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SNO letter

NEWSLETTER OF THE SUSTAINABLE NANOTECHNOLOGY ORGANIZATION

Sustainable Nanotechnology Organization
Research | Education | Responsibility

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SNO Newsletter Submissions

Please send news, conference announcements, job postings, letters to the editor, and other contributions to the newsletter to Drs. Sadik or Karn osadik@binghamton.edu barbara.karn@susnano.org

The next newsletter will be released in February 2013.

Edited by:
Kyle Doudrick
doudrick@asu.edu

Greetings SNO Members,

Fess Parker's Double Tree Hotel, Santa Barbara, CA.

We have an exciting month ahead of us in November with our annual conference taking place. The 2nd SNO Conference will be held on November 3-5, 2013 in Santa Barbara, CA, at the Fess Parker's Double Tree Hotel.

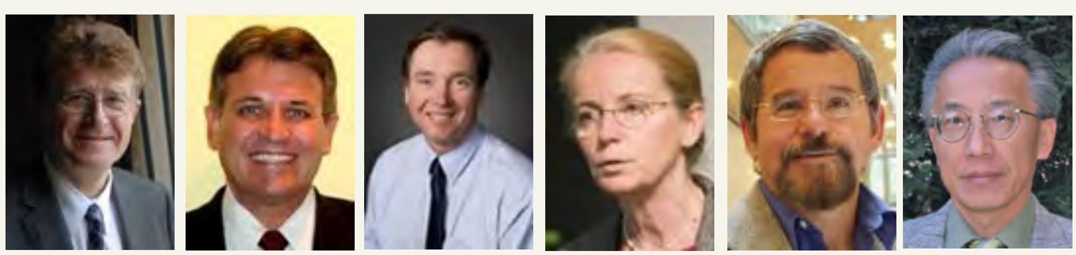
The conference chair for this year is Dr. Arturo Keller from UCSB. There will also be a Ceria workshop on November 2nd at the same location, sponsored by SNO and the University of Kentucky.

The objective of this conference is to bring together scientific experts from academia, industry, and government agencies from around the world to present and discuss current research findings on the subject of nanotechnology and sustainability.

In this issue we will preview the upcoming conference with a few highlighted abstracts from each session, a list of the student awardees, and some additional detail on the Ceria Workshop. For our recurring Q&A session, we have Dr. Paul Westerhoff from Arizona State University joining us.

PLENARIES FOR THE 2ND SNO CONFERENCE

Dr. Mikhail (Mike) Roco, National Science Foundation
Dr. Andre Nel, University of California, Los Angeles
Dr. David Allen, University of Texas at Austin
Dr. Francoise D. Roure, French High Council for Economy, Industry, Energy and Technologies
Dr. Joseph Wang, University of California, San Diego



SNO Q&A SESSION

DR. PAUL WESTERHOFF, ARIZONA STATE UNIVERSITY

Professor, Associate Dean of Research

(Doudrick) Thanks for participating in our Q&A session, Paul. So, why did you get involved with SNO?

(Westerhoff) When SNO was hatched at the first Environmental Nanotechnology GRC, I wondered how I could contribute to set SNO apart from other nanotechnology conferences, and I thought if it was ever going to be successful that a lot of young people needed to be involved. New members have to be attracted somehow, and I thought taking charge of selecting recipients for graduate student travel awards was a good way to contribute. I think SNO is a good idea based on the large number and broad topics trying to be encompassed. When reviewing the different student abstracts and resumes, I was amazed at the broad array of these topics and realize that such an array is not covered elsewhere – and this reinforced the need for SNO as an organization and conference forum.

(Doudrick) You have an extensive research background dealing with traditional physical/chemical treatment technologies and emerging contaminants. Why did you start researching nanotechnology, and how does it fit into traditional environmental engineering programs?

(Westerhoff) My research group has been investigating for years emerging water quality issues. In the past, for example, I've looked at emerging issues such as pharmaceuticals, disinfection by-products including bromate, THMs and nitrosamines, plus arsenate when they changed the regulation. As the nanotechnology evolution began gaining speed in the early 2000's, colleagues (Yongsheng Chen and John Crittenden) had a NIRT to develop new catalysts, and we decided together to look at how the release of nanoparticles into water might impact drinking water treatment. Fortunately, I did my Master's Thesis on sub-micron particles, what we now consider to be nanoparticles. So my first nano-grant built upon what we already knew about aquatic colloids in water treatment and aimed to see if "engineered" nanoparticles would really be any different and to develop appropriate analytical techniques.

Related to environmental engineering, there are a lot of natural nanoparticles out there, so how can we use some of these techniques we've developed for engineered nanoparticles for detection of natural nano-sized particles like viruses in potable water sources. We can use the same analytical methods we developed for nanoparticles to improve our understanding of the traditional definition of "small," being what passes through a 0.45 micron filter. I don't necessarily see nanotechnology being embedded into a part of ABET accreditation, as nanotechnology is actually a pretty small group in environmental engineering discipline, and I currently don't yet see it being as a broad, transformative thing like biotechnology was. However, nanotechnology is an excellent example for how environmental engineering can contribute to understanding the risks and opportunities of an emerging technology, where environmental engineers can play a role in evaluating the risk and sustainability far beyond just say a CO_2 footprint.

(Doudrick) Do you see nanotechnology playing an important role in the development of new drinking water technologies?

(Westerhoff) I think there is definitely a role for nanotechnology in developing new drinking water treatment technologies, but we are still a long way off, and I don't think we are going to be dumping nanoparticles into water treatment systems anytime soon without a lot of oversight and regulation. The first generation of treatment systems will use "attached" nanoparticles, and then move to more "freely" dispersed nanoparticles in water. The applications are already starting with industry and niche applications, and in 25 years we'll have treatment options we wouldn't normally consider using on a large scale today. One of the biggest things will be public acceptance. The closer nanoparticles get to your mouth, the less acceptable it will be, so it will certainly be a challenge for drinking water treatment. We will start out with industry, then wastewater treatment, then maybe something else, with potable drinking water being last for acceptance. Also, nanotechnology should be separated from nanoparticles. Nano-analytics or nanometrology will be used within five years, allowing us to have a better understanding of sub-micron water quality

Westerhoff, contd.
parameters, which will improve our treatment operations. Nanometrology should revolutionize our understanding of viruses, and give us a better understanding of what is "dissolved," and we will realize we can't just assume everything we filter through a 0.45 micron filter is colloidal.

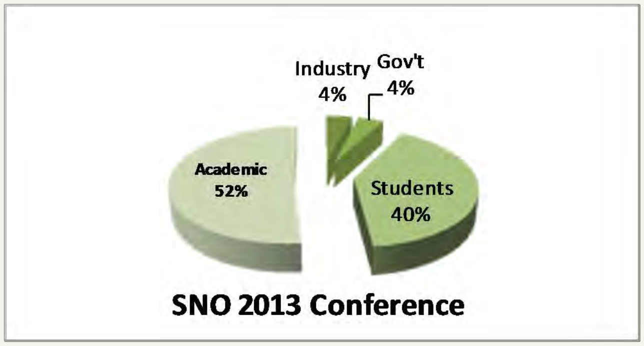
(Doudrick) Great, that leads right into our next question. Nanomaterial metrology is a critical piece to achieving sustainable nanotechnology. There has been a lot of progress on this to date, including the work by your group. What do you see as the remaining challenges?

(Westerhoff) We have gotten to generation 1 of nanometrology, which is leveraging and maximizing the use of existing technologies to look at the nano-scale. Now we need to look at developing new technologies, those that are tailored to engineered nanomaterials. These will have to get cheaper, easier, and faster. For example, we are working on a "colorimetric kit" for detecting nanoparticles. This will provide a quick answer to a basic question—are there nanoparticles present? Something like this will be good for work place exposure, given a saliva sample, it will answer the simple question—was I exposed to nanoparticles? I think some of the industry is starting to recognize this as well and have begun developing nanometrology options.

(Doudrick) Do you see SNO playing an active role in decision making?

(Westerhoff) Organizations that have strong industry participation have more influence on policy and decision making. We can start doing this by developing closer ties to start-up nanotechnology companies, helping them to think sustainability as they develop. SNO can act as a clearinghouse of information about nanotechnology risks, and we can establish ourselves as a good place to archive this kind of information. We also need to develop a strong force of young people who see nanotechnology as 75% of what they do, people that are totally committed to SNO. A lot of people are still on the fence as to if this is their career, so until people commit to it, it will be difficult to have influence. Are these first generation people, those that have been involved less than 5 years, going to own it? Right now, most of the SNO steering committee consists of full professors or higher ups. It is a good opportunity for the younger generation to step up and provide some direction as to where they want SNO to go.

2nd SNO CONFERENCE



In addition to the industry, government, and academic representatives, the SNO conference will include attendees from the press and non-governmental organizations. Almost all US states are represented (where are you, Alaska?). International participants have traveled from Canada, France, Great Britain, India, Korea, Japan, and Poland. About 25% are women. The conference is evidence that SNO has built a firm base of diversity to carry the organization into a strong and sustainable future.

Attendance at the 2013 SNO conference is projected to increase by 25% from 200 last year to almost 250 this year. The sizeable student presence is indicative of the recentness of the field, and these young people bring fresh approaches that bode well for the future of SNO.

Sustainable development

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Brundtland Report, 1987

2ND SNO CONFERENCE STUDENT AWARD WINNERS

Congratulations to this year's student award winners! Students had to write a short essay describing how their work related to SNO and why it was important for sustainable nanotechnology.

Adeyemi Adeleye[a]	UC Santa Barbara
Nirupam Aich	University of South Carolina
Xiangyu Bi	Arizona State University
Allen Chen	Rice University
Marco Cinelli	Warwick University
Joel Cohen[a]	Harvard University
Charles-Francois de Lannoy	Duke University
Jie Hong	University of Texas at El Paso
Chitrada Kaweeteerawat	UCLA
Youngjae Kim	Arizona State University
Clare Mahoney	Carnegie Mellon University
Adam Eugene Marsh	University of Wyoming
Rameech McCormack[b]	University of Central Florida
Manuel Montano	Colorado School of Mines
Arnab Kumar Mukherjee	University of Texas at El Paso
Rifat E. Ozel	Clarkson University
Sandra Pirela	Harvard University
Maria Virginia Prieto Riquelme	Virginia Tech
Laura Reese	Virginia Tech
Yang Shen	Columbia University
Gargi Singh	Virginia Tech
Farrah Solomon	University of Rhode Island
Heather Stancl	Arizona State University
Tiezheng Tong	Northwestern University
Julianne Troiano	Northwestern University
Ben Wender	Arizona State University
Xing Xie	Stanford University
Peng Zheng	University of West Virginia

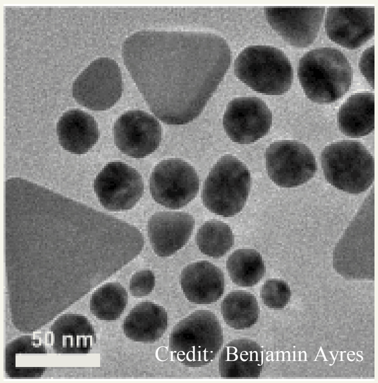
[a]Also awarded in the first year
[b]Undergraduate student

2nd SNO Conference Preview

Selecting Benign Reagents for the Synthesis of Metal Nanostructures

Scott M. Reed, University of Colorado, Denver

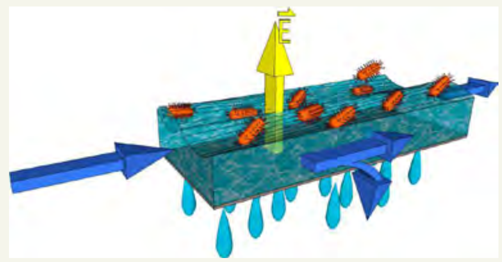
By selecting reagents from renewable feedstocks, it is possible to reduce the ecological footprint of nanomaterials. We have developed nanoparticle (NP) syntheses using lipids extracted from soybeans as ligands as an alternative to petroleum based ligands. The optical properties of metal nanoparticles 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.



Electrically Conducting Carbon Nanotube - Polymer Composite Membranes for Fouling Prevention

David Jassby, University of California, Riverside

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 $CaSO_2$ 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.

2nd SNO Conference Preview

Quantitative assessment of nanoparticle-induced toxicity in embryonic zebrafish

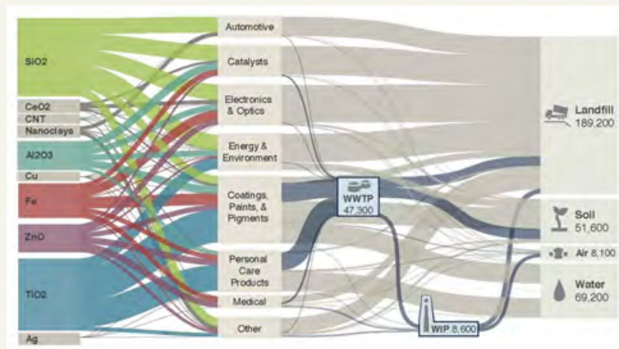
Rıfat Emrah Özel, Clarkson University

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.

Regional and local life cycle releases of engineered nanomaterials

Anastasiya Lazareva, University of California, Santa Barbara

Analysis 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

Ethical Positions and Nanotechnology Acceptance: A Social Component of Environmental Sustainability

Mary Collins, University of Maryland

Sustainability is described as having three pil

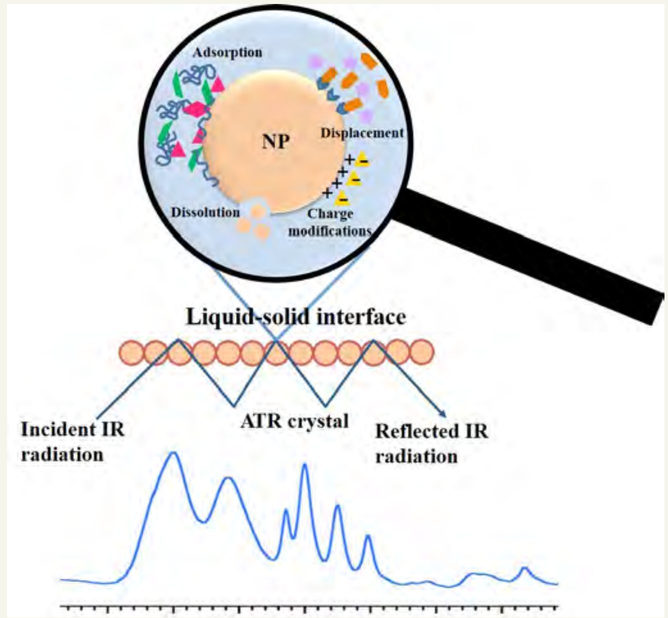
(Collins, contd)

lars—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.

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

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 pro-



vide 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.

Material properties that control the cytotoxicity of ZnO nanoparticles

Alex Punnooose, Boise State University

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 etha

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(Punoose, contd)
nol 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.

Public Acceptance of Nanofood: Another Episode of Genetic Modification?

Guzhen Zhou, University of Florida

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.

Nanomaterial removal by conventional and advanced water treatment processes

Jonathan A. Brant, University of Wyoming

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 incom

2nd SNO Conference Preview

(Brandt, contd)
plete 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 (TiO_2, CeO_2, 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.

Multi-Walled Carbon Nanotube Supported Titania for Enhanced Solar Hydrogen Production

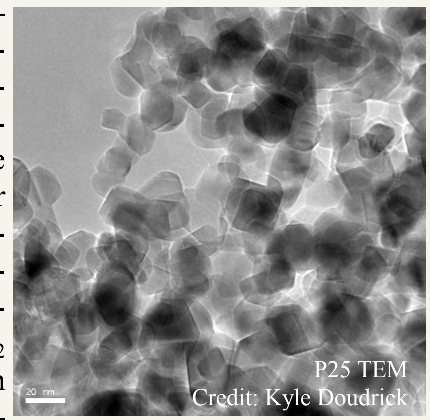
Ming Li, University of Notre Dame

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 TiO_2. To investigate this hypothesis, we synthesized TiO_2-CNT nanocomposites using polyol reduction. In comparison to unsupported TiO_2 nanoparticles, CNT-supported TiO_2 nanoparticles showed much improved catalytic ability in solar hydrogen production. After normalizing to surface area, hydrogen production rate using CNT-supported TiO_2 nanoparticles were found to be 5 times the rate obtained with suspended TiO_2 nanoparticles.

Toxicity of Titanium Dioxide Nanoparticles in Brain

Christina Davis, University of Nebraska-Lincoln

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 (TiO_2) 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 TiO_2 leads to nanoparticle accumulation in several organs including penetration of the blood brain barrier to the central nervous system. However, the toxicological effects of TiO_2 on brain function have not been extensively investigated. In this work, we investigated the effect of TiO_2 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 TiO_2 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 TiO_2 on brain cells at a transcriptional level. We plan to further investigate the molecular mechanisms that drive the TiO_2 mediated brain toxicity.



P25 TEM
Credit: Kyle Doudrick

Biological and Environmental Transformations of Copper-Based Nanomaterials

Zhongying Wang, Brown University

Copper-based nanoparticles are an important class of

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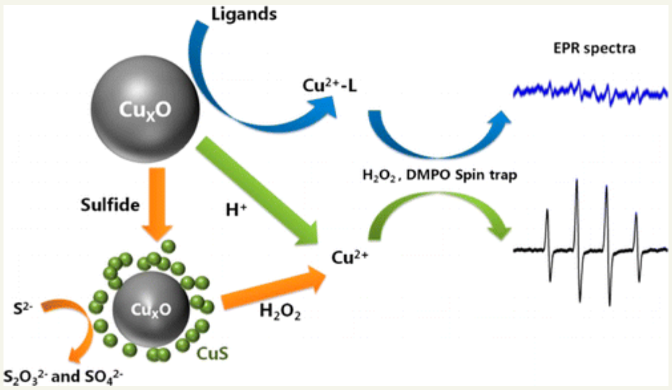
materials with applications as catalysts, conductive inks, antimicrobial agents and those involved in CO2 reduction and CO oxidation. The potential

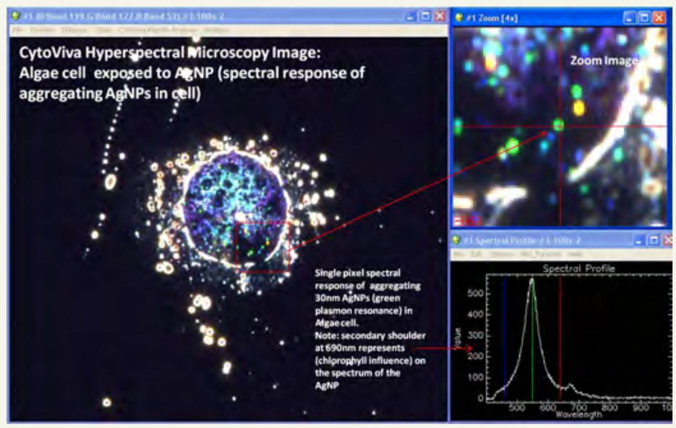


large-scale use of Copper-based nanoparticles provides strong motivation of a careful assessment of their environmental and human health risks. Elemental nanocopper oxidizes readily, so copper oxides are highly relevant phases to consider in studies of environmental and health impacts. Here we show that 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.

Optical Observation and Hyperspectral Characterization of Nanomaterials in-situ

Byron J. Cheatham, CytoViva, Inc.

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.

NANOCERIA WORKSHOP

The nano-ceria workshop is a one-day workshop preceding the SNO conference on Saturday, Nov. 2, 2014. The meeting focuses on what we know, what we do not know, and suggestions for what needs to be determined (i.e., research recommendations) about the sustainability of nanoceria. A number of investigators have uncovered properties, some beneficial and some detrimental, to biological systems. The differences in findings drive the need to bring together the community to discuss the biological, human health, environmental and societal improvement aspects of nanoceria. Proceedings from this workshop will be published as state of the science reviews, research recommendations in addition to new research results

Contact Robert A. Yokel (ryokel@email.uky.edu) for more information.

ANNOUNCEMENTS

USA Science & Engineering Festival

SNO was selected to be an exhibitor at the 3rd USA Science & Engineering Festival (USASEF; www.usasciencefestival.org) Expo on April 26-27 and Sneak Peak on April 25 at the Walter E. Washington Convention Center in Washington D.C. SNO is looking for volunteers to participate in our "Nanotechnology in Our Life" with either short activities/ hand-on activities related to sustainable nanotechnologies or just volunteering for an hour to attend help us to attend the booth. SNO will also present a workshop on "Communicating Nanostuff" on June 25. For more information contact Vinka Oyanedel-Craver (vinka.craver@susnano.org) or see www.susnano.org for workshop info.

ACS Sustainable Chemistry and Engineering Special Issue

Selected oral presentations and posters from the 2013 SNO conference will be invited to be included in a special issue of the ACS Sustainable Chemistry and Engineering Journal focused on sustainable nanotechnology. Works presented during the 2012 SNO conference were published on the July issue of the journal (Vol. 1, Iss. 7, Pgs. 687-857).

SNO Session at NanoTech Conference

SNO will sponsor a session, "Sustainable Nanotechnology: Environmental Apps and EHS Implications," at the 2014 NSTI Nano Conference June 15-19. Abstracts are due January 15, 2014.
See http://www.techconnectworld.com/Nanotech2014/sym/
Sustainable_Nanotechnology_Environmental_Apps_EHS_Implications.html or
For more information contact Philip Demokritou (pdemokri@hsph.harvard.edu).

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