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A CONSTRUCTIVE CONTRIBUTION TO THE RESPONSIBLE DEVELOPMENT AND USE OF ENGINEERED NANOMATERIALS

# nanoRISK

OPTIMIZING THE BENEFITS OF NANOTECHNOLOGY WHILE MINIMIZING AND CONTROLLING THE RISKS

*Insider Report*

A recent article *addresses issues that the authors perceive to be myths and misconceptions regarding nanotoxicology*

## NANOTOXICOLOGY MYTH BUSTER

Some scientists believe that, with the increased mass production of engineered nanoparticles like carbon nanotubes, there is a realistic chance for these particles to interact with water, soil and air, and subsequently enter the food chain. However, understanding the behavior and impacts of nanomaterials in the environment and in human health is a daunting task.

Today, we don't even know what the impact of most chemicals is, and that includes products we have been using for many years. Nevertheless, a general understanding about nanotoxicity is slowly emerging as the body of research on cytotoxicity, genotoxicity, and ecotoxicity of nanomaterials grows.

What we are currently seeing is that individual research groups are picking certain areas of toxicological concern and forge ahead with – often highly specific – toxicology studies. Unfortunately, for lack of a common standard system, these studies are difficult to compare and sometimes they even appear to contradict each other; a situation that is especially confusing in risk assessments of carbon.

As a result, many of the published toxicity studies have limited relevance, due, in large part, to study design limitations, including inadequate justification for dose selection or route of exposure criteria.

### Five "Myths"

David B. Warheit from the DuPont Haskell Global Centers for Health and Environmental Sciences has written an article in the October 29, 2010 online edition of *Nano Letters* ("Debunking Some Misconceptions about Nanotoxicology"), where he addresses issues that he perceives to be myths and misconceptions regarding nanotoxicology:

**Myth 1**: Nanoparticles are always more toxic than bulk particles of similar or identical composition.

**Myth 2**: Particle size and surface area are the critical indices that influence nanoparticle toxicity.

**Myth 3**: All forms of nanotitanium dioxide particles have similar toxicity profiles – or nano $TiO_2$ is nano $TiO_2$ – i.e., we can identify nanoparticle types by their "core identities" without specifying their compositional physicochemical characteristics.

**Myth 4**: No current methodologies are available for the responsible development of nanoscale materials.

**Myth 5**: Pulmonary hazard assessments for nanoparticles can be accurately evaluated using *in vitro* or *in silico* methodologies.

Most of the documented adverse effects from studies of nanomaterial toxicity have been attributed to the small particle size. However, some studies have demonstrated that factors other than particle size, such as particle surface reactivity, may play important roles in defining nanomaterial toxicity.

### Numerous factors involved

Warheit notes that "perhaps the most important point to be made is that nanoparticle toxicological effects are complex and involve a variety of factors including physicochemical characteristics, particle-cellular interactions, routes and degrees of exposure, biokinetics, logistics, and other considerations. Unfortunately, these effects cannot yet be accurately modeled using simple systems."

He points out that risk determination is a product of both exposure and hazard assessments. "However, in many cases the exposure potential cannot be quantified, due to current

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*A new research field called 'experimental nanotoxicology' could help predict the biological effects of manufactured nanoparticles*

# Predicting The Toxicological Effects Of Nanomaterials With Novel Modeling Approach

Nanotoxicology can be defined as the science of engineered nanodevices and nanostructures that deals with their effects in living organisms, emerging from the toxicology of nanoparticles and gaining increasing importance with the growth of nanotechnological applications. When adapting the existing definition of 'toxicology' of the Society of Toxicology to nanomaterials one would describe nanotoxicology as the study of the adverse effects of engineered nanomaterials on living organisms and the ecosystems, including the prevention and amelioration of such adverse effects (source).

The question, of course, is whether it will be possible to rationally design environmentally benign engineered nanoparticles that are not expected to cause toxicity – rather than forge ahead with creating new nanomaterials just on the basis of their intended functionality and then test their toxicity *after* they have been produced or even included in commercial products and applications.

## Experimental nanotoxicology

In a new research field that could be called 'experimental nanotoxicology', scientists have now, for the first time, demonstrated that biological effects of manufactured nanoparticles (MNPs) can be predicted using their chemical, physical, and geometrical properties. The results successfully demonstrate the high potential of cheminformatics approaches for improving the experimental design and prioritizing the biological testing of novel MNPs.

"Our main motivation was our general interest in extending statistical molecular modeling techniques that in principle can relate structural features to the function or biological effects of complex molecules towards increasingly more complex systems – such as proteins or manufactured nanoparticles" explains Alexander Tropsha, K. H. Lee Distinguished Professor and Chair, UNC School of Pharmacy.

Reporting their findings in a recent issue of *ACS Nano* ("Quantitative Nanostructure-Activity Relationship Modeling"), Tropsha and his collaborators have, for the first time, tested the feasibility of modelling the very complex problem of biological properties of nanoparticles. They termed their approach *quantitative nanostructure-activity relationship (QNAR) modeling*.

The team modeled their approach after a process used in drug design and chemical synthesis, where the chemical structure of a new compound is quantitatively correlated with a well defined process, such as biological activity or chemical reactivity. Such a *Quantitative Structure Activity Relationship*

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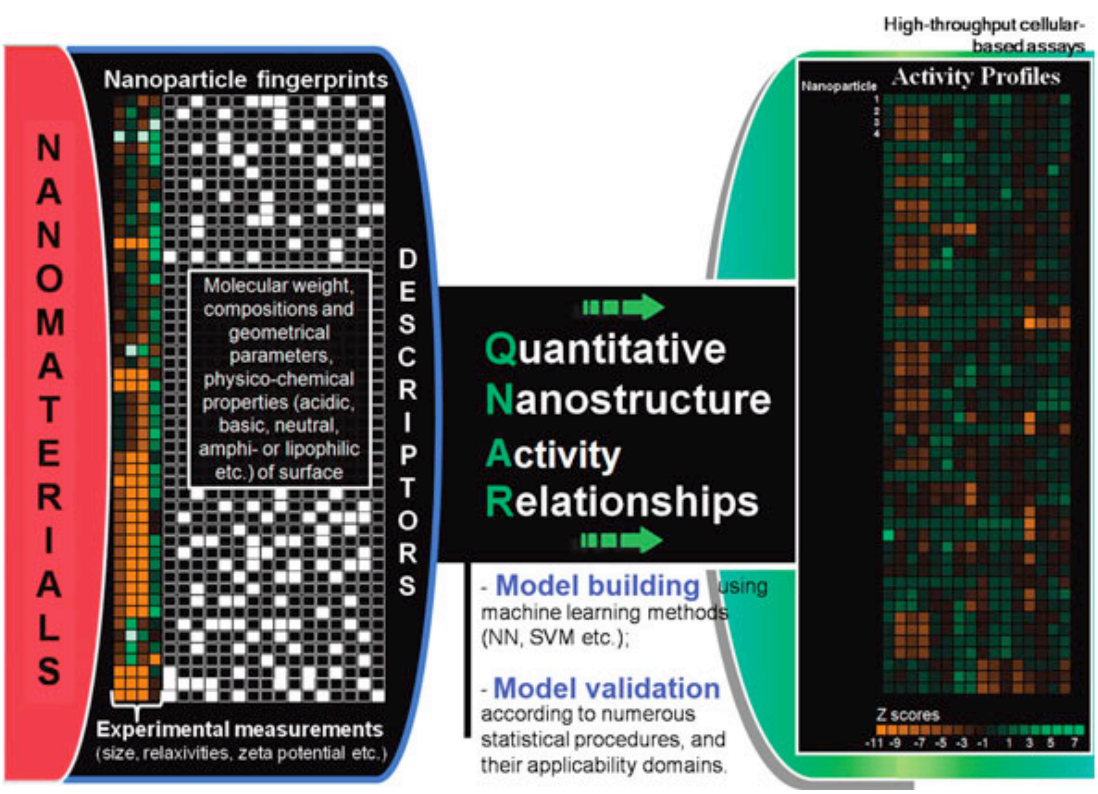


*Study design for quantitative nanostructure-activity relationship (QNAR) modeling using both calculated as well as experimentally measured properties of manufactured nanoparticles as descriptors.*

*Silver nanoparticles will likely get into wastewater streams and subsequently enter wastewater treatment plants. During wastewater treatment processes, silver nanoparticles may be incorporated into the sewage sludge matrix and concentrated over time*

# RESEARCHERS IDENTIFY SILVER NANOPARTICLES IN SEWAGE SLUDGE OF WASTEWATER TREATMENT PLANTS

Silver nanoparticles are one of the most extensively used type of nanoparticles in consumer products due to the unique antibacterial activity of silver. There have been raising environmental concerns over their adverse ecological effects, along with ionic silver potentially released from the particles.

"To predict the environmental impact of engineered silver nanoparticles, their characterization from environmental matrices should be pursued, yet no field-scale studies are available to date" says Bojeong Kim, a research associate at The Center for NanoBioEarth at Virginia Tech's Department of Geosciences. "In addition, analyses examining the sizes, morphologies, elemental compositions, degrees of crystallinity and atomic structures, coatings, and aggregation states of nanosized silver particles in the environment are rare, limiting our ability to conduct a sound risk assessment. Absence of such information may be due to technical difficulties of retrieving trace levels of the silver nanoparticles from very complex heterogeneous systems."

Kim is first author of a recent research paper in *Environmental Science & Technology* ("Discovery and Characterization of Silver Sulfide Nanoparticles in Final Sewage Sludge Products") that was motivated by the fact that silver nanoparticles in consumer products are likely being released during and/or after the product's lifetime. The silver nanoparticles will likely get into wastewater streams and subsequently enter wastewater treatment plants. During wastewater treatment processes, silver nanoparticles may be incorporated into the sewage sludge matrix and concentrated over time.

"Therefore, we looked for the presence of silver nanoparticles in sewage sludge materials that were collected from a full-scale municipal wastewater treatment plant located in a metropolitan area of the Midwest region of the US" explains Kim. "We successfully identified and characterized the silver nanoparticles that were present in the sewage sludge materials using analytical high-resolution TEM."

This analytical high-resolution transmission electron microscopy (TEM) study by the Virginia Tech researchers , led by Michael Hochella, provides for the first time field-scale nanoparticle-level information of silver sulfide ($Ag_2S$) that was present in the final stage sewage sludge materials. They also developed and refined a sampling and TEM-sample preparation protocol for this type of very complex, heterogeneous environmental material.

"Certain types of metal-based nanoparticles can transform once they are released into different environments, possessing completely different properties than those of the mother – or original – material" says Kim. "This is certainly true for the case of silver. The type and source of silver that enter the wastewater plant can vary, but they are likely to form silver sulfide in the presence of reduced sulfur under anaerobic conditions in the plant. Therefore, the potential transformation processes and their products need to take into consideration to predict the environmental fate and entire life cycle of engineered nanoparticles."

In recent risk assessment studies, not only for silver but also other engineered nanomaterials, sewage treatment plants are considered to be key intermediate stations that control the most prominent flows of nanoparticle between anthropogenic and natural environments.

The Virginia Tech team points out that the speciation of silver nanoparticles collected in settled sewage sludges is also valuable information to wastewater treatment plant managers for operation planning and control. This is because the inhibitory action of engineered silver nanoparticles on bacterial communities and biofilms has been well-documented, but once they undergo transformation processes, like forming silver sulfide complexes/precipitates with sulfide, their toxicity will differ.

While this current study provides for the first time nanoparticle-level information of the silver sulfide present in sewage sludge products, and further suggests the role of wastewater treatment processes on transformation of silver nanoparticles and ionic silver potentially released from them, future studies of size-dependent reactivity, particularly solubility, of silver sulfide nanoparticles will be useful in understanding the environmental fate, influence, and entire life cycle of engineered silver nanoparticles.

As Kim points out, "first of all, at a field scale, we still need detailed information regarding silver nanoparticles levels and speciation in wastewater streams, treated plant effluent, and receiving streams from the plant. Working with very complex environmental samples is always challenging, but such studies will be very useful in understanding the environmental fate, influence, and entire life cycle of engineered silver nanoparticles."

"Secondly, the presence of silver sulfide nanocrystals in sewage sludge materials is now identified, and it is necessary to investigate the time-dependent changes in their chemical and physical properties when they enter different environments later in their life. For example, this would be the case for using the sewage sludge materials containing silver sulfide on agricultural lands as a soil amendment."

"Finally, size-dependent reactivity, particularly solubility of silver sulfide, needs to be studied. silver sulfide is known to be one of the most insoluble minerals with extremely low water solubility. The size of silver sulfide shown in our study ranged from 5 to 20 nm. At the nanosize regime, its solubility may differ from that of bulk silver sulfide, but no one has studied this systematically, yet."

# NANOTOXICOLOGY MYTHS…

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technological limitations of measuring nanoparticle exposures in the workplace. Despite these limitations, the risk management framework could include a minimum base set of toxicity (hazard) screening studies, thus providing a fundamental hazard characterization for the nanoscale particulates of interest."

### A minimum base set set of assays

The minimum base set of acute toxicity assays – not intended to provide for a comprehensive evaluation of toxicity but is designed to facilitate a practical strategy for the development of new nanoscale materials – could include the following criteria: substantial particle characterization; pulmonary toxicity studies; acute dermal toxicity and sensitization studies; acute oral and ocular toxicity studies; along with screening type genotoxicity; and aquatic toxicity studies.

After reviewing a number of nanotoxicology research papers addressing the above-mentioned five 'myths', Warheit concludes that, because hazard effects cannot yet be accurately modeled and the hazard database for nanomaterials is very limited, it will be important to rigorously characterize the material of interest and generate substantive hazard data that is accurate and can be confirmed independently by other research investigators.

In his view, evaluations of human health and ecological implications of nanoparticle exposures will be required to attain nanotechnology's full commercialization potential.

# PREDICTING THE TOXICOLOGICAL EFECTS OF NANOMATERIALS…

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(QSAR) can then be utilized to help guide chemical synthesis and drug design.

"The chief scientific core of our work is that we have thought of applying statistical molecular modeling approaches to datasets of very structurally complex molecules – such as manufactured nanoparticles – in the context of relating their structural features to – also complex – biological effects e.g., cellular uptake" Tropsha explains. "What we have demonstrated, perhaps unexpectedly, is that despite the complexity of the underlying system the use of rigorous modeling procedures resulted in models that were both statistically significant and externally predictive."

He points out that modeling MNPs and their biological effects is challenging due to two major issues: "First, because of the high structural complexity and diversity of MNPs, it is difficult to develop quantitative parameters capable of characterizing the structural and chemical properties of MNPs. Second, systematic physicochemical, geometrical, structural, and biological studies of MNPs are nearly absent in the public domain, making the development of statistically significant computational models and their validation difficult as these procedures require relatively large amounts of data."

Following the established principles of conventional QSAR modeling workflows, the UNC team set out to develop predictive QNAR models. Similar to general QSAR modeling strategies, the overall objective of QNAR models is to relate a set of descriptors characterizing MNPs with their measured biological effects, for example, cell viability, or cellular uptake.

The intended result of these models would be the ability to apply them to newly designed or available MNPs in order to quickly and efficiently assess their potential biological effects.

To demonstrate the validity of the QNAR modeling approach, the team applied it in two case studies comprising two series of diverse MNPs. In case study 1, they studied a data set of 51 MNPs that have previously been tested extensively against four cell lines in four different assays ("Perturbational profiling of nanomaterial biologic activity"). In case study 2, they investigated 109 MNPs with the same core structure but diverse organic molecules attached to their surfaces that were tested for cellular uptake against different cell lines ("ISIDA - Platform for Virtual Screening Based on Fragment and Pharmacophoric Descriptors").

"In both case studies, QNAR calculations led to statistically validated and externally predictive models; these models quantitatively relate the chemical, physical, and geometrical properties of MNPs with their biological effects measured *in vitro* in different cell-based assays" says Tropsha. "We believe that this report, which to the best of our knowledge is the first example of QNAR analysis of relatively large data sets of MNPs, successfully demonstrates the high potential of cheminformatics approaches for improving the experimental design and prioritizing the biological testing of novel MNPs."

Instead of current practice, where nanomaterials are tested, and if needed modified, after their production, the models built by the UNC scientists can be used to prioritize and bias the synthesis of MNPs towards particles with the desired biological activity and safety profiles.

Tropsha says that the team's long-term goal is to extend their approach to a broader variety of nanomaterials – which is daunting given the large variety of nanomaterials possible. "This will require complete datasets, where different materials are routinely evaluated using the same repertoire of assays, and would be helped by an ethos where investigators make their data publicly available for analyses that include multiple datasets and different types of materials."

# How To Gauge Safety Of Nanomaterial-Based Pesticides

Nanotechnology is about to emerge in the world of pesticides and pest control, and a range of new approaches are needed to understand the implications for public health, ensure that this is done safely, maximize the potential benefits and prevent possible risks, researchers say in a new report.

In a study published in the International *Journal of Occupational and Environmental Health* (*"*Exposure Assessment: Recommendations for Nanotechnology-Based Pesticides"), scientists from Oregon State University and the European Union outline six regulatory and educational issues that should be considered whenever nanoparticles are going to be used in pesticides.

"If we do it right, it should be possible to design nanoparticles with safety as a primary consideration, so they can help create pesticides that work better or are actually safer," said Stacey Harper, an assistant professor of nanotoxicology at Oregon State University. Harper is a national leader in the safety and environmental impacts of this science that deals with particles so extraordinarily small they can have novel and useful characteristics.

"Unlike some other applications of nanotechnology, which are further along in development, applications for pesticides are in their infancy," Harper said. "There are risks and a lot of uncertainties, however, so we need to understand exactly what's going on, what a particular nanoparticle might do, and work to eliminate use of any that do pose dangers."

A program is already addressing that at OSU, as part of the Oregon Nanoscience and Microtechnologies Institute.

The positive aspect of nanotechnology use with pesticides, researchers say, is that it might allow better control and delivery of active ingredients, less environmental drift, formulations that will most effectively reach the desired pest, and perhaps better protection for agricultural workers.

"The emergence of nanotechnology in the pesticide industry has already begun, this isn't just theoretical," said David Stone, an assistant professor in the OSU Department of Environmental and Molecular Toxicology. "But pesticides are already one of the most rigorously tested and regulated class of compounds, so we should be able to modify the existing infrastructure."

One important concern, the researchers said, will be for manufacturers to disclose exactly what nanoparticles are involved in their products and what their characteristics are. Another issue is to ensure that compounds are tested in the same way humans would be exposed in the real world.

"You can't use oral ingestion of a pesticide by a laboratory rat and assume that will tell you what happens when a human inhales the same substance," Stone said. "Exposure of the respiratory tract to nanoparticles is one of our key concerns, and we have to test compounds that way."

Future regulations also need to acknowledge the additional level of uncertainty that will exist for nano-based pesticides with inadequate data, the scientists said in their report. Tests should be done using the commercial form of the pesticides, a health surveillance program should be initiated, and other public educational programs developed.

# Molecular Interactions Hold Key To How Nanoparticles Behave In Cells

Nanoparticles show promise in solving a host of problems, from pinpointing medical diagnoses to developing alternative forms of energy and creating more durable materials. But scientists have yet to determine exactly how these tiny particles interact in their environment, whether inside humans or in the world at large, and if those interactions can be toxic.

In a recent study ("Cellular recognition and trafficking of amorphous silica nanoparticles by macrophage scavenger receptor A"), scientists discovered cellular interactions of nanoparticles at the molecular level that may lead to answers about how these particles impact living systems.

The researchers focused on identifying the underlying mechanisms that govern how nanoparticles with specific properties interact with cells. Using a time-lapse high-sensitivity fluorescence microscopy capability, the team studied amorphous silica nanoparticles in macrophages, part of the human immune system. The high-sensitivity microscope allowed them to track individual nanoparticles in real time as the particle entered a cell, how it interacted within the live cell, and its fate. They found that the nanoparticles tended to move together with a particular macrophage protein, Scavenger Receptor A, in the cell.

When the receptor was expressed in cells that normally do not express this protein, the cells became associated with more nanoparticles. When the expression of the receptor was inhibited in the macrophages, the cells became associated with a smaller number of nanoparticles. However, the receptor's mediation was mainly associated with individual nanoparticles. When nanoparticles agglomerated and became a larger mass, as they tend to do, only a smaller fraction was found associated with the receptor.

Studying the cellular interactions of nanoparticles, at the molecular level, showed the team that the particles can interact in unique ways compared to larger structures.

Scientific Impact: As scientists begin to understand the mechanisms and molecules that influence the cellular interactions of nanoparticles carrying specific physical and chemical properties, they can better predict how nanoparticles will impact biological systems.

Societal Impact: With a greater understanding of the cellular interactions and response to nanoparticles, government agencies and scientific associations can set realistic standards for how these particles can be used, safeguarding human health and the environment while speeding innovations in energy, medicine, and materials sciences.

# NIEHS And NCL/NCI Partner To Study Nanomaterial Safety

Engineered nanomaterials (ENMs) are increasingly appearing in a host of consumer products ranging from electronics to cosmetics. As ENMs are engineered into more and more products with widespread use, government labs are being called upon to proactively investigate ENM interactions with biological systems and the environment.

The National Cancer Institute (NCI)'s Nanotechnology Characterization Laboratory (NCL) is an accomplished source for testing nanomaterials for biomedical applications and is now partnering with the National Institute of Environmental Health Sciences (NIEHS) to characterize ENMs used in risk/hazard studies.

Through a formal collaboration with the NIEHS, NCL will thoroughly characterize the physicochemical properties of nanomaterials as part of a new NIEHS program focused on developing an understanding of how ENM physicochemical characteristics influence their molecular interactions with biological matrices and elicit biological responses.

"NCL and NIEHS share common goals related to nanotechnology safety," said Dr. Scott McNeil, the NCL's Director. "NIEHS and NCL are both interested in understanding how nanomaterial properties influence their biological behavior. This collaboration allows NIEHS and NCI to benefit from each other's expertise."

The NCL conducts preclinical assessment of nanomaterials, and is a collaboration among NCI, NIST and the FDA. The NCL is operated by SAIC-Frederick through the NCI's Federally Funded Research & Development Center (FFRDC) and performs nanomaterial safety and toxicity testing in vitro (in the laboratory) and in animal models.

To date, the NCL has evaluated more than 200 different nanoparticles and serves as a national resource and knowledge base for the nanotech research community.

# Limited Response To Australian Nanomaterial Information Call

Seven companies reported using six nanomaterials in response to a voluntary information call in 2008 by Australia's National Industrial Notification and Assessment Scheme (NICNAS). In contrast, 22 companies reported on 21 types of nanomaterial when the first information call was made two years earlier. In a summary report just released, this time a total of only seven respondents provided information on their introduction and/or use of nanomaterials.

The call for information was again voluntary and directed to all persons who manufactured or imported nanomaterials or products (mixtures) containing nanomaterials for commercial development purposes in the calendar year 2008 in volumes greater than 100g of any individual nanomaterial.

NICNAS' conclusion: "The response to the 2008 NICNAS call for information was limited, similar to responses to the voluntary calls for information undertaken in the US and the UK."

## Upcoming Events
### Looking At The Risky Side Of Nano

**2011 Conference on Environmental Science And Development (ICESD 2011)**
*January 7-9, 2011, Mumbai (India)*
The aim of the ICESD conference series is to provide a forum for laying the foundations of a new principled approach to Environmental Science and Development. To this end, the meeting aims to attract participants with different backgrounds, to foster cross-pollination between different research fields, and to expose and discuss innovative theories, frameworks, methodologies, tools, and applications.

**Reproducible Uptake & Quantification of Nanoparticles in vitro (and in vivo)**
*February 17, 2011, Lausanne (Switzerland)*
The third NanoImpactNet Training School in the series on *"Handling protocols and toxicological testing strategies"* will focus on methods of ensuring reproducible presentation of nanoparticles to cells and on methods to quantitate the uptake of nanoparticles into cells.

**Risks Associated With Nanoparticles And Nanomaterials**
*April 5-7, 2011, Nancy (France)*
Organized by the Institut National de Recherche et de Sécurité in association with the Partnership for European Research in Occupational Safety and Health, this conference will be the first of the INRS Occupational Health Research Conference new series and is addressing in 2011 the occupational risks associated to nanoparticles and nanomaterials.

**EuroNanoForum**
*May 30 – June 1, 2011, Budapest (Hungary)*
EuroNanoForum is a biannual event supported by the European Commission. One of the topical areas of this conference is "Society, taking a holistic approach to address societal benefits and risks".

**Nanotech Conference & Expo 2011**
*June 13-16, 2011, Boston, MA (USA)*
Nanotech 2011 is the world's largest and most anticipated annual nanotechnology conference and expo. The "Energy & Environment" track deals with environment, health and safety issues as well as cleantech and 'green' technology issues.

**Fifth International Conference on Nanotechnology – Occupational And Environmental Health**
*August 9-12, 2011, Boston, MA (USA)*
This conference will provide a high quality of professional presentations to scientists and engineers who wish to promote and communicate the interaction between technical advances and societal, occupational and environmental impacts in the field of nanotechnology research.

# IN SHORT – PAPERS, INITIATIVES & UPDATES

### REPORT: International Council of Chemical Associations addresses key issues for nanomaterial definition

The International Council of Chemical Associations (ICCA) has released a document addressing key issues that need to addressed when considering the definition of manufactured nanomaterials for regulatory purposes. It advocates five "Core Elements of a Regulatory Definition of *Manufactured Nanomaterial*". Download the document as PDF from the ICCA website.

### REPORT: An anticipatory governance approach to carbon nanotubes

Because environmental and health information on carbon nanotubes is incomplete and sometimes conflicting, an "anticipatory governance" approach to the technology is needed, according to Mark Philbrick, post-doctoral researcher at the Center of Integrated Nanomechanical Systems at the University of California, Berkeley. Anticipatory governance is an approach designed to support decision makers where there is uncertainty about safety, a common situation when managing emerging technologies. "An Anticipatory Governance Approach to Carbon Nanotubes" appeared in the November issue of *Risk Analysis*.

### PAPER: Importance of determining toxicity of nanosilver to aquatic test organisms

This investigation applied novel techniques for characterizing andfractionating nanosilver particlesandaggregatesandrelating these measurements to toxicological endpoints. The results suggest that dissolved Ag+ plays a critical role in acute toxicity and underscores the importance of characterizing dissolved fractions in nanometal suspensions.
doi: 10.1021/es1025382

### PAPER: Evidence for bioavailability of gold nanoparticles from soil and biodistribution within earthworms

Previous studies provide somewhat limited evidence for bioavailability of gold nanoparticles in food webs, because the spatial distribution within tissues and the speciation of gold was not determined. In this study, we provide multiple lines of evidence, including orthogonal microspectroscopic techniques, as well as evidence from biological responses, that gold nanoparticles are bioavailable from soil to a model detritivore (*Eisenia fetida*).
doi: 10.1021/es101885w

### REPORT: Voluntary initiatives, regulation, and nanotechnology oversight

A new report from the Project on Emerging Nanotechnologies (PEN) explores a variety of voluntary options available for the oversight of nanotechnology products and processes. The report, *Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path*, by Dr. Daniel Fiorino, Director of the Center for Environmental Policy at American University, provides a historical overview of voluntary approaches to environmental protection and assesses their applicability to the emerging field of nanotechnology.

### STUDY: Discussion can hurt consensus-building on science/technology

A new study ("Interpersonal Amplification of Risk? Citizen Discussions and Their Impact on Perceptions of Risks and Benefits of a Biological Research Facility") shows that the more people discuss the risks and benefits associated with scientific endeavors, the more entrenched they become in their viewpoint – and the less likely they are to see the merit of other viewpoints. The researchers set out to see how people talk about risks associated with unfamiliar science and technology issues.

### STUDY: Nanoparticle emission of selected products during their life cycle

The German Federal Environment Agency (Umweltbundesamt) has released a study paper "Study of nanoparticle emission of selected products during their life cycle". The summary is available for download in English or the full version in German: "Emission von Nanopartikeln aus ausgewählten Produkten in ihrem Lebenszyklus".

### PAPER: Understanding how cells respond to nanoparticles

Gold nanoparticles are showing real promise as vehicles for efficiently delivering therapeutic nucleic acids, such as disease-fighting genes and small interfering RNA (siRNA) molecules, to tumors. Now, a team of investigators from Northwestern University has shown that the safety of gold nanoparticle-nucleic acid formulations depends significantly on how the nucleic acids and nanoparticles are linked to one another, a finding with important implications for those researchers developing such constructs.
doi: 10.1021/nn102228s

### INITIATIVE: Nanomaterial product inventory updated

As consumers know very little about products containing nanomaterials, in 2009 the European Consumers' Organization (BEUC) started to monitor the availability of such products and their evolution. The results are very clear: while the 2009 inventory listed 151 products, this year they found 475. BEUC selected product categories representing those most often consumed in everyday life such as child products, food & drink, cosmetics, products for cars and electronic devices. The inventory and explanatory leaflet can be found on the BEUC website.

### PAPER: Impact of metal oxide nanoparticles on marine phytoplankton

Scientists tested the effects of two types of metal oxide nanoparticles, $TiO_2$ and ZnO, on population growth rates of four species of marine phytoplankton representing three major coastal groups (diatoms, chlorophytes, and prymnesio-phytes). These metal oxide nanoparticles (NPs) are becoming common components in many industrial, household, and cosmetic products that are released into coastal ecosystems. The results suggest that effects of metal oxide NPs on marine organisms is likely to vary with particle type and organism taxonomy.
doi: 10.1021/es100247x

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**OPTIMIZING THE BENEFITS OF NANOTECHNOLOGY WHILE MINIMIZING AND CONTROLLING THE RISKS**


The nano*RISK* newsletter is dedicated to providing objective and accurate information about critical issues and developments related to the risks arising from engineered nanomaterials. nano*RISK* appears bi-monthly (ISSN 1931-6941). For a complete list of all published nano*RISK* newsletters please go to www.nanorisk.org.

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