

## Proceedings of the 2<sup>nd</sup> NanoWorld Conference in Boston (NWC-2017). Part V: Poster Presentations

### Metastable-Zr<sub>2</sub>Ni Alloy Powders for Enhancing the Absorption/Desorption Kinetics of MgH<sub>2</sub> System

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#### Abstract

However, the hydrogenation and dehydrogenation kinetics of MgH<sub>2</sub> is very slow, Mg with its low cost and ability to store a high hydrogen content (7.60 wt.%) is considered to be the most promising materials for solid-state hydrogen storage applications in light vehicles. The absorption and desorption kinetics of MgH<sub>2</sub> powders can be improved by subjecting the powders to long-term of milling followed by mechanical milling with 3d transition metals and their alloys. Although there are many reported efforts performed to improve the hydrogenation/dehydrogenation properties of this binary system, there is still a space for new attempts that aims to find a suitable catalytic system(s) used to improve the absorption and desorption kinetics of this promising metal hydride system. The present study has been addressed in part to investigate the effect of new catalytic systems for improving the kinetics of hydrogenation and dehydrogenation properties for MgH<sub>2</sub> system synthesized by reactive ball milling technique.

In the present study, metallic glassy- and big cube- Zr<sub>2</sub>Ni powders were prepared by mechanical alloying and then individually doped (10 wt.%) to MgH<sub>2</sub> powders, using high-energy ball milling. The results have shown that the sorption and desorption kinetics of the two MgH<sub>2</sub> systems examined at 250 °C were significantly improved. This implied by the fast absorption and desorption processes taking place within very short time. Moreover, our new systems showed extraordinary cycle-life-time extended to 1240 h (2546 cycles) without serious degradations.

### Optimization of Nano Silica Production by Diatom *Navicula*: Effect of Nitrate

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#### Abstract

How will nitrate in the food affect the production of silica in Diatom *Navicula*? To investigate on this fact tested seven different concentration of 0-160 mg/L nitrate. Measured the diatom biomass and silica weight every day for six days. By measuring the amount of biomass and silica able to see the growth change in diatoms. Performed all the above tests three time and average values used to calculate final results.

The experimental results showed that when nitrate is not present in the medium, diatom didn't grow at all and did not produce biomass or silica for all six days. When potassium nitrate amount increased in the media from 5 mg/L to 160 mg/L diatoms produced more biomass and silica with increasing potassium nitrate concentration. The experimental results also indicated that most of the diatom dry weight consisted of silica. The difference between the dry weight of diatom and dry weight of silica is about 4% at all tested concentrations. This indicated about 96% of the diatom dry weight consists of silica and about 4% of the dry weight consists of remaining body mass. Also based on the experimental results cost effective analysis was modeled for silicon manufacturing industry on biogenic silica vs. geo genic silica.

## Development of Advanced Chitosan-Based Gadodiamide Nanoparticle for Highly Efficient MRI Diagnosis

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### Abstract

Magnetic resonance imaging (MRI) is the powerful technique for medical diagnosis, which could present abnormal tissue especially with MRI contrast agents. However, most MRI contrast agents are gadolinium ( ${}_{64}\text{Gd}$ )-based, and may cause nephrogenic systemic fibrosis (NSF) while Gd ion accumulated in kidney. To advance the contrast ability and reduce the toxicity of Gd-based contrast agents, the multifunctional MRI contrast nanocarrier should be development.

In this research, gadodiamide, a FDA-approved MRI contrast agent, was chosen as the candidate and chemically modified on carboxymethyl-hexanoyl-chitosan (CHC), a biocompatible polymer made in our lab. After modification, the Gd-polymer did self-assemble in aqueous environment and became 100 nm spherical nanoparticle, which named as CHCGd. Its longitudinal relaxivity ( $r_1$ ) constant is  $5.203 \text{ mM}^{-1}\text{s}^{-1}$ , which is 2-time higher  $r_1$  constant than gadodiamide, and also the best  $r_1$  value amount other polymer-based contrast agent because of larger molecular weight with CHC modification. Additionally, the clinical MRI contrast dosage of CHC-Gd in mice to observe lung and liver structure was  $0.0047 \text{ mmol/kg}$ , which was 21-time lower dosing than gadodiamide,  $0.1 \text{ mmol/kg}$ . These impressing results indicate that CHC-Gd nanoparticle is potential and suggested next-generation MRI contrast agent for precision medical diagnosis.

## Electrospun Nanofibrous Scaffolds: Towards Enhanced Tissue-engineered Heart Valves [TEHVs]

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### Abstract

Heart valve diseases lead to the death of 492,042 patients in the developing world and 20,000 patients in the US annually. Improving the life expectancy of the patients is done through replacing the diseased valves with mechanical or biological valves. However, both of them have major drawbacks. Hence, TEHVs have emerged to be the ideal substitute. TEHVs are biodegradable, biocompatible and mechanically stable scaffolds that resemble native valves. These scaffolds are seeded with autologous cells and conditioned in a bioreactor prior to implantation.

There are many techniques to fabricate such scaffolds, however electrospun nanofibrous scaffolds are considered the golden standard because they resemble the natural extra-cellular matrix of the native valves. There are two type of polymersthat can be electrospun: natural and synthetic. Synthetic polymers are considered superior because their physical and mechanical properties can be controlled. In addition, they have varied degradation rate. Synthetic polymers that have been used so far to fabricate electrospun scaffolds for TEHVs include: PLA, PGA and their copolymers, PCL and PGS. All the aforementioned polymers have drawbacks that render them far from being ideal materials for TEHV scaffolds.

PGS was reported recently as a good candidate for soft tissue engineering, however it has some limitations. Herein, we are working on a modified form of the PGS mixed with another polymer that can be electrospun into nanofibrous scaffolds. The resulting scaffolds are expected to overcome the limitation accompanied by the already reported PGS scaffolds in literature. In addition, the scaffolds will have different surface topographies that is expected to enhance the cellular attachment.

The outline of this work is divided into two parts: (A) Polymer synthesis and scaffolds fabrication followed by: chemical and physical characterization, mechanical characterization degradation and swelling tests. (B) Biological assessment.

The modified polymer was successfully synthesized and characterized. The current ongoing work is concerning scaffolds fabrication using blend of the two proposed polymers.

## Exfoliated MoS<sub>2</sub> Mixed in Butyl Rubber to Enhance Gas Barrier and Mechanical Properties

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### Abstract

In this study, the MoS<sub>2</sub> nanosheet were added into butyl rubber to improve its' gas barrier properties. MoS<sub>2</sub> is a two dimensional material and non-conducting due to the large band gap. To prepare MoS<sub>2</sub> nanosheet, the bulk MoS<sub>2</sub> materials was exfoliated into single- or few-layer nanosheet by probe sonicator. To improve the compatibility of MoS<sub>2</sub> in butyl rubber, ethanethiol was conjugated on the surface of MoS<sub>2</sub> through thiol coupling reaction. Two kinds of solvent, ethanol and hexane, was used to disperse the MoS<sub>2</sub> with butyl rubber. Different ratio of MoS<sub>2</sub> to butyl rubber has also been prepared. The successfully exfoliated of MoS<sub>2</sub> in the butyl rubber was examined by transmission electron microscope and X-ray diffraction. The nanosheet of MoS<sub>2</sub> was inserted into polymer chain of butyl rubber. Therefore, the gas molecules are hard to pass through the butyl rubber. Finally, we found that the gas barrier and mechanical properties of butyl rubber was improved by adding MoS<sub>2</sub> nanosheet.

## Synthesis of Block Copolymer with Diacetylene Junction for Stabilization of Block Copolymer Interface via Photo-crosslinking

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### Abstract

In nature, there are many kinds of helix structures (e.g., DNA, *spirulina*, rose, nebula). By taking advantage of chirality effect, chiral block copolymers (BCPs) can also mimic helical structure via self-assembly. Also, well-defined nanostructures can easily be tailored by the volume fraction of block copolymers for attractive applications in material science.

In this study, diacetylene, which is a photo-crosslinkable chromophore upon uv irradiation, was introduced to BCP junction between PS and chiral polylactide (i.e., Poly-L-lactide and Poly-D-lactide). By controlling the volume fraction of chiral blocks in chiral BCP, a well-defined helical nanostructure can be observed by transmission electron microscope (TEM) via self-assembly. Most importantly, the helical nanostructures can be stabilized by photo-crosslinking of diacetylene junctions upon UV irradiation. Also, the induced chirality of the diacetylene junctions in the self-assembled chiral BCP thin film can be identified by electronic circular dichroism (ECD) spectrum. Furthermore, the handedness of the helical nanostructures in the BCP can be determined from the split-type Cotton effects in ECD spectrum.

## A Novel Amphiphilic Gadolinium-Conjugate Chitosan Macromolecule for MR Imaging and Drug Delivery Against Non-Small Cell Lung Cancer

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### Abstract

Improved therapeutic performance in cancer treatment has been a goal for many nanosystems that combine drug delivery and functions such as diagnosis, imaging, and/or targeting. However, the complexity of synthesis processing and subsequent stringent FDA approval procedure may be hurdles in bringing such multifunctional systems to clinical practices with desirable, pre-designated therapeutic advantages. Therefore, a facile synthetic scheme to construct a pre-designated multifunctional nanodevice becomes crucial for success in clinical translation. In this study, we employed an amphiphilic carboxymethyl-hexanol chitosan (CHC). It was conjugated with gadodiamide (termed as Gd), a FDA-approved MRI contrast agent, creating a Gd-conjugated CHC polymer. Experimental results reveal outstanding relaxivity 1 (r1) compared to the relaxivity of the original Gd complex. This CHC-GD nanocarrier is excellent for drug delivery because it has considerably improved cytocompatibility and the capability to self-assemble into a nanoparticle in neutral aqueous phase. Also, it is a high-sensitive imaging agent for practical demands.

Demethoxycurcumin (DMC) was chosen as the anti-cancer drug to be encapsulated into the CHC-Gd nanoparticle, with an appropriated morphology suitable for intratumoral accumulation via EPR. The encapsulation efficiency of DMC was determined while the encapsulating process was optimized. Cellular toxicity of the CHC-Gd/DMC nanoparticles was examined systematically, and a significant inhibition against the growth and proliferation of the NSCLCs of the CHCGd/ DMC nanoparticle was observed. Associated with a strong MR imaging performance *in vitro*, this novel CHC-Gd nanocarrier is surely able to act as an outstanding multifunctionalized vehicle for diagnosis, imaging, and drug delivery in a numerous medical applications.

## Exciton Localization in A-plane ZnO/Mg<sub>x</sub>Zn<sub>1-x</sub>O Multiple Quantum Wells on R-sapphire

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### Abstract

Nonpolar ten-period a-plane ZnO/Mg<sub>x</sub>Zn<sub>1-x</sub>O multiple quantum wells (MQWs) with the well thickness ranging from ~1.4 to 5.6 nm have been epitaxially grown on R-plane sapphire by pulsed laser deposition. High resolution cross-sectional transmission electron microscopy (TEM) images confirmed the regularly arranged well and barrier layers. The pronounced Pendellösung fringes observed in the X-ray crystal truncation rods manifest the high crystalline quality of samples because interface roughness and inhomogeneity in thickness and composition would decrease the phase coherence and suppress the fringes. The optical properties of the MQWs were studied by using photoluminescence (PL). PL lines was dominated by localized exciton (LE) emissions at low temperatures, while the confined free exciton (FE) transition was the dominating emissions at temperatures above 130K. No obvious S-curve appeared in temperature-dependent PL spectra and the invariant PL peak in power-dependent PL spectra revealed the less carrier localization effect and the lack of built-in electric fields. The results demonstrate the potential of the heteroepitaxial nonpolar ZnO/Mg<sub>x</sub>Zn<sub>1-x</sub>O MQWs for future UV emission application.

## Phosphorene Heterostructure Nanodevices for Ultrafast Energy Harvesting and Next Generation Electronics

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### Abstract

Transition metal dichalcogenides (TMDCs) have recently shown much promise as thin layer semiconductors in application to field effect transistor technology. As n-type materials in heterostructures, TMDCs provide a unique vantage point for studying the properties of graphene analogous phosphorene. Phosphorene-TMDC heterostructure nanodevices have remained largely unexplored due to the lack of air stability observed in samples of black phosphorus under both ambient and dry vacuumed conditions. Few-layer phosphorene represents much promise as a p-type material because of its demonstrated high mobility and tunable band gap. A heterojunction was synthesized via dry transfer methods using MoS<sub>2</sub> and WS<sub>2</sub> alternately. Microscopy, Raman spectroscopy, transport, and photocurrent response techniques were employed to characterize the device physically and electronically. Also proposed and preliminarily characterized is a proposed method for air stable phosphorene over longer periods of time using an extended contact in heterostructure context, with promising results. Preliminary results indicate a promising heterojunction with high speed energy harvesting and photovoltaic properties. Potential applications include next generation electronic devices, photodetectors, energy storage devices, and photovoltaic cells.

## Effects of Consumer Use Practices on Nanosilver Release from Nanoenabled Food Contact

Materials Susana Addo Ntim<sup>1</sup>, Samuel Norris<sup>2</sup>, David Goodwin<sup>2</sup>, Keana Scott<sup>2</sup>, Lipiin Sung<sup>2</sup>, Treye A. Thomas<sup>3</sup> and Gregory O. Noonan<sup>1</sup>

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### Abstract

Potential consumer exposure to nanoparticles from nanoenabled food contact materials (FCMs) has been a driving force for migration studies involving these FCMs. Although no nanoparticle release is detectable in fresh unused FCMs, conditions that result in significant changes to the surface properties of the FCMs may influence particle release. Therefore a quantitative assessment of nanoparticle release from commercially available nanosilver-enabled cutting board was performed using three consumer use conditions. Knife motion, normal washing/scrubbing and aggressive scratching scenarios were simulated by linear abrasion using razor blades, scrubbing pads and tungsten carbide burr attachments, respectively. Migration was evaluated using water and 3% acetic acid as food simulants. Low concentrations of Ag were detected in water simulants, a small portion ([2.2 – 3.9] ng dm<sup>-2</sup>) in the form of silver nanoparticles (AgNPs) with particle number concentrations ranging from 2.3 × 10<sup>6</sup> – 5.9 × 10<sup>6</sup> particles dm<sup>-2</sup>. Median particle diameter was 43 nm. Nanoparticle release into water was observed under all three consumer

use scenarios studied without any apparent dependence on the different levels of stress simulated. Total Ag migration into 3% acetic acid was significantly higher than in water; however, 3% acetic acid is not suitable for evaluation of nanoparticle release due to dissolution of AgNP to Ag<sup>+</sup> under acidic solution chemistries.

## Enhanced Nanoarchitected Coronary Stents: Towards Smart Drug Release

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### Abstract

The treatment of coronary artery disease (CAD) has been one of the ongoing developments with new insights over the past few decades. For long time, coronary artery bypass graft (CABG) has been the main procedure used to treat coronary artery diseases. Due to the limitations associated with such procedure, drug eluting stent (DES) has been introduced to treat CAD. Basically, CAD results from a series of biological cascades that cause the deposition of plaque in the arteries' wall. This leads to restriction of blood flow to the heart muscle (myocardium) that eventually leads to heart attack. Despite the fact that the DES is widely used to treat CAD, different material platforms are still under different stages of development to tackle the associated long-term side effects such as in-stent restenosis and thrombosis. Using nanotechnology the use of nanoscale material as nano reservoirs for local drug delivery strategy may introduce an effective treatment of in-stent restenosis. This proposed work introduces a new technology to control the drug release kinetics in order to get a sustained release profile, which is required to treat late side effects. To achieve this objective a biocompatible nickel free alloy without polymer coating will be studied as a stent platform for controlled and light-assisted local drug delivery. The nanoarchitectures were successfully fabricated and characterized using SEM, EDX, XRD, XPS, FTIR and the mechanical properties are evaluated as well as UV-VIS absorption spectroscopy. The ongoing stage involves further characterization techniques to evaluate the biological response of the nanoarchitectures.

## IL-6 Antibody and RGD Peptide Conjugated Poly(amidoamine) Dendrimer for Targeting the HeLa cells

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### Abstract

Nowadays, cancer is the major cause of mortality throughout the world. Accordingly, researchers have focused on developing suitable drug carriers to deliver pharmaceutical agents to treat cancer diseases. But, there are limitations of nonselectivity lead to be the high toxicity to normal cells. To overcome these setbacks, targeted deliveries of anticancer drugs to realize minimizing the toxicity to normal tissue while the goal of maximize anticancer drugs efficacy and delivers effectively to tumor tissue. Herein, we studied PAMAM dendrimer derivatized with two targeted nanocarriers (G4.5-IL6 and G4.5-RGD) for targeting of HeLa cells and evaluate the dendrimer's complex on the drug loading, release kinetics and toxicity of cancer cells. The anticancer doxorubicin was loaded into the dendrimer void space through the hydrophobic interaction and the encapsulation efficiencies were calculated as 51.3 and 30.1% for G4.5-IL6 and G4.5-RGD. *In vitro* release studies were done at different pH value for 200 h of incubation and the results clearly showed that dendrimer complexes follow a biphasic pattern release mechanism and high drug release was obtained in acidic pH. In addition, the cytotoxic and cellular internalization of G4.5-IL6/DOX and G4.5-RGD/DOX were confirmed using flow cytometry and confocal microscopy. The lower IC<sub>50</sub> value of G4.5-IL6/DOX in comparison to G4.5-RGD/DOX was acquired which indicates higher targeting ability with higher cytotoxicity. Furthermore, the toxicity of late apoptotic stage increase after treatment owing to high cellular internalization through receptor-mediated endocytosis. On the other hand, receptor of HeLa cells is better suited with G4.5-IL6 than G4.5-RGD for targeted drug delivery.

## Designing the Molecular Weight of Photo-curable Polymer for 3D Printing Materials: Its Effect on Mechanical Properties

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### Abstract

Photo-curable polymer-based 3D printed structures are of great interest, for their smooth surface and high resolution. Particularly, the molecular weight of a photo-curable polymer is one of the key factors determining the viscosity, photocuring behavior and mechanical properties. Herein, a series of photo-curable polymer with different molecular weights were prepared and their effects on the photo-curing behavior and mechanical properties were studied. Photo-curable polymers with various molecular weights were functionalized through introducing acrylate group at the end of oligomer chain. Fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR) were used to verify the presence of acrylate group. The viscosity of each photo-curable polymers was characterized via viscometer. Then, photo-curing process and the fabrication of 3D structure were carried out by using Stereolithography Apparatus (SLA) printer. Photo-curing behavior of polymers with various molecular weights was monitored by photo-DSC. Furthermore, the tensile strength and elongation measurement were performed to reveal the effect of molecular weight of photo-curable polymers on the mechanical properties of 3D-printed structures. As molecular weight of photo-curable polymer increased, the elongation at break increased from 60% to 100% while the tensile strength was reduced significantly from 40 N/mm to 4 N/mm. Additionally, we confirmed that the addition of acrylic monomer also influences the mechanical properties of photo-curable polymer. This study aims to demonstrate the importance of designing of photo-curable polymer for obtaining high-quality 3D printing result.

## Ionic Modification to Bentonite and Kaolinite for the Decontamination of Sr<sup>2+</sup> in Radioactive Wastewater

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### Abstract

Sr-90 radionuclides are the main nuclear fission product largely remained in the cooling wastewater. Low-cost and earth abundant natural kaolinite and bentonite minerals were applied for the decontamination of Sr<sup>2+</sup> ions. Ionic modification by simply acid and base washing treatments allowed inserting Na<sup>+</sup> ions into the mineral structures that served as ionic exchange sites to adsorb Sr<sup>2+</sup> ions. The variations of structural and chemical composition according to the post-treatments were investigated and compared. The sorption efficiencies increase from 5.84 mg/g and 28.9 mg/g to 32.89 mg/g and 78.1 mg/g for kaolinite and bentonite, respectively.

## Brass Made to Rust: Efficient Nanostructured Material for Solar Energy Conversion

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### Abstract

Unlike gasoline and coal, hydrogen is a non-toxic, green fuel. One of the ways to produce hydrogen is via water splitting. In this regard, a material that efficiently captures energy from the sun and splits water is needed. Brass is a promising material for such an application due to its stability and absorption in the visible region of the light spectrum. Both, zinc and copper oxides are used in many applications due to their favorable band gaps. They have been investigated independently and many progresses have been made. However, little research has been done on brass due to its challenging optimization. Herein, we combine the advantages of both zinc and copper oxides in one composite electrode. In this work, using controlled anodization at room temperature, we were able to produce nanoparticles and nanorods of Cu-Zn oxides. The fabricated nanostructures have been used to split water photoelectrochemically under AM 1.5 illumination. The study shows very promising results towards visible light water splitting. Incident photon to current efficiency (IPCE) and current transients were conducted to understand the charge transfer and stability of such composite material. Mott-Schottky analysis was also used to calculate the density of charge carriers and the flat band potential.

## **In vivo Study of Gold Nanoparticles: Dose Dependent Effect on Ulcerative Colitis in Rat**

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### **Abstract**

Recently, the unique and novel properties of Gold nanoparticles (AuNPs) have been receiving more attention in the field of nanomedicine research. The successful using of AuNPs either in diagnosis or therapy *in vivo* is dependent on their low cytotoxicity and high ability to target cells. Several factors including AuNPs's size, shape and surface area significantly influence their cellular interactions. AuNPs have been reported to improve the inflammatory response by decreasing the mRNA expression of interleukin-6 and tumor necrosis factor- $\alpha$ , suppressing cell proliferation and reducing the level of reactive oxygen species (ROS). However, there is lack of information about their new properties and effects on the healing of ulcerative colitis. The purpose of the present study was to evaluate the therapeutic effect of two different doses of AuNPs on the ulcerative colitis and their distribution in different biological organs. Currently, available treatments for ulcerative colitis are only effective in ameliorating the disease symptoms while having many concomitant disadvantages. Colitis was induced in rats by a single intra-colonic instillation of Dinitro-benzene sulfonic acid (DNBS). After 4 days of colitis induction, animals were randomized to receive 40 and 400  $\mu$ l GNPs of size 16-23 nm intravenously. By the end of 72 hours of the injection, AuNP effects and distribution were investigated. The high concentration dose of AuNPs (400  $\mu$ l) caused the most significant therapeutic effect on ulcerative colitis. AuNPs were found to increase the regenerative capacity of damaged tissues, reduce the inflammation of colon cells, suppress the inflammatory cytokine response and diminish the oxidative stress markers. Our study suggested a new therapy for ulcerative colitis without any drawbacks and minimum distribution of AuNPs in other biological systems.

## **A Comprehensive Evaluation of Lignocellulosic Biomass Characteristics and Interactions at the Nanoscale**

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### **Abstract**

Biomass recalcitrance is known to be the major challenge facing economic conversion of lignocellulosic biomass to biofuels. This is largely due to it being influenced by many factors including lignin and hemicellulose contents, degree of polymerization, particle size, steric hindrance, morphology, hydrophobicity and surface charge of the biomass components. To improve our fundamental understanding of how these factors affect lignocellulosic biomass interactions to enzymes, a set of reference substrates with precise surface composition of cellulose, lignin and xylan as well as the model cellulase enzyme carbohydrate-binding module of cellobiohydrolase I were developed. Nanoscale interaction forces were then quantified between the reference substrates and different model surfaces. By combining theoretical, experimental and statistical unique approaches, the effects of biomass composition, conformation of surface biopolymers and steric forces on the types and strengths of forces that govern cellulase-biomass interactions were elucidated. Our results indicated that the presence of lignin increases the hydrophobicity and heterogeneity and nonproductive binding of the biomass to enzymes. Permanent dipole-dipole interactions dominated the adhesion of the hydrophilic model surface to lignosulfonates whereas hydrophobic interactions facilitated the adhesion of the hydrophobic model surface to Kraft lignin. Finally, we have shown that, in liquid media, cellulose microfibrils were extended from the fibril matrix and that resulted in a long-range steric repulsion and low attractive forces to the hydrophobic model enzyme. The opposite was true for xylan. Our findings would allow engineers to design better enzymes or to develop unique pretreatment technologies for effective enzymatic hydrolysis of lignocellulose.

## **ZnFe<sub>2</sub>O<sub>4</sub> Heterostructures as Ultra-high Sensitive Electrode for Formaldehyde Chemical Sensor**

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### **Abstract**

Zinc ferrite (ZnFe<sub>2</sub>O<sub>4</sub>), which is one of the ferrite spinel (AFe<sub>2</sub>O<sub>4</sub>; A=Mn, Zn, Co, Ni, Cd), has received great interests due to its various applications such as gas sensors, electronic devices and magnetic materials etc. Zinc ferrite (ZnFe<sub>2</sub>O<sub>4</sub>) heterostructures was successfully synthesized at low temperature (150 °C) under solvothermal conditions without using any surfactant or agents.

The bulk electrode of ZnFe<sub>2</sub>O<sub>4</sub> was prepared in the form of pellet and coated with graphene for the effective detection of toxic formaldehyde chemical. The phase purity and composition of ZnFe<sub>2</sub>O<sub>4</sub> were characterized by elemental analysis such as Raman Spectroscopy, X-Ray diffraction and X-Ray photoelectron spectroscopy. From room temperature photoluminescence (PL) spectroscopy, the synthesized ZnFe<sub>2</sub>O<sub>4</sub> exhibited prominent band-edge ultraviolet (UV) and weak visible emission (violet), indicated the optical properties of ZnFe<sub>2</sub>O<sub>4</sub>. The electrochemical revealed that the prepared ZnFe<sub>2</sub>O<sub>4</sub> heterostructures based electrode showed the sensing response toward formaldehyde. The enhanced electrochemical performances could be attributed to the synergistic effect between ZnFe<sub>2</sub>O<sub>4</sub> and graphene and the observed results demonstrated ZnFe<sub>2</sub>O<sub>4</sub> heterostructures as promising probe candidate for the fabrication of highly sensitive (1.36x10<sup>-6</sup> A/μM·cm<sup>2</sup>) and selective chemical sensors.

## Hydrothermal Synthesis of Highly Porous Cobalt Oxide Nanocubes and their Supercapacitor Applications

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### Abstract

An eco-friendly p-type transitional metal oxide, cobalt oxide (Co<sub>3</sub>O<sub>4</sub>) materials have recently received an immense attention of researchers owing to their utilizations in several electrical and electrochemical devices such as gas sensors, supercapacitors, Li-ion batteries, magnetic materials, and heterogeneous catalysts. Intrinsic properties of metal oxide materials are basically depend on their morphology, size, specific surface area and microstructures, which highly influence the electrochemical properties. In this work, the porous Co<sub>3</sub>O<sub>4</sub> nanocubes (NCs) were synthesized through a facile hydrothermal method using sodium hexanitrocobaltate (Na<sub>3</sub>Co(NO<sub>2</sub>)<sub>6</sub>) as precursor and employed as electro-active materials for supercapacitor. Well-crystalline and highly porous cube like morphology were obtained. Fourier transform infrared (FT-IR) and Raman spectroscopies revealed that synthesized nanomaterials possessed the cubic single crystal Co<sub>3</sub>O<sub>4</sub> of good quality. On the basis of the observed crystallite morphologies, a possible aggregate-dissolution-recrystallization growth mechanism was proposed to explain the formation process of the Co<sub>3</sub>O<sub>4</sub> NCs. From the electrochemical analysis, the synthesized porous Co<sub>3</sub>O<sub>4</sub> NCs based supercapacitor exhibited the high specific capacitance of 430.6 F/g at ~10 mV/s, resulted from their unique porous cube like morphology.

## Assembly of Virus-like Nanoparticles with Superparamagnetic Core: Multifunctional Platform for Biomedical Applications

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### Abstract

Superparamagnetic iron oxide nanoparticles (SPIONs) poses a set of unique magnetic and physicochemical characteristics qualifying them as a promising tool in many biomedical applications as for example: contrast agent in MRI, magnetically driven carrier in targeted drug delivery or in hyperthermia for cancer treatment, etc. Physicochemical properties of SPIONs allow for wide range of surface functionalizations suitable for specific applications [1].

Virus like particles (VLPs) are defined as a structure containing viral proteins, mainly capsid and coat proteins. One of exemplary applications of VLPs is vaccine production. VLPs based vaccines obtained by self-assembly have entered clinical trials. However, this technology still suffers from many drawbacks such as low production yield, morphological polydispersity and low stability. Combining viral proteins with SPIONs into core-shell structures may provide a solution for aforementioned issues [2-4] vaccines have been one of the most effective medical interventions for reducing infectious disease, and are estimated to save millions of lives globally each year. Nevertheless, many diseases are not yet preventable by vaccination. This large unmet medical need demands further research and the development of novel vaccines with high efficacy and safety. Compared to the 19<sup>th</sup> and early 20<sup>th</sup> century vaccines that were made of killed, inactivated, or live attenuated pathogens, modern vaccines containing isolated, highly purified antigenic protein subunits are safer but tend to induce lower levels of protective immunity. One strategy to overcome the latter is to design antigen nanoparticles: assemblies of polypeptides that present multiple copies of subunit antigens in well-ordered arrays with defined orientations that can potentially mimic the repetitiveness, geometry, size,

and shape of the natural host-pathogen surface interactions. Such nanoparticles offer a collective strength of multiple binding sites (avidity).

In our study, 15nm SPIONs were synthesized by thermal decomposition of iron (III) acetylacetonate, functionalized with HOOC-PEG-PL and dihexadecyl phosphate (DHP). These modifications were performed to obtain water solubility and negative surface charge, required for VLPs assembly. Prepared SPIONs were analyzed by various methods and used in assembly.

Viral proteins used in experiment were: plant origin Brome Mosaic Virus (BMV; coat protein) and human Hepatitis B Virus core antigen (HBcAg). Both proteins were assembled with HOOC-PEG-PL and DHP. The process of assembly was performed using two protein-specific protocols [5, 6]. Obtained VLPs were purified and analyzed using different methods.

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## Superparamagnetic Iron Oxide Nanoparticles for *in vivo* Magnetic Resonance Imaging of Myoblasts and Mesenchymal Stem Cells in Post-Infarction Heart

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## Abstract

Stem cell therapy in the recovery of the myocardial muscle function after cardiac infarction is a very promising and thoroughly researched concept [1, 2]. The basis of this therapy is the injection of stem cells directly between the scar composed of connective tissue and healthy cardiac muscle tissue. However, to date, this procedure struggles with low cell retention in the place of injection, low percentage of stem cells differentiated into the functional myocytes and different character of differentiated myocytes than cardiomyocytes.

Our group aim to resolve these issues. We managed to obtain successful overexpression of connexin Cx43 in myoblasts [3], which improved functional tests results (e. g. echocardiography) in infarcted heart in mice. To monitor the cells after injection we decided to use superparamagnetic iron oxide nanoparticles (SPIONs). Moreover, we attempt to stimulate differentiation and retention of cells in place of injection employing various cytokines (e. g. SDF-1) [4] which are released *in situ* from PNIPAAm hydrogels.

Nanoparticles were synthesized using thermal decomposition in organic phase [5]. *meso*-2,3-dimercaptosuccinic acid (DMSA) was used to replace capping agent, yielding hydrophilic, biocompatible nanoparticles [6]. In our experiments we employed two cell lines: human myoblasts and human mesenchymal stem cells (hMSCs). To assess nanoparticle impact on cells we performed panel of tests including: cytotoxicity, proliferation and gene expression profiling for genes responsible for inflammation and iron metabolism. They showed little, or no statistically important difference in cellular metabolism. Ultimately, labelled cells were injected into the infarcted heart in mice and imaged using MRI.

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## Use of Exosome-Delivered Synthetic Nonribosomal Peptide Synthetases as a Novel Anti- Parkinson's Disease Therapeutic

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### Abstract

This study analyzes the potential therapeutic value of nonribosomal peptide synthetases for producing compounds which counteract Parkinson's Disease *in vivo*. Parkinson's Disease occurs when there is an unusual build-up of alpha-synuclein in the portion of the brain known the substantia nigra pars compacta, which results in cell death of dopaminergic cells and a subsequent dopamine shortage. The use of nonribosomal peptide synthetases allows the cells themselves to produce anti- Parkinson's compounds which prevent the coagulation of alpha-synuclein oligomers. Anti-Parkinson's compounds were screened using a yeast *Saccharomyces cerevisiae* model. A novel nonribosomal peptide synthetase was designed using *in silico* analysis. The synthetic nonribosomal peptide synthetases can be delivered to the dopaminergic neurons via stealth exosomes. These stealth exosomes are themselves delivered to the brain intranasally and by-pass the blood-brain barrier. This gives a route of direct delivery to dopaminergic neurons and allows the nonribosomal peptide synthetases the ability to interoperate within the cells. This localized designer drug strategy provides an alternative to the existing treatment of levodopa-carbidopa anti-Parkinson's medications.

## Proteomic Platform Together with Optical Tweezers Technology is a Powerful Method to Study Adhesion Abnormalities in Lymphoma Patients

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### Abstract

Cell adhesion is of fundamental importance in the cell communication, signaling and motility, and its dysfunction occurs prevalently during cancer progression. The knowledge of the molecular and cellular processes involved in abnormalities in cancer cells adhesion has dramatically increased and it has been focused mainly on cellular adhesion molecules (CAMs) and tumor microenvironment. During the last decade, several methods for measuring and studying cell adhesion properties were also developed, including optical tweezers technology.

The wide range of applications of optical tweezers includes delivering cells to specific locations, sorting cells and transporting foreign materials into single cells. In our study, optical traps were used to assemble diffuse large B cell lymphoma cell lines on the stromal cell layer and to enable their interactions by applying trapping force to maintain the cell contact until a stable connection was created between cells. After we characterized the adhesion properties of diffuse large B cell lymphoma cells, we performed the proteomics investigations on CAMs (cellular adhesion molecules) using LC-MS/MS. We identified several significantly deregulated proteins among cell lines, and by correlating data obtained from proteomics and optical trapping study, we were able to indicate which proteins are critical for maintaining adhesion. The reported approach provides a new opportunity to investigate adhesion abnormalities in lymphoma cells which may indicate more invasive phenotype of cancer.

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## Delonix Galactomannan Polymeric Nanoparticle with Prospects for Ocular Delivery

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### Abstract

The micro-environment of the eye has posed challenges in terms of an effective drug delivery in the treatment of eye diseases. Nanoparticulate drug delivery to both the anterior and posterior eye has shown promising results. However, the quest for biomaterials that could effectively target the eye, improve bioavailability and minimize collateral has not abated. This study which aims at the development of a polymeric nanoparticulate drug delivery system from an underutilized natural polymer, Delonix polymer (DLX), by deploying a quality by design approach also evaluates its prospect as an ocular delivery tool. DLX is a galactomannan extracted from the seed endosperm of Delonix regia plant. DLX Nanoparticles were prepared by a reverse nanoprecipitation method and evaluated for ocular delivery prospects. Characterized DLX galactomannan contains Mannose:Galactose ratio of 4.6:1, 5.3:1 and 6.3:1 respectively. DLX nanoparticles sizes determined by dynamic light scattering were < 240 nm, PdI < 0.2 and zeta potential < -30 mV while transmission electron microscopy analysis showed monodispersed sizes between 28-38 nm. Mixing surfactants with different hydrophilic-lipophilic balance controlled nanoparticle size and swelling. Nanoparticles were stable in simulated lachrymal fluid, lysozyme and mucin while labelled-DLX nanoparticle sustained the release of BODIPY probe. DLX nanoparticles in concentration range of 100-1483.3 µg/mL had no *in vitro* toxicity on retinal and corneal epithelial cells. Flow cytometry and confocal techniques demonstrated ~18% nanoparticle uptake by retinal cells and no or minimal uptake by corneal cells. DLX nanoparticle could be a safe and promising tool for ocular delivery of active molecules.

## Fabrication of Multifunctional Chitosan Based Dual Drug Nanocarrier, Applied in Cancer Therapy

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### Abstract

Multi-drug resistance (MDR) in cancer stem cells, is the main reason for tumor metastasis and invalid treatment. Thus, to develop an anti-MDR cancer therapy become the emergency work. This research established one multifunctional dualdrug delivery system with one-pot synthesis, which combined targeting, biodegradable and dual-drug encapsulation on one nanoparticle to inhibit MDR-pathway in cancer stem cells. The second-line anti-cancer drug, gemcitabine (dFdC), and the Chinese herbal extract demethoxycurcumin (DMC) were chosen and loaded in biodegradable carboxymethyl-hexanoyl chitosan (CHC) nanoparticles modified with CD133 antibody, which is the biomarker on non-small cell lung cancer stem cell, A549-ON.

The CHC/dual-drug/anti-CD133 nanoparticle did out-standing IC50 and CI value on killing A549-ON compared with free dFdC and DMC combination, which meant the highly efficiency and synergy of this drug co-delivery system. In addition, CHC/dual-drug/anti-CD133 nanoparticle performed better treatment on A549-ON xenograft in mice than other experiment groups, indicating that this multifunctional nanocarrier may provide a new way for chemotherapy in cancer treatment.

## Disclosure of the Self-Assemble Behavior of Carboxymethyl-Hexanoyl-Chitosan and the Mechanism of Drug Encapsulation in Aqueous Phase

Wei-Ting Huang\* and Dean-Mo Liu

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### Abstract

Carboxymethyl-hexanoyl-chitosan (CHC), the amphiphilic chitosan made by our lab, has self-assemble ability in natural aqueous phase and becomes spherical nanoparticle with 50 nm diameter. Besides, CHC owns well properties of biocompatible, biodegradable and easily modification with chemical-bio molecules. Therefore, using CHC as multifunctional drug carriers is a promising system to apply in medical field, which could do targeting, drugs encapsulation, co-delivery and even imaging. In this research, the mechanism of CHC self-assembling was disclosed through DLS, TEM, SAXS and NMR, and the results explained the internal structure of CHC nanoparticles and the assemble process. Additionally, there are many hydrophobic and hydrophilic domains in CHC nanoparticle, so both kinds of drugs could be wrapped in CHC while self-assembling with well efficiency and keeping the drug activity. The interaction among drugs and CHC was proved by NMR and SAXS, and the *in*

*in vitro* drug releasing model was also observed. To expose the architecture and mechanism of CHC-drug carriers advance our knowledge of polymeric particle in nanoscale, and lead better application of CHC in biomedicine based on strong realization.

## **Drug Delivery System for Cancer Treatment: Ultrasound-Triggered Drug Release from Targeted Nano-carriers**

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### **Abstract**

Cancer is one of the deadliest diseases and it claims the lives of millions of people worldwide annually. The current methods of treatment involve the use of chemotherapeutic drugs that are highly toxic to the healthy tissues and leads to serious side-effects which impacts the life quality of the patient. In order to minimize the side effects of the drugs, nano-carriers (liposomes) are used to encapsulate the drug and prevent its interaction with healthy cells. However, this strategy leads also to lower efficacy of the drug on the tumor and requires the usage of higher dosage. Here we report on the design and the preliminary results of a drug delivery system utilizing a new strategy that combines targeted liposomes with ultrasound (US) waves to increase the efficacy of the chemotherapy and decrease its side effects. Targeted nano-carriers are made from liposomes that are brandished with polyethylene glycol (PEG) chains which are chemically modified to be furnished with targeting moieties for over-expressed receptors on tumor cells. Previous reports have shown that targeted nano-carriers increase the accumulation of drug on the tumor site significantly (up to 80% increase) as compared to nontargeted liposomes. Once accumulated, focused US waves are then applied to induce the release of the drug from the nanocarriers into the tumor site; thus, minimizing the exposure of health cells to the drug. This presentation will describe the preparation of the targeted nano-carriers and the results of US-induced release experiments.

## **Investigation of Length Effect on Power Conversion Efficiency of Perovskite Solar Cells Composed of ZnO Nanowires**

**Wei-Shuo Li<sup>\*</sup>, Shiu-Ting Yang, and Huang-Chung Cheng**

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### **Abstract**

The power conversion efficiency (PCE) of the perovskite solar cells has been achieved by inserting vertically-aligned ZnO nanowires (NWs) between the cathode and the active layer and shows better solar cells performance. Perovskite solar cells have drawn significant attention due to the superb efficiency and low-cost fabrication process. In this experiment, ZnO nanowires are used as the electron transport layer (ETL) due to its low temperature process. The main idea of this thesis is utilizing the 3D structures of the hydrothermally-grown ZnO nanowires to increase the junction area to improve the photovoltaic performance of the perovskite solar cells. The infiltration and the surface coverage of the perovskite precursor solution changed as tuning the length of the ZnO nanowires. It is revealed that the devices with ZnO nanowires of 150 nm demonstrated the best PCE of 8.46% under the AM 1.5G illumination (100 mW/cm<sup>2</sup>).

## **Continuous Wave Laser Crystallization and Laser Spike Annealing Technologies for Low Thermal Budget Integration of N-channel Polycrystalline-Germanium Thin Film Transistors**

**Hao-Hsiang Liang<sup>\*</sup>, Yi-Shao Li and Huang-Chung Cheng**

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### **Abstract**

In this article, we propose a continuous wave laser crystallization (CLC) and laser spike anneal process to realize a low thermal budget integration. Germanium (Ge) has the advantages of high carrier mobility and low melting point, which can further promote the electrical characteristics. Large grains could be obtained after CLC process and the largest grain size of 1  $\mu\text{m}$  was reached at the laser power of 6 W. However, a high-temperature annealing ( $\geq 600$  °C) is needed for phosphorus in Ge and the activation efficiency of n-type dopant is reported to be poor. Therefore, we apply green nanosecond laser annealing to replace the rapid thermal process which form an n+/p junction with a low sheet resistance. The laser pulse lasts only a few nanoseconds, resulting in minimal thermal diffusion of dopants and suppressing the dopant loss. Furthermore, this process is

optimized to achieve field-effect mobility of  $322 \text{ cm}^2/\text{V}\cdot\text{s}$ , as it allows excellent junction depth control when combined with optimized implant conditions. The observed performance shows promise for low thermal budget integration.

## Effects of Capping Layers with Various Thicknesses for Grain Enlargement of Poly-Si Thin-Film Transistors via Continuous Wave Laser Crystallization

Yi-Shao Li<sup>1</sup>, Chun-Yi Wu, Chia-Hsin Chou and Huang-Chung Cheng

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### Abstract

Low-temperature polycrystalline-silicon (LTPS) thin-film transistors (TFTs) fabricated via continuous-wave laser crystallization (CLC) have been reported to have an extremely high carrier mobility comparable to that of transistors fabricated on single-crystalline Si. However, conventional CLC TFTs suffer from poor device-to-device uniformity due to the formation of narrow longitudinal Si grains with randomly distributed grain boundaries. In this work, we investigate the CLC with oxide capping layer with various thicknesses under anti-reflection condition in order to overcome this difficulty. Four thicknesses of capping oxide layer, i.e., 90 nm, 270 nm, 450 nm and 630 nm, are chosen for the study of capping oxide thickness effect. Then, the a-Si layer with the capping oxide layer was irradiated by a diode-pumped solid-state CW laser with a wavelength of 532 nm at  $450^\circ\text{C}$  in air. The laser powers were varied from 3.1 W to 7.6 W, and the scanning speed was 30 mm/s. The maximum width of longitudinal-crystallization region of  $211 \mu\text{m}$  was reached at a laser power of 6.7 W by using a 450-nm-thick capping oxide layer. In addition, the polycrystalline silicon film in the longitudinal-crystallization region with 450-nm-thick capping oxide could achieve the largest grain size of  $2.5 \mu\text{m} \times 20 \mu\text{m}$ . Thus, the CLC with capping oxide layer is a promising technology for fabricating high performance TFTs. A field effect mobility of  $830 \text{ cm}^2/\text{Vs}$  and a subthreshold slope of  $140 \text{ mV}/\text{dec}$  were obtained with the 450-nm-thick capping oxide layer.

## Study of SHI Irradiation Induced Modification in Tin Oxide Thin Films

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### Abstract

Thin films of tin oxide ( $\text{SnO}_2$ ) having thickness of 100 nm were grown on silicon  $\langle 100 \rangle$  and glass substrates by electron beam evaporation deposition technique under high vacuum. Calibration of film thickness was done by piezo-sensor attached to the deposition chamber. Modification in material properties was done by Swift Heavy Ion (SHI) irradiation with beams of 100 MeV Ni at constant current of 1 pna at normal incidence. The irradiation fluences varies between  $5 \times 10^{11}$  ions/ $\text{cm}^2$  to  $1 \times 10^{13}$  ions/ $\text{cm}^2$ . Swift Heavy Ion beam irradiation was carried by using 15UD Pelletron Accelerator at Inter University Accelerator Center, New Delhi, India. Optical studies of these ion irradiated thin films were done by UVVisible spectroscopy. Surface topographical studies and grain size calculations are done by atomic force microscopy (AFM) technique in tapping mode. Roughness exponent was deduced from Power Spectral Density (AFM-PSD) data generated from AFM signals. Glancing angle X-ray diffraction (GAXRD) results using Bruker-D8 advance model instrument show improvement in crystallinity and new phase formation due to swift heavy ion irradiation. Grain size and particle size is verified by AFM and GAXRD results respectively. Temperature dependence electrical properties were studied from R-T results. Depth profile and elemental composition was verified by Resonance RBS method. Detailed results will be discussed during the presentation.

## Characterization and Separation of U937 Monocytes and U937-Differentiated Macrophages Using 3D Carbon Electrode Dielectrophoresis

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### Abstract

Tumor-associated macrophages (TAM), one of the key players in tumor microenvironment, are involved in tumor development and progression in many cancers. Here, we will present carbon electrode dielectrophoresis (carbon-DEP) as a characterization tool to identify and separate U937 monocytes and U937-differentiated macrophages. First, we will differentiate monocytes to

obtain macrophages. Next, we will apply carbon-DEP to determine specific crossover frequencies as signatures. Since DEP does not require any pre-labeling for the cells, it will allow direct characterization of cells based on their physical intrinsic properties without altering their genetic and phenotypic properties. Finally, we will verify our results using traditional assays. When we obtain their dielectrophoretic signatures, we will isolate and enrich them for high-throughput biochemical analysis.

## Preparation and Characterization of 5-Fluorouracil Loaded Fluorescent Nanoparticles

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### Abstract

The development of novel nanoparticles that can enhance effective and safe delivery of drug is always a challenge. Good carrier with sustained release of drug and long shelf life is very limited. Lack of safe and effective drug delivery system also restrict the clinical applications. Therefore, the goal of this research is to design a kind of biocompatible and biodegradable polymeric nanoparticles which is capable to serve as an antitumor drug carrier to control drug release for cancer therapy. In present work, the polymer poly (cyclohexane-1, 4-diyl acetone dimethylene ketal) (PCADK), Alginate acid and Polyethylenimine were designed as the carrier and then to prepare drug loaded carrier. PCADK, PEI and alginate acid have electrostatic interaction that can self-assembly to form micelles. Fluorouracil, an antitumor drug, was successfully loaded into the nanoparticles. The size of fluorouracil loaded nanoparticles was examined by scanning electron microscope and transmission electron microscope. Drug release studies were done at different pH value for about 200 h of incubation and the release profiles are composed of burst release and sustained release. In conclusion, a kind of new fluorouracil loaded PCADK polymeric nanoparticles was successfully prepared by complexation between anionic Alginate acid and cationic Polyethylenimine in aqueous solution. The fluorouracil loaded nanoparticles have potential to act as an anticancer drug delivery system that may be useful in clinical applications.

## Synthesis and Properties of Phosphorus-doped $\gamma$ -Al<sub>2</sub>O<sub>3</sub> with Ordered Mesoporous Structure

Ying Zheng\*, Xiaohua Chen, Xuelin Zheng, Shimin Wang and Qinhui Chen

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### Abstract

Ordered mesoporous phosphorus-doped  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> with high thermal stability has been successfully synthesized through a simple sol-gel method with the assistance of acetic acid as interfacial protector. Since P<sup>5+</sup> ionic radius is less than that of Al<sup>3+</sup>, it is possible for P<sup>5+</sup> ions to occupy the oxygen tetrahedral gap in the network of  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>, resulting in the decrease of the aluminum atoms in tetrahedral positions and relative increase of the aluminum atoms in octahedral sites. As a result, the obtained P-doped OMA samples demonstrate higher thermal stability. Taking the as-synthesized phosphorus-doped alumina as carriers, Pd-supported catalysts were obtained and effectively improved the catalytic activity, especially for the CO oxidation reaction. As compared with un-doped OMA, the d orbital of P<sup>5+</sup> in the P-doped OMA samples can accept a portion of donors of Pd<sup>2+</sup>, hence resulting in the weakened Pd-C interaction and enhanced C-O interaction of the linearly absorbed CO mode (Pd<sup>2+</sup>-CO), which may be beneficial to the CO oxidation reaction. The consequence was proved by the *In situ* DRIFTS spectra of chemisorbed CO analysis. Meanwhile, the addition of phosphorus may lead to the increasing of the amount of oxygen vacancy, which also has an effective influence on the CO oxidation reaction. The doping of phosphorus can improve the surface acid-base properties of the catalytic supports, which could effectively enhance the HC conversion of the catalysts.

## Effect of Growing Conditions on the Adaptation of Bacteria Cultures Exposed to Nanoparticles

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### Abstract

Several studies have documented the capability of bacteria to modify their phenotype in response to stress in environmental and xenobiotic conditions. With the increase used of anthropogenic nanoparticle, studying the response mechanisms of bacteria to nanoparticles exposure is extremely relevant. In order to assess extreme and environmentally relevant conditions the *Escherichia coli* (K-12 MG1655) (*E. coli*) was exposed to acute and chronic levels of casein-coated silver nanoparticles (AgNPs) [1 mg/L], at two specific growth rates ( $\mu_1=0.1 \text{ h}^{-1}$  and  $\mu_2=0.2 \text{ h}^{-1}$ ) using continuous reactors. The experiments were performed in multiplex bioreactor systems in which six vessels could be operated simultaneously. Bacteria collected from the effluent of the bioreactors were used to determine the minimum inhibitory effect (MIC) for AgNPs in terms of growth, respiration, and

membrane permeation.

Preliminary results showed that *E.coli* culture at steady state conditions reached a second steady state after exposure to AgNPs. This second steady stage occurred faster in the cultures growing at  $\mu_1$  than those growing at  $\mu_2$ . The statistical analysis of MIC results showed a difference between the percentage of disturbed cell membrane (DCM) among bacteria exposed to AgNPs and control cultures. *E.coli* exposed to AgNPs showed lower DCM than control cultures with 8% DCM at  $\mu_1$ , and 6% DCM at  $\mu_2$  while control cultures showed 18% and 23% DCM at  $\mu_1$  and  $\mu_2$ , respectively. In term of respiration rate, treated *E. coli* growing at  $\mu_1$  showed 12% less reduction of respiration rate in comparison with the non-treated growing at the same specific growth rate. Growth studies results did not show any statistical differences between the non-treated and treated group for both specific growth rates.

In conclusion, continuous reactors by controlled specific growth rate can elucidate phenotypic changes that bacteria can present due to continue chronic exposure of nanoparticles. Future experiments will include growth kinetic parameters to fully understand the impact of the growth conditions in the adaptation of bacteria exposed to nanoparticles.

## Distinguishing between Role of Porosity Size Distribution and Porosity Morphology on the Elastoplastic Response of an Infinite 2D Extra Cellular Matrix

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### Abstract

The topology of natural tissues consists of a porous media demonstrating a relative extend of hierarchy—or ordering—and a variety of porosity size scattering. The relative ordering and the variation of the size in the distribution of porosities both are deterministic to the fate of the embedded cells via determining the mechanical properties of the Extra Cellular Matrix (ECM) which hosts the living cells. However, the distinct role of the ordering and the separate role of variations of the porosity size distribution on the mechanical properties of the tissue are less distinguished in the literature. In this study, the role of ordering in morphology of hexagonal-like porosities and the role of their size distribution on the mechanical response of the tissue are systematically investigated. Finite element approach together with a non-linear homogenization technique are used to capture the elasto-plastic behavior of 2D infinite porous environments. It is shown that the degree of ordering and the size distribution of the porosities may not distinguishably influence on the elasticity of the ECM. However, the post-yield response of the ECM can highly be influenced by the degree of ordering in distribution of porosities in the system. On the other side, increasing the scattering of the porosity size distribution can deteriorate the mechanical strength of the tissue in a macroscopic scale.

## DNA Barcoding of Ichthyoplankton in Hampton Roads Bay Estuary

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### Abstract

Zooplankton is composed of animals that drift within the water column. The study of zooplankton biodiversity and distribution is crucial to understand oceanic ecosystems and the effects of climate change. In this study, our focus is on ichthyoplankton (fish eggs and larvae). Our aim is to employ molecular genetic techniques such as DNA barcoding to begin a detailed characterization of ichthyoplankton diversity, abundance and community structure in the Hampton Roads Bay Estuary (HRBE). A sampling of zooplankton was performed on June 19, 2015. Samples were taken with a 0.5m, 200  $\mu$ m mesh net in triplicates at two stations: inner shore in the mouth of Jones Creek and 5 miles off of the lower part of Chesapeake Bay. Physical parameters (dissolved oxygen, salinity, temperature and water transparency) were measured simultaneously. Species were identified by DNA barcoding using the mitochondrial DNA (mtDNA) of the Cytochrome Oxidase 1 (CO1) gene. Fish eggs were identified from *Opistonema oglinum* (Atlantic Thread Herring) at the offshore stations while, *Anchoa mitchilli* (Bay Anchovy) was found at both stations. Both were known to exhibit a certain salinity tolerance. This work indicates that using mtDNA-CO1 barcoding is suitable to identify ichthyoplankton to the species level and helped validate DNA barcoding as a faster taxonomic approach. This data will be a reference for broad monitoring programs; for a better understanding and management of ecologically and commercially important species in the HRBE.

## Introducing the Effect of ZnO Nanostructures on Enhancing Thermal Stability of Natural Polymers in Polymer Flooding Application

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### Abstract

Natural polymers are limited to less deep reservoirs due their fast thermal degradation compared to synthetic polymers such as polyacrylamides. Furthermore, natural polymers generally have an excellent viscosifying power in high salinity as well as resistance to shear degradation. Although such characteristics are highly desired in deeper reservoirs but natural polymers are usually not used due to their thermal degradation. In the work done, various zinc oxide nanostructures such as Electrospun Nanofibers, Nanowires, Nanorods and Nanoparticles were synthesized and mixed with guar gum polymer. Such structures have varying particle sizes and diameters that directly affect their surface to volume ratio and subsequently affect the thermal degradation temperature. Each of the fabricated nanostructures go through different techniques of characterization in order to examine their structural morphology, chemical composition, functional groups, and their specific surface area using Scanning Electron Microscopy (SEM), Raman, X-Ray Diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Brunauer–Emmett–Teller (BET), and Thermogravimetric Analysis (TGA). In this work, the characterization techniques executed verified the existence of zinc oxide in different structures with different specific surface areas. The Thermogravimetric Analysis tests performed upon guar gum polymer have shown that mixing the polymer with higher specific surface area nanostructures increased its degradation temperature hence enhancing the polymer's thermal stability.

## Cellulose Fibers Functionalized by Metal Nanoparticles Stabilized in Dendrimer for Formaldehyde Decomposition and Antimicrobial Activity

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### Abstract

Viscose rayon cellulose fiber was selectively oxidized so that carboxylate functional group was introduced on the fiber. Enough dispersed platinum nanoparticles and silver nanoparticles having average sizes of around 5 nm with small size distribution were prepared with capping of amine-terminated poly(amido amine) dendrimer and they were immobilized on oxidized fibers through amidation between terminal amine groups of dendrimer and carboxylic acids on oxidized fibers. The fiber containing dendrimer (1 wt%) and platinum (2 wt%) exhibited the 84 times higher adsorption capacity for formaldehyde gas on dendrimer site than on fiber site and the catalytic efficiency (65%) towards decomposition of formaldehyde gas adsorbed on the dendrimer site, and the silver (0.2 wt%)-loaded fiber revealed excellent biocidal activity against *E. coli*. Thus, it can be noted that the immobilization of functional metal nanoparticles protected by dendrimer on cellulose fibers is effective to produce efficient textile products with smart functions like the degradation of causative agents for sick building syndromes.

## Evaluation of Cy5-conjugated Polymeric Nanogels on 3D Spheroid Tumor Model of BT-474 Breast Cancer Cells

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### Abstract

Polymeric nanogels are being studied as drug delivery carriers for BT-474 breast cancer cells at The University of Nebraska Medical Center. Cy5-conjugated copolymer PEG-b-PGlu150 was grafted with phenylalanine methyl ester moieties (25, 50, and 75 substituted units) using EDC as the coupling reagent. The nanogels were cross-linked using ethylenediamine to a targeted degree of 20%. Using these Cy5-conjugated nanogels, we monitored their penetration abilities into 3D spheroid tumor model of BT-474 breast cancer cells, over a 2 h, 4 h and 8 h time period using Zeiss LSM 710 confocal microscopy. In this study, we found that RAS(150-50)-NG is the most proficient at penetrating the BT-474 tumor spheroids due to its relatively small size. Thus, this drug delivery system has been proposed as a potential approach to improve the efficacy of delivery of chemotherapeutic drugs for breast cancer therapy.

## Facial Layer-by-layer Engineering of Upconversion Nanoparticles for Gene Delivery: NIR Initiated FRET Tracking and Overcoming Drug Resistance in Ovarian Cancer

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### Abstract

Development of multidrug resistance (MDR) contributes to the majority of treatment failures in clinical chemotherapy. We report facial layer-by-layer engineered upconversion nanoparticles (UCNPs) for near infrared (NIR) initiated tracking and delivery of small interfering RNA (siRNA) to enhance chemotherapy efficacy by silencing the MDR1 gene and resensitizing resistant ovarian cancer cells to drug. Layer-by-layer engineered UCNPs were loaded with MDR1 gene-silencing siRNA (MDR1-siRNA) by electrostatic interaction. The delivery vehicle enhances MDR1-siRNA cellular uptake, protects MDR1-siRNA from nuclease degradation, and promotes endosomal escape for silencing the MDR gene. The intrinsic photon upconversion of UCNPs provides an unprecedented opportunity for monitoring intracellular attachment and release of MDR1-siRNA by NIR initiated fluorescence resonance energy transfer (FRET) occurs between donor UCNPs and acceptor fluorescence dye labeled MDR1-siRNA. Enhanced chemotherapeutic efficacy *in vitro* was demonstrated by cell viability assay. The developed delivery vehicle holds great potential in delivery and imaging-guided tracking of therapeutic gene targets for effective treatment of drug resistant cancers.

## Development of Nanotechnology Commercialization Index

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### Abstract

Although there has been a great interest in nanotechnology commercialization with its significance, there have been only a few researches on index of technology transfer and commercialization achievement evaluation since 1960.

In this research, we studied previous researches on various indices measuring the level of technology transfer and commercialization achievement, and empirically investigated a critical index measuring them. We used AHP analysis to find challenges in the field of technology commercialization evaluation, and suggested appropriate strategies to solve them. We selected total 82 candidate indices through reviewing previous 14 reports on global technology transfer commercialization achievement index. Also, we carried out questionnaire surveys twice to empirically investigate indices, which affect measuring the technology transfer commercialization achievement. From the results of surveys, finally AHP analysis was carried out to investigate proper index of nanotechnology commercialization evaluation.

As a result, in order to improve nanotechnology commercialization, S. Korean government should politically focus on capability of nanotechnology commercialization agency as well as development of DB for searching technology, plan/ strategy of technology transfer commercialization agency, collaboration in technology transfer and commercialization, and royalty income compared to R&D expenses. In addition, S. Korean government should develop policies to support a variety of related agencies and their collaboration, regarding to infrastructure construction policy of major nanotechnology commercialization agencies.

## Investment Efficiency Evaluation of Nanotechnology R&D Programs in S. Korea: Focused on Detailed Technical Fields

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### Abstract

In this research, the efficiency of nanotechnology R&D programs is objectively measured by systematically evaluating the inputs and outputs of nanotechnology R&D programs, and then implications for efficiency enhancement and strategic budget allocation are derived. For this purpose, DEA models are utilized on data obtained from National Science and Technology Knowledge Information Service to conduct the efficiency evaluation for each nanotechnology area, each R&D stage, and each subject institution. By analyzing and comparing efficiencies between nanotechnology areas, R&D stages, and subject institutions, implications for efficiency enhancement and strategic budget allocation are derived.

## Utilizing Quantum Computing within Nanotechnology

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### Abstract

New technologies are emerging yearly with every enhancement. With technology getting faster and smaller, security is needed at a much higher rate due to privacy issues. Nanoscience and nanotechnology are both the now and the future. Nanotechnology can be the vanguard of innovations for security. Often times, security has the lowest priority when implementing new ideas. This lack of thought could cause a host of vulnerabilities in the implementation, thus creating a negative stigma for the technology. Quantum Computing combines concepts from classical information theory, computer science, and quantum physics. Quantum Key Distribution is a subset of Quantum Computing. Quantum Key Distribution is a method of using quantum states to establish a random secret key for encryption. Quantum Key Distribution promises unconditional security in data communication and is currently being placed in commercial applications. Nanotechnology is evolving and creating the need to develop Quantum Key Distribution. Is security keeping pace with these changing advancements in technology? This research will focus on possibility of quantum computing systems can be transferred to nano-science/nanotechnology. Also, the research will include how quantum computing can enhance the security of nanotechnologies without hindering the capabilities.

## Langmuir-Blodgett Assembly of Molecules and Nanoparticles at the Air-Water Interface: Control on Organization and Tuning of Optical Properties

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### Abstract

Langmuir-Blodgett (LB) technique is an elegant method for assembling molecules/nanoparticles at the air-water interface and transferring them on to suitable substrates in the form of ultrathin films. Mechanical control over the aggregation of molecules is a major advantage over other thin film fabrication techniques. Interaction between the amphiphile molecules and nanoparticles/ions at the air-water interface and fabrication of corresponding LB films is the focus of the work that we present. Gold nanoparticles could be assembled in to extended chains at the air-water interface on Langmuir film of an amphiphile; the aggregation process induced in nanoparticles as result of the interactions was shown to follow Langmuir- Hinshelwood kinetics. The study inferred an increase in size as well as connectivity for nanoparticle networks in fabricated LB films with deposition pressure and an unusual blue shift in absorption peak of the networks. In another study, Fluorescence of an amphiphilie was shown to be affected in presence of silver nanoparticles assembled on to it; slight variation in the assembly sequence generated contrasting fluorescence responses. Polymerization of N-octadecyl aniline (NOA) was carried out at the air-water interface by introducing oxidizer under the Langmuir film. While ammonium persulphate produced the polymer poly(N-octadecylaniline) (PNOA), chloroauric acid ( $\text{HAuCl}_4$ ) gives the polymer nanocomposite, PNOA\_Au. Polymerization in LB trough under surface pressure control enabled study of kinetics of the process, revealing higher rates with  $\text{HAuCl}_4$ . Microscopy analysis of the LB films transferred reveal PNOA and PNOA\_Au in the form of well-organized nanofibers aligned parallel to direction of compression in LB trough.

## Studies on Hydrogen Production from Ammonia Over Cobalt Incorporated Carbon Nanomaterials

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### Abstract

Characterization and activity tests of carbon nanotube mesoporous carbon and active carbon supported cobalt incorporated nanocatalysts for hydrogen production from ammonia were carried out. Catalysts were synthesized following the impregnation procedure and different cobalt precursors, namely cobalt nitrate and cobalt acetate, were incorporated at different loadings. Structural properties of catalysts were determined by XRD, azot physisorption and SEM-EDS techniques. Reaction experiments were carried out in a continuous flow packed bed reactor using 0.1 g of each catalyst under the flow of pure ammonia with 60 ml/min at reaction temperatures between 400 and 700 °C. Carbon Nanotube supported catalysts have higher surface area than active carbon or mesopors carbon supported ones. Cobalt oxide crystals were observed in the structure of all the synthesized catalysts while some chlorine particles were determined in the structure of catalysts prepared using cobalt chloride in spite of applied thermal steps. Among the catalysts having the same metal loading in their synthesis solution, higher amount of cobalt was

determined in the structure of carbon Nanotube supported catalysts in comparison to active and mesopores carbon supported ones according to EDS results. Total conversion was achieved over carbon nanotube supported cobalt acetate incorporated catalysts such as CoAs@CN(0.1) at 600 °C. At 500 °C, other compounds ammonia conversion values 100%. Under the same reaction conditions, among the Nanotube carbon supported catalysts, cobalt acetate incorporated ones show the highest activity in hydrogen production from ammonia. It was seen that the activities of active carbon, mesopores carbon supported cobalt catalysts were lower than nanotube supported cobalt catalysts due to structural differences.

## **Fabrication of Flexible Low Temperature Polycrystalline Silicon TFT via the Novel Pillar Structures with Improved Transfer Efficiency**

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### **Abstract**

Flexible electronics had attracted considerable attentions for fundamental investigations and future applications in domains of nanoelectronics, photonics, nanobiotechnology and nanomedicine. Moreover, flexible integrated circuits (ICs) using thin-film transistors (TFTs) would enable different applications beyond traditional electronics products, like flexible displays, epidermal electronics and electronic textiles. To achieve better flexible electronics products, devices were usually fabricated on temporary substrates which could sustain high temperature, and then transferred fabricated devices to another substrate. However, during transfer processes, devices were easily flown away with sacrificial layers together. To solve this problem, special pillar structures were proposed to improve the transfer efficiency.

Firstly, the silicon wafer with 1- $\mu\text{m}$ -thick wet oxide was used as the substrate. Then 100-nm-thick  $\text{Si}_3\text{N}_4$  was deposited to act as the separation layer. After the standard RCA cleaning process, the 50-nm-thick  $\text{SiO}_2$  was deposited and patterned to act as the sacrificial layer. Another 100-nm-thick  $\text{Si}_3\text{N}_4$  was deposited and followed by the fabrication of TFT devices with 500-nm-thick  $\text{Si}_3\text{N}_4$  passivation layer. Via lithography and dry etching, variant  $\text{Si}_3\text{N}_4$  layers above the  $\text{SiO}_2$  sacrificial layer would be etched, then the wafer was dipped in the buffered oxide etch (BOE) solution to etch these dummy oxides to complete pillar structures. Then pyrogenic silica and PET were used to finish transfer processes. Finally, high performance low temperature polycrystalline silicon (LTPS) flexible electronics could be achieved and showed good electrical characteristics. Moreover, the transfer efficiency could be successfully improved from 5% to 90% via these special pillar structures.

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