 0.04) filled the tank. An empirical data set based on a single-phase formulation is possible with this concentration of ferrofluid. Kelvin force is produced by the fluctuating magnetic field strength inside the tank. To solve the equations that were made simpler by specifying the stream function, the Control Volume Based Finite Element Method (CVFEM) technique was used. The effects of the Kelvin force (MnF), buoyancy (Ra), and

ferrofluid fraction (φ) have been studied in the results. The temperature of the inner wall decreases by roughly 28.5% as a result of the Kelvin force and buoyancy force.
Impose of variable magnetic makes main eddy to convert into two eddies. The upper eddy rotates clockwise whereas the bottom smaller eddy rotates counterclockwise. The bottom eddy's is proximity to the wire. Nu increases by 80.81% and 64.6% with an increase in MnF and Ra, respectively. Augment of φ leads to augmentation of Nu about 33.71%.

Post-acceleration of Electron Bunches from Laser-irradiated Nano Clusters

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Abstract

The optical and physical properties of the attosecond relativistic electron bunches emitted from a nanometer-sized droplet irradiated by an intense few-cycle laser pulse are investigated by means of three-dimensional PIC simulations. Special attention is devoted to the acceleration mechanism that allows these bunches to gain energy after emission while traveling in vacuum together with the outcoming laser pulse. The radius of the droplet is between the relativistic skin depth and the laser focus size; therefore, it is a sub-micron spherical solid object. In the simulations it is represented as frozen hydrogen of 100 critical density hit by a laser pulse whose duration is 4.5 cycles. The first stage of the process-the emission of the bunches-has been studied in detail in previous works, which have determined the direction at which they are propagated, basically the intensity-dependent forward ponderomotive scattering orientations. The bunches are then phase-locked to the laser and travel in vacuum together with the electromagnetic waves; this second stage is analyzed in this work both numerically and analytically. On the side of simulations, a three-dimensional forward tracking is set: the bunch is represented as a single particle, which is in accordance with the quasiparticle theoretical treatment that is presented in the equations. The result is displayed for laser intensities rising from 5 x 1019 W/cm2 up to 1021 W/cm2, showing the reach of a plateau, consistently with the acquisition of a mean bunch energy. This energy is of the order of MeV, comparable to the one of the bunches that are produced in current LINAC technologies. The electrons are emitted in the attosecond regime, and they merge lately in a unique bunch, making therefore the mean energy characteristic to be more dominant.

The obtained value is in agreement with theoretical predictions-the original treatment by Hartemann is the starting point for a characterization of the process of the energy gain; in practice the gauge of the equations is maintained but a novel approach based on laser phase is introduced, explaining why the energy gain is finite. A comparison with previous experimental results is also made possible by this study, but a more systematical way of analyzing is introduced, allowing to predict the achievements for the above specified levels of intensity in the light source.

Synthesis of Nanoparticles of YVO4:Eu

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Abstract

The development of resource-efficient synthesis of technologically important materials is an ongoing challenge. Since the 1960s, methods for the preparation of europium-doped yttrium orthovanadate (YVO4:Eu) have attracted considerable interest mainly due to its highly efficient photoluminescent properties [1]. Previous works have demonstrated the synthesis of YVO4:Eu nanoparticles by room-temperature precipitation from aqueous solutions [2], conventional hydrothermal method [3], microwave- assisted heating4, and ball-milling of aqueous systems [5], among others.

Here we report the first water-free synthesis of YVO4:Eu nanoparticles at room temperature by milling stoichiometric

amounts of chemical precursors of vanadium, yttrium, and europium. These results open an environmentally friendly route to the production of YVO4 and might serve as a starting point for other rare-earth element droppings.

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

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Abstract

Fluorescence lifetime is a powerful tool for the non-invasive *in vitro* and *in vivo* biomolecular and cellular investigations. Even though FLT contrast is well known to be a powerful alternative for fluorescence based biomolecular *in vivo* imaging, the lack in appropriate suite of NIR fluorophores with distinct lifetimes and a fast and performant macroscopic fluorescence lifetime imaging instrument has stalled significant translational development in the field. These limitations are in the focus of this proposal, in which we aim to develop a set of smart compounds of gold nanoparticles (GNPs)-NIR dyes (Au nanodyes), with controlled FLT and improved quantum yield (QY), that will be used in wide field fluorescence lifetime imaging (FLI). The metallic surface of the GNP can provide the enhancement of the fluorescence signal of the adjacent fluorophores though the phenomenon known as metal-enhanced fluorescence (MEF), as well as to enable the fine-tuning the fluorophore's lifetime. A macroscopic time-gated FLT imager along with phasor-based analyses will enable wide field acquisition of the Au nanodyes fluorescence and lifetime. The commercial ICG and IRdye800 dyes will be conjugated to different types of gold nanoparticles (GNPs, gold nanospheres, and gold nanorods), to present Au nanodyes with increased quantum yield and lifetimes spanning over 1 order of magnitude (100 ps to 1 ns) for multiplexed imaging in the 800-900 nm region of the electromagnetic spectrum. The findings of this new study can be further used for the real-time multiplexed tracking of cells biodistribution *in vivo*.

Green Synthesis of Silver Nanoparticles Using Natural Precursors and their Application in Antimicrobial Activities

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Abstract

Green synthesis of metallic nanoparticles is gaining considerable attention due to its environmental and economic benefits. This study describes the synthesis of silver nanoparticles (AgNPs) by the reduction of a silver nitrate solution using natural precursors. Various preparation factors and parameters such as the methods used for green

nanoparticle synthesis, microalgal extract, pH, temperatures, contact time, particle size, and proximity greatly affect the quantity and quality of the biosynthesized AgNPs and their properties from microalgal species. Microalgae were found to be able to produce AgNPs with high stability and predominantly spherical shape through a short process. The AgNPs biosynthesis were easy and without the use of high heat or chemical agents. The characterization of the AgNPs was done using UV-visible spectroscopy, X-ray diffraction (XRD), scanning electron microscopy with energy dispersive X-ray microanalysis (SEM-EDS), and inductively coupled plasma atomic emission spectroscopy (ICP-AES). Our data revealed that microalgae are an alternative material for the synthesis of AgNPs due to their advantages of fast growth, low cost, and short time for collection and harvesting, in addition to the presence of various reducing, capping, and stabilizing agents in the microalgal filtrate and extract which may be used to convert metal ions to nanostructure. The effectiveness of AgNPs as an antibacterial agent against many strains of bacteria, was tested using the Broth Dilution Method and the Kirby-Bauer Disc Diffusion Sensitivity Test Method. The findings showed that AgNPs are found to possess remarkable antibacterial properties against both Gram- negative and Gram-positive bacteria.

How Ultra-short Lasers Help Creating Hierarchical Reliefs Efficiently Guiding Cells on Nanostructured Patterns

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Abstract

Ultra-short laser texturing allows us to produce various surface reliefs on both nano- and micro scales as complex hierarchical pattern. This kind of surface treatment has also been advantageous in the reduction of thermal effects, of debris, and, particularly, in the minimization of surface contamination. Particularly, surface micro-patterns with additional nano-reliefs, or so called "hierarchical reliefs" can be quite easily produced considerably alternating not only surface roughness and wettability but allowing additional opportunities to better guide the behavior of different objects ranging from nanoparticles and viruses to larger droplets and/or living microorganisms. Previously, a clear connection between cell behavior and wetting properties on laser-structured patterns was revealed [1]. However, the optimum laser treatment is still under discussion. In fact, laser interactions affect not only surface relief and morphology, but also composition, phase state, etc. The obtained surface properties can be unstable and evolve with time. They are strongly affected by additional heating, sterilization, ultra-sound, or cold plasma treatment. Herein, multi-pulse femtosecond laser irradiation of titanium-based surfaces is used. As a result, multi-scale textures are produced with high precision. Additionally, computer simulations were performed to examine droplets' behavior on such surfaces. Then, wetting properties are analyzed. Finally, the capacities to capture and guide human stem cell cultures (HSC) were evaluated. The obtained results confirm that wettability maps can help predicting cellular behavior and also provide indication for surface relief optimization. The obtained results have numerous applications in bioengineering, cellular tests, the treatment of dental implants and various prosthesis.

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Influence of Sustainable Synthesized Nano Silica Enhanced with Plastic Waste, on the Mechanical Properties of Concrete: A Comparative Study on Varying Temperatures

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Abstract

This research features the sustainable synthesis of nano silica using waste materials from plants waste. The process of synthesizing the nano silica particle was conducted at different temperatures to investigate the performance at the studied temperature. The study temperatures were 500 ˚C, 600 ˚C, and 700 ˚C, respectively. The synthesis of nano silica greatly improved as the temperature increased. However, the temperature increase played major roles in defining the structure and properties of nano silica during characterization. scanning electron microscopy, (SEM), X-ray diffraction (XRD), and Xray fluorescence (XRF) were used for the characterization of the synthesized silica nano particles. All properties of the nano silica synthesized at varying temperatures were checked during the characterization process, and the result of the various characterization exposes the presence of Si, C, and O elements in the synthesized nanoparticles. The purpose of synthesizing Nano silica was producing an improvement material for concrete. The nano silica is used as an additional enhancer together with powdered plastic waste materials for the mixing of concrete at various mixing ratios. Tensile test, compressive strength and flexural strength were investigated at 7 and 28 days curing for the various mixing of the nano silica synthesized at various temperature. The results showed maximum improvement in the durability of the concrete with the presence of nano silica, also nano silica synthesized at 700˚C showed better properties as compared to other temperatures.

Keywords: Concrete, Nano Silica, Plastic, Waste, Sustainable

Non-functionalized Gold Nanoparticles Inhibit Human Papillomavirus (HPV) Infection

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Abstract

The spontaneous interaction between human papillomavirus type 16 (HPV16) L1 virus-like particles (VLPs) and non-functionalized gold nanoparticles (nfGNPs) interferes with the nfGNPs' salt- induced aggregation, inhibiting the red–blue color shift in the presence of NaCl. Electron microscopy and competition studies showed that color-shift inhibition is a consequence of direct nfGNP–VLP interaction and, thus, may produce a negative impact on the virus entry cell process. Here, an *in vitro* infection system based on the HPV16 pseudovirus (PsV) was used to stimulate the natural infection process *in vitro*. PsVs carry a pseudogenome with a reporter gene, resulting in a fluorescent signal when PsVs infect a cell, allowing quantification of the viral infection process. Aggregation assays showed that nfGNP-treated PsVs also inhibit color shift in the presence of NaCl. High-resolution microscopy confirmed nfGNP–PsV complex formation. In addition, PsVs can interact with silver nanoparticles, suggesting a generalized interaction of metallic nanoparticles with HPV16 capsids. The treatment of PsVs with nfGNPs produced viral infection inhibition at a higher level than heparin, the canonical inhibitor of HPV infection. Thus, nfGNPs can efficiently interfere with the HPV16 cell entry process and may represent a potential active component in prophylactic formulations to reduce the risk of HPV infection.

Nanomedicine: Cytotoxicity of Gold Nanoparticles

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Abstract

Gold nanoparticles (AuNPs) have unique characteristics compared to their bulk counterpart, making them ideal for various medical uses such as cancer therapy, biomedical imaging, photothermal therapy, and drug delivery. Given their extensive applications, it is imperative to understand both the benefits and potential side effects of AuNPs once they exhibit sufficient uptake in the tissue and cells of interest. In particular, the accurate quantitative assessment of AuNP delivery in tumours remains challenging, as currently used clinical approaches employ cumbersome sample preparation methods and questionable precision and accuracy. Cytotoxic effects of AuNP are investigated sporadically, examining the influence of the total mass of gold taken up by the cell (in picograms), rather than the AuNP itself. In this work, total reflection X- ray fluorescence (TXRF) spectroscopy was used as a novel method to measure the AuNP (10 and 50 nm gold nanospheres and rods) and the absolute amount of gold taken up in epithelial breast cancer cells. Our results agree with previous findings that 50 nm spheres are internalized most effectively, and rods are more toxic than spheres for the same number of nanoparticles. Furthermore, the linear quadratic and Hill models to estimate the cytotoxicity of gold from AuNP uptake exhibit a better fit than the exponential model ($p < 0.05$). This work is one of the first to model gold cytotoxicity following AuNP uptake with the Hill model proposed for future research.

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