Sustainable
Nanotechnology
Organization

Research | Education | Responsibility

ABSTRACTS
2013

Oral presentations followed by Posters
Alphabetical by first name of first author

ORAL PRESENTATIONS

CLEAN ENERGY FROM ETHANOL

A. Kowal, Institute of Non-ferrous MetalCentral Laboratory ofs

R, Adzic, Brookhaven National Laboratory

M. Kopczyk, Institute of Non-ferrous MetalCentral Laboratory ofs

The possibility of obtaining electrical energy from bio-ethanol has caused increased interest in Direct Ethanol Fuel Cells (DEFC). Currently-available commercial platinum nano composites do not ensure complete combustion of ethanol. Two-component catalysts containing Pt and SnOx, characterized by higher selectivity, are still not satisfactory. Catalyst which effectively oxidize ethanol and split the C-C bond in ethanol at room temperature was prepared in 2005-2009 [1- 4]. In order to improve the efficiency of high-temperature solid oxide fuel cells (SOFCs), particularly those utilizing ethanol as a fuel (ESOFC), catalysts have been researched which increase the power density of such a fuel cell. In order to find the most effective catalyst, research was conducted in the field of nano-oxides such as SnO2, SnO2/Sb2O5, CeO2 and TiO2. The physicochemical properties of such synthesized oxides were evaluated using XRD and SEM. These oxides were then deposited on nickel foam in an external reformer, which was placed before an anode of the SOFC . It was found that a Ni/CeO2 catalyst placed in external reformer gives the highest power density of ESOFC (Ethanol Solid Oxide Fuel Cell).

THE EFFECTS OF NANOTECHNOLOGY IN NON-R&D SECTORS: INSIGHTS FROM ECONOMIC THEORY AND HISTORY

Aashish Mehta, Center for Nanotechnology in Society - UCSB

Abstract: There appear to be no empirical studies of the effects of nanotechnology on non-R&D employment opportunities. This reflects data constraints that arise because standard economic classifications do not identify nano-products or nano-jobs, and because firms do not publish accounts of who or how many are involved in producing nano-enabled products.

I therefore review economic theory and history to assess the likely effects of greater nanotechnology utilization on employment. I distinguish between general purpose technologies (GPTs) and non-GPTs. I derive sets of micro-economic conditions under which a non-GPT increases/decreases the demand for labor. These sets of conditions are corollaries to claims of job creation, and may be empirically verifiable. I use this framework to discuss the likely employment implications of some key existing nano-enabled products. Next, I argue that if nanotechnology does unlock new GPTs, their productive

characteristics are likely to be similar to those of some previous GPTs: they will probably involve scale economies, push workers into jobs producing non-nano products, and lift demand for highly educated workers. The likely employment effects of nanotechnology development will therefore be familiar, but nonetheless strengthen the case for more effective public intervention to increase equality of educational and employment opportunity.

PLANT-NANOPARTICLE INTERACTIONS: TRANSDISCIPLINARY RESEARCH AT MOLECULAR LEVEL

Achintya Bezbaruah, North Dakota State University

Anurag Sharma, Chunju Gu, Khurram Sheikh, Amanda Grosz, Katelyn Jipson, Priyanka Deka, Achintyamugdha Sharma, Kalpana Katti, Dinesh Katti, Jose Gonzalez, Marinus Otte, Donna Jacob, Achintya Bezbaruah, North Dakota State University

Abstract: The interactions between engineered nanoparticles (single-walled carbon nanotubes/CNT and ZnO) and plants was investigated. Spinach and rice cells and DNA were extracted, exposed to nanomaterials, and tested in this NIFA-USDA supported research. Spinach leaves from 4-8 weeks old plants are collected for chloroplast cell isolation and DNA separately is extracted from spinach leaves. CNT (0-50 mg C/L) and Zn nanoparticles (0-500 μM Zn) and 1 mL of chloroplast cell (or DNA) suspension are allowed to interact for definite amount of time. Electron microscopy with electron energy loss spectroscopy, atomic force microscopy, and Polymerase Chain Reaction protocol were used to compare the samples and controls. Simultaneous in-vivo, in-vitro experiments, genetic, and molecular dynamic modeling experiments confirm that here are molecular level changes in plants due to nanomaterials exposure. This supported by NIFA-USDA (Grant# 2012-67018-30186).

RESOURCE RECOVERY FROM WASTEWATER USING MAGNETIC NANO-ADSORBENTS

Adam Marsh, University of Wyoming

Jonathan A. Brant, University of Wyoming

Abstract: Recovering valuable resources and nutrients from municipal and industrial wastewaters is a promising path towards achieving zero waste within the water energy nexus. Industrial wastewaters contain high concentrations of economically valuable metals and municipal wastewater contains significant concentrations of nutrients like phosphates and nitrates. Surface functionalized magnetic nanoparticles present the possibility of rapid, effective, low energy resource recovery from wastewater. By selecting an appropriate surface coating the magnetic nano-adsorbent can be selective to the specific element or compound that is to be removed from solution. Furthermore, because the maghemite core is paramagnetic the nano-adsorbent may be removed from complex mixture using a magnetic field. This avoids the need for clarification and/or filtration systems. These characteristics greatly reduce the equipment footprint and energy required to recover elements of value from wastewaters. To realize these advantages, an array of complex technical challenges, including particle stability, selectivity, regeneration and surface functionalization must be overcome. This presentation will cover our work to

date on the synthesis and performance of surface functionalized magnetic nano-adsorbents for recovering phosphates and copper from complex source waters (municipal wastewater, desalination concentrate streams, and oil and gas produced waters).

NANOMANUFACTURING AND SUSTAINABILITY: OPPORTUNITIES AND CHALLENGES

Ahmed Busnaina, Northeastern University

Joey Mead, University of Massachusetts Lowell

Jacqueline Isaacs, Northeastern University

Abstract: New nanomanufacturing technologies, although still in research labs, present a great opportunity to drastically reduce the cost of making nanostructures on a large scale and at high-rates. Such new bottoms up directed assembly based approaches involve adding materials selectively thereby both reducing waste and the number of required processes. Directed assembly based processes are conducted at room pressure and temperatures which significantly reduces the cost of nanomanufacturing equipment and tools, ensuring long-term sustainability by reducing energy, consumables, and waste costs. This paradigm shift in nanomanufacturing will unleash not only a wave of creativity in sustainable nanomanufacturing but lessons learnt along the way can be used in various other sectors. Along with the exquisite technological promise that nanotechnology holds, nano-enabled products are heralded as a means for energy and resource reduction, resulting in potential manufacturing cost reductions and further, for potential improvements to environmental remediation. Sustainable nanomanufacturing will, by dramatically lowering current nanomanufacturing barriers, spur innovation and the creation of entirely new industries by leveling the playing and ultimately leading to the democratization of nanomanufacturing.

MATERIAL PROPERTIES THAT CONTROL THE CYTOTOXICITY OF ZNO NANOPARTICLES

Alex Punnooose, Boise State University

Jordan Chess, Boise State University

Jeffery Greenwood, Oregon State University

Abstract: We have investigated the roles of electrostatic charge, crystallite size, surface structure, catalytic activity, and hydrodynamic size of a series of well characterized ZnO nanoparticles (with sizes ~ 8nm) on their cytotoxicity to resting primary human immune cells (T lymphocytes), Jurkat T cell leukemic and Hut-78 lymphoma T cell lines, and embryonic zebrafish. Zinc oxide NPs were prepared using two

similar chemical hydrolysis methods, one in diethylene glycol (ZnO-I) and the other in denatured ethanol solutions (ZnO-II), both prepared from the same zinc acetate dihydrate precursor. By varying the reaction conditions, surface charge of the particles was varied between +10mV and +48mV. X-ray diffraction (XRD) and TEM studies confirmed that the samples were high purity single phase wurtzite ZnO. Photoluminescence measurements demonstrated similar band gap energy. However, the ZnO-II samples showed a significant broad emission near 527nm, often attributed to emission involving surface traps, while the same was completely absent in the ZnO-I samples. These studies have shown that the cytotoxicity of all ZnO-I samples is significantly higher than that of ZnO-II samples, indicating the strong role of with synthesis method/conditions. The cytotoxicity of ZnO nanoparticles showed significant variations with changing zeta potential, catalytic rate constant, and hydrodynamic size.

ECONOMIC ANALYSIS OF MANUFACTURING OF CNT LI-ION BATTERIES

Ali Hakimian, Northeastern University

Jacqueline Isaacs, Northeastern University

Thomas Cullinane, Northeastern University

Abstract: Recent advances in nanotechnology have resulted in the development of advanced lithium-ion batteries enhanced with CNTs that has much greater energy density than the common lithium-ion batteries. CNTs propose great potential for improving the battery cells in terms of conductivity and the capacity.On the other hand, using CNTs in manufacturing of the newly developed lithium-ion batteries may cause the manufactures to consider some extra safety parameters in their production lines for preventing the potential harms of CNTs toward the human health and the environment. Having the extra safety parameters in the production line will affect the total cost of fabrication of batteries.This study investigates the cost of different drivers of the newly developed CNT lithium -ion batteries. A process based technical cost model is developed for the manufacturing phase of CNT lithium manganese oxide batteries. By performing the sensitivity analysis, the best scenario in terms of alternative materials, resources, number of labors, and number of machines of the projects can be determined. There are five categories of goals which try to improve in the new generation of lithium-ion batteries: energy, power, lifetime, safety, and cost. Of these five goals, cost may be the most challenged and uncertain one.

SYNCHROTRON MICRO-XRF AND MICRO-XANES CONFIRMATION OF THE UPTAKE AND TRANSLOCATION OF TIO2 NANOPARTICLES IN CUCUMBER FRUIT (CUCUMIS SATIVUS L.)

Alia D. Servin, University of Texas at El Paso

Hiram Castillo-Michel, European Synchrotron Radiation Facility

Jorge L. Gardea-Torresdey, University of Texas at El Paso

Abstract: The profuse use of nanoparticles (NPs) in consumer products has raised concerns about their impacts in environmental and human health and a possible transfer to the food chain through plants. In this research, the impact of TiO2 NPs was evaluated in (Cucumis sativus L.) plants grown in hydroponics and soil. Hydroponically grown plants were cultivated for 15 days with 0-4000 mg/L of TiO2 NPs, and their vegetative tissues analyzed using synchrotron X-Ray fluorescence technique. In soil, the cucumber seeds were germinated and grown to full maturity with 0-750 mg/kg of TiO2 NPs. At harvest, the fruits were analyzed using synchrotron μ-XRF, μ-XANES and spectroscopic techniques and biochemical assays. Results from hydroponics experiments, showed that TiO2 significantly increased root length at all concentrations (average >300%). In addition, the μ-XRF, μ-XANES showed that the TiO2 NPs were taken up from the hydroponic solution and transported through the xylem from the root to leaves and trichomes as TiO2. Results from soil experiments, showed a significant increase in catalase activity at all NP concentrations and a decrease in APX activity at 500 mg kg-1 in cucumber leaves. μ-XRF and μ-XANES results showed that TiO2 NPs were translocated from the root to the fruit without biotransformation or crystal modification, suggesting that TiO2 NPs could be introduced into the food chain with unknown consequences.

DIFFERENCES IN THE MECHANISMS OF TOXICITY OF NANO SILVER AND IONIC SILVER IN BACTERIA

Angela Ivask, National Institute of Chemical Physics and Biophysics, Laboratory of Molecular Genetics, Tallinn, Estonia

Chitrada Kaweeteerawat, UCLA

Hilary Godwin, UCLA

Abstract: Silver nanoparticles are commonly used as antimicrobial biocides. A critical question for nanosilver producers and for policy makers is whether nanosilver materials are fundamentally new or whether they simply represent new ways to deliver ionic silver, which is known to be toxic to bacteria. Here, we describe how the members of a library of gene deletion strains in Escherichia coli respond to nanoparticles using a library of well-characterized silver nanoparticles in which size and surface charge/coating are systematically varied. These data provide genome-wide information about how the absence of specific proteins impacts sensitivity to different silver species. The results of these studies reveal that although many (but not all) silver nanoparticles elicit responses similar to that of ionic silver, most also elicit other biological responses as well, and that the pathways involved in these responses

are highly dependent on both the size and surface charge/coating of the particles. These results have important implications for how silver nanoparticles should be regulated and tested going forward.

OPTIMIZED DESIGN AND DEVELOPMENT OF SUSTAINABLE NANOMATERIALS - A TOXICOLOGICAL PERSPECTIVE.

Anna A Shvedova, Pathology & Physiology Research Branch/NIOSH/CDC, & Department of Physiology and Pharmacology, School of Medicine, WVU, Morgantown, WV

Green chemistry is a sustainable new area of the science encompassing chemicals and processes targeted to reduce negative impacts on human health and the environment. The necessity of developing novel nanomaterials that overcome intrinsic theoretical bulk limits by changing fundamental physicochemical properties while keeping manufacturing costs along with the foot-print of adverse health/environmental outcomes to a minimum is major goal. Research and development exploiting nanotechnology has the greatest potential to efficiently contribute to such vital goals by discovering products and practices that are ecologically sound providing enhanced energy and resource efficiencies. The transitions from a fossil based fuel to renewable clean biofuels are relying on the widespread implementation of sustainability not only in industries but in human lifestyles. This talk will be focused on studies addressing potential health effects caused by exposures to combustion products of biodiesel and to engineered nanomaterials. The objective of these studies is to identify the pathways through which inhaled biodiesel, man-made synthetic nanomaterials, and naturally derived nanoparticles (nano crystalline cellulose) aggravate lung injury and affect whole body immune responses The talk will also address important issues of computer based modeling to assess structural aspects of interactions of nanomaterials with target biomolecules, their complexes and other biostructures (eg, biomembranes). Finally, the mechanisms of toxicity will be discussed in the context of current regulations for protection and their sufficiency in environmental and occupational settings.

DIFFERENTIAL BEHAVIOR OF AL NANOPHASES

Armand Masion, CEREGE

Catherine Santaella, LEMIRE CEA Cadarache

Laetitia Shintu, ISM2

Abstract: Aluminum toxicity is usually attributed to dissolved species in general and the Al3+ ions in particular. The free ions are the main concern whereas complexed Al is less toxic. Regarding non-dissolved, there is a consensus that solid Al does not pose any toxicity problems. However, this is based

on the study of large objects (>µm), but little is known about the toxicity of nano-Al phases. We examined the toxicity of two Al nanophases, viz. nano-boehmite and the Al13 tridecamer, a nanosized Al polymer. Boehmite is a common Al oxyhydroxide; it is considered as non toxic. In a first approximation, nano-boehmite is also considered as harmless.Nano-boehmite as well as Al13 exhibit toxic effects toward P. Brassicacearum. Oxidative stress is a likely mechanisms. A remarkable point is the amplitude of the responses which differs greatly between AlOOH or Al13 The toxic effects in terms of survival rate observed with nano-boehmite occur also with Al13 at concentrations 100 tiems lower.The evolution of the Al speciation occurred on a timescale incompatible with NMR analyses. Ferron based determinations showed however that the Al13 nanophase becomes undetectable in the growth medium within 90 minutes. Proton NMR based metabolomics suggest that distinct metabolic routes are affected by nano-boehmite and Al13

EFFECTS OF BARE ZNO NANOPARTICLES ON GREEN PEA PLANTS (PISUM SATIVUM L.) CULTIVATED IN SOIL

Arnab Mukherjee, UTEP

Susmita Bandyopadhyay, UTEP

Jorge L. Gardea-Torresdey, UTEP

In this study, authors have studied the toxicological effects of ZnO NPs on green pea plants (Pisum sativum L.) by treating them with 0, 125, 250, and 500 mg/kg of ZnO NPs in organic matter augmented soil for 25 days and measuring resultant effects on the basis of plant growth, Zn bioaccumulation, chlorophyll production, H_2O_2 generation, lipid peroxidation (LPOX), stress enzyme activities (catalase [CAT] and ascorbate peroxidase [APOX]), using different cellular, molecular, and biochemical approaches. Results showed significant increase in root lengths but stem lengths remained unaffected (at $p \leq 0.05$). In root and stem, Zn accumulation increased in a concentration dependent manner. After 25 days, chlorophyll in leaves decreased by ~61%, 67%, and 77% in plants treated with 125, 250, and 500 mg/kg ZnO NPs, respectively, compared to control. At 500 mg/kg treatment, in leaves, H_2O_2 concentration and LPOX increased significantly compared to all other treatments. APOX concentration decreased in root and leaves compared to control. However, a decrease in CAT concentration was observed only in leaves. This work can serve as a good indicator for measuring the effects of ZnO NPs in terrestrial plants grown in organic matter enriched soil.

BROKEN PROMISES AND BREAKING GROUND – ANTICIPATORY GOVERNANCE RESEARCH AGAINST BUSINESS-AS-USUAL IN NANOTECHNOLOGY INNOVATION

Arnim Wiek, Center for Nanotechnology in Society, Consortium for Science, Policy, and Outcomes, Arizona State University, Tempe, AZ 85287, USA

Rider Foley, Center for Nanotechnology in Society, Consortium for Science, Policy, and Outcomes, Arizona State University, Tempe, AZ 85287, USA

David H. Guston, Center for Nanotechnology in Society, Consortium for Science, Policy, and Outcomes, Arizona State University, Tempe, AZ 85287, USA

Abstract: Despite widely spread calls for novel forms of governance, including real-time, anticipatory, and sustainability-oriented governance, nanotechnology continues to be largely innovated following conventional schemes. These include, commercialization as primary objective; dominant triple-helix network of industry, government, and research organizations; guided by compliance, not foresight; limited public involvement; paucity of cooperation across different sectors; and gaps in sharing and coordinating the fulfillment of critical responsibilities. The result is a wide spectrum of nanotechnologies, already on the market or in the making, that offer very little in support of addressing the major challenges societies face around the world. In fact, the majority of current nanotechnologies rather contribute to the challenges of over-consuming resources, aggravating environmental and human health risks, fostering violent conflicts, or widening the gap between the poor and the rich. While the current state of nanotechnology innovation stands in stark contrast to the promotional nano-safes-the-world promises, shifting the dominant schemes requires inconvenient decisions to be made, not only in government and industry – but in research as well. We outline a new role for research concerned with nanotechnology innovation that explores in reflexive and disruptive settings alternatives to the current governance schemes. While technology assessment has moved from real-time analysis to anticipatory procedures, we suggest now adopting Socio-Technical Integration Research (STIR) and intervention research methods to conduct participatory, real-world experiments on how to actually change nanotechnology governance towards responsible innovation. This presentation synthesizes insights from four years of research on nanotechnology innovation, anticipatory governance, and sustainability in urban environments, with a focus on Phoenix, Arizona.

REGIONAL AND LOCAL LIFE CYCLE RELEASES OF ENGINEERED NANOMATERIALS

Arturo Keller, UCSB

Anastasiya Lazareva, UCSB

nalysis of the life cycle impacts of engineered nanomaterials (ENMs) requires an understanding of ENM mass flows through various life cycle stages as well as life cycle ENM releases into the environment. We combined EMN market information and material flow modeling to produce the first global assessment of ENM life cycle flows and likely ENM releases to the environment and landfills. The top ten most produced ENMs by mass were analyzed in a dozen major applications. ENM releases during the

manufacturing, use, and disposal stages were estimated, including intermediate steps through wastewater treatment plants and waste incineration plants. We estimate that 63-91% of over 260,000-309,000 metric tons of global ENM production in 2010 end up in landfills, with the balance released to soils (8-28%), water bodies (0.4 – 7%) and atmosphere (0.1 – 1.5%). The global material flow estimates were then used to quantify regional ENM environmental releases, releases of ENMs in the United States, and local ENM releases in the San Francisco Bay Area. Additionally, Bay Area release estimates were used to estimate ENM concentrations in wastewater effluent and biosolids generated by Bay Area wastewater treatment facilities

INVESTIGATION OF SILVER NANOPARTICLE SORPTION AND DISSOLUTION IN QUARTZ COLUMNS

Ashley E. Hart, Clemson University

Brian A. Powell, Clemson University

Christopher L. Kitchens, Clemson University

Abstract: Silver nanoparticles (AgNPs) are currently available in over 1000 consumer products; as this number increases, the concern over environmental consequences becomes more important. Environmental nanoparticle transport is largely governed by nanoparticle composition, surface charge, surface coating composition, and size. This work examines the chemical/physical fate and transport of AgNPs with citrate and Suwanee River natural organic matter (SR-NOM) surface chemistries and the transport through IOTA-STD high purity quartz packed columns in the presence of NaCl, (CH3)4NClO4, and NaClO4. Transport of AgNPs stabilized with citrate or SR-NOM of diameter 5.9 ± 2.5nm and 7.6 ± 4.5nm, respectively, was monitored using miscible displacement, saturated flow column experiments. The first column was loaded with one pore volume of citrate-stabilized AgNPs, followed by several pore volumes of 0.001M NaCl, distilled deionized water, then 0.1M NaCl. Results showed an initial breakthrough curve followed by a second breakthrough curve. A third breakthrough occured after a 0.1M NaCl pore volume injection. AgNPs have a tendency to form soluble AgClx(x-1)- complexes as the Cl- to Ag ratio increases, which are thermodynamically favored. Interestingly the additional NP/electrolyte combinations did not display second or third breakthrough curves. It is possible that NOM inhibits AgNP dissolution in the presence of Cl-.

NANOSENSORS IN AGRICULTURE AND ENVIRONMENTAL SUSTAINABILITY

Ashok Mulchandani, University of California, Riverside

Abstract: Abundant, nutritious and safe food and an environment free of chemicals dangerous to health are essential for our well-being. Ensuring these require detecting and monitoring pests, pesticide residues, food spoilage, contaminants, pollutants, etc. in a sensitive and selective manner. Because of their integrated nature, biosensors are ideal for these applications as they can be portable and provide selective and sensitive rapid responses in real-time. This presentation will provide an overview of my research on the development and application of one-dimensional carbon nanostructures (such as conducting polymer nanowires, carbon nanotubes and graphene)-based chemiresistor and field-effect transistor bio- and chemical-sensors for detection of proteins, viruses, spores, bacteria, pesticides, air contaminants, etc. that has applications in agriculture and environment monitoring.

TOWARDS ANTICIPATORY LIFE CYCLE ASSESSMENT: A CASE STUDY OF NANOTECHNOLOGY

B.A. Wender, Arizona State University

R.W. Foley, Arizona State University

Thomas P Seager, Arizona State University

Abstract: Life cycle assessment (LCA) is a powerful framework to explore the environmental impacts of products, processes, and technologies because its broad boundaries prevent the shifting of environmental burdens from one life-cycle phase to another. Policymakers increasingly call for tools such as LCA to identify social and environmental concerns early and guide the development of emerging technologies, including nanotechnology, towards decreased burden. However, LCA is ineffective at promoting the integration of social and environmental research into nanotechnology innovation for at least two reasons: 1) LCA is largely retrospective, relying heavily on data collected from mature industries with existing supply chains, and 2) LCA isolates environmental impacts from salient institutional, social, political, and economic drivers of nanotechnology development. On the contrary, social values are incorporated into LCA through boundary definition, functional unit selection, and impact category definition. This presentation describes anticipatory LCA as an alternative framework that emphasizes knowledge flows between distinct research efforts and elucidates how implicit social values determine LCA practice and results. This framework may broaden stakeholder and decision maker perspectives reflected in LCA, promote integration of social and environmental concerns into nanotechnology development through knowledge feedback, and increase the efficacy of LCA as a design tool.

GREEN SYNTHESIS: AN INTEGRAL PART OF SUSTAINABLE NANO

Barbara Karn, NSF

Abstract: Sustainable nanotechnology necessitates making new materials without generating the old pollutants. As such, the tenets of green chemistry apply to the production of nanomaterials. This presentation will discuss three aspects of green synthesis. First, how does green synthesis of nanomaterials fit into the bigger picture of sustainability. I will discuss examples of how making environmentally benign nanomaterials in an environmentally benign manner can influence major sustainability issues such as energy, natural resources, health. Next, an update on the state of green synthesis research will be given. Finally, examples of research using a variety of green techniques to make nanomaterials will be presented.

DNA REPAIR PROTEIN INHIBITION BY GOLD NANOCLUSTERS

Bryant C. Nelson, NIST

Abstract: An emerging research area in nanoscience is the design, development and characterization of nanoparticulate or nano-enabled therapeutics that can potentially inhibit the activity and/or modulate the expression of DNA repair proteins. The unique size-dependent cytotoxicity of 1.4 nm triphenylphosphine monosulfonate (TPPMS) coated gold nanoparticles (AuMS) to cancer cell lines motivates our investigation of them as potential DNA repair protein inhibitors. The base excision repair activity and specificity of hNEIL1 preincubated in the presence / absence of increasing concentrations of AuMS were tested using 40 Gy irradiated calf thymus DNA (ct-DNA) and quantitatively characterized using isotope-dilution GC/MS. The TPPMS nanoparticle coating was determined to have a negligible effect on NEIL1's enzymatic excision of the ring-opened formamidopyrimidine lesions (FapyA IC50 = 396 µM; FapyG IC50 = 291 µM). In stark contrast to this observation, when AuMS was preincubated with hNEIL1, there was strong AuMS dose-dependent inhibition of NEIL1's enzymatic activity (FapyA IC50 = 27 µM; FapyG IC50 = 23 µM). Further, when AuMS was preincubated with ct-DNA and then with hNEIL1, the previously observed strong dose-dependent inhibition was reduced (FapyA IC50 = 46 µM; FapyG IC50 = 60 µM), suggesting that the biological activity of AuMS may potentially be fine-tuned toward hNEIL1.

OPTICAL OBSERVATION AND HYPERSPECTRAL CHARACTERIZATION OF NANOMATERIALS IN-SITU

Byron J. Cheatham, Principal, CytoViva, Inc.

Abstract: Critical research is ongoing to quantify the potential benefits of nanoparticles in a wide range of industrial applications and for use as drug delivery vectors and disease biomarkers. Additionally, work

is being conducted to understand the long term fate of nanomaterials and their possible effect on the environment. These efforts all require an ability to observe and characterize nanomaterials without alteration as they interact with other materials and biological matrixes. A specialized hyperspectral microscope technology has been developed by CytoViva, Inc. to support these research needs. This technology utilizes patented darkfield-based microscopy illumination optics, creating high signal-to-noise images of nanomaterials interacting with both biological and materials samples. The integration of hyperspectral imaging with this high signal-to-noise microscopy technology allows the creation of high resolution spectral images. This enables the characterization of individual nano-particles based on their chemical composition and added functional groups. It also enables the ability to spectrally confirm the presence and location of nanomaterials as they are integrated into multiple environments. Examples illustrating the use of this technology with multiple nanomaterials applications will be presented.

POTENTIAL INHALATION EXPOSURE AND CONTAINMENT EFFICIENCY WHEN USING HOODS FOR HANDLING NANOPARTICLES

Candace SJ Tsai, Purdue University

Abstract: Inhalation exposure to airborne nanoparticles (NPs) has been reported during manual activities using typical fume hoods. This research studied potential inhalation exposure associated with the manual handling of NPs using two new nanoparticle-handling enclosures and two biological safety cabinets (BSC), and discussed the ability to contain NPs in the hoods to reduce environmental release and exposure. Airborne concentrations of 5 nm to 20µm diameter particles were measured while handling nanoalumina particles in various ventilated enclosures. Tests were conducted using two handling conditions and concentrations were measured using real-time particle counters, and particles were collected on TEM grids to determine particle morphology and elemental composition. Airflow patterns were characterized visually using a laser light sheet and fog. The average number concentration increase at breathing zone outside the enclosure was less than 1400 particle/cm3 for each particle size at all tested conditions and the estimated overall mass concentration was about 83 µg/m3 which was less than the dosage of typical nanoparticle inhalation exposure studies. The typical front-to-back airflow was used in the studied hoods, which could potentially induce reverse turbulence in the wake region. However, containment of NPs using studied hoods was demonstrated with excellent performance. Smoke tests showed that worker's hand motion could potentially cause nanoparticle escape. The challenge of front-to-back airflow can be partially overcome by gentle motion, low face velocity and front exhaust to reduce nanoparticle escape.

NANOTECHNOLOGY AND WATER TREATMENT IN MEXICO

Casey Walsh, UCSB

Laura Saldivar

Abstract: This paper discusses the role of nanotechnology in infrastructures that manage water quality in Mexico. During the last decade or so attention among Mexican water engineers has shifted from supply to demand, from quantity to quality, from public works to private, and from monumental to nano scales. Faced with serious contamination problems, social movements that demand environmental justice, and extreme socioeconomic difficulties in assuring water quality through conventional means, hopes have turned to new technologies that 1) treat water at a much smaller (micro and nano) scale, and 2) pay for themselves through the recovery of usable materials. Cases from Mexico are considered. Fieldwork conducted among scientists and government officials will clarify these two historical trends, determine how they are reshaping social and physical infrastructures, and assess their impact on the environment.

PUBLIC ENGAGEMENT IN SUSTAINABLE NANOTECHNOLOGY

Catherine Nameth, UC CEIN

Christine Truong, UC CEIN

Hilary Godwin, UC-CEIN

Abstract: Research on public engagement with science finds that adults attend public scientific events because it is an opportunity for them to interact directly with scientific researchers. Research on the Ethical, Legal, and Social Implications of Nanotechnology suggests that it is important to engage public audiences in substantive discussions about both the benefits and the potential risks of new technologies before these new technologies are introduced into the marketplace. These two concepts have informed our development of educational activities and public engagement programs at UCLA, the California Science Center, and the Santa Monica Public Library, wherein we explore, with our audience, both the positive contributions and the possible harmful side effects of nanotechnology. In this session, we will present a brief overview of our public engagement programming, and then we will highlight specific public engagement activities while discussing lessons learned from their design and implementation.

PREVENTING CARBON NANOTUBE-LEACHING FROM POLYMER MATRICES: A STUDY OF SULFONATED POLYSULFONE-CARBON NANOTUBE ULTRAFILTRATION MEMBRANES

Charles-Francois de Lannoy, Duke University

Katie Gloe, Virginia Tech

Mark Wiesner, Duke University

Abstract: CNTs can improve the properties of traditional polymer membranes used for water filtration and desalination. Research has shown that CNT-polymer nanocomposite membranes demonstrate increased water permeability, greater tensile strength, and resistance to biofouling, over polymer membranes. CNT stability within polymer products is important for effective and efficient long-term operation, but stability is particularly crucial in water filtration and desalination applications in order to avoid contaminating permeate waters. We have previously shown that CNTs mix-blended in polymer membranes leach from their matrices during membrane production and membrane cleaning. To prevent CNT losses, we have developed ionically bound, stable polymer nanocomposite membranes. This was achieved through simple CNT- and polymer-functionalizations. Sulfonated polysulfone membranes were formed with randomly oriented, bulk dispersed carboxylated and amylated multiwalled carbon nanotubes in quantities between 0.5 – 5.0 wt% with respect to the bulk polymer membrane. These membranes are characterized by a complete lack of CNT loss and leaching and further demonstrate increases in tensile strength and surface hydrophilicity. However, adverse changes to trans-membrane flux and rejection were observed. Improvements in polymer-CNT associations are needed for greater control over flux and rejection characteristics. This work suggests that sustainable nanomaterial solutions to environmental issues are possible with responsibly developed nanomaterials.

TOXICITY OF TITANIUM DIOXIDE NANOPARTICLES IN BRAIN

Christina Davis, University of Nebraska-Lincoln

Srivatsan Kidambi, University of Nebraska-Lincoln

Abstract: Nanotechnology has resulted in an exponential increase in the application of nanoparticles for drug delivery systems, antibacterial materials, cosmetics, sunscreens, and electronics with over 1000 nanotechnology based products already on the market. Among the manufactured nanoparticles, titanium oxide nanoparticles (TiO2) are among the earliest industrially produced nanomaterials and one of the most highly manufactured in the world. Recent studies on animal models have shown that exposure to TiO2 leads to nanoparticle accumulation in several organs including penetration of the blood brain barrier to the central nervous system. However, the toxicological effects of TiO2 on brain function have not been extensively investigated. In this work, we investigated the effect of TiO2 on primary neurons and astrocytes. We treated the neurons and astrocytes with Anatase, Rutile and Degussa P25 (70% Anatase, 30% Rutile) at a concentration of 10 ppm. We observed that the TiO2 exposure altered the neuron and astrocytes viability. Astrocytes treated with TiO2 also indicated a higher oxidative stress regime with P25 treated cells having the highest effect. Currently, we are

studying the effect of TiO2 on brain cells at a transcriptional level. We plan to further investigate the molecular mechanisms that drive the TiO2 mediated brain toxicity.

END OF LIFE POLICIES FOR NANO-ENABLED ELECTRONICS: INSIGHTS FROM CURRENT PRODUCT STEWARDSHIP PROGRAMS

Christopher Bosso, Northeastern University

Jennifer Nash, Harvard University

Jacqueline Isaacs, Northeastern University

Abstract: This study examines current policies in various U.S. states directed at the return and recycling of cellular telephones to understand the challenges facing policymakers seeking to manage next generation nano-enabled electronics at end of useful life. Such consumer products are likely to have built into them a range of nanomaterials in memory chips, batteries, and electro-magnetic (EMI) shielding. As the number of nano-enabled products rises, so does the likelihood that nanomaterials will end in municipal solid waste (MSW) landfills when products are disposed. As a result, a new generation of nano-enabled electronics may introduce novel EHS profiles, with subsequent impacts on extant recycling and disposal policies. Even assuming the absence of novelty, a new wave of nano-enhanced products is likely to exacerbate existing policy dilemmas, which include decisions whether to promote recycling over disposal / incineration. At present, there are no regulations governing disposal of nano-enabled electronics, so we focus on current product recycling policies, which in the U.S. largely exist at the state level, to assess how new nano-enbabled technologies might affect their operation and efficacy.

CELLULOSE NANOCRYSTAL - BIOPOLYMER NANOCOMPOSITES: BIOMIMICRY MEETS POLYMER PROCESSING

Christopher L. Kitchens, Clemson University

Jose Luis Orellana, Clemson University

Esteban E. Urena Benavides, Georgia Tech

Abstract: Cellulose nanocrystals (CNCs) are the nano-scale building blocks that provide natural fibers their unique and often unmatched properties. The goal of this work is to isolate these cellulose nanocrystals and use them as a reinforcing additive for polymers from renewable resources; taking a biomimetic approach to polymer nanocomposite design. This talk will present our recent work with CNC

nanocomposites of 1) alginate fibers and 2) polylactic acid films, as well as cellulose-based MEMS Devices.

CNCs are elongated nanoparticles of crystalline cellulose with an average length of 130nm, an average width of 20 nm, and an average height of 7 nm. This anisotropic structure and the chiral nature of the cellulose polymer results in unique phase behavior, specifically the formation of chiral nematic liquid crystals. CNC – alginate nanocomposite fibers were produced using a wet spinning process. It was found that when the apparent jet stretch (ratio of the fiber draw velocity to extrusion velocity) is kept constant, addition of the nanocrystals reduces the tensile strength and modulus of the material; however a small concentration of CNCs in the dope solution increases the toughness and enables an increase in the fiber spinning apparent jet stretch ratio by nearly two fold. Fiber spinning at the maximum jet stretch yielded a 38% increase in tenacity and a 123% increase in tensile modulus with 10%wt CNCs loading. This suggests that CNC alignment in the composites is a key factor influencing the mechanical properties.

Wide angle X-ray diffraction was used to determine the orientation of CNCs within the alginate nanocomposite fibers and provide correlations with the resulting mechanical property enhancements. The orientation of the CNC was studied from the azimuthal intensity distribution of the (2,0,0) reflection where the spread of the orientations increased with higher loads until the nanoparticles spiraled around the fiber axis. Increased fiber stretching during spinning retarded the appearance of a spiral assembly, increased CNC alignment and resulted in a stronger fiber. In short, the CNC orientation can be tuned with percent loading and fiber processing parameters, which directly impacts the resulting fiber mechanical properties. These findings are significant because similar behavior is also observed in natural fibers where cotton, a fiber with a higher elastic modulus possesses a higher spiral angle, while hemp, ramie and jute fibers are stronger fibers and the CNCs are more aligned with the fiber axis.

Additional work has demonstrated the ability to increase the toughness of PLA films with the addition of CNCs without compromising the film strength, the ability to create structural color within the CNC-PLA nanocomposite films, and initial work in the MEMS device formation with cellulose as a drop-in substitute for silicon.

LESSONS LEARNED FROM TEACHING AN INTRODUCTORY NANOTECHNOLOGY COURSE TO UNDERGRADUATES

Christopher L. Kitchens, Clemson University, Dept. of Chemical Engineering

O. Thompson Mefford, Clemson University, School of Materials Science and Engineering

Abstract: Over the past three years, we have taught an Introduction to Nanotechnology course to honors students at Clemson University. The class is open to honors students from all majors and classes and enrollment is limited to less than 20 students. This talk will present the methods employed in the course to instill what defines nanotechnology and nanoscience. It will discuss our experiences in teaching the material through active learning where the students were able to synthesize their own nanomaterials and then learn the characterization techniques by characterizing their own nanomaterials. This group-based hands-on experimentation lab component of the course has been very successful. In addition, guest lectures from other researchers from Clemson and University of South Carolina have also been popular. The students enjoy learning about the research being performed at the university and how the course material is relevant to that research. The talk will also cover some of our formative assessment and the lessons learned from teaching this course.

NANOPARTICLE TOXICITY ASSESSMENT IN A BACTERIAL MODEL

Christy L. Haynes, University of Minnesota

Robert J. Hamers, University of Wisconsin, Madison

Catherine J. Murphy, University of Illinois

Abstract: Engineered nanoparticles are found in many everyday products and hold great potential as therapeutic agents. Accordingly, it is critical to consider how engineered nanoparticles interact with physiological and ecological systems. This work focuses on functional assessment of bacterial cell behavior following exposure to Au, nanodiamond, and semiconductor nanoparticles. Functional considerations include biofilm formation, cell delivery of chemical messengers, production of reactive oxygen species, and gene expression, among others. In this new collaborative study, obtained bacterial toxicity results can be compared to those obtained in other model systems (lipid bilayers and the multicellular water flea, Daphnia) to identify common modes of nanoparticle interactions and the resultant effects. The goal of this work is to discover critical nanoparticle features that determine cellular toxicity and then redesign nanoparticles to promote sustainable use.

MULTI-FUNCTIONAL NANOCOMPOSITES

Clare Mahoney, Carnegie Mellon University

The progression of sustainable environmental technologies requires materials with property combinations unattainable using current materials. One example is the area of solid state lighting in which transparent polymer materials with higher thermal transport could increase lifetime of product,

decrease processing expense and leave a smaller ecological footprint. Polymer nanocomposite materials in which the properties of the matrix are augmented by the addition of inorganic fillers hold the promise to overcome existing challenges in solid state lighting. However, a primary challenge remains in the control of the scattering properties of the composite that limit the application of particle-filled polymers as materials for said application. To overcome these existing challenges, it is necessary to understand the origin of miscibility and optical scattering in composite material. Using surface initiated atomic radical polymerization (SI-ATRP) polymer grafted nanoparticles, it is possible to manipulate the nature of interfacial interactions between an inorganic filler and polymer matrix while keeping all other parameters highly controlled, resulting in better understandings on the influence of interface on miscibility and thermal transport in polymer nanocomposites

SORPTION OF RADIONUCLIDES USING NANOMETRIC CALCIUM TUNGSTATE

Cory Perkins, Oklahoma State University

Allen Apblett, Oklahoma State University

Abstract: Nuclear incidences such as the ones at the Fukushima nuclear plant in Japan and at Chernobyl along with the past detonation of nuclear weapons have highlighted the need for technologies to decontaminate aqueous systems containing radionuclides. While there are many potential solutions to the problem, it has been found that predictions about contaminant mobility often prove inaccurate while in situ cleanup technologies do not perform as well as expected. Calcium tungstate has proven to be an attractive candidate for remediation due to its high selectivity and capacity for sorption of radionuclides like 90Sr2+ and UO22+. Equally beneficial is the ability for the sorbant to be separated and regenerated for reuse, along with the isolation of the contaminants allowing for their proper disposal or reuse. This presentation will feature the synthesis of a calcium tungstate precursor along with sorption kinetics and capacity for Sr2+ and UO22+using nanometric CaWO4. Furthermore, the separation and regeneration of the starting material will also be demonstrated. For a more convenient reaction process, nanometric calcium tungstate was also tested on high surface area support pellets, leading to a more rapid uptake and recovery process.

CERIUM OXIDE NANOPARTICLES COMPROMISES THE QUALITY OF RICE (ORYZA SATIVA L.) GRAINS

Cyren Rico, The University of Texas at El Paso, University of California Center for Environmental Implication of Nanotechnology

Ana C. Barrios, The University of Texas at El Paso

Jorge L. Gardea-Torresdey, The University of Texas at El Paso, University of California Center for Environmental Implication of Nanotechnology

Abstract: The current knowledge on the implications of ENPs in the nutritional value of food crops is limited. This research was conducted to investigate the quality of rice grains harvested from plants grown in soil treated with cerium oxide nanoparticles (nCeO2). Three rice varieties (high, medium and low amylose) were cultivated to grain production in soil amended with nCeO2 at 0 and 500 mg kg-1 soil. Ce accumulation, nutrient content, antioxidant capacity, and nutritional quality of the rice grains were evaluated. Results showed that nCeO2 reduced the amount of Fe, S, prolamin, glutelin, lauric and valeric acids, and starch in rice grains. Moreover, the nCeO2 decreased the antioxidant capacity in grains, except flavonoids. Medium and low amylose varieties accumulated more Ce in grains than high amylose variety, but the grain quality of medium amylose variety showed higher sensitivity to the nCeO2 treatment. These results indicate that nCeO2 could compromise the quality of rice.

NANOTECHNOLOGY AND SUSTAINABILITY THROUGH INSURANCE MANDATESES

David Dana, Northwestern University

Abstract: Insurance mandates are one means of introducing regulation in the interest of sustainability that may be politically viable even when traditional substantive regulation is not an which may be more flexible and information-forcing than traditional substantive regulation. In particular, in new, fast-evolving industries, enlisting insurers as a kind of de facto private regulator may result in adaptive improvements in safety practices industry-wide, as insurers learn about about safer practices and incentivize insureds to follow them. One large question is whether private insurance for health and safety and environmental impacts is economically feasible absent some government guarantee of reinsurance of the insurance policies, so that insurers can limit their possible losses. The presentations will address the role for government in facilitating the development of the insurance market.

THE USE OF LIFE CYCLE TOOLS TO SUPPORT DECISION MAKING FOR SUSTAINABLE NANOTECHNOLOGIES

David E. Meyer, U.S. Environmental Protection Agency

Michael A. Gonzalez, U.S. Environmental Protection Agency

Abstract: Nanotechnology is a broad-impact technology with applications ranging from materials and electronics to analytical methods and metrology. The many benefits that can be realized through the

utilization of nanotechnology are intended to lead to an improved quality of life. However, numerous concerns have been expressed regarding the unchecked growth of nanotechnology and the unforeseen consequences it may bring. To address these concerns, nanotechnology must be examined under the microscope of sustainability. This work applies the life cycle perspective to first provide an understanding of the challenges facing the development of sustainable nanotechnology. A discussion of next-generation life cycle tools is used to examine how a harmony between policy and product development can be maintained using decision making for sustainability. This harmony will be most readily achieved using an enhanced risk management strategy for sustainability that combines sustainability assessment with sustainable chemical design.

ELECTRICALLY CONDUCTING CARBON NANOTUBE - POLYMER COMPOSITE MEMBRANES FOR FOULING PREVENTION

David Jassby, UC Riverside

Wenyan Duan, UC Riverside

Alexander Dudchenko, UC Riverside

Abstract: Electrically conducting carbon nanotube – polymer composite thin-film membranes are demonstrated to have anti-biofouling and anti-scaling properties when charged with low voltages. Here, we describe simple routes towards the creation of these membranes (UF and RO) along with detailed material and surface characterization, as well as performance characteristics. The carbon nanotubes are covalently bound through ester bonds with the different polymers used for the different membrane applications. The membranes boast high electrical conductivity (400 – 2000 S/m) excellent rejection properties, and high water permeability. When electrically charged, the membranes show superior anti-fouling properties. Electrically charged RO membranes demonstrate exceptional anti-biofouling properties, as well as anti-scaling properties when challenged with waters with high CaSO2 scaling potential. Electrically charged UF membranes significantly inhibit fouling by electrically charged biomolecules, such as alginate. In this presentation we offer experimental evidence of the membrane's performance as well as a theoretical basis for our observations. These membranes potentially offer significant benefits in the areas of wastewater treatment and reuse and brackish groundwater desalination.

GREENWASHING NANO AND DUE DILIGENCE

David M Berube, North Carolina State University, PCOST

Abstract: Nanotechnology has not captured the public attention (see survey upon survey in the USA and abroad). Advocates of nanotechnology are searching for new ways to embed nanotechnology favorably into the public consciousness. Many have made efforts to market science and technology much like we market products and services. Greenwashing is a PR or marketing strategy used to promote the perception that a product, aim, or policy is environmentally friendly. We must beware efforts to promote environmental considerations with terms like sustainable and green nanotechnology evoking environmental health, safety, and well-being when there is evidence to the contrary. Green nanotechnology involves claims about natural resource conservation, waste minimized production, and opportunities to remediate polluted sites. Add in claims about safe and affordable energy, water treatments and desalination, new approaches to recycling, and others and we have a rhetorical strategy that opens opportunities for less than responsible advocacy. This paper examines the due diligence involved in protecting the public interest when green arguments are used to describe any advanced technology by evaluating claims made about green nanotechnology by its proponents as well as tracking the overclaims made by devotees and the debates made by others over environmental health, safety, and public well-being.

INTEGRATING SUSTAINABLITY ASPECTS INTO A NANOSCIENCE PROGRAM

Deb Newberry, Dakota Country Technical College

Abstract: The multiple aspects of sustainable nanotechnology - societal, environmental and economic - can prove to be a challenge to integrate into programs in a comprehensive manner. This presentation will provide examples of how various thought exercises and hands on activities have been used in classes to introduce students to the concepts of sustainability, its importance, impact and influence at national and global levels.

ENVIRONMENTAL APPLICATIONS OF GRAPHENE OXIDE NANOCOMPOSITES ON SURFACES

Debora F. Rodrigues, University of Houston

bstract: This investigation aims to verify the antibacterial and anti-corrosion properties of modified surfaces of indium-tin oxide (ITO) and nitrocellulose filters with poly-N-vinyl carbazole (PVK)-graphene oxide (GO) and graphene oxide (GO). To coat the surfaces, a ratio of 97:3 (wt%) of the nanocomposite PVK-GO was used. The materials used for coating were also tested for mammalian cell toxicity. The results show that the new materials are non-toxic to fibroblast cells. Antibacterial measurements (plate count assay, DNA measurements, live-dead assay) of the modified filter surfaces with GO and PVK-GO indicated high bacterial toxicity and 6 log bacterial removal capacity against different microorganisms,

such as E. coli and B. subtilis. Coated surfaces of ITO with GO and PVK-GO were also resistant to bacterial deposition, and resistant to biological corrosion under prolonged exposure to wastewater. Therefore, these nanomaterials have anti-microbial and anti-corrosive environmental engineering applications.

ORGANIC AND MEDICINAL CHEMISTRY OF HIGH ALTITUDE BOTANICALS: APPLICATIONS IN NANOMEDICINE

Devendra S. Negi, HNB Garhwal University (A Central University), Srinagar(Garhwal) Uttarakhand , India

The biodiversity of Himalaya is well recognized. It is a repository of medicinal and aromatic plants. The medicinal plants of Himalaya are ingredients of several Ayurvedic, Unani, Homeopathic and Allopathic medicines. The chemical analysis of ethnomedicinal flora of Uttarakhand Himalaya and documentation of the activity and clinical data of their bioactive constituents have been the scarcely studied field. Also there is a lack of information on the distribution of different biological activities in different plants parts.. The lecture will discuss phytochemical investigation of some of the unexplored medicinal plants of Himalayan region, traditionally used by the native people of Uttarakhand with a view to identify the bioactive secondary metabolites present therein as a source of nanomedicine

X-RAY AND ELECTRON MICROSCOPIC STUDIES OF BIOACCUMULATION, BIODISTRIBUTION AND BIOMODIFICATION OF IRON OXIDE NANOPARTICLES IN A FRESHWATER INVERTEBRATE

Dongwook Kwon, Hanyang University

Hyun Woo Nho, Hanyang University

Tae Hyun Yoon, Hanyang University

Abstract: Bioaccumulation, biodistribution, and biomodification of iron oxide (Fe3O4 and a-Fe2O3) nanoparticles (NPs) in planktonic invertebrates were investigated using transmission electron microscopy (TEM) and scanning transmission X-ray microscopy (STXM). Our study confirmed the preferred accumulation pathways and distribution patterns of iron oxide NPs as well as the biomodification processes in a well-known toxicity test organism, Daphnia magna. Iron oxide NPs accumulated heavily within the digestive tract of D. magna, while distinct morphological changes in the microvilli and the epithelial cells of the D. magna gut were observed along with bacterial colonization. However, despite the observed morphological changes, NPs had not entered into epithelial cells. We also found modifications of iron oxide NPs via biological processes, which can be associated with potential risks in biological systems.

SUSTAINABLE DEVELOPMENT AND NANOTECHNOLOGY RESEARCH IN MEXICO

Edgar Zayago Lau, Universidad Autonoma de Zacatecas

Stacey Frederick, Center for Nanotechnology in Society. University of California, Santa Barbara

Guillermo Foladori, Universidad Autonoma de Zacatecas

Abstract: Sustainable Development (SD) is a common framework of most government plans in Mexico. The country is also part of a United Nations' pilot program to create green national accounts. In this context, the notion of SD has been an important outline in Mexican Science and Technology (S&T) policy. Mexico, second only to Brazil, has become an important player in nanotechnology and nanoscience (N&N) research in Latin America. In this article, we explore how much of the topics associated with SD are targeted by N&N research in the country. There is no mechanic relation between R&D and SD; but we have chosen three key areas in which N&N research is expected to provide some solutions: drinking water, energy and nanomedicine. To this aim, we review information from the Web of Science relevant to articles on N&N stretching back 12 years. We evaluate the articles published on N&N with at least one author with an institutional affiliation in Mexico. Subsequently, we analyze the occurrence of the three key areas, follow relevant subtopics and identify the main institutions doing research on these matters.

ENVIRONMENTAL CYTOTOXICITY OF NANOPARTICLES: STUDY OF INTERACTIONS OF GOLD NANOPARTICLES WITH SUPPORTED LIPID BILAYER

Elaheh Kamaloo, WPI

Kellie Waterman, WPI

Terri A. Camesano, WPI

Abstract: With the increasing applications of nanotechnology in different industries, it is essential to consider the effect of nanoparticles on the environment. Cytotoxicity of nanoparticles (NP) can originate from several physical and chemical properties, such as NP size, nature of functionalization or stabilizing groups, concentration, and the environment in which nanoparticles are interacting with cells. Each of these factors must be evaluated. In this research, the interactions of gold NPs with supported lipid bilayers (SLB; models for cell membranes) were studied via Quartz Crystal Microbalance with Dissipation (QCM-D). NPs ranging in size from 2 nm to 40 nm were studied at several concentrations, and their interactions with a SLB composed of L-α-phosphatidylcholine were characterized. . In order to better

understand how NPs behave in the natural environment, these interactions were also studied in the presence of different types of natural organic matter (NOM), including Suwannee River humic acid standard, Suwannee River fulvic acid standard, and Elliot soil humic acid. Relationships were developed between NP properties and the presence of NOM with interactions to model cell membranes. This work has implications for environmental health and safety.

LEVERAGING THE NEW PREDICTIVE TOXICOLOGY PARADIGM: THE POTENTIAL USE OF ALTERNATIVE TESTING STRATEGIES IN REGULATORY DECISION-MAKING

Elizabeth Beryt, UC CEIN/Luskin Center for Innovation

Tim Malloy, UCLA School of Law

Abstract: Three provisions of the Toxic Substances Control Act (TSCA) are particular relevant to testing chemical substances: Section 4 regarding testing of new and existing chemicals, Section 5 relating to evaluation of new chemicals, and Section 6 concerning regulation of unreasonable risks from new and existing chemicals. A determination that data is sufficient for regulatory purposes is based on the intended use of such information. Through TSCA, testing data are used by the EPA in three key circumstances: (1) to prioritize or identify chemicals for preliminary decision-making, including the need for further testing, (2) to evaluate the risk posed by a particular chemical for risk management purposes, and (3) to evaluate the relative risks posed by a set of alternative chemicals. The state of the science and the agency's judgment determines whether a specific test can be applied for screening purposes, risk assessment purposes, or comparison purposes to assist the EPA in making decisions. This study considers the near term adoption of alternative testing strategies in the setting of TSCA, using a case study of carbon nanotubes to examine how the legal-institutional context may drive the integration of alternative testing strategies into TSCA regulation of new and existing chemicals.

EXPOSURE TIME INDEPENDENT ASSESSMENT OF CUO ENP TOXICITY ON ZEBRAFISH EGG HATCHING

Erik Muller, Marine Science Institute, UCSB

Sijie Lin, CEIN, UCLA

Roger Nisbet, EEMB, UCSB

Abstract: Zebrafish eggs typically hatch within 2-3 days after fertilization under standard laboratory conditions. Metal ENPs, notably CuO ENPs, may delay or prevent successful hatching, while leaving normal embryo development unimpaired. The toxic mechanism is via inhibition of the enzyme digesting

the egg membrane (ZHE1) by copper ions. In order to characterize the impact of CuO ENPs on the hatching process in quantitative terms, we have developed and validated a process-based modeling framework consisting of formalism that dynamically describes egg hatching, CuO ENP dissolution, Cu ion uptake and ZHE1 inhibition. A major advantage of using process-based models is that toxicity assessment is relatively independent of the particular choice of experimental protocol and exposure duration. Notably, exposure time independent ECx values can be calculated. This modeling framework will be used to assess the toxicity of various ENPs on fish egg hatching

A LOW-TEMPERATURE PRECURSOR ROUTE TO NANOCRYSTALLINE ZINC OXIDE FOR ARSENIC REMEDIATION

Evangeline Rukundo, Oklahoma State University

Abstract: Arsenic's toxicity to people and other living organisms is responsible for environmental problems and difficulties in obtaining potable water in many parts of the world. Zinc oxide materials offer a combination of catalytic oxidation and adsorption properties that can be utilized to efficiently remove arsenic (III) and arsenic (V) from drinking or waste water. In this project, nanocrystalline zinc oxide with a specific surface area up to 56 m2 g-1 was prepared by low-temperature solid-state decomposition of zinc methyl pyruvic acid oxime. The precursor is designed to decompose to produce carbon dioxide, proprionitrile, and zinc oxide. The influence of this low temperature decomposition on the particle size, surface area, and surface chemistry of the zinc oxide produced by thermal decomposition were determined. The precursor compound and the zinc oxide product were characterized by infrared, Raman, proton and carbon NMR spectroscopy, thermal gravimetric analysis, X-ray powder diffraction, and X-ray crystallography. The zinc methyl pyruvic acid oxime decomposes to plate-like zinc oxide nanocrystalline aggregates upon exposure to temperatures equal or greater to 295oC. The resulting material was tested for arsenic remediation and was successful in the removal of arsenic from simulated and real world arsenic contaminated water samples at their natural pH.

DETERMINATION OF THE GENOTOXIC EFFECTS OF TIO2 NANOPARTICLES IN CUCURBITA PEPO BY RANDOM AMPLIFIED POLYMORPHIC DNA ANALYSIS

Fabiola Moreno-Olivas, University of Texas at El Paso

Kyle L. Johnson, University of Texas at El Paso

Jorge L. Gardea-Torresdey, University of Texas at El Paso

Abstract: Nanoparticles (NPs) have a wide range of applications in medicine, electronics, catalysis, cosmetics, and pharmaceuticals. TiO_2 NPs are very stable and can be transported and dispersed into aquatic environments. The possibility of environmental release is higher in the production process or through contaminated foods. Several animal species have shown negative reaction to TiO_2 NPs. However, little is known about their toxicity on plants. We have studied the possible genotoxic effects of TiO_2 NPs on zucchini (Cucurbita pepo), a worldwide cultivated species that serves as food for insects and other animals in the food web. Seven-day old hydroponically grown zucchini plants were treated with 21 nm TiO_2 NPs (Nippon Aerosil) suspended in a modified Hoagland nutrient solution at a concentration of 50 mg/L. NPs suspensions were sonicated for 30 min in an ultrasonic homogenizer to avoid aggregation. Genomic DNA quantification was performed in root tips after seven days of treatment following standard DNA extraction procedures. A Random Amplified Polymorphic DNA analysis showed evidence of DNA alterations in the plants treated with NPs compared to the controls.

ENVIRONMENTAL FATE OF NANO-CELLULOSE: TOXICITY AND BIODEGRADATION

Gargi Singh, Virginia Tech

Amy Pruden, Virginia Tech

Peter Vikesland, Virginia Tech

Abstract: Mass production of cellulose-based nanomaterials (nanocellulose) and their incorporation in various products is underway with scant knowledge of their potential impact on environment. As is the case with other nanomaterials, nanocellulose can behave very different from its native and microcrystalline forms due to its readily functionalized surface-chemistry. This study focuses on isolating and characterizing nanocellulose with different surface modifications (list the modifications in parentheses here), and investigates their effect on two different cellulose-degrading microbial enrichments representing a cellulosic wetland and an anaerobic digester.

In this study, microbial community shifts in response to spiking of various functionalized forms of nanocellulose were examined using Illumina sequencing. Changes in expression of glycoside hydrolase genes involved in cellulose degradation were also examined and nanocellulose was characterized by atomic force microscopy and HPLC. It is hypothesized in this study that surface charge, hydrophobicity, and steric hindrance will impact the biodegradation of nanocellulose, and negatively charged nanocellulose will not interact with microbial cellular membranes, whereas positively charged surface modified nanocellulose will disrupt cellular membrane and exhibit toxicity for microbes. This study can aid in identifying the least toxic and most biodegradable forms of nanocellulose as attractive features for manufacturing and application.

LIABILITY AND INSURANCE DRIVERS OF SOFT LAW PROGRAMS FOR NANO?

Gary Marchant, Arizona State University

Abstract: For a variety of reasons, traditional government regulation of nanotechnology has been slow to develop. In its place, a number of voluntary and partnership programs (collectively referred to as soft law programs) have been proposed or implemented, but the success of these programs to date -- both in terms of attracting industry participation and in reducing risks -- has been minimal. In this presentation, I will examine, using mainly precedents from other technologies and industries, whether the threat of liability and insurer requirements can be a driver to compel more companies to actively participate in such voluntary risk management and risk reduction programs.

ENGINEERING SAFER, TRANSPARENT, UV-ABSORBING ZNO NANORODS WITH MINIMAL GENOTOXICITY

Georgios A. Sotiriou, Christa Watson, Kimberly M. Murdaugh, Georgios Pyrgiotakis, Joseph D. Brain, Department of Environmental Health, Harvard University

Alison Elder, University of Rochester Medical Center

Philip Demokritou, Department of Environmental Health, Harvard University

Abstract: Zinc oxide (ZnO) is a wide-bandgap metal oxide semiconductor that can be excited at room temperature by UV irradiation, and finds applications in a variety of fields and products including paints, pigments, batteries, photocatalysis, foods, to name a few. When in nanometer size range, it may be used in polymer nanocomposites and sunscreens as an efficient UV-filter with high transparency in the visible wavelength range. However, the photocatalytic activity of ZnO causes the degradation of the surrounding polymer rendering it unsuitable for long-term employment. Furthermore, ZnO nanoparticles are highly toxic and may pose risks to the public and the environment. Here, ZnO nanorods are made by scalable flame synthesis and are in-situ encapsulated by an amorphous nanothin SiO2 layer [1,2,3]. The as-prepared nanoparticles are characterized by electron microscopy (EM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and N2 adsorption. The hermetic nature of the SiO2 coating is evaluated by a detailed dissolution study and the photocatalytic activity is monitored by the decomposition of methylene blue dye. The presence of SiO2 facilitates the dispersion of these nanorods in relevant solutions. The core ZnO nanorods exhibit the characteristic optical properties as determined by UV/vis and diffuse reflectance spectrometry, while the SiO2 coating eliminates the photocatalytic activity [4] and minimizes the DNA damage to human cells, as illustrated in in-vitro cellular studies using multiple cell lines by the nano-cometchip screening assay [5]. Therefore, these safer by design, flame-made, SiO2-coated ZnO nanorods may be safely used as fillers in polymer UV-

filter nanocomposites and in sunscreens exhibiting superior performance while mitigating their impact on environmental health.

NANOPARTICLE-NANOPARTICLE AND NANOPARTICLE-CELL INTERACTIONS IN BIOLOGICAL MEDIA BY ATOMIC FORCE MICROSCOPY

Georgios Pyrgiotakis, Harvard University

Christoph O. Blattmann, Swiss Federal Institute of Technology Zurich (ETH Zurich)

Philip Demokritou, Harvard University

Abstract: The increased incorporation of engineered nanomaterials (ENMs) in consumer products and industrial processes is inevitably increasing the risk of exposure. In this project, an Atomic Force Microscopy (AFM) based platform suitable for the assessment of ENM-bio interactions in physiologic fluids was developed and utilized to directly measure the ENM-ENM and ENM-cell interactions. Industry-relevant CeO2, Fe2O3, and SiO2 ENMs of various sizes were made by the flame spray pyrolysis (FSP) based Harvard Versatile Engineering Nanomaterials Generation System (Harvard VENGES). The ENMs were attached on AFM tips and deposited on Si substrates to measure particle–particle and ENM-cell interactions. The ENM – ENM force was measured in air, water and biological media. The ENM-cell interaction was also measured for both fast (30s) and long-term interactions (3 min) using A549 lung epithelia cells. Our results indicated that the Fe2O3 ENMs have stronger agglomeration potential compared to the CeO2. Moreover for the Fe2O3 the agglomeration potential depends on the primary particle (PP) size, while for the CeO2 is independent of the PP size. This platform also allowed us to estimate the corona thickness formed in the physiological media. It was found to be between 5-15 nm, and depends both on the PP size and the type of the nanoparticle. In addition it was found that the CeO2 nanoparticles have a higher affinity towards the cells as compared to the Fe2O3 nanoparticles.

WHAT CAN ENGINEERING APPLICATIONS OF NANOMATERIALS TELL US ABOUT THE ENVIRONMENTAL IMPLICATIONS OF NANOMATERIALS?

Greg Lowry, Carnegie Mellon University

Engineering applications for nanomaterials is outpacing information about their potential implications. However, much of the data acquired to develop and optimize nanomaterials for their intended applications, is also highly useful for predicting the environmental and human health implications of those materials. I will provide an overview of the types of nanomaterial applications and

characterization of performance that may be used to assess the potential for impacts from the use of those materials and at the end of their life.

WHAT WE'VE LEARNED ABOUT NANO AND SOCIETY: SHARING MATERIALS AND METHODS FOR NEXT GENERATION RESEARCH AND PRACTICE

Gretchen Gano, University of Massachusetts Amherst

Jessica Adamick, University of Massachusetts Amherst

Abstract: This session reports the outcomes of a planning workshop supported under a National Leadership Grant at the Institute for Museum and Library Services entitled Nanoscience and Emerging Technologies in Society: Sharing Research and Learning Tools. The project aims to articulate how data and tools, curricula and methods developed for the analysis of social legal and ethics implications research can be collected, curated, and made available for a new generation of interdisciplinary social science research on emerging technologies. This working session invites SNO attendees to comment and expand upon the outcomes of the planning workshop.

By 2015, NSF Centers for Nanotechnology in Society as well as other NSECs conducting social dimensions research will have spent 10 years collecting qualitative and quantitative data and developing analytic and methodological tools for examining the ethical legal and social impacts of nanotechnology. The Nanoscience and Emerging Technologies in Society: Sharing Research and Learning Tools (NETS) project is an investigation of digital resources to advance the collection, dissemination, and preservation of ethical, legal, and social implications scholarship associated with the development of nano and emerging technologies, a domain that represents millions of dollars in federal funding.

PUBLIC ACCEPTANCE OF NANOFOOD: ANOTHER EPISODE OF GENETIC MODIFICATION?

Guzhen Zhou, University of Florida

Ping Qing, Huazhong Agricultural University

Wuyang Hu, University of Kentucky

Abstract: While scientists are making processes to develop nanotechnology, the public demands to be informed and involved in decisions about the technology, especially when billions of tax dollars are invested in nanotechnology R&D. It is crucial for policy makers to have a grasp of public opinion in the early stages of development to avoid the fate of genetic modification—negative public perception.

Most past studies concentrated on public attitudes toward nanotechnology applications in general. Few focused on physical products, let alone food-related products emerging from nanotechnology, which can be the most touchy area. Our study will contribute to the society by examining not only consumers' general attitudes towards food nanotechnology but also their acceptance towards a specific food (canola oil) where new product features are introduced. A U.S. nationwide online survey was completed at the end of November 2012 collecting 1,131 completed questionnaires. Results indicate that consumers are rather neutral about nanotechnology in general but are not in favor of canola oil with new nano-features. However, once the technology is applied to increase consumer benefit, and with proper consumer education, the perception can be quite positive. Calls for policy support are made to better assist the development of nanotechnology and nanofood.

SYNTHESIS OF MILLIMETER-LONG VERTICALLY ALIGNED CARBON NANOTUBE ARRAYS ON ALUMINUM OXIDE BUFFER PREPARED BY LAYER-BY-LAYER ASSEMBLY OF BOEHMITE NANOPLATES

Haitao Wang, University of Notre Dame

Chongzheng Na, University of Notre Dame

Abstract: To synthesize vertically aligned carbon nanotube (VA-CNT) arrays longer than a millimeter using chemical vapor deposition (CVD), aluminum oxide buffer has to be deposited on supporting substrates to prevent diffusion and aggregation of catalyst nanoparticles. Currently, reliable deposition has to be made using expensive and time-consuming e-beam evaporation or thermal sputtering. Here, we report a simple, low-cost, and scalable method for buffer preparation using layer-by-layer assembly of boehmite nanoplates followed by thermal annealing. On top of buffer prepared using this method, we have grown VA-CNT arrays having a length of 1.3(±0.1) mm, an inner diameter of 5.6(±1.3) nm, and an average wall number of 4(±1) by using CVD with iron as catalyst and ethylene as carbon source.

MICROWAVE-ASSISTED SYNTHESIS OF GRAPHENE-SUPPORTED PLATINUM NICKEL NANOALLOY AS CATALYST FOR NITROAROMATIC REDUCTION

Hanyu Ma, University of Notre Dame

Chongzheng Na, University of Notre Dame

Abstract: Catalytic treatment of water pollutants has the advantage of being rapid and selective particularly when poisoning-resistant platinum is used. The obvious drawback is the high cost of the material, which may be reduced by blending platinum with inexpensive metals such as nickel. Here we report the synthesis of platinum and nickel nanoalloys supported on reduced graphene oxide sheets

using microwave-assisted polyol reduction. The resulting nanoparticles are well-dispersed on the supporting sheets, exhibiting a structure with a platinum core and a platinum/nickel shell and having a diameter of only a few nanomaterials. Using model contaminant p-nitrophenol, we show that the supported nanoalloy particles outperform supported platinum nanoparticles of similar size. Our results suggest that using nanoalloys in catalytic water treatment can both reduce material cost and improve material performance at the same time.

OVERVIEW AND UPDATES: RISK AND OCCUPATIONAL HEALTH AND SAFETY OF NANOMATERIALS

Hilary Godwin, UCLA

Abstract: To launch the session on Risk and Occupational Health and Safety of Nanomaterials and set the stage for the later talks, I will provide an overview of the field, updates on important advances in this arena that have occurred over the last year, and a summary of important challenges that we still face as a community.

ULTRA-SENTITIVE NANOSENSORS FOR DETERMINATION, MONITORING AND MAPPING OF POLYAROMATIC HYDROCARBON IN POLLUTED WASTE WATER.

Hlamulo Makelane, University of the Western Cape

Emmanuel I.Iwuoha, University of the Western Cape

Sufficient clean water for human consumption, agriculture, and industrial processes is an ongoing and increasing challenge as a result of population growth, extended droughts, and numerous competing demands. The chemicals to which man and environment are exposed are increasing every year. Polyaromatic Hydrocarbons (PAHs) pollutants are among the most dangerous pollutants released in the environment. A simple, sensitive and rapid voltammetric method has been developed for the determination of polyaromatic hydrocabons (PAHs) in waste water. The method is based on the generation 3 poly(propylene imine) and polythiophene on gold electrode as a substrate, followed by the selection of voltammetric technique mode, i.e cyclic voltammetry, alternating current and square-wave using 0.1 M Bu4NClO4 in acetonitrile as a supporting electrolyte. Voltmmograms for various sample concentrations were recorded and the respective calibration graphs constructed. The method gave reproducible and stability results of the platform and the detection limits for all measurement modes were recorded. AC and SW modes seems to achieve lower detection limits that the CV modes. The three modes proved to be equal précised and accurate.

NANOSCALE SCIENCE AND ENGINEERING IN AGRICULTURE AND FOOD SYSTEMS

Hongda Chen, USDA/NIFA

Abstract: Sustainability has been identified as a principal challenge we are facing now and years ahead by governments, scholars, and public opinion leaders around the world. The daunting challenges of more people, greater demands of materials and increased living standards, and a need to reduce poverty without destroying the environment and exhausting natural resources are more pressing than ever before. Scientific and technological development for a sustainable society needs to focus on integration of technological, economic, social and political considerations to present arrays of balanced solutions. Nanoscale science, engineering and technology have shown enormous potential to address broad ranges of sustainability issues, at the same time, suggest the needs to responsibly address unintended consequence of nanotechnology to the environment, health and safety of workers and the public. USDA/NIFA has supported a wide range of nanotechnology research projects on agriculture and food sustainability. The focus of this presentation is to introduce some examples of nanotechnology applications and implications to agriculture (plant and animal) production, value added products of biological resources, food quality, safety and nutritional values, improving human health, renewable energy, catalysis, and biosensors and detection of hazardous materials and environmental stresses.

GRAPHENE MICROSHEETS ENTER CELLS THROUGH SPONTANEOUS MEMBRANE PENETRATION AT EDGE ASPERITIES AND CORNER SITES

Huajian Gao, Brown University

Agnes Kane, Brown University

Robert Hurt, Brown University

Abstract: Understanding and controlling the interaction of graphene-based materials with cell membranes is key to the management of graphene health and safety issues. Here we investigate the interactions of graphene and few-layer graphene (FLG) microsheets with three cell types and with model lipid bilayers by combining coarse-grained molecular dynamics (MD), all-atom MD, analytical modeling, confocal fluorescence imaging, and electron imaging. The imaging experiments show edge-first uptake and complete internalization for a range of FLG samples of 4-10 um lateral dimension. In contrast, the simulations show large energy barriers relative to kBT for membrane penetration by model graphene or FLG microsheets of similar size. More detailed simulations resolve this paradox by showing that entry is initiated at corners or asperities that are abundant along the irregular edges of fabricated graphene materials. Local piercing by these sharp protrusions initiates membrane propagation along the extended graphene edge and thus avoids the high energy barrier calculated in simple idealized MD simulations. We propose that this mechanism allows cellular uptake of even large multilayer sheets of

micron-scale lateral dimension, which is consistent with our multimodal bioimaging results for primary human keratinocytes, human lung epithelial cells, and murine macrophages.

IMPEDANCE BIOSENSORS FOR SUSTAINABILITY

Ian Suni, Southern Illinois University

Abstract: Due to their all-electrical nature, modest cost, and simplicity, electrochemical sensors have significant advantages for portable applications. The most common format for AC impedance biosensors involves surface immobilization of an antibody, receptor protein, DNA strand, or other species capable of bio-recognition, and AC impedance detection of the binding event as an increase in the polymer-protein film thickness.

Norfluoxetine, an endocrine-disrupting chemical (EDC), is an active metabolite of fluoxetine, and has been investigated as an anti-depressant. Impedance detection of norfluoxetine by its surface-immobilized sheep polyclonal antibody is demonstrated in two different format, direct detection and detection of its conjugate with horseradish peroxidase. The detection limit is measured as 8.5 ng/ml , or 28 nM, which is comparable to that reported by chromatography measurements. From the variation in Rct with norfluoxetine concentration, the dissociation constant (Kd) for the surface antibody-antigen complex is determined to be approximately 0.017 µg/ml, which corresponds to 57.5 nM. Other possible applications for sustainability include sensors for wastewater and drinking water, and other environmental contaminants such as pesticides and flame retardants.

ABSOLUTE DISINFECTION OF DRINKING WATER USING GREEN NANOSTRUCTURED BIOMEMBRANES

Idris Yazgan, State Universityn of New York at Binghamton

Nian Du, State Universityn of New York at Binghamton

Omowunmi A. Sadik, State Universityn of New York at Binghamton

Abstract: The integration of biological building-blocks with synthetic nanomaterials may permit unprecedented ability to detect, disinfect and completely remove pathogens in water. We hereby described the synthesis and application of a green, biodegradable polymeric membrane of poly(amic) acid (PAA) and chitosan-modified poly(amic) acid (PAA-CS). The resulting membrane was used for an absolute decontamination of bacteria in drinking water. PAA and PAA-CS membranes were fabricated using phase-inversion procedures with glutaraldehyde as a cross-linking reagent. NMR, FT-IR, SEM and cyclic voltammetry characterizations confirmed the formation of electroactive, bifunctional,

glutaraldehyde-linked PAA. The morphological, toxicological and mechanical tests showed the successful formation of non-toxic, porous, free-standing and mechanically strong PAA and PAA-CS membranes. The pore sizes were controlled from 4-35 nm, and the optimized membranes were tested against three of the most common drinking water contaminants, namely Escherichia coli, Citrobacter freundii and Staphylococcus epidermidis. As a result, we were able to remove 100% of these microbial species through dead end filtration and tangential flow filtration. The results were validated using plate counting and SEM imaging. Through this work, we envisage an advancement of innovative technologies for treating drinking water by simultaneously removing and inactivating classes of bacteria contaminants using low-cost, reusable and sustainable bio-membrane technologies.

ENVIRONMENTALLY RELEVANT CONDITIONS IMPACTING GRAPHENE OXIDE TRANSPORT IN AQUEOUS ENVIRONMENTS

Jacob Lanphere, University of California, Riverside

Sharon Walker, University of California, Riverside

Abstract: To inform policy makers and promote sustainable graphene oxide (GO) handling methods, this study looked at key parameters present in the environment that influence GO nanoparticle fate and transport in subsurface and aqueous environments. An in depth study regarding the stability and transport of GO over a wide range of environmental conditions was performed. Transport experiments were performed in saturated porous to simulate conditions GO would experience if released in the subsurface environment. The deposition rate of the GO nanoparticles was quantified under a range of critical aquatic parameters such as ionic strength (IS), pH, salt type (mono and divalent), water type (groundwater vs. surface water), and presence of natural organic matter (NOM). Additionally, systematic evaluation was carried out on the electro-kinetic properties and hydrodynamic diameters of GO to shed light on the transport trends. Results indicate that the GO deposition rate onto sand as a function of valence was 30 times greater for CaCl2 compared to KCl at the same salt concentration (10-3 M). Finally, GO deposition onto sand was decreased 13-fold as the presence of NOM was increased from 0.1 to 10 mg/L and was greater in the presence of groundwater compared to surface water.

DETECTION OF NANOMATERIALS RELEASED FROM POLYMER NANOCOMPOSITES USING SINGLE PARTICLE INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY

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Abstract: The majority of nanoparticles (NPs) such as TiO2 and carbon nanotubes (CNTs) will enter the environment as components of nanoproducts, such as polymer nanocomposites. As such, methods for examining the releases rates of NPs from nanoproducts, as well as their environmental fate are needed. A major challenge is the need to accurately detect and quantify released NPs under environmentally relevant conditions. We have employed single particle – inductively coupled plasma – mass spectrometry (spICPMS) which allows for simultaneous detection, quantification, and sizing of metal-containing engineered NPs at part-per-trillion levels. CNTs and TiO2 were embedded in polymers (e.g. chitosan, polystyrene) to create nanocomposites, which were then subjected to potential NP release scenarios. The resulting supernatants were sampled for spICPMS analysis. Results will be shown for detection and sizing of TiO2, as well as detection of CNTs by monitoring residual metal catalysts such as Co, Y, and Mo. In aqueous leaching studies the number of released nanomaterials scaled with polymer loading and exposure time, making this technique ideal for quantifying released nanomaterial particle number concentrations. Quantifying NP release rates from nanocomposites is important not only from a life cycle perspective, but also in terms of risk assessment, because NP release is the precursor to exposure.

ENGINEERED NANOMATERIALS AND AGRICULTURAL CROPS- CO-CONTAMINANT INTERACTIONS AND TROPHIC TRANSFER

Jason C. White, CT Agricultural Experiment Station

Baoshan Xing, University of Massachusetts

Lee Newman, SUNY ESF

Abstract: A mechanistic understanding of nanomaterial (NM) interactions with agricultural crops remains elusive. In one study, fullerenes or MWCNTs were added (0-5000 mg/Kg) to soil containing weathered chlordane/DDX that was subsequently planted with zucchini, corn, tomato, or soybean for 28d. MWCNT reduced pesticide accumulation by all plants in a concentration dependent fashion, with decreases ranging from 20% to 100-fold. Fullerenes either had minimal impact on pesticide fate or in some cases, significantly increased organochlorine uptake. These findings show that the carbon nanomaterial properties may significantly influence co-contaminant-NM interactions in agricultural systems. Separately, cerium oxide trophic transfer was evaluated. Bulk or nanoparticle cerium oxide was added to soil (1000 mg/Kg) that was subsequently planted with zucchini for 28d. At harvest, plant cerium content was determined by ICP-MS. Bulk cerium levels in plant roots, stems, leaves and flowers were 140, 0.29, 0.69, and 0.04 mg/Kg, respectively. Analysis for nanoparticle cerium is currently

underway. Select leaves (bulk, NP) were fed to crickets for 21 days. Cricket tissues will be digested for ICP-MS or fed to predatory mantids, which will then be analyzed for cerium content. Results from these ongoing experiments will characterize the particle size-specific trophic transfer of cerium in a terrestrial food chain.

RECENT DEVELOPMENTS IN NANOMATERIAL CHARACTERIZATION IN COMPLEX MEDIA

Jason M. Unrine, University of Kentucky

Abstract: At the inception of studies of the fate, transport and toxicity of engineered nanomaterials, detection and characterization of nanomaterials was seen as a nearly intractable problem. While obstacles to quantitative detection, characterization and analysis in complex matrices remain, considerable progress has been made over the past 5 years. A suite of analytical methodologies have been developed and applied that can provide complimentary information at toxicologically relevant concentrations on the presence and concentrations of engineered nanomaterials as well as information on their transformations. Recent life cycle material flow analyses have suggested that present environmental concentrations of engineered nanomaterials are typically in the sub to low mg/kg range for soils and sediments and the sub to low ug/L range for surface waters. To meet the challenge of detecting and characterizing particles at these trace concentrations, continued improvements in analytical techniques are needed. Current progress is pushing existing instruments to their theoretical limits. Further progress in ultra-trace nanomaterial analysis will likely require the development of new instruments that focus on multi-parameter single particle detection.

DISSOLVED ORGANIC CARBON INDUCED MITIGATION OF THE TOXICITY OF NANOSILVER TO AQUATIC ORGANISMS

JC BONZONGO, UNIVERSITY OF FLORIDA

Julianne McLaughlin, UNIVERSITY OF FLORIDA

Abstract: The behavior and toxicity of nAg particles and ionic Ag (Ag+) were investigated in natural and synthetic waters. Batch experiments were conducted to determine the effect of waters with different solution chemistries on nAg dispersion and stability, and its toxicity in comparison with ionic Ag used as AgNO3. Two model freshwater aquatic organisms, the invertebrate C. dubia and the green algae P. subcapitata were used model organisms after for dose-exposure studies. The results show that natural dissolved organic carbon mitigates the adverse impacts of nAg to aquatic organisms. A combination of high ionic strength and low DOC content showed nAg toxicity trends similar to those observed in

synthetic growth media. Ag dissolution results paired with nAg particle stability results suggested that the toxic impacts, when observed, were not completely due to silver ions released to solution. The results also point to the potential for nAg particles to persist in aquatic systems as a function of water chemical composition.

HOW TO PREDICT TOXICITY OF NANOMATERIALS-DEVELOPMENT OF NEW THEORETICAL

Jerzy Leszczynski, Jackson State University

Abstract: Nanotechnology is expanding rapidly, but development of novel materials synthesized at the 'nano' scale should be always accompanied by a comprehensive assessment of risk to human health and to environmental ecosystems. It is vital to be able to predict possible environmental impact of new nanomaterials before their mass production and application. We believe that the Computational Chemistry is able to provide various tools to evaluate interaction of nanomaterials with biomolecules, shed a light on mechanisms of such phenomena, and predict toxicity of nano sized species. We suppose that there is a strong need to develop nano descriptors i.e. novel and reproducible ways of representing the structures and/or physical properties of nanoparticles that are suitable for distinctive grouping these types of chemicals. This will facilitate development of QSARs that could reliable predict their characteristics and activities. A conceptual framework for grouping NPs should be considered as a first step in identifying QSARs that are applicable within each group. Due to high variability in the molecular structure and different mechanisms of action, individual groups of nanoparticles should be modeled separately. In each case, according to the general QSAR rules, the applicability domain of the models should be carefully validated. Based on experimental testing we developed and tested novel interpretative nano-QSAR model describing cytotoxicity of 17 nano-sized metal oxides to bacteria Escherichia coli. The proposed model allows us to formulate a hypothesis that mechanistically explains differences in toxicity between the individual oxides.

COUPLING SEMICONDUCTOR TO PLASMONIC NANOSTRUCTURE FOR ENHANCED SOLAR FUEL PRODUCTION

Jiangtain Li, West Virginia University

Scott K. Cusing, West Virginia University

Nianqiang Wu, West Virginia University

Abstract: Incorporation of plasmonic nanostructures with semiconductors has a great potential in improving the solar energy conversion efficiency of semiconductors. However, it remains a significant

challenge in achieving effective coupling between the plasmonic nanostructure and the semiconductor. This presentation shows our effort to develop a facile metal-semiconductor heterostructure for efficient transfer of the plasmonic energy from the metal to the semiconductor. As compared to the semiconductor alone, the metal-semiconductor composite exhibits significant enhancement in the photocatalytic activity due to the effective coupling between the plasmonic nanostructure and the semiconductor.

TOXICITY EFFECTS OF SEVEN CU COMPOUNDS /NANOPARTICLES IN LETTUCE (LACTUCA SATIVA) AND ALFALFA (MEDICAGO SATIVA)

Jie Hong, The University of Texas at El Paso

Lijuan Zhao, The University of Texas at El Paso

Jorge L. Gardea-Torresdey, The University of Texas at El Paso

Abstract: If the increase in nanomaterials utilization continues at the same pace, the release of nanoparticles (NPs) to the environment will inevitably have an impact in organisms, especially plants. In this study, the effects of seven Cu compounds/nanoparticles [Cu NPs, Cu bulk, CuO NPs, CuO bulk, Cu (OH)2 (Kocide2005, Kocide3000), and CuCl2] were studied in lettuce (Lactuca sativa) and alfalfa (Medicago sativa).Ten day-old hydroponically grown lettuce and alfalfa plants were treated, with each one of the Cu compounds/NPs at 5, 10, 20 mg/L. Fifteen days after treatment, the root and shoot lengths were measured and plant samples were processed and analyzed for Cu, macro and micro element concentrations by using ICP-OES. In addition, the activity of stress enzymes catalase and ascorbate peroxidase was determined. Results showed that all Cu compounds/NPs significantly reduced the root length in both plant species but not affected the shoot length. Cu and S uptake significantly increased in roots of both plants, but Fe and P uptake decreased. Cu, P, S translocation increased in alfalfa shoot, but P and Fe translocation to lettuce shoot decreased. The biochemical assays showed that the treatments reduced catalase activity in alfalfa (root and shoot), and increased ascorbate peroxidase activity in root of both plants. The results showed that Cu ionic forms and Cu NPs have higher toxicity and the toxicity was associated to plant species.

SYNTHESIS OF NOVEL NANOCOMPOSITE REVERSE ELECTRODIALYSIS (RED) ION-EXCHANGE MEMBRANES FOR SALINITY GRADIENT POWER GENERATION

Jin Gi Hong, Georgia Institute of Technology

Yongsheng Chen, Georgia Institute of Technology

The development of sustainable nanotechnology has been geared toward promoting the application of clean and renewable energy production. The reverse electrodialysis (RED) process captures the energy from the waters in different saline concentration as the source of power in membrane-based system. Despite the important role of membranes in RED, the current absence of proper ion-exchange membranes delays the sustainable development of RED for energy generation. This work presents the preparation of a new type of organic-inorganic nanocomposite cation exchange membranes and the successful application in RED system. The incorporation of functionalized iron (III) oxide (Fe2O3-SO42-) as inorganic fillers and the sulfonated poly (2,6-dimethyl-1,4-phenylene oxide) (sPPO) polymer matrix was introduced and the membrane properties were examined comprehensively. The results showed that the optimum amount of Fe2O3-SO42- (0.5-0.7 wt %) enhanced the key electrochemical properties of the ion-exchange membranes: a permselectivity up to 87.65 % and an area resistance of 0.87 Ω cm2. The nanocomposite membrane with 0.7 wt% Fe2O3-SO42- showed remarkable performance in RED by achieving a maximum power density level of 1.3 W m2-, which is relatively higher than that of the commercially available CSO membranes. To the best of our knowledge, this is the first work on the synthesis and application of cation exchange membranes for salinity gradient power generation in RED system.

ROADMAP FOR THE DEVELOPMENT OF NANOCELLULOSE AS A SUSTAINABLE NANOMATERIAL

Jo Anne Shatkin, Vireo Advisors

Abstract: There is global interest in the use of nanocellulose as a novel material to improve performance in a number of product applications where strength, optical performance, barrier properties and lightweighting are sought. Early indicators suggest nanocellulose may have better performance in terms of sustainability over current or potential alternative materials. This talk evaluates the current state of knowledge for nanocellulose across a broad range of indicators that may considered in sustainability assessments as a foundation in establishing a path forward toward commercialization. Assessing overall product sustainability is multi-dimensional, and complex; at early stages of commercial development, indicators used for screening purposes can simplify the assessment process and allow comparative assessments across multiple endpoints. The use of life cycle assessment tools for measuring the broad environmental impacts of nanomaterials is explored. Indicator categories include environmental health and safety, climate impacts, energy consumption, material availability and end of life alternatives. Options for incorporating the assessment of climate impacts and related sustainability criteria are identified. The state of practice, research needs, and current options are explored with an aim toward more comprehensive alternatives analysis in sustainable technology innovation. The outcome is a roadmap for a comprehensive sustainability evaluation for nanocellulose.

A SIMPLIFIED APPROACH FOR IN VITRO DOSIMETRY OF ENGINEERED NANOMATERIALS

Joel Cohen, Harvard School of Public Health

Zhaoxia Ji; Tian Xia, University of California, Los Angeles

Philip Demokritou, Harvard School of Public Health

Abstract: There is a great need for screening tools capable of rapidly and accurately assessing engineered nanomaterial (ENM) toxicity. One impediment to the development of reliable in vitro screening methods is the need for accurate and relevant dosimetry. In a typical in vitro cytotoxicity study ENM powders are suspended in liquid media for application to cells. ENMs in liquid suspension can form large fractal agglomerates thereby altering (1) the total number of free particles, (2) the total surface area available for biointeractions, and (3) the effective size and density of the particles, two properties that influence their fate and transport and determine the effective dose actually delivered to cells in culture over the duration of exposure. We present here a methodology for in vitro nanotoxicology that takes into consideration particokinetics and enables accurate determination and reporting of effective dosimetry. This methodology is based upon (1) standardization of ENM liquid suspension preparation; (2) careful characterization of critical ENM transformations in exposure media including agglomerate effective density; and (3) numeric calculation of the delivered to cell dose as a function of exposure time. The derived mathematical equation, referred to as Relevant In Vitro Dose (RID), can be used to accurately calculate the particle mass (RIDM), particle surface area (RIDSA), or particle number (RIDN) delivered to cells as a function of exposure time. This methodology is then employed for 24 industrially relevant metal oxide ENMs suspended in two cell culture media, at two different concentrations, in two well plate systems (96 well and 384 well plates). Following our established dispersion protocol to achieve small stable ENM agglomerates in suspension, nanotoxicologists can simply use our reported agglomerate diameters, effective densities, and deposition fraction constants to easily calculate RID values and perform meta analyses on previously reported toxicity studies.

EFFECT OF RECYCLING ON THE PROPERTIES OF CARBON NANOTUBE POLYMER NANOCOMPOSITES

Joey Mead, University of Massachusetts Lowell

Jinde Zhang, University of Massachusetts Lowell

Artee Panwar, University of Massachusetts Lowell

Abstract: The recycling processes for thermoplastic based nanocomposites involve grinding the material into small pieces, which are then used in typical plastics processing, such as injection molding or

extrusion. During the grinding process, nanoparticles may be released into the air, causing worker exposure. The potential harm from such releases is an important concern for nanoproduct recycling. A second concern is the effect of recycling on nanoproduct properties. Due to molecular chain breakage during the grinding and reprocessing, mechanical properties such as impact resistance, stiffness and strength may be decreased. However, for CNTs filled thermoplastics, the conductivity may increase for some content ratios, since orientation of the CNTs may occur under the high shearing of the injection molding process. The choice of recycling method will depend upon the resultant properties, and will affect cost and life cycle decisions. In this work we evaluate the effect of grinding and recycling processes on the properties of polypropylene (PP)/carbon nanotube (CNT) and polycarbonate (PC)/CNT composites. Materials were injection molded, some of the samples kept for property testing, then the rest of the material was ground and injection molded. The procedure was repeated up to twenty cycles and the effect on properties was measured.

HIGH EFFICIENCY THERMOELECTRICS FOR WASTE HEAT RECOVERY

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Chris Palmstrom, Ben Curtin, Peter Burke, Rachel Koltun

Research on several approaches to increase the efficiency of thermoelectrics by modifying the materials utilized or by tailoring the nanostructure morphology. One approach uses rare earth nanoparticles Another approach uses nanostructured silicon to offer considerable zT enhancement over bulk Si due to a large reduction in thermal conductivity (κ) without significantly degrading Seebeck (S) and electrical conductivity (σ). While further decreases in thermal conductivity may be achieved through tailoring the nanostructure morphology, methods to increase power factor (S2σ) are also of interest for improved zT.

EFFECTS OF SOIL-DELIVERED MANUFACTURED NANOMATERIALS ON SOYBEAN PLANTS

John H. Priester, UCSB/UC-CEIN

Jorge L. Gardea-Torresdey, UTEP/UC-CEIN

Patricia A. Holden, UCSB/UC-CEIN

Abstract: With the increased use and release of manufactured nanomaterials (MNMs), there is concern that environmental build-up could influence food crop quality and yield. Previous experiments have generally focused on hydroponic exposure scenarios. In this work, soybean (Glycine max), a major

global commodity crop, was grown to full maturity from seed in agricultural soil amended with nano-ZnO or nano-CeO2. Soybean growth was monitored, and the uptake of Zn and Ce were measured. Plant damage indicators were evaluated at the conclusion of the experiment. Both Zn and Ce translocated from the soil into the plant, and intact CeO2 particles were detected in above-ground tissues by x-ray absorption spectroscopy. Exposure to CeO2 resulted in stunted growth, reduced yield, and the termination of nitrogen fixation in root nodules. Exposure to both particle types caused visible leaf damage, and CeO2 resulted in increased leaf reactive oxygen species (ROS) levels and corresponding oxidative damage. These results highlight the potential for adverse effects on food crops exposed to soil MNMs, and point to leaf damage as a possible mechanism for observed reductions in growth and yield.

THE BIOAVAILABILITY OF SILVER AND SILVER SULFIDE NANOPARTICLES TO DUCKWEED (LANDOLTIA PUNCTATA) AND ALFALFA (MEDICAGO SATIVA) PLANTS

John Stegemeier, Carnegie Mellon University

Greg Lowry, Carnegie Mellon University

Ben Colman, Duke University

Abstract: The incorporation of engineered metal nanomaterials into consumer products leads to an increased demand to understand the environmental transformations and ultimate fate of these nanoparticles once released. Although several studies have demonstrated nanoparticles are likely to transform in waste water treatment plants before being introduced into the environment, relatively few studies investigate the interactions between these transformed particles and the environment. Sulfur interactions with soft metals such as silver are expected to dominate the potential environmental transformations. This experiment spatially and temporally investigated the distribution and speciation of silver in the plant tissue harvested from hydroponically exposed plants by using a host of laboratory characterization techniques as well as synchrotron based X-ray absorption spectroscopic techniques. Metal nanoparticles were found to be associated with the rhizodermis of the roots indicating limited transport into the roots and throughout the plant. Metal sulfide nanoparticles were found to be taken into plants slower than their counterparts. Metallic silver was identified in the samples exposed to Ag2S nanoparticles but the presence of metallic nanoparticles inside the plant tissue for all the samples may be expected as plants can spontaneously form metal nanoparticles as a response to high aqueous metal concentrations.

NANOMATERIAL REMOVAL BY CONVENTIONAL AND ADVANCED WATER TREATMENT PROCESSES

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Erik Pfeiffer, University of Wyoming

Luke Ruff, University of Wyoming

Abstract: The increasing use of nanomaterials makes them much more prominent as environmental contaminants, particularly in drinking water supplies. The removal of nanomaterials by conventional and advanced separation processes is complicated by the their unique properties and size, which makes detection difficult. Our relative lack of understanding on the removal of nanomaterials by potable water systems makes it difficult to accurately assess the risk that these materials pose to human populations. Additionally, existing studies are often based on evaluating nanomaterial removal in terms of changes in mass concentrations between the feed and finished water streams. Such an approach paints an incomplete picture because a high number (# particles per unit volume) of nanomaterials may yet remain in the treated drinking water. This presentation covers our work to date on the removal of three commonly used nanomaterials (TiO2, CeO2, and nano-Ag) by conventional and advanced separation processes. Pristine and modified forms of nanomaterials are considered. Removal will be reported in terms of the number and mass of nanomaterials removed by a given process or set of processes. Number concentrations were measured using Nanoparticle Tracking Analysis, which is a relatively new nanomaterial characterization technique. Separation processes tested include flocculation/clarification/media filtration and membrane filtration.

NANOPARTICLE INTERACTIONS WITH LIPID BILAYERS STUDIED BY SECOND HARMONIC GENERATION

Julianne Troiano, Northwestern University

Eseohi Ehimiaghe, Northwestern University

Franz Geiger, Northwestern University

Abstract: As part of a broad research effort in the NSF-funded Center for Chemical Innovation on Sustainable Nanotechnology, the goal of this work is to understand the fundamental chemistry of how nanoparticles interact with biologically relevant interfaces in situ at the molecular level. Second harmonic generation (SHG), a surface specific, nonlinear optical technique, is used to investigate the interactions of nanoparticles with lipid bilayers as model cell membranes. SHG provides unique, molecular level adsorption information with surface specificity, in real time, as a table-top experiment. Understanding how nanomaterials interact with lipid bilayers at the molecular level is important for predicting and controlling molecular interactions of nanomaterials with living systems as well as designing environmentally and biologically sustainable nanomaterials.We use resonant and nonresonant SHG to quantify binding constants, adsorption free energies, and interfacial charge densities in real time for nanoparticles interacting with bilayers of various lipid compositions. The impact of lipid composition

and capping ligand on the nanoparticle-membrane interactions has been investigated. Combining this knowledge with the sum frequency generation and quartz crystal microbalance results obtained under the same conditions allows us to predict possible pathways for the nanoparticle-lipid bilayer interactions at the molecular level.

DIFFERENCES IN THE NEUROPROTECTIVE EFFECTS OF NANOCERIA IN A MURINE MODEL OF MULTIPLE SCLEROSIS

Kari Heckman, St. Lawrence University

Matt Skeels, St. Lawrence University

Joe Erlichman, St. Lawrence University

Abstract: Comparing the biological effects of nanoceria has been difficult due to significant differences in methods of synthesis, particle size, surface charge, stabilizing agents and the biological assay tested. We examined the effects of differing nanoceria characteristics in a murine model of multiple sclerosis (MS) by comparing the neuroprotective potential of several nanoceria formulations: Ce- citrate stabilized (~15 nm, Sigma-Aldrich), Ce-acetate stabilized (~ 9 nm, Alfa-Aesar), and custom-synthesized citrate-EDTA stabilized (~2.5 nm; CeNPs). The citrate-EDTA stabilized CeNPs reduced clinical symptoms and motor impairment in EAE animals, whereas the other nanoparticles provided no neuroprotection or worsened symptoms. Nanoceria brain deposition did not necessarily correlate with biological efficacy, suggesting that peripheral factors may influence their biological activity. For example, though Alfa-Aesar particles were present in the brain, they failed to improve EAE severity, whereas the CeNPs were detected at a three times higher level and did alleviate disease symptoms. The acetate and citrate-only stabilized nanoceria also accumulated at relatively high levels in the spleen and liver compared to the citrate-EDTA stabilized nanoparticles. Thus, the surface stabilizer appears to markedly impact the in vivo biodistribution patterns and biological efficacy of nanoceria, perhaps by influencing protein adsorption and initiation of additional biological cascades.

GREEN NANOTECHNOLOGY—A SUSTAINABLE AND ECONOMICALLY IMPERATIVE INTERDISCIPLINARY APPROACH

Kattesh V. Katti, University of Missouri Cancer Nanotechnology Platform

Green nanotechnology is about manufacturing processes that are economically and environmentally sustainable. Green nanotechnology is increasingly being referred to in connection with other concepts such as green chemistry and sustainable and green engineering and manufacturing. The principles of green chemistry can be applied to produce safer and more sustainable nanomaterials and more efficient and sustainable nano manufacturing processes. Most importantly, in the context of renewability, sustainability and long term environmental benignity, green nanotechnology will invoke the utility of herbs, leaves, and a myriad of agricultural produce to develop value added nanotechnology-based products. For example phytochemicals from a variety of herbs, leaves, and agricultural produce serve as reservoir of electrons because of their rich antioxidant capacities. This means that application of environmentally safe phytochemicals can replace more toxic chemical reducing agents such as sodium borohydride, hydrazine and related chemicals in the overall nanoparticle production processes. Our laboratory has pioneered green nanotechnology innovations through applications of phytochemicals from Soy, Cumin, Tea, Broccoli, Mango and a host of agricultural produce for the production of nanomaterials (1-2). We have also shown that specific phytochemicals serve dual roles of chemical reduction with consequent capping of nanoparticulate surface to afford stability against aggregation and agglomeration processes.

EVALUATION OF ADVENTITIOUS PROTEIN MODIFICATIONS IN THE ENVIRONMENTAL FATE AND REACTIVITY OF NANOMATERIALS.

Korin Wheeler, Santa Clara University

Abstract: The safe and sustainable use engineered nanoparticles (NPs) will not be possible until between the structure of NPs and the reactivity with molecules in the environment is better understood. Proteins encountered in biological and environmental systems play a dominant role in altering and controlling the surface chemistry and reactivity of NPs. We present results from a two-pronged approach that examining two different types of protein interactions with NPs. In the first, a small library of loosely associated, rapidly exchanging proteins are examined for catalysis of reactions at the NP surface. Specifically, we analyze the role of these dynamic proteins in metal and metal oxide NP surface reactivity, oxidative dissolution. Second, we use MS proteomics approaches to analyze slowly exchanging proteins that provide a major element in the biological identity of particles. Although the profile of proteins that adsorb to NPs is dependent on environmental conditions, a small population is strongly bound and persists through changes in sample conditions. These two very different types of protein-NP interactions give insight into the dominant role of adventitious interactions between NPs and environmental molecules in altering NP environmental fate and toxicity.

ASSOCIATION OF FUNCTIONALIZED GOLD NANOPARTICLES WITH LIPOPOLYSACCHARIDES: IMPLICATIONS FOR BACTERIAL EXPOSURE TO NANOPARTICLES

Kurt H Jacobson, University of Wisconsin - Madison

Joel A Pedersen, University of Wisconsin - Madison

Catherine J Murphy, University of Illinois at Urbana-Champaign

Abstract: Lipopolysaccharides (LPS) are dominant components of the outer leaflet of the outer-membrane of Gram-negative bacteria. Lipopolysaccharides are complex macromolecules containing a hydrophobic lipid core (Lipid A), a hydrophilic inner polysaccharide region and a variable length hydrophilic tail of oligosaccharides. The structure of this oligosaccharide tail (the O-antigen), varies greatly among bacterial species and strains and also with culture conditions. Due to its display on the outer leaflet and high concentration in the outer membrane, LPS properties are expected to strongly influence the interactions of Gram-negative bacteria with their local environment, including engineered nanoparticles. We assessed association of functionalized gold and diamond nanoparticles with supported lipid bilayers incorporating Salmonella or Shewanella LPS using a combination of quartz crystal microbalance with dissipation monitoring (QCM-D) and optical waveguide lightmode spectrometer (OWLS). We find that increasing concentrations of LPS in lipid bilayers increases the association of nanoparticles functionalized to carry a net positive charge. Due to the net negative surface charge on LPS, this suggests that electrostatic forces contribute significantly to the interaction energies between charged nanoparticles and Gram-negative bacteria.

ASSESSING THE HETEROAGGREGATION OF MANUFACTURED NANOPARTICLES WITH NATURALLY OCCURRING COLLOIDS IN A TYPICAL SURFACE WATER

Labille Jerome, CNRS, France

Praetorius Antonia, ETH, Swiss

Brant Jonathan, University of Wyoming, USA

Abstract: To study and predict the fate of engineered nanoparticles (ENP) in surface water, relevant environmental conditions should be applied, regarding both the system composition and the ENP concentration. This is likely to favour the heteroaggregation of ENPs with naturally occurring colloids. In this work, we studied these interactions as a function of the physicochemical conditions of the solution.In a mechanistic approach, pure montmorillonite clay and silica with 0.5 - 1 µm size were used as surrogates for natural colloids in a pure water of controlled pH, ionic strength and natural organic matter. Natural surface waters were also used in a holistic approach. TiO2 nanoparticles were spiked in these systems, and the heteroaggregation induced was assessed using laser diffraction. It appeared that,

depending on pH and ionic strength, ENPs show a significant affinity for the colloids, which induces rapid heteroaggregation of the system and sedimentation of the aggregates formed. The concentration ratio between ENP and colloid appears highly determining for this mechanism, a critical ENP concentration being evidenced. These data, coupled to a fate model, will enable to deliver a probability ranking of the potential scenarios on the fate of ENPs in natural aqueous systems at the river scale

NANOMEDICINE NOW: ACHIEVEMENTS AND CHALLENGES

Lajos (Lou) Balogh, Nanomedicine: Nanotechnology, Biology, and Medicine

Nanomedicine and nanobiotechnology are two rapidly emerging areas closely related to and depending on modern materials science creating novel bioresponsive materials. Nanomedicine focuses on the patient and nanobiotechnology concentrates on new materials and medical technologies. Nanobiotechnology is developing better and better approaches and solutions to existing problems that have the potential to forever change how patients are diagnosed and treated in the next decade. However, all these changes are happening when both medical science and the pharmaceutical industry are undergoing revolutionary transformations. Apart from the great promises of nanomedicine, there are many general challenges for these paradigm-changing fields, especially in the area of scientific communication and commercialization. In order to produce affordable and not only revolutionary clinical applications, nanomedicine must be fueled by successful business. In this talk, the latest developments in nanomedicine and nanopharmaceuticals will be summarized, including popular discussion topics, such as personalized medicine and theranostics. Emerging research and market trends along with the introduction of a few real breakthroughs will also be illustrated.

TOOLS FOR RISK MANAGEMENT OF ENGINEERED NANOPARTICLES IN THE WORKPLACE

Laura Hodson, MSPH, CIH, NIOSH

Charles Geraci, PhD, CIH, NIOSH

Abstract: Nanotechnology has the potential to provide great benefit to society, but it must be developed responsibly. This responsibility involves addressing any adverse human and environmental impacts of the technology associated with engineered nanomaterials. Workers are among the first people in any society to be exposed to the potential health hazards caused by the products of new technology, and

their exposure to any new material is often greater than for the general population. Therefore, worker safety and health can be seen as the core of responsible development. Timely targeted research is needed to define hazards, exposures, and risks; and provide guidance for safe handling of nanomaterials. Those responsible for worker safety and health need to select various techniques from their toolbox that include evaluating the available toxicologic literature, conducting exposure monitoring, using hazard and control banding tools, recommending and evaluating engineering control solutions, and recommending administrative controls and personal protective equipment.

OBSERVING LIPID BILAYER RESPONSE TO GOLD NANOPARTICLES USING NONLINEAR OPTICAL SPECTROSCOPY

Laura Olenick, Northwestern University

Stephanie Walter, Northwestern University

Franz Geiger, Northwestern University

Abstract: Understanding the interactions between nanoparticles and lipid bilayers is one step towards understanding the fate and transport of nanoparticles in biological systems. To study these interactions, we use nonlinear optical spectroscopy, specifically, sum frequency generation (SFG). SFG allows us to focus on the interactions at the interface between a model lipid bilayer system and carefully designed gold nanoparticles by monitoring the response of the lipid bilayer to the introduction of nanoparticles. In directed experiments, we see an interaction between gold nanoparticles and various lipid bilayer compositions. By varying the charges of the lipid bilayers and the nanoparticles, we probe the influence of electrostatics. Other factors researched include the effect of aggregation of the nanoparticles and the effect of NaCl concentration on the nanoparticle-lipid bilayer interaction.

REALIZING COMPARABLE OXIDATIVE AND CYTOTOXIC POTENTIAL OF SINGLE- AND MULTI-WALLED CARBON NANOTUBES THROUGH ANNEALING

Leanne M. Pasquini, Yale University

Dr. Julie B. Zimmerman, Yale University

Dr. Howard Fairbrother, Johns Hopkins University

Abstract: The potential applications as well as the environmental and human health implications of carbon nanomaterials (CNMs) are well represented in the literature. There has been a recent focus on how specific physicochemical properties influence carbon nanotube (CNT) function as well as

cytotoxicity. The ultimate goal is a better understanding of the causal relationship between fundamental physiochemical properties and cytotoxic mechanism in order to both advance functional design and to minimize unintended consequences of CNTs. This study provides characterization data on a series of multi-walled carbon nanotubes (MWNTs) that underwent acid treatment followed by annealing at increasing temperatures, ranging from 400 – 900 °C. These results show that MWNTs can be imparted with the same toxicity as single-walled carbon nanotubes (SWNTs) by acid treatment and annealing. Further, we were able to correlate this toxicity to the chemical reactivity of the MWNT suggesting that it is a chemical rather than physical hazard. Analytical techniques are being pursued to identify the likely functionalization characteristics that are most closely related to this reactivity and toxicity. This informs the design of MWNT to be less hazardous or enables their implementation in antimicrobial applications. Given the reduced cost and ready dispersivity of MWNT as compared to SWNT, there is a significant opportunity to pursue the use of MWNT in novel applications previously thought reserved for SWNT.

BLOGGING AT SUSTAINABLE-NANO.COM: INFORMAL SCIENCE EDUCATION & PROFESSIONAL DEVELOPMENT

Lee M. Bishop, University of Wisconsin - Madison

Robert J. Hamers, University of Wisconsin - Madison

Abstract: We at the Center for Sustainable Nanotechnology have created a blog, sustainable-nano.com, with the goal of communicating with the general public. Our target audience is individuals in their 20s and 30s—a demographic that is difficult to reach through other formats. Research suggests that information delivered in a hyperlinked manner more effectively promotes a comprehensive understanding of interrelated topics than does information delivered in a linear fashion, and so a blog provides an ideal tool with which to communicate the complex issues surrounding sustainable nanotechnology. The interactivity of this online tool means we have created a unique venue for direct communication between the general public and research-active scientists.

The blog also provides a professional development opportunity for scientists. Independent assessment has revealed that participants are highly engaged in writing and responding to blog posts. This format enables one-on-one training in communication of science with general audiences via editing of blog posts by an experienced blogger on staff at our center. Informal science education through a blog thus overcomes two traditional barriers to scientists participating in outreach—lack of motivation and access to relevant training.

This talk will address the creation, maintenance, and future outlook of this blog.

LIFE CYCLE ASSESSMENT OF SILVER NANOPARTICLES ENABLED IN MEDICAL BANDAGES

Leila Pourzahedi, Northeastern University

Matthew Eckelman, Northeastern University

Abstract: Over 400 tons of silver nanoparticles (AgNPs) are produced annually, 30% of which are used for medical purposes due to their antibacterial properties. With these particles finding increasing direct contact applications, potential routes of human and ecotoxicity alongside environmental fate and transport have received significant attention. Studies on nanomaterial toxicity typically focus on either production or release-related emissions. In the present work, we consider AgNP ecotoxicity from a life cycle perspective in order to estimate the relative importance of these various sources of emissions. A product-centric approach, rather than material-centric, was chosen to determine the relative contribution of AgNPs to other materials and the overall burden of product. Hence, a cradle-to-grave Life-Cycle-Assessment was performed for nanosilver-enabled medical bandages, considering the impacts associated with non-silver emissions from the multiple routes of AgNP synthesis (physical, bio-based, and chemical reduction methods), use, and end-of-life waste management. Modeling results suggest that (1) production-phase toxicity is significantly greater than plausible end-of-life scenarios, (2) silver holds the largest share of any impact category in any stage of the life cycle. This study can be used to prioritize research and policy measures to improve the ecotoxicity impacts of AgNP-enabled bandages under a life cycle framework.

IMPROVING NANOPARTICLE DETECTION AND CHARACTERIZATION USING SPICPMS WITH MICROSECOND DWELL TIMES

Manuel Montano, Colorado School of Mines

James F. Ranville, Colorado School of Mines

Hamid Badiei, Perkin-Elmer Inc.

Abstract: To keep pace with the ever-growing manufacturing and production of engineered nanomaterials, new analytical techniques are being developed with the purpose of detection and characterization of man-made nanoparticles in environmental systems. In recent years, single particle ICP-MS has been used to detect and characterize a variety of ENPs such as carbon nanotubes, metallic nanoparticles and metal oxide nanomaterials at environmentally relevant concentrations (ng L-1). Analytical issues occur when a significant concentration of dissolved analyte is present resulting in diminished resolution between particle signal and background signal, or if there is a high particle number concentration such that two particles enter the plasma at the same time, causing a coincidence

signal. To this end, shorter dwell times in the microsecond range have been exploited to increase resolution between the dissolved background and particle signals as well as distinguish between individual particles at high concentrations. In addition, multi-element detection for single particles has been developed, which may lead to methods for differentiating between engineered nanomaterials and naturally occurring particles. It is expected that these advancements may begin to overcome some of the analytical obstacles that arise from the analysis of ENPs in natural systems.

LARGE AIR VOLUME REAL TIME NANO-AEROSOL MONITORING SYSTEM

Maria D. King, Texas A&M University

Victor M. Ugaz, Texas A&M University

Raymond M. Pierson, Northrop Grumman Inc., Elkridge

Abstract: Efforts to establish correlations between aerosolized nanomaterials and potential health risks critically depend on the effective sampling of nanoaerosols from room-sized volumes and quantitative characterization of their size, chemical species, and concentration. We have established a Real-Time Nano-Aerosol Monitoring System (RTNAMS) for the continuous monitoring of nanoparticles in ~200 microgram/cubic meter concentrations with high collection efficiency (~75%).

The Low Cutpoint (LCP) Wetted Wall Cyclone (WWC) collects nano- and larger aerosols from the environment at 300 LPM, using Tween-20 for the continuous elution of the nanoparticles.

During laboratory trials different nanoparticles were released into a flowcell and RTNAMS was allowed to sample these materials. The LCPWWC injects the nano-aerosol laden liquid into the microchannel and the NanoSight-LM20 at 0.04 – 0.2 mL/min flow rates. In the microchannel co-flowing aqueous streams containing Al particles and a fluorescein solution result in complexation, producing a fluorescent plume with intense interfacial fluorescence. The opposite effect occurs with Ti nanoparticles, resulting in fluorescence quenching. Different reactivity with fluorescent dye enables the quantitation, speciation and sizing of the nanoparticles. In the LM20 the sample is automatically sized and quantitated. For reference quantitation mass spectrometry was used. RTNAMS was also applied in mass-transit centers, classrooms, agricultural fields and farms.

REINVENTING THE INVENTORY OF NANOTECHNOLOGY CONSUMER PRODUCTS

Marina E. Quadros, Virginia Tech

Todd Kuiken, Woodrow Wilson International Center for Scholars

Sean McGinnis, Virginia Tech

Abstract: The Nanotechnology Consumer Product Inventory (NCPI) was created in 2005 by the Project on Emerging Nanotechnologies. This inventory is of the most popular evidences of current widespread applications of nanotechnology, but it has also been criticized due to its lack of scientific endorsement. Our objective is to perform a large upgrade to this inventory. Specifically, we are adding scientific significance and usefulness to the inventory by including new descriptors for the consumer products and the nanomaterials contained in these products, such as size, concentration, and potential exposure routes. We are including scientific data related to those products and providing a metric for the reliability of the data on each inventory entry. We developed a survey to assess key stakeholders' needs for the NCPI and interviewed 56 nanotechnology experts with over 350 combined years of experience in nanotechnology. Their answers guided the upgrade and provided an idea of the expectations related to the inventory. Of the 1317 products initially listed in the inventory, 834 were updated, including the removal of 196 products that are no longer available or no longer advertise to contain nanotechnology, and 325 new products were added, totaling 1446 products. The NCPI will be released in October 2013.

PAPER BASED SENSORS FOR POLIOVIRUS DETECTION

Marjorie R. Willner, Virginia Tech

Rebecca H. Lahr, Virginia Tech

Peter J. Vikesland, Virginia Tech

Abstract: In the United States, water security is often dealt with using large scale infrastructure. However, consolidated treatment techniques are not feasible and/or not reliable in many parts of the developing world. That is, accessible water might be of questionable quality. Nano-enabled paper based sensors represent an exciting method to empower individuals to check/verify their own water quality. Compared to traditional techniques, paper-based sensors are cheap, portable and do not require any advanced training. Poliovirus serves as an excellent test case for paper based virus detection because it is a well characterized pathogen and its eradication has positive global consequences. We will describe the four major steps we have taken towards the development of a paper based sensor: 1) the synthesis of poliovirus antibody decorated gold nanoparticles (immunogold); 2) the development of low cost wax printed channels on paper; 3) the integration of the immunogold into the channels; and 4) colorimetric detection based on gold nanoparticle aggregation.

ETHICAL POSITIONS AND NANOTECHNOLOGY ACCEPTANCE: A SOCIAL COMPONENT OF ENVIRONMENTAL SUSTAINABILITY

Mary Collins, University of Maryland

Shannon Hanna, National Institute of Standards and Technology

Barbara Herr Harthorn, University of California, Santa Barbara

Abstract: Sustainability is described as having three pillars—environmental, societal, and economic. Given the importance of sustainability in nanotechnology development, it is critical that research also reflect these three pillars. This research addresses two of the three by exploring the relationship between ethical values and perception of acceptability in environmental uses or implications of nanotechnology among US publics. Using US public survey data, we conducted a principal components analysis (PCA) that identified four factors of nanotechnology ethics. These four factors include: valuing public input in development, issues of equity and power, institutional trust, and informed consent for development. These factors were then used with other demographic and descriptive covariates to predict environmental nanotechnologies' acceptability. While controlling for nanotechnology-related knowledge, educational attainment, income, age, and race, we found that as respondents' acceptance of environmental nanotechnologies decreases, they are more likely to have equity and power concerns related to its development, believe in the necessity of informed consent, have lower levels of trust in institutions, be older, be female, and be more liberal. We argue these findings form a cluster of responsible development ethical and cultural values important to consider in promoting the sustainable development of nanotechnology.

FOOD STARCH COATED IRON NANOPARTICLES FOR APPLICATION IN CONTAMINANT REMEDIATION

Mary Pate, North Dakota State University

Senay Simsek, North Dakota State University

Achintya Bezbaruah, North Dakota State University

Nanoscale zero-valent iron (NZVI) has highly reactive surface area for reduction and sorption of contaminants. However, due to agglomeration and resulting sedimentation, the available surface area is reduced, and this reduces the remediation efficiency of NZVI particles. Surface modification of the particles is known to help in increasing their colloidal stability and reduce agglomeration. The present National Science Foundation supported (Grant # CMMI-1125674) work involves the use of various food starches derived from wheat, corn, rice, potato, and tapioca to coat NZVI. The starches are functionalized with various acid groups and the coatings are optimized for decreased agglomeration and

sedimentation. The coated nanoparticles are used for trichloroethylene (TCE) remediation in batch experiments and 80-95% TCE removal has been achieved.

THREE-DIMENSIONAL VISUALIZATION AND QUANTIFICATION OF GOLD NANOMATERIAL DEPOSITION AND AGGREGATION IN POROUS MEDIA VIA RAMAN SPECTROSCOPY

Matthew Chan, Virginia Tech

Weinan Leng, Virginia Tech

Peter J. Vikesland, Department of Civil and Environmental Engineering, Virginia Tech

Gold-based nanomaterials such as gold nanoparticles and gold nanorods are used in a variety of applications. However, there is a poor understanding as to the fate and behavior of these nanomaterials in the environment. When gold nanomaterials are released into groundwater environments their interactions with sediments may be very complex. The effect of the geometrical shape of the gold nanomaterials on their transport and aggregation behavior is also poorly understood. Raman spectroscopy allows us to observe in situ the three-dimensional transport and aggregation behavior of gold nanomaterials of various shapes and sizes. When gold nanomaterials aggregate, a unique signal that originates from phonon-plasmon coupling can be detected by Raman spectroscopy with high sensitivity, thus allowing us to observe and quantify transport and aggregation behavior. A flow-cell packed with media serves as a model of the subsurface environment, where gold nanomaterials are introduced into the flow cell. Confocal Raman spectroscopy enables capture of three-dimensional maps from the phonon-plasmon coupling peak in the flow cell interior. By varying the solution chemistry within the flow cell, the geometric dimensions of the gold nanomaterials, and applying a Raman mapping technique, the transport and aggregation behavior of gold nanomaterials can be much better understood.

DETECTION OF HEAVY METALS WITH GRAPHENE OXIDE-BASED BIOSENSORS

Ming Li, West Virginia University

Nianqiang Wu, West Virginia University

Abstract: Heavy metals are highly toxic and dangerous pollutants. Heavy metals enter the environment due to industrial activities, which have raised concerns about sustainable development. There is critical need for development of sensors for on-site detection of heavy metals in the environment. This talk presents the graphene oxide (GO)-based biosensors for detection of Heavy metals. Our work shows that

GO can act as not only an acceptor (quencher) but also a donor (fluorophore) in the energy transfer based fluorescent sensors. GO has been employed as a fluorophore in a biosensor, which shows a limit of detection (LOD) of 0.92 nM toward label-free detection of mercury(II) in an aqueous solution. In addition, GO has been used as an energy acceptor in a fluorescent sensor, which exhibits a LOD of 90 pM for lead(II).

MULTI-WALLED CARBON NANOTUBE SUPPORTED TITANIA FOR ENHANCED SOLAR HYDROGEN PRODUCTION

Ming Li, University of Notre Dame

Chongzheng Na, University of Notre Dame

Abstract: Multiwalled carbon nanotubes (CNTs) have been proposed as a conductive support that can facilitate the separation of photogenerated electrons and holes and thus improve the performance of conventional photocatalytic materials such as TiO2. To investigate this hypothesis, we synthesized TiO2-CNT nanocomposites using polyol reduction. In comparison to unsupported TiO2 nanoparticles, CNT-supported TiO2 nanoparticles showed much improved catalytic ability in solar hydrogen production. After normalizing to surface area, hydrogen production rate using CNT-supported TiO2 nanoparticles were found to be 5 times the rate obtained with suspended TiO2 nanoparticles.

A ROBUST, ENERGY-FREE, SUSTAINABLE POINT-OF-USE WATER PURIFICATION SYSTEM

Mingliang Zhang, Stanford University

Xing Xie, Stanford University

Shan X. Wang, Stanford University

The development of sustainable, robust and energy efficient water purification technology is still challenging. While use of nanoparticles is promising, methods are needed for their efficient recovery post-treatment. Here we address this issue by fabrication of magnetically ultra-responsive nanoscavengers, nanoparticles containing synthetic antiferromagnetic core layers and functional capping layers. When dispersed in water, the nanoscavengers efficiently interact with contaminants to remove them from the water. They are then quickly collected (<5 minutes) with a permanent magnet, owing to their magnetically ultra-responsive core layers. Specifically, we demonstrate fabrication and deployment of Ag-capped nanoscavengers for disinfection followed by application of an external

magnetic field for separation. We propose a cyclical water purification scheme in which nanoscavengers are recovered and recycled for contaminant removal.

AGGREGATION AND DISSOLUTION BEHAVIORS OF METAL OXIDE NANOPARTICLES IN AQUEOUS ENVIRONMENT

Myunghee Lim, Korea Institute of Toxicology

Sujin Bae, Seong Min Hong, Korea Institute of Toxicology

Yu Sik Hwang, Korea Institute of Toxicology

Abstract: Metal oxide nanoparticles are among the most widely used engineered nanoparticles (ENPs) having various applications in the fields such as medicine, cosmetics, water purification and textiles. With metal oxides (MeOs) increasingly being manufactured and used for these applications, those nanoparticles will be released into natural and engineered aquatic systems during production, transport and use. However, research investigating the fate and transport of MeOs is still very limited. In this study, we investigate the dissolution and aggregation behaviors of several MeOs (CeO, Fe2O3, SiO2, TiO2, ZnO etc.) in aqueous environment. In particular, the effects of initial concentration of nanoparticles, pH, ionic strength and organic compounds (natural organic matter, organic acids) towards the dissolution of metal oxide nanoparticles in aquatic system were studied. Also the homoaggregation of MeOs and their heteroaggregation behavior with clay particles in different water chemistry conditions were thoroughly evaluated. These results can provide a better understanding of the environmental risks posed by these nanoparticles in natural water system.

ARE NANOHYBRID ENVIRONMENTAL IMPLICATION STUDIES OVERDUE?

Navid Saleh, University of South Carolina

Jamie Lead, University of South Carolina

Nirupam Aich, University of South Carolina

Recent focus on material synthesis and development at the nano-scale shows a clear shift from single material processing toward hierarchical assemblages. Such ensembles of two or more pre-synthesized nanomaterials are primarily pursued to extract multifunctionality through alteration of their interfacial, electronic, and optical properties. A rendition of environmentally relevant nanohybrid (NH) definition can be stated as: more than one nanomaterial of unique chemical origin when conjugated with a molecular or macromolecular link or other physicochemical forces and nanomaterials with altered

chemical structure via overcoating or doping when serves multifunctional purposes can be defined as a NH. Within this definition, exotic nano-ensembles such as: nano-peapods, nano-onions, carbon-metallic conjugates, and metal-metal NHs are being researched to achieve multifunctionality. Such assemblages not only contribute to enhanced functionality but also present unknown and unique physicochemical properties, which will likely cause unpredictable environmental behavior from their release and exposure. However, while researchers focus on the merits of such NHs, their potential toxic and environmental implication has largely been ignored. This study will introduce the most studied next generation NHs and will attempt to highlight their unique properties that will likely result in unpredictable environmental interactions.

REAL TIME VISUALIZATION AND QUANTIFICATION OF SILVER NANOPARTICLES IMPACT ON ESCHERICHIA COLI USING ATOMIC FORCE MICROSCOPY-LIQUID CELL

Nelson Anaya, University of Rhode Island

Teresa Kirschling, Jeison Killgore, NIST

Vinka Oyanedel-Craver, University of Rhode Island

Abstract:Few studies have performed real time visualization and quantification of the physical changes on live bacteria when exposed to sublethal concentrations of nanoparticles. Atomic Force Microscopy (AFM) is a tool that can be used to visualize living cells immobilized to a solid substrate producing high-resolution images. Topographic imaging and mechanical information can be obtained in buffer or culture medium, while minimally perturbing cell function.

Imaging in an enclosed physiological environment is typically accomplished with a liquid cell. A liquid cell secures the probe and positions the cantilever tip at the surface to be imaged while maintaining an enclosed and sealed environment containing a small volume of liquid, which is pumped continuously.

This study will determine the feasibility to image and measure the impact of nanoparticle exposure on the cell morphology of Escherichia coli, using an AFM-liquid cell. Data obtained will be used to interpret toxicity data and predict the environmental risk associated with AgNPs and Ag+ at environmentally relevant concentrations.

Preliminary results indicated that bacteria exposed under the dynamic flow conditions to 10 mg/L of AgNPs had minimal changes to the cell morphology unlike what previous researchers have shown with electron microscopy.

EFFECTS OF DENDRIMER OIL DISPERSANTS ON DICTYOSTELIUM DISCOIDEUM

Nicholas K Geitner, Clemson University

Rhonda Rogers-Powell, Clemson University

Pu-Chun Ke, Clemson University

Abstract: Chemical dispersion is a frequently used yet controversial strategy in an attempt to minimize the environmental and economic impact of large-scale oil spills. Previously, cationic poly(amidoamine) (PAMAM) dendrimers have been proposed as novel, biocompatible oil dispersants. Here, we investigate the effect of such dendrimer oil dispersants on the soil amoeba Dictyostelium discoideum, using phenanthrene as a model polyaromatic hydrocarbon. In examining cell culture proliferation and changes in membrane potential, we find that low concentrations of cationic generation-4 PAMAM dendrimers were non-toxic to Dictyostelium discoideum. In comparison, the same low concentration of the primary surfactant in the COREXIT oil dispersant, Tween 80, did display limited acute cytotoxicity. Higher concentrations of dendrimer oil dispersant elicited cytotoxicity due to significant depolarization of the cell membrane resulting from the uptake of highly cationic PAMAM dendrimers. Cellular uptake of cationic PAMAM dendrimers was confirmed by a cellular association experiment conducted at room temperature and 2ºC, using fluorescence imaging. The uptake and corresponding membrane depolarization was found to be significantly inhibited by the presence of phenanthrene within and around the periphery of the dendrimers. This study offers a new insight on the environmental implications of oil dispersants.

EXTENT OF TIN DOPING INFLUENCES NANO INDIUM TIN OXIDE'S AGGREGATION BEHAVIOR IN AQUEOUS SYSTEMS

Nirupam Aich, Civil and Environmental Engineering, University of South Carolina

Dipesh Das, Civil and Environmental Engineering, University of South Carolina

Navid B Saleh, Civil and Environmental Engineering, University of South Carolina

Abstract: Nano indium tin oxide (nITO) has been the most widely used material as transparent conducting thin film for state-of-the-art electronic display modules. However, known fatal inhalation and carcinogenic toxicity of ITO necessitate systematic fate and transport studies to reliably evaluate their environmental impacts. The goal of this study was to assess the effects of tin (Sn4+) doping on the aggregation behavior of nITO materials. Time-resolved dynamic light scattering (TRDLS) was employed to systematically evaluate aggregation kinetics of nITO for a range of tin doping; i.e., 0%, 5%, and 10%. Environmentally relevant concentrations of monovalent and divalent cations (Na+ and Ca2+) and Suwanee River humic acid (SRHA) were used to evaluate the role of background chemistry. Both nano In2O3 and the two nITO samples showed typical DLVO type behavior. Obtained critical coagulation concentrations (CCCs) increased with the increase of tin doping, indicating increased stability for the bimetallics. SRHA enhanced stability for all nITO samples, likely due to steric stabilization. These results have significant and far-reaching implications or nITO fate. Since ITO has been known to be extremely

toxic, the higher stability (low aggregation) will make them more mobile in the aqueous environment and increase environmental exposure and risk to nITO materials.

A PORTABLE EC-TFF SYSTEM FOR IN-SITU CHARACTERIZATION OF ENGINEERED NANOMATERIALS

Omowunmi A. Sadik, State Universityn of New York at Binghamton

Nian Du, State Universityn of New York at Binghamton

Veronica Okello, State Universityn of New York at Binghamton

Abstract: The first step in maximizing the benefits of nanomaterials while reducing the risk is to develop novel analytical tools that can accurately and rapidly characterize manufactured nanomaterials in complex biological and environmental matrices. Conventional methods for assessing the properties and characteristics of raw nanomaterial focus on the size distribution and effects. They are however unsuitable for measurements in complex biological and environmental matrices. Hence the creation of new instruments or approaches, or further development of existing tools is necessary to obtain fundamental information such as mass, size, charge, toxicity in complex environment. This presentation will provide an overview of conventional tools and a survey of new techniques. It will focus on the design, fabrication and testing of a portable nanoparticle analyzer based on tangential flow filtration and electrochemical detection (EC-TFF). EC-TFF is equipped with nanoporous membrane electrode arrays that perform multiple functions: captures, isolates, and detects (CID) engineered nanoparticles. The application of EC-TFF for CID of nanomaterials (ZnTe quantum dots, Core-shell Au-TiO2, nanostructured LiFePO4, and commercial Sony battery materials) directly from pure standards, simulated matrices and real-world samples will be presented.

ASSESSING GREEN SYNTHESIS PROCESSES FOR NANOPARTICLES THROUGH A LIFE CYCLE PERSPECTIVE

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Peter J. Vikesland, Department of Civil and Environmental Engineering, Virginia Tech

Sean McGinnis, VT Green Engineering Program, Virginia Tech

Abstract: In recent years, so-called green synthesis methods for nanomaterials have been explored using natural alternatives (e.g., phytochemicals) to industrial chemicals. Although the feasibility of synthesizing nanoparticles using phytochemicals has been well established, the sustainability of the synthesis processes has not been critically studied from a life cycle perspective. Nanotechnology can be made more sustainable by applying green chemistry and green engineering principles. However, doing

so without thoroughly evaluating the life cycle environmental impacts of a process may be misleading; merely replacing a conventional chemical with a plant-derived alternative does not assure improved sustainability. To address this gap, we conducted a screening-level, cradle-to-gate life cycle assessment (LCA) of several laboratory-scale methods for gold nanoparticle synthesis using phytochemicals. We found that green synthesis methods can have environmental impacts that can vary significantly from process-to-process. We will also discuss the challenges in choosing appropriate functional units and identify the major gaps in the green nano-synthesis literature that limit the comparability of reported green synthesis protocols. Our results show that despite the lack of nano-specific LCA data, screening-level LCAs of nanoparticle synthesis methods can help facilitate choice of the most environmentally benign process with the lowest life cycle footprint.

CHARACTERIZATION OF FOOD GRADE TITANIUM DIOXIDE

Paul Westerhoff, Arizona State University

Kyle Doudrick, Arizona State University

Yu Yang, Arizona State University

Six samples of food grade titanium dioxide (TiO_2) was obtained from major food suppliers and thoroughly characterized by spectroscopic and other analytical techniques. The results were compared against P25, a commonly used non-food grade TiO_2 source (P25 is used as a catalyst). Nano-size (<100 nm in one dimension) materials were present in all food grade samples, but on average primary TiO_2 particles in food grade materials were larger than the 25 to 30 nm primary particles in P25. All the food-grade materials were contained a phosphorous based coating, we believe to stabilize the materials in liquid suspensions. Consequently, the zeta potential of the food grade TiO_2 differed from P25. Phosphorous content was validated by ICP-MS and XPS analyses. XRD analysis confirmed the presence of anatase and/or rutile in the food grade materials, and P25; although the presence of amorphous TiO_2 could not be ruled out. Size distributions of food grade TiO_2 in water were evaluated using DLS and single particle ICP-MS. The results will be presented and holistically described as part of a life cycle assessment of food-grade nanomaterials.

THE VIRGINIA TECH INTERDISCIPLINARY GRADUATE EDUCATION PROGRAM IN SUSTAINABLE NANOTECHNOLOGY

Peter Vikesland, Virginia Tech

Amy Pruden, Virginia Tech

Linsey Marr, Virginia Tech

Abstract: The Virginia Tech Sustainable Nanotechnology Interdisciplinary Graduate Education Program (SuN-IGEP) was initiated in the Fall of 2011. This effort, funded by the Virginia Tech graduate school, annually provides support for a number of Ph.D. students as well as ancillary support for research staff with the goal to support development of expertise in sustainable nanotechnology, This presentation will discuss the central educational and research tenets of the SuN-IGEP effort.

NANOMATERIAL FATE IN THE ENVIRONMENT - WHERE HAVE WE BEEN AND WHERE ARE WE GOING?

Peter Vikesland, Virginia Tech

Greg Lowry, Carnegie Mellon

Over the past ten years there has been an intense effort to examine the environmental fate of engineered nanomaterials. Over this period of time, many fundamental insights have been gained as to the processes that control nanomaterial distribution in both natural and engineered systems. In this overview presentation, we will discuss what has been learned thus far and we will consider how that knowledge is being used to develop future research avenues.

A NOVEL, CHEMICAL FREE INTERVENTION NANOTECHNOLOGY FOR FRESH PRODUCE SURFACE DISINFECTION USING ENGINEERED WATER NANOSTRUCTURES

Phillip Demokritou, Harvard University

Georgios Pyrgiotakis, Harvard University

Abstract: Fruits and Vegetables can become contaminated with pathogens all along their production chain, and when consumed raw or minimally-processed may lead to serious foodborne diseases. In addition, non-pathogenic organisms present on their surface can bring about fast spoilage, causing huge losses in the agricultural and food industry. Here, we explore the effectiveness of a recently developed, by the investigators, novel intervention nanotechnology-based method for the inactivation of microorganisms (pathogenic and non-pathogenic) on the surface of a variety of fresh produce, resulting in increased safety and shelf life. This method utilizes Engineered Water Nanostructures (EWNS) produced by electrospraying the condensed atmospheric water vapor and possess unique physico-chemical and biological properties. EWNS are highly charged (10 electrons/structure), and have extended lifetime in the air (hours). They are very small in size (25 nm) and loaded primarily with two dominant ROS species (OH• and O2•), known for their ability to inactivate bacteria. Preliminary experiments demonstrated that the EWNS, have the potential to be an effective means for inactivating common vegetative bacteria on surfaces. This novel intervention approach is cost effective, chemical

and radiation free and leaves no residues and byproducts and can be employed in key points in the fresh produce production chain, from Farm to Fork.

IMPLICATIONS OF NANOTECHNOLOGY IN SUSTAINABLE ENERGY

Prof. S.K. Singh, Vice Chancellor, HNB garhwal (A Central University), Srinagar(Garhwal), Uttarakhand, India

Nanotechnology is an important area of research these days. It can design new structures at micro scale level and produce novel materials with great potential applications in a wide number of fields. Among them, significant breakthroughs are especially required in the energy sector that will allow us to maintain our increasing demand for energy, which increases with the population and with our demand per capita. This could be done in a way protecting the environment so as to minimize the human impact on the climate and biodiversity. Nanotechnology has specific contributions to the various sustainable energies. Solar energy which is the largest energy source available to human race has been explored with limited technological advances during last 30 years.

Therefore, offering formal education at the undergraduate and graduate levels in various aspects of Green Nanotechnology has become absolutely important o prepare intellectual world force for the 21st century. As the Vice Chancellor of India's premier University, situated within the picturesque foothills of Himalayas, I will discuss in my lecture various plans of offering formal education and our activities in advanced research on Green Nanotechnology.

NANO-CATALYSTS WITH MAGNETIC CORE: SUSTAINABLE APPLICATIONS IN CHEMICAL SYNTHESIS

Rajender S. Varma, Sustainable Technology Division, National Risk Management Research Laboratory, U.S. Environmental Protection Agency

Efficient synthesis of magnetic nanoferrites [1] and micro-pine structured catalysts [2] via microwave (MW) hydrothermal process will be described which can be post-synthetically modified with silica and other nanoparticles or benign ligands such as glutathione. The sustainable applications of such magnetic nano-catalysts in catalysis (and organocatalysis) will be highlighted [3] for a wide variety of synthetic reactions wherein their recyclability and reuse is facilitated by simple magnetic separation; their use in aqueous media and in conjunction with microwaves is especailly attractive. [4] A sustainable approach to the utility of nano-catalysts (Pd, Ni, Ru, Ce, Cu etc.) immobilized on biodegradable and recyclable supports e. g. cellulose and chitosan or on magnetic ferrites via ligands such as dopamine or glutathione will be presented.

SURFACE-ENHANCED RAMAN SPECTROSCOPY (SERS) CELLULAR IMAGING FOR DETERMINATION OF INTRACELLULAR GOLD NANOPARTICLE BIOCOATINGS

Rebecca H. Lahr, Virginia Tech

Peter J. Vikesland, Virginia Tech

Abstract: Nanoparticle biosynthesis has the potential to facilitate green nanoparticle production and recovery of metal ions from wastewaters, but the mechanisms and optimal conditions for nanoparticle biosynthesis by most organisms are still unclear. Surface-enhanced Raman spectroscopy (SERS) cellular imaging was applied to identify intracellularly biosynthesized gold nanoparticle (AuNP) surface associated (< 4 nm) biomolecules in the green algae Pseudokirchneriella subcapitata. SERS spectral maps and algal cross-sections analyzed by transmission electron microscopy indicate bioproduction of intracellular AuNP upon incubation of the algae with HAuCl4. Patterns in the spatial variability of SERS spectra collected across a single organism, a set of organisms, and organisms under an array of biosynthesis conditions were identified using principle component analysis and cluster analysis. SERS peak positions and intensities suggest that biosynthesized AuNP predominantly associate with biomolecules thought to be involved in the nanoparticle biosynthesis (e.g., chlorophyll a, β-carotene, phytochelatin, nicotinamide adenine dinucleotide, or a reductase enzyme). SERS cellular imaging aids in elucidation of the mechanisms responsible for AuNP biosynthesis by algae and bacteria, thereby improving green nanoparticle synthesis protocols to produce reproducibly monodisperse particles.

MOLECULAR INTERACTIONS OF NANOMATERIALS AND ORGANISMS

Rebecca Klaper, School of Freshwater Sciences, University of Wisconsin-Milwaukee

In order to create sustainable nanomaterials it will be necessary to understand the molecular-level interactions of a nanomaterial and a cell, tissue or organism. To date there has been a large focus on oxidative stress markers in investigations of the toxicity of nanomaterials. However, oxidative stress can be a temporary effect and may not really indicate the potential toxicity of a toxin. Many other physiological pathways may provide better indication and more specific information of the interaction of a nanomaterial with a cell or organism and the ultimate environmental impact of a nanomaterial. Here we present evidence of the multitude of pathways of response to nanomaterials and how they differ with changes in surface chemistry of the material. In addition, we present concentration and time – dependent impacts. Finally, molecular changes are place in context as they relate to apical endpoints of survival, growth and reproduction. The implications of surface chemistry interactions with biological entities at the molecular scale in the sustainable design of materials will be discussed.

CARBON NANOTUBE-ENABLED OZONATION FOR REMOVAL OF ORGANIC MICROPOLLUTANTS DURING WATER TREATMENT

Rebekah Oulton, University of Iowa

David M. Cwiertny, University of Iowa

Jason Haase, University of Iowa

Achieving sustainability of fresh water resources requires developing alternatives for nonpotable uses, such as treated wastewater. The ubiquity of organic micropollutants, such as pharmaceuticals, in wastewater effluent limits use of this resource. Multi-walled carbon nanotubes (MWCNTs) increase hydroxyl radical (•OH) production during ozonation, making them potentially viable substrates to improve micropollutant removal during treatment. However, a number of practical issues must be considered. Here, we examine the reactive lifetime of MWCNTs during oxidative treatment, •OH generation in complex water matrices, and treatment efficacy against the ozone-recalcitrant herbicide atrazine. Results of accelerated aging studies indicate that ozonation initially increases •OH generation, thereby extending reactive lifetime. In model water matrices containing environmentally-relevant levels of radical scavengers, and in real water systems using partially-treated river water, •OH generation was comparable to previous experiments. Atrazine showed significantly improved degradation during ozonation of MWCNT suspensions, in both model and real water systems. A flow-through study with MWCNTs immobilized on a ceramic membrane verified previous batch system results. A preliminary cost analysis suggests that the potential reactive lifetime of a comparable industrial filter makes it cost competitive with current AOPs. Collectively, results suggest that CNT-enabled ozonation may become a viable means to improve water sustainability.

ASSESSMENT OF INTESTINAL NITRIC OXIDE IN EMBRYONIC ZEBRAFISH EXPOSED TO METAL OXIDE NANOPARTICLES

Rıfat Emrah Özel, Clarkson University

Kenneth Wallace, Clarkson University

Silvana Andreescu, Clarkson University

Abstract: Exposure to nanoparticles (NPs) may induce oxidative stress through generation of reactive oxygen and nitrogen species, which can lead to cellular and tissue damage. The digestive system is one of the initial organs affected by NP exposure. This presentation will discuss the effects of metal oxide

NPs exposure on intestinal NO in embryonic zebrafish. Intestinal NO concentrations were monitored quantitatively by electrochemical means with a carbon fiber microelectrode (CFME) inserted in the intestine of live embryos. Specificity of the electrochemical signals was demonstrated by NO-specific pharmacological manipulations and the results were cross validated with the 4,5-diaminofluorescein diacetate (DAF-FM-DA) dye that allows visualization of NO in live vertebrates. This allowed for quantitation of changes in local NO concentrations following NP exposure. We demonstrate that NPs either induce or reduce physiological NO levels in the intestine depending on the redox reactivity, type and dose of NPs. Such changes can indicate alterations in the oxidative system and intestinal malfunction, and therefore can be linked to NPs toxicity and oxidative effects. Further application of this technology can provide a greater understanding of the role of NO and potentially of other oxidative species such as superoxide and peroxynitrate in the digestive system function and their role in nanotoxicity study.

APTAMER-FUNCTIONALIZED GOLD NANOPARTICLES FOR THE RAPID DETECTION OF STAPHYLOCOCCUS AUREUS

Riquelme Breazeal, Maria V., Virginia Tech

Pruden, Amy, Virginia Tech

Vikesland, Peter, Virginia Tech

Abstract: Although transmission of Staphylococcus aureus has historically been associated with hospitals, recent environmental outbreaks of resistant forms such as methicillin resistant S. aureus (MRSA), as well as its detection in wastewater effluent, have inaugurated S. aureus as an emerging environmental pathogen of concern. This calls for the need for rapid monitoring technologies to protect water resources and human health. Herein, we describe such a method for detection of S. aureus that couples highly specific aptamer-functionalized gold nanoparticles (Apt-AuNPs) with sensitive surface enhanced resonance Raman spectroscopy (SERRS). Stable Apt-AuNPs include a Raman reporter that enables rapid and sensitive SERRS detection, a S. aureus-specific ssDNA aptamer, and a PEG linker and monolayer that acts as an Au-aptamer spacer as well as a colloid stabilizer. Apt-AuNPs enable the identification of individual S. aureus cells due to the agglomeration of large numbers of nanoparticles on the cell surface and the resultant amplification in SERRS spectral intensity relative to free Apt-AuNPs in solution. Raman XY images of S. aureus and four negative controls demonstrate the specificity and sensitivity of the probes, and their capacity for quantitative detection of whole S. aureus cells.

BUILDING A NEW NANOTECHNOLOGY CURRICULUM UTILIZING INDUSTRY-UNIVERSITY PARTNERSHIPS

Robert I. MacCuspie, Florida Polytechnic University

Abstract: Florida Polytechnic University is a new university focused on STEM education in an innovative, technology-rich, and interdisciplinary learning environment, with classes beginning August, 2014.

This presentation will describe how Florida Polytechnic University's new Nanotechnology and Multifunctional Materials Program is developing a curriculum incorporating learning goals including an understanding of sustainability in a nanotechnology context, and the principles, operation and research application of nanoinstrumentation.

Florida Polytechnic University is actively seeking partnerships with industry and government to provide applied research and applied learning opportunities for undergraduate and master's students. Partnerships could be formed in novel ways, including co-curriculum development, to more traditional approaches ranging from funding a named collaborative research center to donating equipment or providing staff scientists time to guest lecture. Curriculum development is ongoing, meaning now is the time to form partnerships with maximum impact.

Additionally, examples of how lessons learned by government-funded research can be transferred to an applied learning environment will also be discussed. Teaching topics could include method standards for nanomaterial characterization developed by NIST-NCL, how reference materials like the forthcoming NIST silver nanoparticle reference materials can improve nanoEHS risk assessments or sustainability research, and transferring cutting-edge nanoinstrumentation metrology research, such as recent developments using single nanoparticle ICP-MS.

CONTROLLED EVALUATION OF SILVER NANOPARTICLE SULFIDATION: REACTION MECHANISM AND NANOPARTICLE STABILITY

Ronald D. Kent, Department of Civil and Environmental Engineering, Virginia Tech

Joel G. Oser, Department of Civil and Environmental Engineering, Virginia Tech

Peter J. Vikesland, Department of Civil and Environmental Engineering, Virginia Tech

Abstract: Sulfidation of silver nanoparticles (AgNPs) is likely to occur during transport through wastewater infrastructure, which will alter the reactivity of the AgNPs. Arrays of AgNPs fabricated by nanosphere lithography (NSL) were used to study the mechanism of AgNP sulfidation and the stability of the resultant particles by AFM and TEM/EDS. The characteristic NSL pattern remained discernible following exposure to Na2S solutions and raw sewage sludge, and the mean AgNP height increased in both cases. Measured Ag:S atomic ratios were consistent with near complete conversion to Ag2S in Na2S solutions, yet only partial conversion in sludge. The crystal structure of acanthite (the mineral form of Ag2S) was detected in the nanoparticles after the exposures. Dissolution rates in concentrated NaCl

solutions following 0-30 min exposures to 1 mM Na2S progressively decreased with sulfidation time until they were not statistically significant. Similarly, AgNP dissolution rates were not significantly different than zero in specimens that were exposed to sludge for 6 d. This study shows that AgNPs are converted to Ag2S by a heterogeneous reaction mechanism rather than a dissolution/precipitation mechanism under relevant conditions. These results also indicate that sulfidation will mitigate the toxic effects of AgNPs by preventing the release of Ag+.

THE EFFECT OF SURFACE CHEMISTRY ON GOLD NANOPARTICLE ENVIRONMENTAL STABILITY AND TRANSPORT

Samuel E. Lohse, University of Illinois Department of Chemistry

Nardine Abadeer, University of Illinois Department of Chemistry

Catherine J. Murphy, University of Illinois Department of Chemistry

Abstract: The increased prevalence of functionalized nanomaterials in a variety of applications will inevitably lead to an increase in nanomaterial soil and groundwater contamination. It has been shown that the size, shape, and surface chemistry of functionalized NPs control the majority of their interactions with biological and environmental systems. The details of NP interactions with environmental systems, however, are not well-understood. Gold nanoparticles (AuNPs) are excellent model probes to assess the fate and transport of functionalized NPs in the environment, because their size, shape, and surface chemistry can be exquisitely controlled, and their progress through complex environmental matrices can be closely monitored. We prepared spherical AuNPs and gold nanorods (AuNRs) with different surface chemistries using a poly-electrolyte layer-by-layer coating strategy, and investigated how their surface chemistry influences their stability in natural water, as well as their retention in both algal biofilms and soil. We found that AuNRs with positive surface charges were strongly retained in both soil and algal biofilms, compared to AuNPs with a negative surface charge. In addition, we found that polyelectrolyte wrapping significantly enhanced AuNP stability in natural ground water.

PHYSICOCHEMICAL AND TOXICOLOGICAL CHARACTERIZATIONS OF NANOPARTICLES EMITTED FROM LASER PRINTERS: ENVIRONMENTAL HEALTH IMPLICATIONS

Sandra Pirela, Harvard University

Georgios Pyrgiotakis, Harvard University

Philip Demokritou, Harvard University

Abstract: The use of laser printers has been associated with emission of particulate matter (PM), ozone and VOCs. Recently, there have been concerns due to incorporation of engineered nanomaterials (ENMs) into toner formulations for quality improvements; however, the implications on exposures are unknown. In this study, an exposure system was developed which enables the characterization of real time emitted PM during their operation. Real time instrumentation was used to measure emitted particle and mass number concentration as a function of particle size, and various other air quality parameters. Eleven commonly used printers were subsequently characterized and ranked based on PM emission profiles. Emitted PM was sampled and size-fractionated using the Harvard Compact Cascade Impactor. Morphological examination of the airborne PM and toner powder was performed using TEM/SEM and surface chemistry was assessed using EDS and FTIR. Furthermore, the collected size-fractionated PM from the 6 highest emitting printers was extracted from the impaction substrates and used for both toxicological and chemical characterization. Chemical analysis included SF-ICP-MS for total and water-soluble metals, and gas chromatography/mass spectroscopy for organic and elemental carbon analysis. In addition, the extracted size fractionated PM was used for in-vitro toxicological characterization using various physiologically relevant cell lines and biological outcomes.Results show peak emissions to be brand-independent and varied between 3,000 to 1,200,000 particles/cm3 with modal diameters ranging from 49 to 208 nm. Moreover, we confirmed the toner formulation contained nanoscale materials of complex composition including, but not limited to, metal oxides. Preliminary toxicological data showed that laser printer-emitted particles may induce biological responses, such as increased pro-inflammatory cytokines and decreased cell viability. These results suggest that printer-emitted particles may be deleterious to lungs of those exposed to them.

FATE OF NANOCERIA IN RED KIDNEY BEANS AND ITS FILIAL GENERATION: DIFFERENTIAL RESPONSE TO SOIL QUALITY

Sanghamitra Majumdar, Department of Chemistry, The University of Texas at El Paso; University of California Center for Environmental Implications of Nanotechnology (UC CEIN),United States

Jose R. Peralta-Videa, Department of Chemistry, The University of Texas at El Paso; University of California Center for Environmental Implications of Nanotechnology (UC CEIN),United States

Jorge L. Gardea-Torresdey, Department of Chemistry, UTEP; Environmental Science and Engineering PhD Program, UTEP;University of California Center for Environmental Implications of Nanotechnology (UC CEIN),United States

Abstract: The toxicological studies of various metal oxide nanoparticles (MONPs) on different plants are increasing day by day. Differential responses have been reported depending on the plant species, type of nanoparticles and the growth medium. There is a huge gap in understanding the reason for such a

varied response which lies in the knowledge of the effects of MONPs on the plant metabolic activities and the coordination of the elements comprising the nanoparticles inside the plant. In this study, kidney beans were planted in two types of soils with varying organic matter content, spiked with cerium oxide nanoparticles (0 to 500 mg/Kg). Upon harvesting after 45 days, quadruplicate samples of roots, stems, leaves, pods and seeds are being analyzed for cerium content using ICP-OES and ICP-MS. The plant tissues are also analyzed for chlorophyll content, photosynthesis parameters, stress enzymes, antioxidants, and flavonoid content using different biochemical assays. The next generational seeds are being analyzed for their nutritional quality to understand the impact of nanoceria on food quality. The effects of the nanoceria on the protein expression in the next generation seeds is also being performed using molecular biology techniques.

SELECTING BENIGN REAGENTS FOR THE SYNTHESIS OF METAL NANOSTRUCTURES

Scott M. Reed, University of Colorado Denver

By selecting reagents from renewable feedstocks it is possible to reduce the ecological footprint of nanomaterials. We have developed nanoparticle (NP) syntheses using lipids extracted from soybeans as ligands as an alternative to petroleum based ligands. The optical properties of metal nanoparticles can be tuned using different lipids, making lipids a ligand replacement that adds value to the materials produced. In turn, these lipid-coated NPs function as sensors based on the sensitivity of their plasmon resonance to the local environment. This allows for the detection of binding events that occur on the lipid-coated surface of the NP.We have also developed a method to reduce the use of formaldehyde in the synthesis of core-shell NP. Through a careful analysis of the role of formaldehyde, a previously unnoticed function of the reagent was discovered. Formaldehyde reacts with ammonium hydroxide to form a polymer that alters the optical properties of nanoparticles. Understanding this second role of formaldehyde allowed us to decrease the amount used 100-fold compared to previous methods providing a greener synthesis. This strategy may be effective at minimizing or eliminating formaldehyde from the synthesis of other core-shell NPs and nanoshells.

MULTI-STAGE STOCHASTIC INTEGER PROGRAMMING MODEL FOR

Serkan Erbis, Northeastern University

Sagar Kamarthi, Northeastern University

Jacqueline A Isaacs, Northeastern University

Abstract: As nanotechnology moves from development to commercialization, the number of nanomaterial embedded products in market is increasing exponentially. With growing applications for nanotechnology, an increase in demand for nanomaterials is expected. Therefore, it is predicted that companies in nanotechnology markets are likely to expand their production capacities. However, capacity expansion in nanotechnology has high investment risk due to the large uncertainties regarding technological improvements in synthesis of nanomaterials, appropriate workplace safeguards, and demand for nanomaterials. Due to all these uncertainties, capacity expansion is a challenging problem for investors in the nanotechnology sector. This work considers a start-up company that produces carbon nanotubes (CNTs). To meet the growing demand for its product and to maximize its profit, the company would expand its capacity. It is also assumed that the company aims to achieve aspects of sustainable manufacturing, so their capacity expansion decision should also consider sustainability indicators/metrics. In this work, multi-stage stochastic integer programming (MISP) model is developed as a tool to optimize an investment strategy (timing of expansion, expansion size, and process type), workplace safeguards and capacity allocation for each product for certain period of time with the consideration of the uncertainties in nanotechnology and sustainable manufacturing indicators.

QUANTIFYING CARBON NANOTUBES IN BIOLOGICAL SAMPLES: TECHNIQUES, APPLICATIONS, AND CONSIDERATIONS

Shannon K Hanna, University of California Cente for the Environmental Implications of Nanotechnology

Robert J Miller, University of California Cente for the Environmental Implications of Nanotechnology

Adeyemi S Adeleye, Arturo A Keller and Hunter S Lenihan, University of California Cente for the Environmental Implications of Nanotechnology

Carbon nanotubes (CNTs) are one of the few truly novel nanomaterials and are being incorporated into a wide range of products, which will lead to environmental release and potential ecological impacts. Toxicity tests indicate the potential for biological impacts as well as accumulation in organisms. While researchers have used various methods to detect CNTs in biological samples, few have attempted to quantify the accumulation of CNTs into tissues and no standard method exists for measuring the concentration of CNTs in environmental media or accumulation in organisms, posing problems for regulators and toxicologists. Here we review promising methods for quantifying CNTs in environmental and biological samples and show results from a toxicological study in which marine mussels were exposed to CNTs over four weeks and the rejection and accumulation of CNTs were estimated using Y and Ni content as well as δ13C. While these methods produce similar estimates of CNT concentration and require no alteration of the nanomaterial, issues with metal leeching and large error estimates for δ13C will be discussed.

NANOTECHNOLOGY LCAS AND THE ROLE OF TECHNOLOGY MATURITY – A CASE STUDY ON CARBON NANOTUBES

Sheetal Gavankar, Bren School of Environmental Science & Management, UCSB

Sangwon Suh, Bren School of Environmental Science & Management, UCSB

Arturo Keller, Bren School of Environmental Science & Management, UCSB

Abstract: A growing body of literature is available endorsing life cycle assessment (LCA) as a valuable tool to assess nanotechnology for its environmental costs and benefits. With nanotechnology yet to reach its maturity, the assessments are likely to provide results that may not be indicative of the mature version of the system under assessment. This presentation substantiates this judgment with a case study on carbon nanotubes (CNTs). Using the data supplied by a manufacturer, we conducted a cradle-to-gate assessment on CNTs at two different production scales. The results based on the current manufacturing maturity level of CNT show that CNT's contribution to Global Warming, Ecotoxicity and Acidification impacts are significant. By scaling up, however, the CNT manufacturing can be projected to reduce 84 to 94% of its cradle-to-gate impacts, as efficiency measures such as reuse and recycling of raw materials become economically feasible. Moreover contributing factors to the impact categories may also change with scale. This has implications for decisions informed by LCAs as lack of consideration for scaling-up can result in misidentification of potential environmental hotspots. Thus this case study shows that LCAs on emerging technologies should be interpreted carefully taking the maturity and scale of production into account.

QUANTITATIVE ASSESSMENT OF NANOPARTICLE-INDUCED TOXICITY IN EMBRYONIC ZEBRAFISH

Silvana Andreescu, Clarkson University

Rıfat Emrah Özel, Clarkson University

Kenneth Wallace, Clarkson University

Abstract: Understanding the interaction of nanoparticles (NPs) with biological systems and assessing how exposure to NPs affects biological and chemical mechanisms in living systems is of critical importance. Although there are several observational toxicology studies describing the qualitative effects of NP exposure, their quantitative impact on biomarker concentrations in living organisms remain obscure. This presentation will discuss development of methodologies for direct real-time assessment of physiologically important nanotoxicity markers including neurotransmitters and reactive oxygen and nitrogen species at the NPs accumulation site in zebrafish embryos. We will focus on the use of electrochemical microsensors for assessing localized in vivo nanotoxicity, oxidative stress,

inflammation and neurological damage induced by engineered NPs in zebrafish. Electrochemical microsensors provide real-time in vivo measurement capabilities of various biomarkers for nanotoxicity assessment with high sensitivity and selectivity while providing high spatial resolution. We will show evidence that environmental exposure to NPs might affect the physiology of developing organs in characteristic ways, and indicate the need for more fundamental investigations to assess interaction of NPs (and their ions) with chemical messengers like serotonin and better understand toxic effects of NPs. This information could be used to predict long term physiological effects of NP exposure in living organisms.

CHARACTERIZATION OF NANOPARTICLES USING CENTRIFUGAL FIELD-FLOW FRACTIONATION HYPHENATED TO ICP-MS AND DYNAMIC LIGHT SCATTERING

Soheyl Tadjiki, Postnova Analytics

Evelin Moldenhauer, Postnova Analytics GmbH

Shoeleh Assemi, University of Utah

Abstract: To fully understand the environmental effects of engineered nanoparticles (ENPs), powerful and sensitive analytical techniques are needed to detect and characterize ENPs in complex environmental matrices at environmentally relevant concentrations. Centrifugal Field-Flow Fractionation (CFFF) is a powerful mass-based separation technique used to characterize natural and ENPs over the size range of 6 nm to 30 µm. In these studies, The CF2000 system (CFFF) was interfaced directly with ICP-MS system, Dynamic Light Scattrering detector and UV/Vis spectrometer to characterize a variety of Au and Ag nanoparticles (NPs). The results of four different applications will be presented: 1) Mixtures of Au and Ag NPs standards were analyzed for reproducibility and recovery. The system exhibited a RSD value of ≤ 0.1% in retention time and a total recovery of ≥ 94%, 2) The CF2000-ICPMS system was used to separate a mixture of Ag and Au NPs with respect to their densities. 3) The CFFF-DLS system was used to study the absorption of BSA on the Ag NPs. The absorption isotherm was obtained and the thickness of the BSA coating was measured, 4) The CF2000-UV system was used to characterized a mixture of Au nanorods based on their axial dimensions.

PROSPECTS OF EXTREMOPHILIC MICROBIOLOGY & SULFATED POLYSACCHARIDES IN CANCER THERAPY & NANOMEDICINE

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Polysaccharides (PS) are one of the most essential biomolecules present in all living tissues that supplies energy as well as supports the structural integrity of cells. PS with high degree of sulfation are presently more applied in nanotechnology and biomedicine since they were proven to be active against fighting various disease conditions. Introduction of extremophilic bacterial PS as a novel bioactive material has various advantages over conventionally using synthetic materials in the field of medicine and bionanotechnology. Here, we demonstrate various applications of sulfated PS of extremophilic origin in the field of medicine and therapeutics via developing various bionano platforms1.

Halomonas maura and Halomonas eurihalina are two moderately halophilic bacteria, which were used for extraction of sulfated exo-PS. Mauran (MR) is a highly versatile SPS with exceptionally best physicochemical properties extracted from H. maura. MR has been successfully employed for the fabrication of nanoparticles with chitosan to demonstrate sustained drug delivery, cancer chemotherapy and bioimaging for the first time2. MR based nanofibers were synthesized for various tissue engineering applications using electrospinning technique and were observed to be ideal for cell adhesion, proliferation and differentiation3. MR as a biocompatible PS possesses various biological activities that can be exploited for treatment of various disease conditions. Antioxidant defense mechanism imparted by MR and its nanoparticles were investigated using mammalian cells and liver tissue homogenate under in vitro test conditions. Apart from antioxidant property, MR exhibits antihemolytic, antithrombogenic, anticancer and antiangiogenic properties. Further more, MR has been employed for the stabilization of various nanomaterials like gold nanoparticles and quantum dots, to make it biocompatible for medical applications. Halophiles were also demonstrated for the reduction of graphene oxide to graphene for various microelectronics and bioscience applications4. As the first living beings of earth and as the ultimate living beings of earth, extremophiles can undoubtedly support and enhance the standard of living and sustenance. It is remarkable that the scientific community has adopted extremophiles for future commercial research in food, pharmaceutical, industrial, mechanical and material science. Hereby, we offer a handful of discoveries that will surely revolutionize the trend of microbiology and pharmaceutical research in near future.

WHO IS THE NANOTECHNOLOGY ECONOMY? OBSTACLES AND METHODS OF IDENTIFYING AND ESTIMATES OF U.S. NANO FIRMS & WORKERS

Stacey Frederick, Center on Globalization, Governance & Competitiveness (CGGC), Duke University

Abstract: Central to the ability to measure and track the economic, social and environmental impacts of nanotechnology is the ability to identify the firms and workers engaged in the value chain. However,

given that nanotechnology is not an industry or product, it is not possible to identify a population using existing classification systems (NAICS/SOC/HS). Further complicating the problem, developments related to nanotechnology have implications for almost any product in all stages of its life cycle and manufacturers aren't required to disclose the use or production of nanomaterials. Yet despite these limitations, there is a growing need to identify the nanotechnology economy to justify investments, identify risks and develop educational programs.

This research presents obstacles to identifying nano firms and jobs using publicly available data and existing methods and estimates. Next, a new method with estimates for R&D and production-related employment using supplementary data sources is introduced along with recommendations to improve future estimates. The presented methodology uses a value chain-based approach to label locations by the value-adding activities they engage in, their stage in the supply chain and the degree the firm is focused on nanotechnology-related developments. This methodology is used on the California in the Nano Economy website (www.CaliforniaNanoEconomy.org).

COMPARATIVE ANALYSIS OF NANOMATERIAL IMPACTS IN PRODUCTION PROCESSES

Therese Garvey, Rochester Institute of Technology

Callie Babbitt, Rochester Institute of Technology

Gabrielle Gaustad, Rochester Institute of Technology

Abstract: Nanotechnology is increasingly being incorporated into diverse consumer products and industrial applications. It remains to be seen how the benefits of these emerging materials compare to the impacts associated with increased production and consumer exposure. Life cycle assessment is a tool that can help to understand the environmental burdens of a good's manufacture, use, and disposal or recovery. Established life cycle inventory databases and assessment methods do not yet include information on nano emissions or impacts. For this reason LCAs of nanoproducts have omitted the direct emissions and impacts of nanomaterials themselves and in doing so underestimated the true lifecycle impacts. Here we estimate ecotoxicity and human health impact characterization factors and apply them to major nanomaterial production processes for silver, single wall nanotubes and nanoTiO2 in a best and worst case scenario approach. The resulting l impacts are then compared to the previous LCA results to determine the significance of the nanomaterial emissions with respect to other material and energy requirements. Production method, mass emitted, and type of nanomaterial itself determine the significance of nanomaterial impact. The work provides direction for developing less impactful methods of production and hotspots for targeting risk reduction efforts.

SUSTAINABLE LIGHTING: NANO-ENABLED LIGHTING AND THE REBOUND EFFECT

Thomas L Theis, University of Illinois at Chicago

Andrea L Hicks, University of Illinois at Chicago

Abstract: The consumption of energy for the production of light in the United States consumes a significant portion of the national energy budget, amounting to 694 terawatt-hours (TWh) of energy (7.4 quads of primary energy) equivalent to 7.6% of total energy consumption and 18.8% of total electricity consumption. Improvements in the energy efficiency of residential lighting are projected to significantly decrease the amount of energy used for lighting with the transition from incandescent to compact fluorescent (CFL) and finally to light emitting diode (LED). However, increases in efficiency appear very much to consumers like price reductions, leading to increases in consumption. Accordingly the actual energy savings for LED lighting may be considerably less than current projections, as has consistently occurred for lighting transitions of the past. Life cycle assessments (LCA) have shown the majority of the environmental impact of lighting to occur during the use phase. In this study, agent based modeling (ABM) is coupled with LCA to determine population level impacts for the adoption of energy efficient lighting inclusive of the rebound effect. ABM is a type of modeling where the actions of individuals contribute to overall macro scale impacts and trends, such as population level light and energy consumption. The use phase dependent on consumer adoption of lighting types and consumption of light are modeled using a cellular ABM informed with survey data and probabilistic adoption. The integration of ABM allows all three parameters of sustainability theory to be incorporated, environmental, social, and economic, with respect to how agents evaluate lighting options. The use phase results are then coupled with raw materials and manufacturing impacts derived using standard LCA methods. Results of different scenarios, including policy interventions and potential energy rebound, will be presented and compared for the use phase and the overall population.

PREDICTIVE TOXICOLOGICAL APPROACH LINKING THE PHYSICOCHEMICAL PROPERTIES OF METAL OXIDES AND CARBON NANOTUBES TO PULMONARY TOXICITY IN ANIMALS

Tian Xia, UCLA

Ruibin Li, UCLA

Haiyuan Zhang, UCLA

To investigate the potential adverse effects of ENMs to the environment and human beings, key challenges are to identify which physicochemical properties are responsible for the toxicity and develop reliable and cost-effective in vitro/in vivo methods that can be used for hazard identification. We

propose a predictive toxicological approach, which can be defined as the use of in vitro screening to make predictions about the physicochemical properties of ENMs that may lead to the generation of pathology or disease outcomes in vivo. This predictive paradigm necessitates the establishment of ENM libraries that cover wide ranges of material compositions and properties that are likely to lead to biological injury, development of mechanism-based high throughput in vitro screening platforms, and in silico modeling to establish hazard ranking and structural-activity relationships (SARs) that can be used for assessment of ENM environmental and health impacts. The in vitro screening results have to be validated using animal models in vivo. We will present our results on metal oxides and carbon nanotube induced lung toxicity obtained using this predictive toxicological approach. We think this approach could be helpful for rapid hazard identification for ENMs and facilitate the safe implementation of nanotechnology.

TIT FOR TAT: FACING EMERGING NANOTECHNOLOGIES WITH EVOLVING POLICY AND METHODS

Timothy Malloy, UC CEIN/UCLA Sustainable Technology and Policy

The unique nature of nanomaterials and the governance challenges they present are by now well known. Regulatory science and policy have responded, generating a suite of emerging and re-purposed policy approaches and evolving methodological advances. This presentation provides an overview of those developments, and some specualtions regarding where they may lead. It will continue after the other talks have concluded, identifying and commenting upon common themes and notable differences.

HOW SHAPE AND BINDING TO WOOL FIBERS INFLUENCES SILVER NANOPARTICLE TOXICITY TOWARDS NITROSMONAS EUROPAEA AND PSEUDOMONAS PUTIDA

Tyler Radniecki, Oregon State University

Alyssa Deline, San Diego State University

Steve Oldenburg, Nanocomposix, Inc.

Abstract: This research examines how silver nanoparticle (AgNP) shape (spherical and triangular) influences toxicity towards Nitrosomonas europaea, a model ammonia oxidizing bacteria. Additionally, this research determined how the binding of spherical and triangular AgNPs to wool cloth influenced their toxicity towards N. europaea and Pseudomonas putida, an important soil bacterium. Non-bounded spherical AgNPs increased toxicity with decreases in diameter due to higher silver ion (Ag+) dissolution rates. However, triangular AgNPs, with a major axis diameter of 50 nm, were found to be more toxic than 50 nm spherical AgNPs and equally toxic to 10 nm spherical AgNPs. The enhanced

toxicity was due to increased Ag+ dissolution on the planer edges of the triangular AgNPs. After being bound to wool cloth, the toxicity of both spherical and triangular AgNPs were greatly reduced. When placed in N. europaea media, containing AgNP dissolution enhancing ammonia, bound triangular AgNPs were more toxic than spherical AgNPs. However, when placed in P. putida media, containing AgNP dissolution diminishing chloride ions and proteins, triangular AgNPs were less toxic than spherical AgNPs. Thus, media composition can enhance or mute the effect that shape has on AgNP toxicity.

INVESTIGATING THE TOXICOLOGICAL EFFECT OF TITANIUM DIOXIDE NANOPARTICLES ON LIVER

Vaishaali Natarajan, University of Nebraska-Lincoln

Christina Davis, University of Nebraska-Lincoln

Srivatsan Kidambi, University of Nebraska-Lincoln

Abstract: Titanium dioxide (TiO2) is one of most widely manufactured metal nanoparticles (NPs) in numerous industries such as cosmetics, pharmaceuticals, water treatment and foods. Recent studies indicate that TiO2 NPs has adverse effects in human health via unknown mechanisms. Liver is the major accumulation site of NPs, including TiO2, directly through intentional ingestion or indirectly via NP dissolution from food containers. Additionally, increased environmental contamination and unintentional ingestion via water, food animals, or fish may also result in increased utilization of TiO2 in liver. However, the toxicological effects of TiO2 on liver function have not been extensively investigated. In this work, we investigated the effect of TiO2 on primary liver cells (hepatocytes). We treated the hepatocytes with three different forms of 10 ppm TiO2 NPs; Degussa P25, Anatase (50nm) and Rutile (50nm). We observed that the TiO2 exposure altered the liver cell morphology and the cell viability. Furthermore, liver-specific functions (urea and albumin synthesis) were also affected by TiO2, P25 treated cells being the most significant. Currently, we are studying the effect these NPs exert on liver cells at a transcriptional level. We plan to further investigate the molecular mechanisms that drive the TiO2 mediated liver toxicity.

ATR-FTIR SPECTROSCOPY AS A TOOL TO PROBE ADSORPTION ON NANOPARTICLE SURFACES AT THE GAS-SOLID AND LIQUID-SOLID INTERFACE

Vicki H Grassian, University of Iowa

Abstract: The focus of this talk is on the surface chemistry of metal oxide nanoparticles under different environmental conditions. In particular, the utility of ATR-FTIR spectroscopy as a tool to probe surface adsorption on oxide nanoparticles at the gas-solid and liquid-solid interface is discussed and several examples are provided. These data provide insights into the adsorption process and surface speciation. When combined with other techniques, both surface speciation and quantitative information can be obtained. Given the importance of surface chemistry in nanoparticle behavior, this type of data are critical for better understanding environmental fate, transformations and toxicity of nanomaterials.

CAPTURE, ISOLATION AND ELECTROCHEMICAL DETECTION OF INDUSTRIALLY-RELEVANT ENGINEERED AEROSOL NANOPARTICLES USING POLY (AMIC) ACID, PHASE-INVERTED, NANO-MEMBRANES

Victor kariuki, SUNY Binghamton

Veronica Okello, State Universityn of New York at Binghamton

Nian Du, State Universityn of New York at Binghamton

Abstract: Novel nano-membranes that capture, isolate and quantitatively detect by electrochemistry industrially-relevant engineered aerosol Fe2O3 nanoparticles are described. The Harvard Versatile Engineered Nanomaterials Generation System (VENGES) was used to generate the Fe2O3 test engineered nanomaterial (ENM). Flexible, stand-alone and filter paper-supported, electrically-conducting, poly (amic) acid (PAA) membranes with pore sizes ranging from 5 nm to 60 nm were fabricated and used to design filter array electrodes. The ability of the nanomembranes to collect the aerosol was measured in real time using Scanning Mobility Particle Sizer (SMPS). Electrochemical detection was conducted off-line using cyclic voltammetry and the results were validated using SEM and XRD respectively in order to conceptually illustrate that electrochemistry can be used for the detection of airborne ENMs. The generated aerosol had a mean particle mobility diameter range between 46.5 nm – 65.7 nm. The filtration efficiencies for both the stand-alone and the filter paper-supported PAA membranes were measured to be approximately 99.90% and 99.99% respectively. The oxidation peak for the test nanoaerosol (Fe2O3) appeared at approximately -471 mV with a shoulder at approximately -514 mV while the reduction peak occurred at approximately -778 mV (versus Ag/AgCl) in 0.1 M acetate buffer (pH 6.7). The results from this study illustrate the potential of using electrically-conducting, poly (amic) acid (PAA) nanomembranes for the detection of airborne ENMs.

INTERACTIONS OF COPPER NANOPARTICLES WITH NITRIFYING AND NITROGEN FIXING BACTERIA

Vincent Reyes, Department of Civil and Environmental Engineering at the University of California, Los Angeles

Stephen Opot, Department of Civil and Environmental Engineering at the University of California, Los Angeles

Shaily Mahendra, Department of Civil and Environmental Engineering at the University of California, Los Angeles

Abstract: Properly characterizing interactions of engineered nanoparticles with environmentally-relevant bacteria enables responsible management of nano-enabled product impacts. Herein, nCu and nCuO served as model metal-containing nanoparticles, the highest percentage of consumer nanoparticles, whose effects were investigated on the nitrifying bacterium, Nitrosomonas europaea, and nitrogen-fixing bacterium, Azotobacter vinelandii. IC50 values, determined using a high throughput fluorescence assay based on ATP content, were 54.3 ± 0.5 mg/L for N. europaea and 3.5 ± 0.5 mg/L for A. vinelandii for nCu. In the range tested, nCuO was not toxic. Similarly, growth inhibition data suggest that N. europaea was less sensitive than A. vinelandii as exposure to 25.0 mg/L of nCu caused 68.8 ± 4.0 % and 86.8 ± 11.6 % growth inhibition, respectively. Particle size, zeta potential, and dissolved metal measurements showed that the aggregation of nCu and nCuO in exposure media resulted in reduced toxicity. Furthermore, quantification of amoA and nifH genes and transcripts indicated that in addition to general stress, specific inhibition of ammonium oxidation and nitrogen fixation resulted. Our data suggest that copper nanoparticles caused greater inhibition to nitrogen fixing bacteria than nitrifying bacteria. This can potentially lead to imbalances in primary production, wastewater treatment, and environmental reservoirs of nitrogen oxides.

ENHANCEMENT OF SURFACE RUNOFF QUALITY USING NANO-MODIFIED SORBENTS

Vinka Oyanedel-Craver, Department of Civil and Environmental Engineering, University of Rhode Island

VARUN kasaraneni, Department of Civil and Environmental Engineering, University of Rhode Island

Laura Schifmman, Thomas Boving, Department of GeoscienceEngineering, University of Rhode Island

Abstract: Stormwater runoff, particularly in urban areas, contains several groups of contaminants that negatively impact surface- and groundwater quality if left untreated. Contaminants in runoff are often addressed by structural best management practices (BMP) that capture and treat runoff before discharging it. Many BMPs, such as tree filters, act as primary filtration devices that attenuate total suspended solids, nutrients, and heavy metals from runoff; but typically these BMPs are not designed to treat bacteria and have only minor petroleum hydrocarbon (PH) treatment capabilities. To address this shortcoming, three materials (red cedar wood chips, expanded shale, and crushed concrete) were modified with either functionalized silanes or Silver Nanoparticles (AgNPs) to provide antimicrobial

properties to the matrix and/or exploit their affinity to sorb PH, particularly polycyclic aromatic hydrocarbons (PAH). These materials were selected as they are inexpensive and their proven capacity to remove organic and inorganic contaminants from aqueous phase. Experimental results so far show that, wood chips exhibit the highest sorption capacity for QAS, and making this material favorable for treating bacteria, while at the same time attenuating PAHs by sorption processes. Relative to wood, expanded shale and crushed concrete exhibited less affinity for QAS. In case of AgNP amendments to wood, less uptake and more desorption from the wood matrix was observed where as concrete and shale exhibit the highest sorption capacity for AgNP. Currently, batch isotherm and unsaturated flow column studies are under way to determine the performance of the amended materials with regard to removal of bacteria, nutrients, heavy metals, and PAH from artificially contaminated runoff. In this talk, the contaminant removal efficiency of all modified and unmodified materials will be discussed on the background of how these materials may find use in enhanced treatment of stormwater in tree filter BMPs thereby reducing contamination of surface and ground waters..

INTERDISCIPLINARY NANO TOOLS COURSE AT THE UNIVERSITY OF RHODE ISLAND

Vinka Oyanedel-Craver, University of Rhode Island

Geoffry Bothun, University of Rhode Island

Abstract: this presentation will describe the developing ofinterdisciplinary course entitled Nano Tools that will develop nanotechnology concept competences and professional skills in undergraduate students within STEM majors at the University of Rhode Island by exposing them to state-of-the-art instruments commonly used in nanotechnology. Specific objectives of the course are:

• To provide basic knowledge of the principles and operation of nanoscale instrumentations through lectures and well-designed lab sessions.

• To foster problem-based, peer-to-peer learning through research-oriented group proposal projects, in which students will couple their creativity with knowledge gained in this course to identify hypotheses, develop experimental plans, and coordinate preliminary research that applies Nano Tools under the supervision of the faculty mentors and graduate students.

• To enhance students' technical communication skills through group presentations, journal-formatted project reports, and online learning and professional portfolios.

• To enhance student-faculty and faculty-faculty collaborations to create new research opportunities after the course.

• To expose students to societal, ethical, economic, environmental, and entrepreneurial/commercial implications of nanotechnology through topical seminars.

RESEARCH COMMERCIALIZATION AS A LINK BETWEEN INNOVATION AND INEQUALITY

Walter Valdivia, The Brookings Institution

Abstract: This paper argues that research commercialization is a critical link between economic inequality and innovation. It also offers some evidence that the trends in commercialization of nanotechnologies are not likely to reduce inequality measured by consumer surplus and wage disparities.

Conventional wisdom has it that accelerating the translation of research findings into commercial products improves the economic wellbeing of the nation. Lost from this picture of knowledge-based progress and from the debate about best practices in the commercialization of research is the question of how the benefits of innovation are distributed. I offer here one explanation linking the distribution of benefits to whether innovation takes place in competitive or monopolistic markets.

This perspective is particularly relevant when considering innovation that emerges from universities or national laboratories because the mode of commercialization of new knowledge has a role in determining whether new products are developed in competitive or monopolistic markets. I illustrate my point by reviewing the commercialization of biotechnology in the past three decades. I add some evidence on the commercialization of nanotechnologies in the U.S. showing that it has thus far followed biotech patterns of strengthening existing non-competitive market structures.

STABILITY OF NANOPARTICLE SURFACE LIGANDS DURING PROTEIN ADSORPTION

Wenwan Zhong, University of California, Riverside

Shang Zeng, University of California, Riverside

Yang Liu, University of California, Riverside

Abstract: When nanomaterials are present in biological matrices, they tend to adsorb the biomolecules in the matrix, such as proteins, on the surface. Such adsorptions would affect the interaction between nanomaterials and the cells; and are believed to reduce the toxicity of nanomaterials. My group studies how protein adsorption would occur and the consequence of protein adsorption. We found out that while the surface ligands had great influence on protein adsorption, protein adsorption would in turn alter the stability of ligands on nanomaterial surface. For example, single-walled carbon nanotubes (SWCNTs) precoated by bovine serum albumin (BSA) showed lower cytotoxicity, but the adsorbed BSA

could be replaced by the cellular proteins. More replacement of the adsorbed BSA by cellular proteins would lead to higher cytotoxicity. Interestingly, the binding of another type of surface ligand, the CpG ssDNA coupled with lipid-PEG, to the SWCNTs, could be stabilized by protein adsorption, possibly through a three-party interactive mode. Such adsorption also reduced the toxicity of the SWCNTs and enhanced the delivery effect of the CpG molecules into the target cells. These results point out that, protein adsorption on nanomaterials could not only reduce nanotoxicity, it could also be helpful for retaining drugs on the surface of nanomaterials and achieving higher efficacy of drug delivery.

LIFE CYCLE ASSESSMENT IN POLICY MAKING: IDENTIFYING GAPS BETWEEN INTENT AND ACTION

William C. Walker III, Northeastern University

Christopher Bosso, Northeastern University

Abstract: The National Nanotechnology Initiative (NNI) has called for life-cycle thinking to take a central role in the development and commercialization of nanotechnology. Calls for the use of Life Cycle Assessment (LCA) are prominent in several NNI documents, indicating high expectations for what LCA can accomplish. In this paper we examine the progress being made to incorporate LCA into regulation and policy decision making, evaluate its potential utility for policy makers, and discuss obstacles that may slow or block the adoption of LCA as a regulatory tool as pertains to nanotechnology. To do so we review around 60 recent scholarly articles on Life Cycle Assessment and related fields. Taken as a whole the literature casts doubt on the efficacy of LCA in policy making, largely due to the high need for technical skill on the part of LCA practitioners and the respectively low technical proficiency of policymakers; critical gaps in knowledge about the environmental, health, and safety impacts of nano materials; and a fractured and antiquated regulatory landscape. We propose remedies to many of these obstacles.

NANO-ENHANCED MICROBIAL ELECTROCHEMICAL CELLS

Xing Xie, Stanford University

Microbial electrochemical cells (MECs) show great potential for energy recovery from dilute reservoirs of organic matter, such as domestic wastewater, marine sediment, waste biomass and methane hydrate. In order to enhance the performance of the MECs, this study focuses on applying materials science and nanotechnology to develop new MEC electrodes and configurations. A three-dimensional (3D) microbial bio-electrode design has been proposed and realized by conformally coating carbon nanotubes (CNTs) or graphene on a macroscale porous substrate, such as textile or sponge. Such

composite bio-electrodes provide a two-scale porous structure, a macroscale porous textile or sponge providing an open 3D space accessible for microbial growth and a microscale porous CNT or graphene layer showing strong interactions with the microbial biofilms. Compared with a widely used commercial carbon cloth anode, our composite bio-electrodes achieve significantly improved performance. At the same time, the capital cost is at least one order of magnitude less.

ANTIOXIDANT PROPERTIES OF GRAPHENE-BASED MATERIALS

Yang Qiu, Brown University

Zhongying wang, Brown University

Robert H. Hurt, Brown University

Abstract: The safe development and use of graphene-based materials will require an understanding of their fundamental interactions with biological systems. Graphene-based materials vary widely in lateral dimension, layer number, and surface chemistry, and these variables may be exploited in the design of graphene materials for intrinsic safety. In vitro studies have reported oxidative stress following exposure to graphene oxide or graphene suggesting that at least some graphene-based materials behave as pro-oxidants in biological systems. We hypothesize that some graphene-based materials may also show antioxidant behaviors under some conditions as high-surface-area, sp2-based carbon forms. Here we investigated the antioxidant potential of graphene-based materials using both Fenton- and photo-generated free-radical sources. We find that graphene oxide can protect the organic dye phenol red from oxidation and can suppress hydroxyl radical generation detected by EPR. We show that the antioxidant effect of GO is a combination of UV light attenuation and free radical quenching reactions. The antioxidant effect of graphene oxide is not due to iron binding and suppression of the Habor-Weiss cycle. Future work will address graphene antioxidant behavior in vitro, and whether this behavior can be exploited in the development of graphene encapsulation shells to minimize the toxicity of nanoparticle imaging and therapeutic agents.

SUSTAINABILITY INDEX: EVALUATION OF THE SUSTAINABILITY/GREENNESS OF NANOTECHNOLOGY

Yang Shen, Columbia University

Chi Lo, Columbia University

Ponisseril Somasundaran, Columbia University

Abstract: Nanotechnology has received worldwide controversial popularity, as on one hand nanomaterials have presented extraordinary properties such as catalytic effect (fuel industry) and UV resistance (cosmetic and painting industries), but on the other hand have raised concerns on the potential harm to safety, health and environment. No definitive answer exists as to whether the technology using certain potentially toxic nanomaterials should be abandoned or modified since an overall sustainability/greenness evaluation is not available. A holistic/comprehensive evaluation of the nanotechnology applied in a certain industry is a nontrivial work especially when the overall fate of nanomaterials is not known. We have developed a robust Sustainability Index which is capable of not only defining but also evaluating the sustainability/greenness of nanomaterials throughout life cycle (from cradle to grave). The index is composed of three subindices corresponding to the three phases of life cycle: intuitive subindex (manufacturing/storage/transportation), processing subindex (usage) and emission subindex (post-processing). Among them processing subindex is most complicated as in the usage stage different industries or different companies in the same industry might have distinctive scenarios of using the nanomaterials. Challenges also exist with regards to evaluation in the absence of necessary information and collection of feedbacks from industrial perspectives.

EFFECTS OF NANOMATERIAL DISPOSAL ON WASTEWATER MICROBIAL COMMUNITIES AND TOXICITY IMPLICATIONS

Yanjun Ma, Virginia Tech

Jacob Metch, Virginia Tech

Amy Pruden, Virginia Tech

Abstract: As nanomaterials become widely applied in commercial products, a significant portion will be released and end up in wastewater treatment plants. Toxicity of various nanomaterials to bacteria has been documented in a growing number of studies. Thus, there is concern that they may have adverse effects on biological wastewater treatment, which relies on bacterial communities to remove contaminants. During wastewater treatment, nanomaterials may persist in wastewater effluent or be captured by biosolids. As effluents are discharged and biosolids are land-applied to the environment, their potential toxicity to humans is another concern. In this study, the response of microbial communities to silver (Ag), zero-valent iron (Fe), titanium dioxide (TiO2) and cerium oxide (CeO2) nanomaterials were examined in lab-scale nitrifying sequencing batch reactors (SBRs) with their ionic or bulk counterparts for comparison. Functionally, nitrification was not inhibited, except when shock-loaded with 20 mg/L Ag+ in the influent. However, pyrosequencing analysis revealed distinct responses of the microbial community to nanoAg and nano CeO2. Cytotoxicity of pure nanomaterials relative to effluent and biosolids containing nanomaterials to human lung epithelial cells is currently under investigation using the WST-1 assay.

PULMONARY SURFACTANT LIPOPROTEIN CORONA AFFECTS THE INHIBITORY POTENTIAL OF INHALED NANOPARTICLES

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Bao Jiao, Stake Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing

Guoqing Hu, Stake Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing

Abstract: Interaction with the pulmonary surfactant film, being the first line of host defense, represents the very initial bio-nano interaction in the lungs. Such interaction determines the fate of the inhaled nanoparticles and their potential therapeutic or toxicological effect. Despite considerable progress in optimizing physicochemical properties of nanoparticles for improved delivery and targeting, the mechanisms by which inhaled nanoparticles interact with the pulmonary surfactant film are still largely unknown. Here, using correlated in silico and in vitro methods, we show how hydrophobicity and surface charge of nanoparticles differentially regulate the translocation and interaction with the pulmonary surfactant film. Our results support a novel model of surfactant lipoprotein corona associated with inhaled nanoparticles of different physicochemical properties. Our data suggest that the study of pulmonary nanotoxicology and nanoparticle-based pulmonary drug delivery should consider this lipoprotein corona which is probably comparable to the serum protein corona evidenced when exposing nanoparticles to plasma.

DEVELOPMENT OF AN IN VITRO EXPERIMENTAL METHODOLOGY FOR STUDYING SURFACE ACTIVITY OF LUNG SURFACTANT

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Xianju Wang, Department of Mechanical Engineering, University of Hawaii at Manoa, Honolulu, HI

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Abstract: Lung surfactant is a phospholipid protein mixture synthesized by alveolar type II epithelial cells. It coats a thin film at the air-water interface of the lungs. The main function of this lung surfactant film is to reduce the alveolar surface tension and contribute to the first-line host defense against inhaled pathogens and particles. Increasing studies have demonstrated that exposure to nanoparticles can significantly decrease the surface activity of natural lung surfactant, thus indicating a potential biological

hazard related to particle inhalation. To date, the biophysical evaluation of lung surfactant heavily relies on the classical Langmuir-type balance, which has intrinsic weaknesses that prevent it from simulating the in vivo biophysical conditions of lung surfactant. We will show our recent progress in developing a novel experimental methodology for in vitro simulation of lung surfactant and its interaction with nanoparticles. This droplet-base methodology is called the Constrained Drop Surfactometer (CDS). We will show that the CDS is superior to existing methods in closely simulating the in vivo biophysical conditions of lung surfactant system, thus facilitating rapid and accurate evaluate of lung surfactant samples extracted from animals. The CDS has the potential to be developed into a transformative tool for achieving sustainable nanotechnology.

OXIDATION OF URANIUM DIOXIDE NANOCRYSTALS IN WATER

Yong Wang, University of Notre Dame

Chongzheng Na, University of Notre Dame

Abstract: Uranium dioxide (UO2) nanocrystalline particles are known mineral species in soils and sediments contaminated with radioactive wastes. They are considered as major contributors of uranium mobility in the environment. While the particles move with water, they are also being oxidized by dissolved oxygen. To investigate the transformation process, we synthesized uncapped UO2 nanocrystals with a truncated octohedral shape and a diameter of 2.8(0.3) nm using polyol reduction of U(VI). When they are stored in water, UO2 nanocrystals are first transformed to metashoephite nanowires and then to metashoephite nanosheets. This observation suggests a dissolution-nucleation mechanism of U(VI) to U(IV) oxidation.

HOW DO THE LEADING U.S. NANO-SCIENTISTS VIEW THEIR SOCIAL RESPONSIBILITY FOR NANOTECH RESEARCH?

Youngjae Kim, Arizona State University

Elizabeth A. Corley, Arizona State University

Dietram A. Scheufele, University of Wisconsin-Madison

Abstract: The lack of a clear consensus about the risks and benefits of nanotechnology, as well as the ongoing regulatory gaps for the technology, means that scientists are playing an increasingly important role in nanotechnology governance and regulatory agenda-setting. However, little research has been conducted on how scientists view their participation in this type of policy-making process, including

their views on their sense of responsibility for policies and public safety. Our research explores these perceptions by analyzing data from a 2011 national mail survey with 444 leading U.S. nano-scientists. First, we investigate whether leading U.S. nano-scientists feel responsible for the use or misuse of their discoveries, which we identify as their sense of social responsibility. Then, using hierarchical OLS regression analysis, we study how nano-scientists' perceptions about the general public, politics, scientific and societal ethics are associated with their sense of social responsibility for their research. The relationships between these variables are particularly important for the policy-making process because we hypothesize that scientists who feel a stronger sense of social responsibility for their research will be more likely to engage in regulatory discussions about their disciplinary fields. Lastly, we summarize the importance of our research findings for the future engagement of nano-scientists in the policy-making process. The survey data used in this article were collected with funding from the NSF-funded Center for Nanotechnology in Society at ASU (CNS-ASU), the Lincoln Center for Applied Ethics at ASU, and the John E. Ross Chair in Science Communication at the University of Wisconsin.

ENGINEERED NANOMATERIALS INHIBIT BIOLOGICAL CARBON CONVERSION IN SOILS

Yu YANG, Arizona State University

Xiangyu Bi, Arizona State University

Paul Westerhoff, Arizona State University

Abstract: The land application of biosolids is estimated to be the major approach for the input of engineered nanomaterials (ENMs) to soils. Currently most of research conducts exposure tests by directly dosing ENMs to soils. To simulate the practical scenario, we explored the effects of ENMs on biological carbon conversion in soils with biosolids mixed with ENMs, including nano Ag, ZnO, TiO2, and CeO2. Under dark conditions, nano Ag and ZnO at 1, 000 mg/kg had showed inhibitory effects on aerobic carbon conversion, either in basal respiration or substrate inducted respiration (SIR) tests. Nano CeO2 at 1,000 mg/kg showed positive effects in basal respiration tests, however, suggested being slightly inhibitory with enriched substrates in SIR tests. Nano TiO2 at both 1 and 1,000 mg/kg were proved to be inert materials without light illumination. Single particle-inductively coupled plasma-mass spectrometry (sp-ICP-MS) was applied to examine the presence of ENMs in extracted water after 28-day incubation. Neither nano nor micron particles containing zinc was detected in extracted water from soils with 1,000 mg/kg of nano ZnO. Soils treated with nano TiO2, CeO2, and Ag released nanosized materials in extracted water, suggesting rainfall/storm water could facilitate the release of ENMs from soils to aqueous environment.

BIOLOGICAL AND ENVIRONMENTAL TRANSFORMATIONS OF COPPER-BASED NANOMATERIALS

Zhongying Wang, Brown University

Robert H. Hurt, Brown University

Abstract: Copper-based nanoparticles are an important class of materials with applications as catalysts, conductive inks, antimicrobial agents and those involved in CO2 reduction and CO oxidation. The potential large-scale use of Copper-based nanoparticles provides strong motivation of a careful assessment of their environmental and human health risks. Elemental nanocopper oxidizes readily, so copper oxides are highly relevant phases to consider in studies of environmental and health impacts. Here we show that copper oxide nanoparticles undergo profound chemical transformations under conditions relevant to living systems and the natural environment. CuO-NPs undergo significant dissolution in cell culture media over time scales relevant to toxicity testing due to ligand-assisted ion release, in which amino acid complexation is an important contributor. Electron paramagnetic resonance (EPR) spectroscopy shows that dissolved copper in association with CuO-NPs are the primary redox-active species. CuO-NPs also undergo sulfidation by a dissolution-reprecipitation mechanism. EPR studies show that sulfidated CuO continues to generate ROS activity due to the release of free copper during the EPR assay. While sulfidation has been proposed as a natural detoxification process for nanosilver and other chalcophile metals, our results suggest that sulfidation will not fully detoxify copper in biological or environmental compartments containing reactive oxygen species.

POSTERS

EXTRACELLULAR POLYMERIC SUBSTANCE STABILIZES CARBON NANOTUBES IN AQUEOUS PHASE

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Arturo Keller, University of California, Santa Barbara

Abstract: Extracellular polymeric substances (EPS) are biosynthetic polymers produced by microbes (prokaryotic and eukaryotic) growing in natural as well as artificial environments. EPS may interact with engineered nanomaterials (ENMs) in aquatic systems via electrostatic and/or hydrophobic associations, therefore, influencing the fate and transport of ENMs in the environment. In this study the effect of soluble EPS isolated from Isochrysis galbana, a phytoplankton, on commercial single wall carbon nanotubes (SWCNTs) was investigated. EPS was characterized by measuring hydrodynamic diameter, total organic carbon, carbohydrate, and protein concentrations. Addition of 0.1 mg C-equivalent L-1 EPS shifted the critical coagulation concentration (CCC) of stabilized SWCNT to 54 mM NaCl from 15 mM NaCl. Sedimentation of SWCNT was slower in presence of EPS than in Suwanee River natural organic matter (SRNOM) in all ionic conditions we studied. As an example, C/C0 for EPS-stabilized SWCNT after 6 hr were 0.21 and 0.31 at 10 mM and 100 mM NaCl respectively. Meanwhile, at the same electrolyte concentrations and settling time, C/C0 values were 0.09 and 0.10 for SRNOM-stabilized SWCNT. The results of this study indicate that stability of SWCNTs may be improved by EPS in natural aquatic systems.

PREPARATION AND APPLICATION OF FUNCTIONALIZED CELLULOSE ACETATE/SILICA COMPOSITE NANO FI BROUS MEMBRANE VIA ELECTROSPINNING FOR CR(VI) ION REMOVAL FROM AQUEOUS SOLUTION

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Novel NH2-functionalized cellulose acetate (CA)/silica composite nanofibrous membranes were successfully prepared by sole-gel combined with electrospinning technology. Tetraethoxysilane (TEOS) as a silica source, CA as precursor and 3-ureidopropyltriethoxysilane as a coupling agent were used in membrane preparation. The membrane's chemical and morphological structures were investigated by scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM) images, X-ray diffraction (XRD), element analyzer, Fourier-transform infrared spectroscopy (FTIR) and N2 adsorption desorption isotherms. The composite nanofibrous membranes exhibited high surface area and porosity. The membranes were used for Cr(VI) ion removal from aqueous solution through static and dynamic experiments. The adsorption behavior of Cr(VI) can be well described by the Langmuir adsorption model, and the maximum adsorption capacity for Cr(VI) is estimated to be 19.46 mg/g. The membrane can be conveniently regenerated by alkalization. Thus the composite membrane prepared from biodegradable raw material has potential applications in the field of water treatment

CENTRIFUGATION-BASED ASSAY FOR EXAMINING NANOPARTICLE-LIPID MEMBRANE BINDING AND DISRUPTION

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Centrifugation-based assays are commonly employed to study protein-membrane affinity or binding using lipid bilayer vesicles. An analogous assay has been developed to study nanoparticle-membrane interactions as a function of nanoparticle surface functionalization, membrane lipid composition, and monovalent salt concentration (NaCl). Anionic (carboxylic acid, Ag-COOH), cationic (amine, Ag-NH), and neutral (polyethylene glycol, Ag-PEG) silver nanoparticles (AgNPs) were examined based on their surface plasmon resonance (SPR), which was used to determine the degree of binding to anionic, cationic, and zwitterionic membrane vesicles by analyzing supernatant and sediment phases. SPR was also used to examine AgNP aggregation in solution and at membrane/water interfaces, and direct visualization of AgNP-membrane binding, vesicle aggregation and disruption, and membrane penetration was achieved by cryogenic transmission electron microscopy (cryo-TEM). The extent of AgNP binding, based on AgNP + vesicle heteroaggregation, and vesicle disruption was dependent upon the degree of electrostatic attraction. Because of their biological and environmental relevance, Ag-PEG + anionic vesicles systems were examined in detail. Cryo-TEM image analysis was performed to determine apparent membrane/water partition coefficients and AgNP aggregation states (in solution and bound to membranes) as a function of NaCl concentration. Despite possessing an inert PEG coating and exhibiting a slight negative charge, Ag-PEG was able to bind to and disrupt model anionic bacterial membranes either as individual AgNPs (low salt) or as AgNP aggregates (high salt). The centrifugation assay provides a rapid and straightforward way to screen nanoparticle-membrane interactions.

DIFFERENTIATING BETWEEN CELL MEMBRANE ADSORBED AND CELL INTERNALIZED NANOPARTICLES FOR IMPROVED UNDERSTANDING OF NANOPARTICLE FATE: EFFICACY AND UNINTENDED EFFECTS OF I2/KI ETCHING AND ACID STRIPPING

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Abstract: In order to improve understanding of how nanoparticles (NPs) interact with biological cells, approaches are needed that enable differentiation of NP uptake from adsorption to the cell membrane while not disturbing the intracellular state of the NPs. Here, we study the efficacy and potential unintended intracellular effects of the main etching or acid stripping methods proposed in the literature for dissolving or stripping away gold NPs (AuNPs) from the cell surface. Using hyperspectral imaging and confocal microscopy (reflectance for AuNPs and fluorescence for plasma membrane stain Wheat Germ Agglutinin), we visualized the effect of I2/KI etching on AuNP removal from the exterior and interior of Sk-Br-3 breast adenocarcinoma cells. We found that although AuNPs can be dissolved away from the cell exterior, the percent of cells containing intracellular AuNPs in a cell population dropped by approximately 20% following etching at concentrations as low as 0.25 mM I2 / 1.5 mM KI for 5 minutes. Following 3 mM I2 / 18 mM KI etching for 5 minutes, cells remained >98% viable (trypan blue exclusion assay), but both extracellular and intracellular NPs were dissolved away and NPs were no longer detected intracellularly. Given these potential unintended effects to the intracellular NP distribution, care is advised when utilizing I2/KI etching methods to investigate NP uptake.

EVALUATION OF NANOSILVER TOXICITY TO SOIL DENITRIFICATION PROCESS THROUGH THE CHEMICAL REACTIVITY

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Abstract: Aquatic toxicity of silver nanoparticles to various microorganisms has been extensively investigated in the past decade. However, it is poorly understood as to how the existing toxicological data can be applied to the terrestrial system where silver nanoparticles are expected to be retained in soils and sediments. To improve our understanding of the fate of silver nanoparticles in aquatic and terrestrial environments and its effect on toxicity, we investigated the effect of five different silver

nanoparticles (15 – 60 nm, uncoated, coated with 0.3% polyvinylpyrrolidone (PVP), or coated with 90% PVP) on the soil denitrification process. The reactivity of silver nanoparticles was investigated through the Freundlich isotherm model, and also for chemical speciation change at soil surfaces using Ag K-edge X-ray Absorption Near Edge Structure spectroscopy (XANES) analysis.

The Freundlich model predicted distribution coefficient (Kd) values of silver nanoparticles in Toccoa sandy loam soil ranging from 290 to 77,390. The Kd values indicate that all silver nanoparticles had a strong affinity for soil components, both inorganic and organic. Batch denitrification experiments showed that all silver nanoparticles exhibited much less toxicity to the denitrifying bacterial community than was expected. Only two types of silver nanoparticles (50 nm uncoated, and 15 nm 90% PVP) displayed any toxicity even at the highest concentration (100 mg/L), while ionic silver was toxic at concentrations as low as 1 mg/L. Statistical analysis indicated that toxicity was correlated with silver nanoparticles that had the lowest distribution coefficients. These particles were also susceptible to phase transformation in reducing soils after 30 days. In situ XANES analysis showed that these silver nanoparticles have undergone the most chemical transformation. A linear combination fit with reference spectra revealed Ag2S(s) and/or Ag(I)-sorbed humic acid to be important components in the most highly toxic silver nanoparticles. The results of this study highlight the biogeochemical behavior of silver nanoparticles in terrestrial environments, and the importance of environmental media, e.g., soils, in predicting toxicity.

CHANGES IN SPATIAL DISTRIBUTION OF NANOSILVER AND ITS REACTIVITY IN SOILS

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bstract: Much silver nanoparticle (AgNP) research has focused on toxicological aspects in aquatic systems. Here, we aim to investigate the fate and toxicity of AgNPs in terrestrial environments. Specifically, we studied the effect of physical properties of AgNPs on beneficial soil bacteria, the denitrifiers. Amendments of various AgNPs in anaerobic soils have resulted in different antimicrobial responses. In general, we have found that when AgNPs are well-dispersed across the soil matrix pose, they pose the highest toxicity to denitrifying bacteria, while AgNPs that form large aggregates in the soil matrix do not elicit a toxic response even at 100 mg/L. While dynamic light scattering (DLS) measurements showed a wide range of particle size distribution (<1 to 100,000 nm) in AgNPs stock solutions, the distribution was largely altered in soil matrices. Synchrotron-based microfocused X-ray fluorescence (μXRF) and scanning electron microscopy (SEM) analyses showed that the macroscale (e.g., >100 μm) AgNP aggregates in soils have nearly vanished with aging in two of our AgNPs, leaving only

micron-size NP aggregates. Changes in physical properties of AgNPs in soils might add new insight in assessing the fate and toxicity of AgNPs in terrestrial environment.

TOXICITY ASSESSMENT OF CERIUM OXIDE NANOPARTICLES IN CILANTRO (CORIANDRUM SATIVUM) PLANTS GROWN IN ORGANIC SOIL

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Abstract: Studies have shown that CeO2 nanoparticles (NPs) can be accumulated in plants without modification, which could pose a threat for human health. In this research, cilantro (Coriandrum sativum L.) plants were germinated and grown for 30 days in soil amended with 0 to 500 mg kg−1 CeO2 NPs and analyzed by spectroscopic techniques and biochemical assays. At 125 mg kg−1, plants produced longer roots ($p \leq 0.05$) and at 500 mg kg−1, there was higher Ce accumulation in tissues ($p \leq 0.05$). At 125 mg, catalase activity significantly increased in shoots and ascorbate peroxidase in roots ($p \leq 0.05$). The FTIR analyses revealed that at 125 mg kg-1 the CeO2 NPs changed the chemical environment of carbohydrates in cilantro shoots, for which changes in the area of the stretching frequencies was observed. This suggests that the CeO2 NPs could change the nutritional properties of cilantro.

ESTIMATING EXPOSURE TO ENMS FROM PERSONAL CARE PRODUCTS THROUGHOUT THEIR LIFE CYCLE

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Abstract: Our study calculated the total US emissions of engineered nanomaterials (ENMs) from personal care products to soils, water bodies, the atmosphere, and landfills. We calculated these emissions by combining and extrapolating data on: consumer use, disposal, and purchasing habits, the market sizes of the personal care product and ENM industries, and the amount of nanomaterials in each product (determined with lab tests). We found that the majority of ENMs emitted from personal care products end up in the wastewater system, which leads to an eventual fate of ENMs to soils, water bodies, and landfills. ENMs in color cosmetics have a relatively higher chance of being emitted to landfills. The nanomaterials with the highest emissions are TiO2 and ZnO, which are often used as UV-blockers in SPF formulations. Our results show that a significant amount of ENMs are being released per year in the US to the environment, with the dominant application being sunscreens and personal care

products that have an SPF additive. Since most consumers eventually wash off their personal care products in the sink or shower, wastewater treatment plants are a major pathway for ENMs to the environment and the behavior of ENMs in WWTP warrants further study.

DISRUPTION OF MODEL CELL MEMBRANES BY CARBON NANOTUBES

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Carbon nanotubes (CNTs) have one of the highest production volumes among carbona- ceous engineered nanoparticles (ENPs) worldwide and are have potential uses in applica- tions including biomedicine, nanocomposites, and energy conversion. However, CNTs possible widespread usage and associated likelihood for biological exposures have driven concerns regarding their nanotoxicity and ecological impact. In this work, we probe the responses of planar suspended lipid bilayer membranes, used as model cell membranes, to functionalized multi-walled carbon nanotubes (MWCNT), CdSe/ZnS quantum dots, and a control organic compound, melittin, using an electrophysiological measurement platform. The electrophysiological measurements show that MWCNTs in a concentration range of 1.6–12 ppm disrupt lipid membranes by inducing significant transmembrane cur- rent fluxes, which suggest that MWCNTs insert and traverse the lipid bilayer membrane, forming transmembrane carbon nanotubes channels that allow the transport of ions. This paper demonstrates a direct measurement of ion migration across lipid bilayers induced by CNTs. Electrophysiological measurements can provide unique insights into the lipid bilayer–ENPs interactions and have the potential to serve as a preliminary screening tool for nanotoxicity.

TOXICITY OF METAL OXIDE NANOPARTICLES IN BACTERIA CORRELATES WITH CONDUCTION BAND ENERGY AND HYDRATION ENERGY

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Abstract: Metal oxide nanoparticles (MOx NPs) have been widely used in many fields such as electronics, cosmetics, construction and medicine. The widespread uses of these NPs contaminate the environment

and pose high risks to the ecosystem. Here, we report the growth inhibition effects of 24 MOx NPs and show that ZnO, CuO, CoO, Mn2O3, Co3O4, Ni2O3 and Cr2O3 exert toxicity to Escherichia coli. IC50 at 24 hours was determined to be 33, 39, 43, 70, 138, 181, 232 mg/L respectively. By contrast the remaining MOx (Al2O3, CeO2, Fe2O3, Fe3O4, Gd2O3, HfO2, In2O3, La2O3, NiO, Sb2O3, SiO2, SnO2, TiO2, WO3, Y2O3, Yb2O3 and ZrO2) all had an IC50 > 500 mg/L. The fluorescence-based viability assay was used to confirm that toxic particles perturb membrane integrity and lead to cell death. To determine whether MOx NPs contribute to cellular toxicity due to oxidative stress, accumulation of intracellular ROS was measured using H2DCFDA which fluorescents in the presence of free radicals. Only cells that had been treated with toxic particles showed elevated levels of intracellular (biotic) ROS. To further examine the intrinsic properties of MOx NPs in oxidizing electrons, H2DCFDA assay was also performed in abiotic condition. Mn2O3, CoO, Co3O4, Ni2O3 and CuO NPs was found to be strong oxidizing agents suggesting that these particles cause toxicity via inducing oxidative stress. By contrast, ZnO and CuO highly dissolve in bacterial media (5.27% and 7.89% respectively) and their toxicity is likely due to the dissolved metal ions. Predictive analysis showed that physiochemical properties of MOx NPs studied that most correlate with toxicity outcome are conduction band energy and hydration energy.

INTEGRATED SUSTAINABILITY ANALYSIS AND LIFE CYCLE ASSESSMENT OF ATOMIC LAYER DEPOSITION FOR CLEAN ENERGY APPLICATIONS

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Abstract: Atomic Layer Deposition (ALD) is an enabling nanotechnology with a great potential for a broad array of industrial applications including semiconductors, solar cells, fuel cells, lithium ion batteries, medical devices, etc. However, the sustainability issues of ALD nano-manufacturing are significant due to the heavy use of toxic chemicals, large energy consumptions and generation of nano-wastes and nano-particle emissions. In this presentation, we report our recent research results on an integrated sustainability analysis and a hybrid life cycle assessment (LCA) of ALD nano-manufacturing process, to aid the understanding and the mitigating of the environmental impacts of ALD nanotechnology for future large scale industrial applications. Examples of the ALD nano-manufacturing processes are demonstrated on the fabrications of nano-structured materials in improving the technical performance of dye-sensitized solar cells and high capacity lithium ion batteries.

A HIGH EFFICIENCY, HIGH THROUGHPUT SCREENING ASSAY FOR ENGINEERED NANOPARTICLE MEDIATED DNA DAMAGE USING THE COMETCHIP TECHNOLOGY

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Jing Ge, Massachusetts Institute of Technology

Joel Cohen, Harvard School of Public Health

Abstract: Intentional and unintentional nanoparticle exposures have dramatically increased due to technological advancements within our society. Indeed, engineered nanoparticles (ENPs) have been incorporated in many useful materials and have enhanced our way of life. However, unanswered questions remain in regards to consequences of nanoparticle exposures on the key of life, our DNA. In this study, we present a high throughput and efficiency screening assay which is based on the CometChip technology, to detect single DNA stranded breaks in cells after nanoparticle exposure. Its strategic micro-fabricated, 96 well design and automated processing improves efficiency, reduces processing time, and user bias in comparison to the commonly used standard comet assay. The applicability and versatility of the CometChip assay to screen for DNA damage was also demonstrated in this study by screening five industry relevant ENPs, SiO2, ZnO, Fe2O3, Ag, and CeO2. The TK-6 lymphoblastoid suspension and Chinese hamster ovary (H9T3) adherent cell lines were used to evaluate three sublethal doses (5, 10, and 20 µg/ml) for 4 and 24hr exposure times, respectively. Significant levels of DNA damage in comparison to non-treated cells were found for Fe2O3, Ag, ZnO, nanoparticles at 10µg/ml and 20µg/ml in TK-6 and H9T3 cells. The results from this study demonstrate the versatility of the CometChip as a high throughput screening tool of assessing ENP mediated DNA damage. Furthermore, results from the screening of industry relevant ENPs indicate their potential to induce DNA damage at sublethal low doses.

COLLABORATING WITH SCIENCE BUDDIES: BRINGING UC-CEIN RESEARCH TO MIDDLE- AND HIGH-SCHOOL STUDENTS

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Catherine Nameth, UC CEIN

Hilary Godwin, UC-CEIN

Abstract: For many budding scientists (and science enthusiasts), the first entre into real exploratory science comes in the form of a science fair project. Not surprisingly, coming up with a good project – one that is sufficiently open-ended to constitute a valuable learning experience but also actually works – is non-trivial and often beyond the capabilities of even very bright middle school and high school students. Science Buddies is an award-winning, non-profit organization that partners with scientific researchers to develop detailed and validated project ideas which are then made available free-of-charge on their website (www.sciencebuddies.org). Thousands of K-12 students access the Science Buddies site each year, making it an effective mechanism for bringing cutting-edge science to this population. We have partnered with Science Buddies to develop two projects based on UC-CEIN research: one in which students explore the effects of nanosilver on bacteria and another in which

students explore the impacts of nanosilver on soybean growth. The first of these projects Tiny Titans: Can Silver Nanoparticles Neutralize E. coli Bacteria? is available on the Science Buddies website. The second project on soybeans is currently under development. We will present on the process for developing projects in collaboration with Science Buddies, including how to select a project topic, and how to design projects to assist students in building their scientific literacy.

THE EFFECTS OF CUO NANOMATERIALS ON EMBRYONIC DEVELOPMENT IN TWO ENVIRONMENTALLY RELEVANT SPECIES: THE PAINTED SEA URCHIN (LYTECHINUS PICTUS) AND PACIFIC HERRING (CLUPEA PALLASII)

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Abstract: Low concentrations of copper oxide (CuO) nanomaterial (NM) have been shown to specifically inhibit the zebrafish hatching enzyme (ZHE1) and prevent hatching, with no effect on larval morphology (Lin et al., 2012; Lin et al., 2011). In this study, sea urchin embryos (Lytechinus pictus) and herring embryos (Clupea pallasii) were exposed to CuO NM or CuSO4 until the control embryos reached the larval stage. Hatch success and developmental abnormalities were assessed. In contrast to what has been observed in zebrafish embryos, in neither sea urchin nor herring embryos was there a specific effect on hatching. Furthermore, in sea urchin embryos CuO NM resulted in severe developmental abnormalities at low (μg/L) concentrations, while in herring embryos CuO NM was not toxic under the conditions of our assay until concentrations reached 200 mg/L. The intricacies of biological systems combined with the complex interactions of NMs with the environment highlight the importance of toxicity testing both in vitro and in vivo, in numerous species and environmental media, and at various life stages.

PROTEIN POPULATION ADSORBED TO SILVER NANOPARTICLES VARIES WITH PARTICLE SIZE, SURFACE PROPERTIES, AND REACTION ENVIRONMENT

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Abstract: Studies of nanoparticles (NPs) in the environment are complicated by the chemical and physical changes they undergo upon release. Of the most predominant surface modifiers in the

environment, proteins selectively adsorb onto NPs to permanently alter NP reactivity. Using mass spectrometry proteomic approaches, we have elucidated the biophysicochemical characteristics of Saccharomyces cerevisiae proteins that dominate interactions with silver NPs of various sizes and surface coatings under environmentally relevant conditions. Our results reiterate previous findings that the corona protein profile does not simply correspond to the relative protein concentrations of the greater protein population. Further, the data clearly show an environmentally dependent enrichment of proteins within the NP corona, at detection limits below those in the larger protein sample. Functional classification of the protein corona population reveals that 10 – 15% of bound proteins are considered essential to the survival of yeast by the Essential Genes Database. Biophysical analyses of the enriched proteins reveal trends indicating that protein-NP interactions are driven by electrostatics. This process is dynamic, with some proteins binding tightly in many environments. We use these essential and slowly exchanged proteins to provide insight into the role of proteins in driving AgNP reactivity and its subsequent environmental and cellular fate.

TOXICOLOGICAL STUDY OF DYSPROSIUM NANOPARTICLES ON E. COLI

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Application of rare earth elements (REEs) such as, dysprosium nanoparticles (nDy), to the biomedical field are increasing due to their paramagnetic properties. Current applications of nDy in the biomedical field are in MRI screening and anti-cancer therapy. Environmental impacts of nDy released into the environment is unknown or poorly understood and is a concern due to the lack of appropriate recycling systems. The objective of this toxicological study is to assess the impacts of nDy at relevant environmental concentrations on Escherichia coli. A range of glucose concentrations were used to evaluate the impact under different aerobic metabolic stages when the bacteria are exposed to the nanoparticles. Two traditional techniques used to evaluate the physiological response of E. coli at different environmental conditions were dual staining with fluorescent dyes (Live/Dead BacLight viability kit) and respirometric assays. A high-through put array-based methodology was implemented to provide additional toxicity testing. Preliminary toxicology results for both traditional techniques showed a positive trend between nDy and carbon source concentrations. High concentrations of nDy (>5mg/L) in environments with high glucose concentration (>210mg/L) are more toxic to E. coli than environments with low glucose concentrations. On the other hand, Live/Dead experiments showed higher toxicity effect in comparison to the respirometric tests using the same exposure conditions, suggesting that even at high membrane disruption the bacteria can still performed some metabolic activity.

FATE AND TOXICITY OF CARBON NANOTUBES AND THEIR POLYMER COMPOSITES

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Abstract: It has become increasingly important to determine the behavior and environmental fate of nanomaterials and their composites which have found great applications in most household, office, sports, transport and defense appliances. These CNTs when combined with other inorganic materials - phosphors, superconductors, insulators or semiconductors - result in hetero-structures of diverse functionality. This poses a greater concern on the environmental fate and toxicity to ecosystems of CNTs and CNTs' incorporated products as they age. However, scarce information is available on the topic.

Given the above, we set out to investigate the changes that occur to pristine CNTs if exposed to intense UV-A radiation cycles which mimic summer sunlight as well as condensation cycles over extended timelines in the QUV Accelerated Weathering Tester using a testing protocol developed for aging of CNTs. The pristine and aged samples are then characterized by UV-Vis, Raman, FTIR, ATR, SEM and XPS and the results compared based on aging. The aged and pristine CNTs samples were also tested against plants and the plant growth rate observed. There have been observed differences between aged and pristine CNTs also further work is ongoing to investigate the relationship between the observed results and any changes to CNTs structures.

USE OF METAL OXIDE NANOPARTICLE BAND GAP TO DEVELOP A PREDICTIVE PARADIGM FOR ACUTE PULMONARY INFLAMMATION BASED ON OXIDATIVE STRESS

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Abstract: We demonstrate for 24 metal oxide (MOx) nanoparticles that it is possible to use conduction band energy levels to delineate their toxicological potential at cellular and whole animal levels. Among the materials, the overlap of conduction band energy (Ec) levels with the cellular redox potential (-4.12

to -4.84 eV) was strongly correlated to the ability of Co3O4, Cr2O3, Ni2O3, Mn2O3 and CoO nanoparticles to induce oxygen radicals, oxidative stress and inflammation. This outcome is premised on permissible electron transfers from the biological redox couples that maintain the cellular redox equilibrium to the conduction band of the semiconductor particles. Both single parameter cytotoxic as well as multi-parameter oxidative stress assays in cells showed excellent correlation to the generation of acute neutrophilic inflammation and cytokine responses in the lungs of CB57 Bl/6 mice. Taken together, these results demonstrate, for the first time, that it is possible to predict the toxicity of a large series of MOx nanoparticles in the lung premised on semiconductor properties and an integrated in vitro/in vivo hazard ranking model premised on oxidative stress. This establishes a robust platform for modeling of MOx structure-activity relationships based on band gap energy levels and particle dissolution. This predictive toxicological paradigm is also of considerable importance for regulatory decision-making about this important class of engineered nanomaterials.

SCALING UP AND MANGAGING REMOVAL SELECTIVITIES FOR DRINKING WATER CONTAMINANTS

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Abstract: Drinking water contamination has been a longstanding concern for citizens, municipalities and policymakers, especially as clean sources become scarcer; thus, larger scale engineering solutions are crucial to restoring supplies of drinkable water. With increasing regulation of contaminants known to have negative health effects, such as nitrate, nitrite, and ammonium, as well as hexavalent chromium (expected soon), emerging technologies may advantageously treat, transform and remove constituents from water. Photocatalysis has been used to successfully treat a number of drinking water contaminants, and through implementation of semiconductor nanoparticles, more efficient removal (inclusive of energy, costs of completion) is possible. The ability of titanium dioxide nanoparticles to reduce and remove both nitrate and hexavalent chromium was studied using a small-scale pilot test using a closed loop titanium dioxide slurry reactor with low pressure (254nm) UV lamps. Nitrate by-product selectivity was investigated using a lab-scale reactor to determine viability of different combinations of light wavelength and intensity, added known or possible intermediates, pH, and catalyst selection. Adjusting these parameters led to changing selectivity away from the most detrimental aqueous compounds resultant from nitrate reduction, nitrite and ammonium, toward N-gases.

INTERACTIONS OF MICROORGANISMS WITH CARBON NANOTUBE POLYMER COMPOSITES

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Abstract: One of the most important applications of carbon nanotubes (CNTs) involves their incorporation into polymer matrices to improve properties such electrical conductivity and tensile strength. Post-consumer use, these polymer nanocomposites will enter the environment where their fate will be intimately dependent upon their interactions with microbial populations (e.g. in landfills). This led us to assess the impact of CNT loading on the initial viability and longer term interactions of Pseudomonas aeruginosa with CNT- polymer composites. For initial viability studies, polyvinyl alcohol-CNT nanocomposites were prepared on microscope slides with varied CNT loadings. Following bacterial exposure, the composite surfaces were treated with SYTO 9® and propidium iodide fluorescent stains and imaged using confocal laser scanning microscopy to assess cell viability. An increase in CNT loading caused a systematic increase in cell death for both oxidized multi-walled and single-walled CNTs. To assess the longer term impact of CNTs on nanocomposites biodegradation rates of otherwise biodegradable polymers, such as poly-ε-caprolactone (PCL), modified by the inclusion of CNTs were measured via mass loss and SEM. Over a period of weeks, pure PCL polymers fully degraded but PCL degradation was retarded by the presence of CNTs, with an effect that scaled with increased CNT loading.

SYNTHESIS AND CHARACTERISATION OF CERIA NANOPARTICLES USING A MULTI-METHOD APPRACH

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Abstract: Ceria nanoparticles (NPs), due to their widespread applications, have attracted a lot of concern about their toxic effects on both human health and environment and there is a lot of speculation on the redox behaviour of cerium oxide being responsible for these assessments but there are large gaps in knowledge of whether Ce (III) or Ce (IV) is responsible for such toxic behaviours, their toxicological mechanism and safety assessment. So the aim of this study is to accurately quantify the ratio of Ce (III) and Ce (IV) in selected samples and especially in complex biological and environmental media using a multi-method approach thus providing an insight in understanding their surface chemistry and hence toxicity. The poster depicts the synthesis of ceria NPs using a homogenous precipitation methodology and their characterisation using a combined approach including UV-Vis, DLS, TEM, STEM- EELS and XPS.

The project as a whole is a part of a larger project funded by the NERC/MRC entitled: From Airborne exposures to Biological Effects (FABLE): the impact of NPs on health. The results from this multi-method approach will feed into this larger study with significant improvements to both.

INFLUENCE OF SURFACE CONDUCTIVITY AND PRIMARY PARTICLES SIZE IN THE AGGREGATION KINETICS OF TIO2 NANOPARTICLES

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Abstract: Aggregation and deposition of nanoparticles (NPs) are of paramount importance in many technological and natural processes. Theoretical prediction of the aggregation kinetics of NPs requires accurate knowledge of NP-NP and NP-Collector interaction forces at the interface scale. These interaction forces are controlled by the chemical conditions of the porous medium (pH, ionic strength). The Derjaguin-Landau-Verwey-Overbeek (DLVO) theory [1] is commonly used to describe the deposition and aggregation process. But, this theory fails to estimate quantitatively the aggregation and deposition rate [2]. Therefore, we have developed a new approach based on DLVO theory to describe aggregation kinetics of titanium dioxide nanoparticles in aqueous solutions. The repulsive electrostatic force between NPs is determined using zeta potentials directly calculated by an Extended Stern Model (ESM) and Linear Superposition Approximation (LSA). Derjaguin Approximation (DA) and Surface Element Integration (SEI) are used to calculate interaction energies of spherical particles. Our model has three adjustable parameters: the minimum separation distance between NPs, the Hamaker constant, and the effective interaction radius of the particle. Our model was validated by comparison with stability ratios of pure TiO2 NPs made at different pH values (pH = 6.3, 6.7, and 8.4) over a broad salinity range (between 10-4 and 10-1 M KCl). Our results show that zeta potentials calculated directly by our ESM are significantly higher in amplitude than apparent zeta potentials obtained by the conversion of electrophoretic mobilities with not surface conductivity correction. This is due to the influence of the surface electrical conductivity of elementary NPs which decreases significantly the electrophoretic mobility of the aggregate because this electrokinetic phenomenon is inversely proportional to the size of NPs. We also find that, the aggregation kinetics are controlled by the size of elementary particles rather than the real aggregate size. The comparison between the two methods DA and SEI shows that the effect of surface curvature does not affect the quality of our predictions of aggregation rates. Finally, the aggregation kinetics of TiO2 NPs can be predicted successfully by the DLVO theory if the physicochemical parameters like the zeta potential and the effective interaction radius are estimated accurately

DISINFECTION BY-PRODUCT FORMATION CATALYZED BY NANOPARTICLES IN WASTEWATER EFFLUENTS

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The increasing use of engineered nanomaterials (ENs) in consumer products has raised several concerns about their potential effects once they are released to the environment. ENs are often commonly used to catalyze chemical reactions in industrial settings, thus suggesting that they may catalyze undesirable reactions as they are transported in the environment. Given that a significant portion of ENs will be disposed of via wastewater treatment, the purpose of this study was to examine the potential for ENs to catalyze disinfection byproduct (DBP) formation during effluent disinfection. DBPs are a concern both to human and aquatic health. Experiments were conducted comparing the effects of ENs during disinfection with chlorine or UV, together or individually, on the formation of DBPs using two distinct real-world wastewater effluents. A defined set of disinfection by-products (four trihalomethanes and trichloronitromethane) were monitored using head space gas chromatography. Overall effects on human cell toxicity were also monitored using the WST-1 and the trypan blue assays. This study provides important baseline information regarding potential concerns associated with disposal of ENs to wastewater treatment plants.

CHARACTERIZATION OF NANOPARTICULATE CERIUM OXIDE UPON RELEASE FROM A COMMERCIALLY AVAILABLE DIESEL FUEL CATALYST

James Dale, Virginia Tech

Michael Hochella, Virginia Tech

Linsey Marr, Virginia Tech

Abstract: The fate and transport of nanomaterials are strongly correlated with factors such as primary particle size, aggregate size, chemical composition, and oxidation state, among others. These properties may change drastically during the life cycle of a product. This study aims to characterize cerium oxide in EnviroxTM, a diesel fuel-borne catalyst, captured from the exhaust of a 4-cylinder, 32 kW, turbocharged engine operating at the manufacturer recommended fuel concentration of cerium oxide. Utilizing a series of analytical techniques, EnviroxTM was confirmed to contain well-dispersed 5-7 nm Ce(IV)O2 particles. These cerium oxide particles maintain suspension in the diesel fuel through the addition of an unknown surfactant. Upon combustion, the cerium oxide particles are found as heteroaggregates of Ce(IV)O2 approximately 60-80 nm in diameter bound to carbonaceous materials. These findings indicate that cerium oxide dispersed in the environment via engine exhaust may react differently than predicted by traditional studies of cerium oxide, which have focused on examining uncoated, dispersed 10-50 nm Ce(IV)O2 particles. Studies are currently underway to examine the transport and environmental impact of the exhaust-borne ceria heteroaggregates.

ZEBRAFISH XENOGRAFT MODEL OF GLIOBLASTOMA TO IDENTIFY METAL OXIDE NANOPARTICLES WITH ANTICANCER PROPERTIES

Jeffrey Greenwood, Oregon State University

Leah Wehmas, Oregon State University

Alex Punnoose, Boise State

Abstract: Zinc oxide nanoparticles (ZnO-NPs) demonstrate selective cytotoxicity toward cancer cells in culture, and this effect may extend to other metal oxide nanoparticles (MO-NPs). To realize their potential as anticancer agents, we must identify safe and effective MO-NPs. We developed a screening approach that first utilizes cell culture assays to identify MO-NPs that preferentially inhibit cancer proliferation and determine the mechanism of selective toxicity. Then we assess the toxicity of the MO-NPs utilizing the embryonic zebrafish assay, an efficacious model for nano-safety assessment because of its high homology with humans and use of minimal test material. We prioritize MO-NPs that demonstrate relatively low toxicity to the zebrafish yet maintain preferential toxicity toward cancer cells in culture for assessment in a zebrafish xenograft model of glioblastoma. By xenotransplanting human glioblastoma cells into the brain of zebrafish, we have developed an assay to identify MO-NPs that selectively inhibit cancer cell proliferation in vivo. We plan to test at least four MO-NPs: zinc oxide, titanium dioxide, cerium dioxide, and tin dioxide. Preliminary results demonstrate that ZnO-NPs inhibit glioblastoma cell proliferation at 0.1 mM. Our screening paradigm holds promise for identifying physicochemical traits which enhance the anti-cancer properties of MO-NPs while supporting safe NP design.

SORPTION AND CHEMICAL TRANSFORMATION OF CEO2 NANOPARTICLES

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Abstract: Cerium-based compounds such as CeO2 nanoparticles (NP) have received much attention in the last several years due to their popular applications in industrial and commercial uses. There is a growing concern about the environmental fate of released CeO2 NPs, particularly their unintended impact in environment. To understand the chemical fate of CeO2 NPs in soils, reactivity of CeO2 NPs in soils were studied as a function of particle size (33 and 78 nm), redox condition, and aging time. Batch dissolution experiments show that CeO2 NPs were only soluble at pH <5, and insoluble at near neutral to alkaline pH values. The distribution coefficient for small and large NPs ranged from 5,101 to 102,039 L kg-1, and from 5,356 to 71,427 L kg-1, respectively, showing the strong sorption CeO2 NPs in soils that is

independent of particle size. Furthermore, changes in chemical state of Ce (reduction of Ce(IV) to Ce(III)) was observed after 30d in reduced soils for small CeO2 NPs. However, there was no significant changes in chemical speciation of Ce in the large CeO2 NP reacted soils. The Ce chemical speciation and reactivity of CeO2 in soils might be important in predicting the fate of CeO2NPs to environment.

ENGINEERED NANOMATERIAL UPTAKE AND EFFECTS ON PHOTOSYNTHESIS IN A CALIFORNIA WILDFLOWER

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Abstract: Despite growing concerns about the potential adverse effects of engineered nanomaterials (ENMs) in the environment, few studies have examined the interactions of soil-borne ENMs and plants. Given that plants are the basis for most terrestrial food webs, it is necessary to understand how ENMs in the environment may affect plant performance and/or generate cascading effects on their pollinators or herbivores in order to properly manage ENM use and disposal. In this two part study, Clarkia unguiculata were grown to maturity in soil with excess or limited nutrients and watered with TiO2, CeO2, or CuOH ENM suspensions at 0, 1, and 100 mg·L-1. Tissue and soil samples were taken and ENM concentrations were measured using inductively coupled plasma atomic emission spectroscopy (ICP-AES). Growth measurements and photosynthetic rates were also collected. Significant uptake of both ENMs were seen at the highest concentration of exposure but decreased photosynthetic rates, stunted growth, and chlorosis were seen in unfertilized treatments, showing a nutrient-mediated effect of these ENMs on Clarkia. In a second experiment, C. unguiculata seedlings were grown in TiO2, CeO2, or CuOH contaminated hydroponic media or soil and uptake through the roots was visualized using environmental scanning electron microscopy with energy-dispersive X-ray spectroscopy (ESEM-EDX).

THE NANO-TECHNOLOGICAL STRESS AND THE CONSTRUCTION OF THE SCOPE OF LIABILITY: THE STORY VIEWED FROM THE SOUTH

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Abstract: Nobody can ignore that as with many new technologies, developing a framework for making management decisions for nanotechnology is a challenge, especially when that technology involves the consumer and the environmental protection.

Nanotechnology products offer the promise of highly beneficial uses, but also could pose uncertain risks of adverse health and environmental effects involving a complex mixture of a new legal framework with The Products Liability System, The Environmental Law and the Law of Torts.

The new industry will assume increasing international significance as it offers vast social and economic potential to nations worldwide. However, are those scientific and social uncertainties a new phantom menace to the Law of Tort?. The uncertainty has two unavoidable faces: the information deficit that involves information regarding risk management and monitoring metrics, criteria and methods uniquely suitable for tailored nanotechnology, as well as the information regarding the behavior and associated risks of different categories of nanotechnology and the significance of different pathways for the different categories of nanotechnology and finally the information regarding risks associated with particular products that include nanotechnology and its influence in environment. These deficits are fertile land to the use and abuse of the precautionary principle as the new luminary in the consumer and environmental protection. The other face of the uncertainty is the state of art defense which requires demonstration that the technology available for the manufacture of a safer finished product with the same characteristic was not feasible through the Restatement of Torts (Second and Third).

Therefore, the central question is how to shift the nanotechnology development with both faces of uncertainty. Both have their social and economic costs, and could contribute to create barriers to the products´ development or to the human and environmental protection through the sustainable development principle, especially when thinking about news technologies first and foremost means thinking about future generations and environment and health protection.

Our goal here is really modest: we simply wish to contribute to the construction of the scope of liability through the frontier between negligence and strict liability. An essential question is whether traditional tort principles are enough or we need new tools to treat uncertainty torts in a sustainable society worried about human health and the environment. The response of the FDA (April, 2012) to the request made by the citizen petition could be consider as a new and careful framework in the construction of the scope of liability trying to wonder about the different faces of the common uncertainty in the risk society we live.

This work tries to undertake the Civil Law tradition in South America and its connection to the Common Law tradition.

As Paracelsus said, the dose makes the poison.

A NEW KRIGING METHOD FOR THE MODELING OF MULTI-SOURCE DATA IN TOXICODYNAMICS AND TOXICOKINETICS STUDIES

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Abstract: In toxicology studies, data often arise from multiple sources (e.g., laboratories, subjects, toxicant materials, etc.), and risk assessors are often faced with the challenge to derive as much valid information as possible from all the data sets (pieces of puzzle). This work proposes a new kriging method, which is referred to as SKQ (stochastic kriging with qualitative factors), to synergistically model multi-source toxicology data. Consider as an example the modeling of dose-time-response data: In the framework of SKQ, biological endpoints are considered responses, dose and time the quantitative factors, and multiple sources the different categories of qualitative factors.SKQ has several distinct features. First, it is highly flexible and able to capture the possibly nonlinear and complex underlying relationships; also, it does not rely on any prior-assumed functional form as traditional regression does. Second, SKQ provides statistically-valid inference; stated differently, it is able to quantify the uncertainty of the SKQ-based estimates, which cannot be achieved by other nonparametric models such as neural networks, support vector machines, etc. Third, SKQ accommodates very general error structures: The variance of the error term can vary across the entire experimental space.

KINETICS, BIOAVAILABILITY AND CLEARANCE OF UNCOATED AND SIO2-COATED ZINC OXIDE NANORODS AFTER INGESTION, INHALATION, AND IV INJECTION

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Abstract: Due to their useful functional properties, zinc oxide (ZnO) nanoparticles are widely used in commercial applications, such as cosmetics, thin films, and photovoltaic cells. Despite their advantages, ZnO nanoparticles can release cytotoxic Zn2+ ions in aqueous and biological media and concerns are raised about their environmental health effects. Here we investigated the pharmacokinetics of ZnO nanorods instilled intratracheally (IT), intragastric (IG) gavage, and intravenously (IV). Furthermore, ZnO nanorods have been coated with a nanothin layer of amorphous SiO2 coating as a strategy to reduce ZnO toxicity. The SiO2 coated and uncoated ZnO nanorods were neutron activated and their kinetics, bioavailability, and clearance were compared after IT, IG, and IV instillation. After IT instillation, the silica coating results in faster clearance from the lungs. 28 days post-IT instillation, the 65ZnO and SiO2-coated 65ZnO both have similar organ translocation. However, the silica coating enhances bioavailability to the bone and skin, and causes faster clearance from the blood. The silica coating also causes the ZnO uptake in the liver to double, and results in slower liver clearance. These results can also help establish the dose of administered ZnO and SiO2-coated ZnO based on desired concentrations in organs.

OPTIMIZATION OF GOLD-GOLD SULFIDE NANOPARTICLE SYNTHESIS

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Faranak Zamani and Krystal Le, Virginia Tech School of Biomedical Engineering

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Abstract: In order to create sustainable nanomaterials it will be necessary to understand the molecular-level interactions of a nanomaterial and a cell, tissue or organism. To date there has been a large focus on oxidative stress markers in investigations of the toxicity of nanomaterials. However, oxidative stress can be a temporary effect and may not really indicate the potential toxicity of a toxin. Many other physiological pathways may provide better indication and more specific information of the interaction of a nanomaterial with a cell or organism and the ultimate environmental impact of a nanomaterial. Here we present evidence of the multitude of pathways of response to nanomaterials and how they differ with changes in surface chemistry of the material. In addition, we present concentration and time – dependent impacts. Finally, molecular changes are place in context as they relate to apical endpoints of survival, growth and reproduction. The implications of surface chemistry interactions with biological entities at the molecular scale in the sustainable design of materials will be discussed.

IDENTIFICATION OF PHB PRODUCING BACTERIA IN WASTEWATER AND THE EFFECTS OF MANUFACTURED NANOPARTICLES ON PHB PRODUCTION

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Abstract: Many bacteria naturally produce bio-plastics, or polyhydroxyalkanoates (PHAs), which are dominated by polyhydroxybutyrate (PHB). While PHA production is exploited in wastewater treatment plants (WWTPs) for biological phosphorus removal, and is of interest as a commercial replacement for petroleum-based plastics, little is known about which bacteria produce PHAs, or how manufactured nanomaterials might impact PHB production. Activated sludge (AS) was collected from the anoxic selector of a WWTP in Santa Barbara, CA. PHB producers were recovered from AS subsamples using a density gradient centrifugation method and exposed to TiO2 nanoparticles (TiO2), Ag nanoparticles (Ag NPs), or Ag nitrate (AgNO3). Samples were analyzed before centrifugation, after a starvation phase, and after a final incubation with nanoparticles. Cells were counted, PHB quantified, and bacteria community composition assessed using the G3 PhyloChip. Total Ag/Ti was measured by ICP-AES. PHB producing bacteria comprised 11% of the total in the AS. With adequate carbon, PHB production was stimulated in

control and TiO2 treatments. Ag NPs and AgNO3, however, reduced PHB production. PhyloChip analysis revealed 111 taxa as potential PHB producers. AS bacteria can be manipulated under laboratory conditions to produce PHB, but PHB production can be inhibited by silver in the form of nanoparticles or ions.

ALGAL-PRODUCED ORGANIC COMPOUNDS REDUCE THE TOXICITY OF SILVER NANOPARTICLES TO FRESHWATER ORGANISMS

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Abstract: Engineered nanoparticles have the potential to interrupt basic ecosystem processes and can have cascading effects on entire communities. Further, ecosystem processes can, in turn, impact rates of aggregation and dissolution of nanoparticles. The concentration of organic material, especially dissolved organic carbon (DOC), drastically alters the behavior and toxicity of citrate-coated silver nanoparticles (AgNPs) to freshwater algae and Daphnia. Through experiments on algal populations, we found that greater concentrations of DOC lead to larger particle sizes and mitigate toxicity of AgNPs. Experimental removal of DOC results in increased AgNP toxicity to algal cells. Algal cultures that maintain high concentrations of DOC recover from an initial toxic response to AgNPs and then experience a second toxic effect, possibly due to an increase in silver ion concentration. We analyzed this feedback through the development of a dynamic model that emphasizes the mitigating effect of DOC on the toxicity of AgNPs and silver ions. Further, preliminary data in our lab suggests that algal-produced DOC also has a mitigating effect on toxicity to Daphnia pulicaria. The mitigating effect of algal-produced organic compounds on other freshwater organisms challenge approaches to ecological risk assessment that quantify risk or exposure level without considering how organismal response affects exposure.

DEVELOPMENT OF AN APPROACH FOR THE SUSTAINABILITY ASSESSMENT OF NANOMATERIALS

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Abstract: The area of nanomaterials and nano-enabled products has experienced an impressive development during the last decade and several applications are entering the market or are expected to

do so in the near future. This requires appropriate robust and science based criteria and methodologies to evaluate and manage their sustainability.Currently there is not a holistic set of criteria for evaluating nanomaterials sustainability and in order to fill this research gap a comprehensive set covering environmental, performance, economic and social aspects has been gathered and will be presented in the first part of this study.Furthermore, structured sustainability evaluations require integration of data, which is currently lacking in the area of nanomaterials. In order to overcome this issue and to take into account performance criteria too, a proposal for an integrated sustainability assessment methodology of nanomaterials and related applications based on multi-criteria-decision-analysis (MCDA) is shown in the second part of the study. The main strengths of this methodology are its flexibility and the ability to cover pivotal nano-sustainability issues, such as uncertainty management, sensitivity analysis, life cycle perspective, qualitative and quantitative data, graphical representation of the results and stakeholders involvement.

MODIFICATION OF NANODIAMOND FOR INCREASED BIOLOGICAL STABILITY AND TRACKING

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Abstract: As means to interrogate nanoparticle interactions with biological systems, we have chosen nanodiamond as a model particle. Because nanodiamond is chemically inert, it is an excellent platform to study the fundamental biological responses arising from different ligands and exposed functional groups, while separating these from responses due to the nanoparticle core. It has been generally difficult to study nanoparticles in biologically relevant media where high ionic strength can induce aggregation. By covalently modifying the diamond surface with ligands exposing different functional groups, we have been able to create water-stable diamond nanoparticles with controllable charge and have explored the impact on nanoparticle stability and uptake by Daphnia magna and Shewanella oneidensis. To detect nanodiamond within the organisms, we have taken several approaches. One is make the diamond fluorescent through chemical modification. A second approach has been to use confocal Raman spectroscopy to directly image the spatial distribution of nanodiamond within the organisms. We will present results including single-particle imaging and the successful use of Raman mapping to characterize nanodiamond within whole Daphnia magna, as well as to highlight methods obtain improved particle stability in biologically relevant ionic strength.

AN ANALYSIS OF ETHANOL SOLID OXIDE FUEL CELLS (ESOFCS) LITERATURE

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Abstract: Fuel cells fuelled by ethanol are an active area of sustainable energy research. Ethanol is renewable, easily stored and transported, readily available and non-toxic, but the anode catalysts used must break the C-C bond and carbon deposition must be prevented [1]. Generally, catalysts used in ESOFCs contain metal and oxides. To prevent coking and improve catalyst efficiency, Nobrega et al. used gradual internal reforming on a thin ceria-containing layer on top of a Ni-YSZ cermet, whereas Hansen et al. used an external reformer [2,3]. Monteiro et al. pursued an alternate approach, using a LSCM-Ru electrode [4] whereas Ye et al. used a Cu-CeO2 layer on Ni-YSZ or Cu-LSCM-ScSZ [5,6].Herein we present a comparison of various strategies for improving ESOFCs.

DEVELOPMENT OF NANO-COMPOSITE CONDUCTIVE ULTRAFILTRATION (UF) MEMBRANES FOR WATER PURIFICATION

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Abstract: Membrane processes are currently used in several ways to purify water and wastewater. Because of their high performance and smaller footprint, membranes are likely to grow in importance as compared to other conventional technologies. Therefore, the need to develop improved membranes with higher flux, greater selectivity, and low susceptibility to fouling is critical. In our recent studies, we showed that the multiwalled carbon nanotube (MWNT) electrochemical (EC) filter is extremely effective as a point-of-use technology in achieving complete removal and inactivation of pathogens. However, the cross-flow ultrafiltration membrane system is advantageous over dead-end filtration as the former can be operated continuously without significant clogging (fouling) due to the tangential motion of the bulk fluid across the membrane surface which washes away the filter cake. Therefore, in order to scale-up the electrochemical filtration technology for use in a large centralized water treatment plant, novel conductive nano-composite ultrafiltration membranes are developed in this project by incorporating carboxylic acid functionalized MWNTs (MWNT-COOH) and conductive polyaniline (PANi) nanofibers into polysulfone (PSf) substrates. A complete membrane characterization with respect to its surface topology, morphology, and water permeability and disinfection efficacy is underway and the results will be presented in the conference.

NANOSTRUCTURE-BASED SURFACE-ENHANCED RAMAN SCATTERING SENSORS

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Abstract: Compared with fluorescence sensors, surface-enhanced Raman scattering (SERS) sensors have no photo-bleaching problem and suitable for multiplexed detection with single excitation source. However, SERS is extremely inefficient due to the small scattering cross section. The present paper represents our effort to develop nanostructures for enhancing the SERS signal. When the Au nanoparticles are used as the SERS substrates, the particle shape has significant effect on the SERS enhancement. The Au nanostars have highest enhancement factor among Au nanostars, nanorods and nanospheres. Also, this work shows a three-dimensional nanostructure can further enhance the SERS signal both in intensity and in space.

BIOCOMPATIBLE FUNCTIONALIZATION OF NANOCERIA AND RETENTION OF CATALYTIC PROPERTIES POST ION-PARTICLE INTERACTION

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Swetha Barkam, University of Central Florida

Sudipta Seal, University Of Central Florida

Abstract: Nanoceria (cerium oxide nanoparticle) attains promising catalytic antioxidants properties in biological systems. It exhibits superoxide dismutase (SOD), catalase mimetics, and nitric oxide radical scavenging activity. Nanoceria has shown to protect cells against oxidative stress thereby they have potential biomedical applications like tissue engineering, retinal protection and neurodegenerative diseases. The potency of nanoceria can be hindered by ion interaction due to chemical modifications at the nanomaterial's surface. The problem that arises is the phosphate ion buffer system is relatively ubiquitous; it is one of the most prominent buffer systems used to administer nanomaterials to the human body. Therefore, ion and particles interactions are unavoidable biological systems. Our venture in this study is to synthesize cerium oxide nanoconstructs that have the capability of protecting the surface reactive sites from interaction by phosphate anions. Polymeric coatings of polyethylene glycol and dextran over the surface of nanoceria were adapted in order to synthesize biologically compatible nanomaterials. Catalase and SOD results show that dextran coated nanoceria is more robust than PEG

coated nanoceria at retaining catalytic properties. Ultraviolet-Visible Spectroscopy, Photoluminescence Spectroscopy and conductivity measurements determined that the preserved characteristic of nanoceria is due to the different Ce-3+/Ce-4+ valency ratios attained due to synthesis procedure.

IMPACTS OF CU, AG, ZN, AND CEO2 NANOPARTICLES ON MARINE PHYTOPLANKTON: INTEGRATING ENVIRONMENTAL CHEMISTRY, CYTOTOXICITY, PHYSIOLOGY, DEMOGRAPHICS, AND DYNAMIC ENERGY BUDGET MODELS

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Bryan Cole, Bodega Marine Laboratory, UC Davis

Tyronne Martin, Bren School of Environmental Science and Management, University of California, Santa Barbara

Abstract: Potential impacts of engineered nanomaterials on the marine environment are largely unknown. To determine ecological impacts we examined the effects of long-term, low-dose exposures of metal and metal oxide nanomaterials on marine phytoplankton. Phytoplankton form the basis of most marine foodwebs, so even subtle changes in growth rates can have large outcomes when scaled up to population or ecosystem levels. Endpoints examined in this study were chosen to link cellular targets of toxicity with population and ecosystem level effects so as to provide an integrated perspective. We have adapted a suite of fluorescence-based assays for cellular targets of cytotoxicity in two species of phytoplankton. These assays were performed in high-content screens using a fluorescence plate reader, thus facilitating rapid and inexpensive examination of a large number of nanomaterials. Specific cytotoxicity targets include reactive oxygen species production, mitochondrial membrane potential and cell death. We used the results of the cytotoxicity assays to predict the influence of different nanomaterials on photosystem efficiency in phytoplankton and subsequently population growth rates. Dynamic energy budget models were used to predict No-Effect-Concentrations. Together these methods provide a framework for testing the environmental impacts of nanomaterials on marine phytoplankton across a broad yet interdependent range of scales.

MODELING MECHANISMS OF NANOTOXICITY AT MULTIPLE LEVELS OF BIOLOGICAL ORGANIZATION THROUGH DYNAMIC ENERGY BUDGETS

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Abstract: Biological entities potentially impacted by engineered nanomaterials in the environment include many organisms, life stages, and biochemical pathways, yet most outcomes are anchored in common biochemical processes, including those relating to energy transduction. These processes can be described by Dynamic Energy Budget (DEB) models that describe the assimilation and utilization of energy and elemental matter by living organisms at multiple levels of biological organization. DEB models are increasingly used in ecotoxicology and have been previously implelented to obtain metrics (such as no-effect concentrations) that are independent of specific experimental protocols (details in a 2006 OECD guidance document). The University of California Center for Environmental Implications of Nanotechnology (UC CEIN) is using DEB models in four distinct ways: (i) obtaining biologically-based metrics characterizing toxicity; (ii) projecting effects on populations from data on physiological responses of individual organisms to nanomaterials; (iii) modeling the impact of multiple stressors; (iv) relating population dynamics to sub-organismal information with emphasis on processes involving oxidative stress and to physico- chemical processes in the environment. Examples of each type of application will be presented.

SURFACE CHARGE AND CELLULAR PROCESSING DETERMINES THE PULMONARY TOXICITY OF FUNCTIONALIZED CARBON NANOTUBES

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Abstract: Functionalized carbon nanotubes (f-CNTs) are being produced in increased volume and widely used in composite materials as well as for other commercial applications. However, the potential adverse effects of f-CNTs have not been quantitatively or systematically explored. In this study we used a library of covalently functionalized multiwall carbon nanotubes (f-MWCNTs) to assess the impact of surface charge in a predictive toxicological model that relates the tubes' pro-inflammatory and pro-fibrogenic effects at cellular level to the development of pulmonary fibrosis. Carboxylated (COOH), polyethylene glycol (PEG), amine (NH2), sidewall amine (sw-NH2) and polyetherimide (PEI) modified MWCNTs were successfully established from raw or as-prepared (AP-) MWCNTs. Cellular screening in BEAS-2B and THP-1 cells showed that, compared to AP-MWCNTs, anionic functionalization (COOH and PEG) decreased the production of pro-fibrogenic cytokines and growth factors, while neutral and weak cationic functionalization (NH2 and sw-NH2) showed intermediary effects. In contrast, the strongly cationic PEI-functionalized tubes induced robust biological effects. These differences could be attributed to differences in cellular uptake and NLRP3 inflammasome activation, which depends on the propensity towards lysosomal damage and cathepsin B release in macrophages. Moreover, the in vitro hazard ranking was validated by the pro-fibrogenic potential of the tubes in vivo. Compared to pristine MWCNTs, strong cationic PEI-MWCNTs induced significant lung fibrosis, while carboxylation significantly decreased the extent of pulmonary fibrosis. These results demonstrate that surface charge plays an

important role in the structure-activity relationships that determine the pro-fibrogenic potential of f-CNTs in the lung.

TIO2 REMOVAL VIA CONVENTIONAL WATER TREATMENT: ROLE OF NANOPARTICLE COATING, NATURAL ORGANIC MATTER, AND SOURCE WATER

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Valerie Keene, Howard University

Sharon L. Walker, University of California, Riverside

Abstract: Titanium dioxide (TiO2) nanoparticles have been found in wastewater effluent and have the capacity to enter ground and surface waters. Thus, research is needed on how to effectively remove them. Traditional methods of removing particles include coagulation, flocculation, and sedimentation (CFS). This study involves investigating TiO2 removal using aluminum sulfate as a coagulant in a monovalent electrolyte solution (potassium chloride) and two source waters (artificial groundwater and surface water) during CFS. Absorbance values were recorded at each CFS stage to determine total particle removal. Moreover, characterization work (zeta potential) has also been performed at each of the CFS stages. The role of coagulant dose, coating (bare and meso-2,3-dimercaptosuccinic acid coated), presence of natural organic matter (Suwanee River Humic Acid), and solution chemistry will be discussed. Zeta potential data have been found to directly correlate to the CFS removal experiments. The governing mechanisms involved in TiO2 aggregation and removal under various solution chemistries will be discussed in greater detail.

PHOTOCATALYTIC NANOSTRUCTURED COATING OF TITANIA LINKED TO ORGANIC MOLECULE FOR IMPROVED PERFORMANCE IN SOLAR CELL AND WATER SPLITTING CATALYST

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Dr. Sudipta Seal, Nanoscience Technology Center, Advanced Materials Processing and Analysis Center, Materials Science and Engineering, University of Central Florida

Abstract: Photocatalytic property of titanium oxide (TiO2) has been exploited in applications such as solar cell, water splitting, water purification, etc. It has been found that the property of TiO2

nanoparticles can be greatly enhanced by covalently linking it to folic acid (FA) through silane ((3-aminopropyl)-trimethoxysilane – APTMS) coating. The photocatalytic behavior of modified nanoparticles is manifested in terms of stronger photoluminescence and absorbance of visible light. The mechanism involved is ascribed to the bridged optical states in the molecule and TiO2 nanoparticles. In the present study, the photocatalytic property of APTMS/FA modified TiO2 is used to achieve improved performance in solar cell and water splitting catalysis. The nanostructured coating of TiO2 is applied to polycrystalline silicon solar cell and stainless steel (S.S.) and then covalently modified by APTMS-FA, for solar cell and water splitting applications respectively. Modified solar cell characterized by linear sweep voltammetry exhibited better performance than bare solar cell in terms of increased saturated current density and power output. Water splitting catalysis is analyzed using cathode composed of modified S.S. in a conventional two electrode setup characterized by chronoamperometry measurements. Higher production rate of hydrogen is obtained in S.S. when modified by TiO2-APTMS/FA than by bare TiO2.

USE OF ZEBRAFISH DEVELOPING LARVAE TO STUDY THE ASPECT RATIO-DEPENDENT TOXICITY OF ORAL-INGESTED CEO2

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Shuo Lin, University of California, Los Angeles

Andre Nel, University of California, Los Angeles

Abstract: In this study, we for the first time demonstrated the aspect-ratio dependent toxicity of cerium oxide (CeO2) in the zebrafish model. Utilizing a library of precisely controlled lengths and aspect ratios of CeO2, we systemically evaluated the chronic effects of oral-ingested CeO2 to zebrafish developing larvae after pulse-exposure. Through the use of a suite of assays that qualitatively and quantitatively evaluates the growth of zebrafish larvae, we showed that long aspect ratio CeO2 (AR>52) exerted stunned growth in zebrafish developing larvae, while the spherical/short CeO2 had no effects. Transmission electron microscopy (TEM) analysis revealed clear differences in the patterns of the nano/bio interactions between the long aspect ratio and spherical/short CeO2 with the microvilli structure of GI tract. Such differences in the nano/bio interactions further led to structural damages of the epithelium lining, severe vacuolations of the enterocytes, and significantly reduced digestive function by long aspect ratio CeO2. This study demonstrated the utility of an environmental model, zebrafish developing larvae, to evaluate the potential chronic effects of oral-ingested engineered nanomaterials.

LIPOSOMAL MODEL TO STUDY CELL INTERNALIZATION OF POLYMER COATED NANOPARTICLES

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Kimberley Mai, University of Central Florida

Dr.Sudipta Seal, University of Central Florida

Abstract: Research advances in interaction of nanoparticles with biological cells have proved to be of major importance for drug delivery. Our research aims at developing a model using liposomes, which mimic natural membranes to indirectly assess the penetration of nanoparticles into the cell. In theory this could imitate the naturally existing process of passive diffusion where molecules are driven down their concentration gradients provided they are small to penetrate between the lipid bilayers. Cerium oxide nanoparticles (CNPs) can catalytically scavenge reactive oxygen species (ROS) by mimicking enzymes such as superoxide dismutase and catalase thereby preventing oxidative stress induced disorders. In our previous study, an intravitreal injection of CNPs was shown to inhibit the rise in ROS in the retina. The proposed model can evaluate whether the nanoparticles can be used for topical ocular drug delivery as an alternative to an injection through the optical nerve. In this study, CNPs coated with biocompatible polymers are evaluated in terms of their internalization using the liposome model and establish its efficacy by comparing with the in vitro experiments at low temperatures where the active diffusion of cells is inactive.

WHEN NANO MEETS NANO: EFFECTS OF NANO-TIO2/NANO-ZNO INTERACTIONS ON NANO-ZNO DISSOLUTION AND PHOTOACTIVITY

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Abstract: Most studies on the environmental risks of engineered nanomaterials (ENMs) focus on one material, despite the likely co-existence of different ENMs in nature. Therefore, how interactions between ENMs affect their fate, transport, and toxicity is unknown. In this study, the dissolution and photoactivity of nano-ZnO in Lake Michigan water were measured in the presence of nano-TiO2. The dissolved Zn concentration ([Zn]dis) from 1 mg/L of nano-ZnO, which is partially dissolved, remained stable as nano-TiO2 concentration increased up to 10 mg/L. It is different from an obvious decrease of [Zn]dis from ZnCl2 as a result of Zn sorption onto nano-TiO2 surface. This inconsistency is likely resulted from an enhanced dissolution of nano-ZnO that compensated the loss of [Zn]dis by TiO2 adsorption. Additional experiments using aged or completely dissolved nano-ZnO support this hypothesis. Consequently, the adsorption of Zn dissolved from nano-ZnO to nano-TiO2 deviated from the Freundlich isotherm that was valid for ZnCl2. Furthermore, the photoactivity of nano-ZnO decreased significantly over time due to its dissolution, and the co-photoactivity of nano-ZnO and nano-TiO2 was higher than

that of these ENMs alone. Overall, our study indicates that the coexistence of ENMs potentially changes their environmental impacts that are usually evaluated individually.

SUSTAINABLE NANOTECHNOLOGY: A BALANCE ROLE OF SCIENCE AND ENGINEERING EDUCATION

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As per World Bank Sustainable development is related to meets the needs without negotiating with future needs and planning. Main objective of Sustainable development is to develop an understanding of emerging concepts and technology. In this paper I will focus on education and understanding of Nanotechnology. With the support of world bank a project entitled Technical Education Quality Improvement Program (TEQIP) phase-I was implemented in the Government Engineering College, Chandkheda,Ahmedabad, Gujarat–India. Under this project A Nanotechnology Education and Research Center (NERC) was established. In this paper I will discuss about the important of Nanotechnology at undergraduate level. Initially curriculum was design for Chemical Engineering and Instrumentation and Control Engineering. We have introduced as an elective subject. Also for the final year students we have given project work with laboratory work to develop nanostructure materials for different applications such as sensor, Solar cell etc. I will focus and discuss my talk how Nanotechnology education can play an important role for sustainable development. Also as a conclusion we found that with proper design of curriculum a relation between education and sustainable education can be maintained.

USE OF COATED SILVER NANOPARTICLES TO UNDERSTAND THE RELATIONSHIP OF PARTICLE DISSOLUTION AND BIOAVAILABILITY TO CELL AND LUNG TOXICOLOGICAL POTENTIAL

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Abstract: Since more than 30 % of consumer products that include engineered nanomaterials contain nano-Ag, the safety of this material is of considerable public concern. In this study, we used Ag nanoparticles (NPs) to demonstrate that 20 nm polyvinylpyrrolidone (PVP or P) and citrate (C)-coated Ag NPs induce more cellular toxicity and oxidative stress than larger (110 nm) particles due to a higher rate of dissolution and Ag bioavailability. Moreover, there was also a higher propensity for citrate 20 nm (C20) nanoparticles to generate acute neutrophilic inflammation in the lung and to produce chemokines compared to C110. P110 had less cytotoxic effects than C110, likely due to the ability of PVP to complex released Ag+. In contrast to the more intense acute pulmonary effects of C20, C110 induced mild pulmonary fibrosis at day 21, likely as a result of slow but persistent Ag+ release leading to a sub-chronic

injury response. Interestingly, the released metallic Ag gets incorporated into the collagen fibers depositing around airways and the lung interstitium. Taken together, these results demonstrate that size and surface coating affect the cellular toxicity of Ag NPs as well as their acute versus sub-chronic lung injury potential.

IMPROVED DETECTION OF NANOMATERIALS BY SINGLE PARTICLE ICP-MS AND FATE EVALUATION OF ENGINEERED NANOPARTICLES USED IN SEMICONDUCTOR INDUSTRY

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Abstract: Single particle inductively coupled plasma mass spectrometry (spICP-MS) is an emerging detection technique used to quantify and size metal based nanoparticles. Signal processing of spICP-MS aimed at differentiating particle signal out of background noise is a challenge to accurately characterize nanoparticles. For the fist time, we applied a statistical theory, namely K-means clustering algorithm, to assist the signal processing of spICP-MS and resulted with better particle signal differentiation and good particle size resolution. Size resolution capability of spICP-MS shows significant advantage over traditional dynamic light scattering (DLS) technique. For another perspective, we looked into the fate of main oxide nanoparticles, e.g. silica, used in semiconductor industry. Interaction of these nanoparticles with other constituents within the industry wastewater was investigated to demonstrate their stability behavior, potential toxicity effect to the environment and life-cycle assessment.