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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 review of recent reports on EHS aspects of nanomaterials reveals serious knowledge gaps.

NANOTECHNOLOGY – THE THINGS WE DON'T KNOW

"*To know that we know what we know, and that we do not know what we do not know, that is true knowledge.*" (Thoreau)

There still is a lot we don't know yet about the environmental, health and safety impact of nanomaterials, but at least scientists are making progress in identifying the gaps – the 'known unknowns' as they call it.

A group of researchers at the Technical University of Denmark (DTU) have conducted a systematic analysis of 31 recently published reports and articles which discuss the environmental, health, and safety (EHS) aspects of nanomaterials. They find that serious knowledge gaps pervade nearly all areas of basic nanotechnology EHS knowledge.

Five particular areas for knowledge gaps

These knowledge gaps or areas of uncertainty were ranked to how often they were included in the screened literature. The analysis found that the following areas in particular have been highly cited as important knowledge gaps within the field:

- the lack of reference materials and standardization
- environmental fate and behavior
- human and environmental toxicity
- test methods to assess, particularly, the effects, and
- commercial or industrial-related aspects (e.g. life cycle assessments).

"We expect that further empirical research will presumably reduce most areas of uncertainty, although it is likely to be time-consuming and expensive," says Khara Deanne Grieger, a PhD student in DTU's Department of Environmental Engineering. "Our analysis shows that research should be prioritized towards the assessment and development of testing procedures and equipment and full characterization of nanomaterials in both biotic and abiotic systems in order to most effectively reduce uncertainties in the short term given the minimal presence of inherent stochastic variability in these locations."

Grieger emphasizes that, while research within assessing toxicity/ecotoxicity and monitoring exposure are indeed greatly important in nano-EHS research, the lack of standardized testing procedures, equipment, materials and full characterization of NM may create serious difficulties in comparing test results and drawing conclusions.

The DTU team – Grieger, Steffen Foss Hansen and Anders Braun, part of the research group Nanotechnology & Risk – has published their findings in a recent paper in *Nanotoxicology* (The known unknowns of nanomaterials: Describing and characterizing uncertainty within environmental, health and safety risks).

A need to develop research priorities

This analysis was motivated by the aim of assisting the development of nano-EHS research priorities. The fields of nanotechnology and nanomaterial development are moving extremely fast, and there are many questions and debates on how to assess some of the potential health and environmental impacts of nanomaterials. Therefore, a better description of the most frequently cited knowledge gaps and areas of uncertainty is one possible way to prioritize nano-EHS research.

"Since it is known that describing and communicating scientific uncertainty is very important, especially in terms of making decisions in complex policy-relevant science, we thought it was important to more qualitatively describe the uncertainty within the field to more accurate communicate to various stakeholders the types and levels of uncertainty that are involved with EHS issues of nanomaterials," says Grieger.

Since the presence of uncertainty plays such a large role in

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New research looks at the waste solids generated by the production of metallofullerenes and fullerenes and addresses the question whether feedstock-associated metals pose potential risks to aquatic receptors.

NOT SO GREEN NANOMANUFACTURING

Studies on the environmental, health, and safety (EHS) impact of nanoparticles are becoming increasingly sophisticated but most of the attention is given to the final nanomaterial product; the environmental impacts of impurities and byproducts associated with low-efficiency nanomanufacturing processes has not received as much focus.

The intent of a new EHS study was to communicate that the purity of nanomaterials should be heavily characterized to ensure that the toxicological ramifications of the actual finished nanoproduct is accurately represented. Additionally, the authors suggest that carbon nanomanufacturing byproducts should be characterized so as to facilitate more informed decision-making on management of their associated waste streams.

"Our study was intended to screen whether mobilized impurities from nanomaterials and nanomaterial byproducts may be of potential concern for environmental regulators and for researchers attempting to address toxicity due to nanoparticles alone," says Alan J. Kennedy. " While specific modeling of impurity concentrations that may partition into the environment was beyond the scope of this study, we investigated the metals composition of two different nanomanufacturing outputs: a commercially available, as-produced fullerene product, and two distinct samples of metal-containing fullerene (i.e., metallofullerene) waste byproduct."

Specifically, Kennedy, a research biologist at the US Army Corps of Engineers Environmental Laboratory, and his collaborators from the ERDC nanomaterials research cluster, NanoSafe, Inc., and the Department of Civil and Environmental Engineering at Virginia Polytechnic Institute, determined whether feedstock metals associated with the production of these materials can become mobilized and reach toxic concentrations in simulated aquatic systems.

The team reported their findings, first-authored by Matthew S. Hull, in the May 4, 2009 online edition of *Environmental Science & Technology* ("Release of Metal Impurities from Carbon Nanomaterials Influences Aquatic Toxicity").

"This particular research focus was first brought to our attention in 2004 by Matt Hull, who was working to develop management strategies for carbon nanomaterial waste streams," Kennedy explains. "We elected to conduct this study since there have been a number of review papers that have communicated that characterization of nanoparticle purity is important. The presence of impurities is not commonly quantified in environmental health and safety studies and we were not aware of any published ecotoxicological investigations that specifically looked into this issue."

Furthermore, there also is a paucity of information on the environmental implications of waste streams or discharges that may leach from low purity nanomanufactured byproduct material from sources such as landfills.

Hull, Kennedy and their team therefore set the goal of testing a specific byproduct material of metallofullerenes and fullerenes to communicate the importance of considering the overall effects of impurities in toxicological studies and in the regulation of waste materials – not just for the two subject materials but for other carbon-based materials such as carbon nanotubes.

"It is important to recognize that our test materials do not represent nanomaterials as a whole," says Kennedy. "Rather, our findings should be considered a case study to communicate the presence and possibility of a more general problem."

This work alerts researchers and regulators alike to two different issues when conducting environmental, health and safety investigations of nanomaterials: Firstly, manufacturing of carbon nanomaterials such as fullerenes and nanotubes is not always an efficient process. "In our experience, this can lead to the generation of large amounts of mixed solid waste streams that either need to be stored on-site or disposed of in an appropriate manner," says Hull. "Since these materials may contain impurities such as metals, organic solvents, or residual nanomaterials, it should not be considered for regulation equivalent to that of carbon black." Secondly, researchers need to be aware that even finished nanomaterial products may have impurities that can confound toxicology studies.

According to Kennedy, their study provides strong support that metals – particularly copper, an agent used to enhance yields of certain fullerene species – leach from metallofullerene soot at concentrations sufficient to induce complete mortality in two U.S. EPA-recommended aquatic test organisms: *Pimephales promelas* and *Ceriodaphnia dubia*.

"Today, there is much interest in determining whether new mechanisms of toxicity exist for nanoscale materials" says Hull. "But as our results demonstrate, it's important that researchers characterize test materials adequately and fully consider the toxicological effects of residual impurities, particularly metals."

These findings have immediate applications to toxicological studies with nanoscale materials and to waste management strategies for nanomanufacturing waste streams. Researchers evaluating the toxicity of manufactured nanotechnology products should work with manufacturers to understand the potential impacts of all input materials on the final products. Further, nanomanufacturing waste streams should be characterized to determine whether or not they contain potentially hazardous materials, and then disposed of accordingly.

Kennedy points out that, while their results were based on only two specific types of carbon nanomaterials and their byproducts, additional studies should be performed to assess the impurity and environmental implications of other types of nanoparticles, dependent on the efficiency of their manufacturing processes and the nature of their associated waste streams. The researchers also suggest that that the state of nanomanufacturing practices in general should be assessed to determine the dominant forms of manufacturing and raw materials used.

New toxicological research on titanium dioxide nanofilaments raises concerns.

Cellular Toxicity Of Titanium Nanotubes And Nanowires

One of the complications of nanotoxicology is that the toxicity of a specific nanomaterial cannot be predicted from the toxicity of the same material in a different form. For instance, while the toxicity of inert systems such as iron oxides, gold, or silver has been investigated for nearly isotropic particles (i.e., with a low aspect ratio), the toxicity of these materials in nanofilament form cannot be predicted from their known toxicity as nanoparticles. Fully understanding the toxic mechanisms of nanoscale materials is an essential prerequisite in being able to design harmless nanomaterials whose interactions with biological cells is non-lethal.

Currently, a lot of nanotoxicological research effort is focused on carbon nanotubes, but nanofilaments are not exclusively based on carbon materials and can be produced from many inorganic materials in the form of nanotubes and nanowires. Researchers in Switzerland have now taken a closer look at the fate of titanium dioxide (TiO_2) based nanofilaments in the body. Their results are cause for concern.

"TiO_2 nanoparticles are widely used as UV blockers in sunscreens" says Arnaud Magrez. "Their cytotoxicity has been tested before and they were found to be rather non-toxic. Our new study shows that TiO_2 based nanofilaments, however, can be quite toxic. The geometry of nanoparticles appears to play a crucial role in cytotoxicity. Furthermore, the toxicity can be enhanced by the presence of defects on the nanofilament surface, resulting from chemical treatment."

These new findings clearly demonstrated that the presence of TiO_2 nanofilaments (synthesized by hydrothermal treatment from anatase and highly concentrated NaOH solution) had a strong dose-dependent effect on cell proliferation and cell death. Nanofilament internalization and alterations in cell morphology were observed. Acid treatment performed to substitute Na+ with H+ in the nanofilaments strongly enhanced the cytotoxic action.

Magrez, a researcher at the NN Research Group at the Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, is first author of a recent paper in *ACS Nano* ("Cellular Toxicity of TiO_2-Based Nanofilaments").

In this work, Magrez and colleagues from his group as well as the University of Fribourg, studied the cellular toxicity of TiO_2-based nanofilaments in relation to their morphology and surface chemistry.

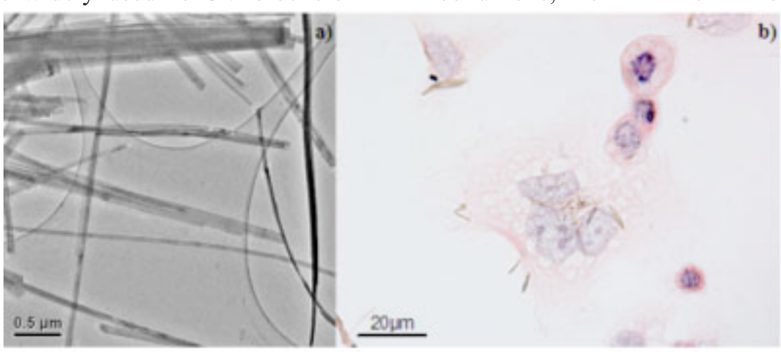
Apart from wide-spread use of TiO_2 nanoparticles, large-scale arrays of TiO_2-based nanofilaments (including nanotubes and nanowires) are already being used in photovoltaic cells and in photoelectrolyzer for the production of hydrogen by water splitting.

The surface cells of the airways, including the epithelial cells of the lungs, are the first cell type to encounter TiO_2-based nanofilaments released into the environment. Therefore the Swiss researchers decided to investigate the acute cytotoxicity of different TiO_2-based nanofilaments on lung cells *in vitro*. In their experiments they evaluated the cytotoxic effect of the TiO_2-based nanofilaments by the widely established MTT assay performed with H596 human lung tumor cells.

Because the MTT assay measures the combined effects of cell proliferation and metabolic activity of cells and was reported to be prone to artifacts under certain experimental conditions, the EPFL team also validated their results by directly counting the number of surviving cells from microphotographs. Magrez says that, in comparison to untreated cells, both the MTT signals and number of cells were decreased in all nanomaterial-treated samples and the two methods – MTT assay and cell counting – yielded essentially identical results.

The researchers found that geometry of the nanomaterials appears to play a role but surface chemistry was the most important aspect in determining the survival of exposed cells.

"The importance of surface chemistry had already been observed in a previous report on carbon-based nanomaterials," says Magrez. "Even though multiwalled carbon nanotubes have comparable diameter and length as TiO_2 nanofilaments, their toxicity is markedly different. Thus, the chemical composition of nanomaterials also appears to have an effect on cell survival. Whether the toxicity determined in this acute model will also translate to models of chronic toxicity or even tumor development (lung carcinoma or mesotheliomas) needs to be addressed in future studies."



Transmission Electron micrograph of TiO2-based nanowires. (a) Irreversible injuries and several morphological alterations of H596 epithelial cells can be observed after 2 days exposure with TiO2-based nanofibers (concentration is 2µg per ml). TiO2-based Nanofibers appear as golden wires (b). (Image: Arnaud Magrez, EPFL)

THE THINGS WE DON'T KNOW…

Continued from page 1

environmental and health assessments of nanomaterials as well as decision making processes within the field, this analysis is highly relevant and timely in order to fully evaluate the collective knowledge on the potential EHS risks of nanomaterial exposure.

This information may increase transparency and openness within nano-risk characterization and analysis processes, which is also important when considering the e.g. prioritization of research efforts and performing risk assessments.

Specific uncertainties

Within the 31 documents reviewed the researchers found a total of 2752 different citations of uncertainty or incomplete knowledge regarding the potential environmental, health and safety risks of nanomaterials. These fall within four general groups:

- testing considerations (which covers how to perform various tests on nanomaterials, including, e.g., equipment, methodology and risk assessment procedures) (31% of total uncertainty citations found);
- assessing effects from nanomaterials exposure (including beneficial or deleterious effects from nanomaterials exposure) (25%)
- characterization of nanomaterials (including, e.g., inherent properties of NM and how they behave in organisms and the environment) (21%);
- assessing exposure (including, e.g., human and environmental exposures and routes) (13%)

The three DTU scientists acknowledge the limitations of this type of analysis: that it may not necessarily reflect all EHS-related uncertainties within the production and use of nanomaterials; that estimating the current level of knowledge may be debatable in itself especially considering 'unknown unknowns'; and that the selected reports focused mainly on broad EHS aspects of NM and the selected review articles were not intended for detailed discussions on, for example, specific testing methodologies.

Novel findings

Nevertheless, these findings are novel in that it is the first attempt known to the authors to systematically and comprehensively describe and characterize scientific uncertainty beyond merely statistical terms in regards to EHS risks of nanomaterials.

"To put the analysis in a broader context, it has been known for over two decades that characterizing and communicating scientific uncertainty and ignorance within particularly complex, policy-relevant science has played an increasingly important role," explains Grieger. "Also, while there are other methods and frameworks to assess scientific uncertainty – e.g. Monte Carlo analysis, sensitivity analysis, etc. – the knowledge gaps within estimating EHS risks of nanomaterials are likely to be too large, complex, and potentially serious to be handled with solely quantitative estimates, and therefore we chose a qualitative uncertainty analysis framework for this analysis."

The main field of application of this work is to better communicate the scientific uncertainty involved in estimates of potential health and environmental risks of nanomaterials. This is in terms of not only the areas of uncertainty but also the level and nature of this uncertainty. Regulators, industry, and scientists may benefit from this knowledge since it will likely provide a more comprehensive evaluation of the current knowledge (or on the other side, uncertainty) associated with the potential risks of nanomaterials. With this, there are some fields which have varying degrees of uncertainty compared to others, similar to the fact that it is likely that more knowledge is available for e.g. some nanomaterials than others as well. Therefore, a more comprehensive and thorough description of the uncertainties involved in the different aspects of EHS risks can be better communicated, and ultimately aid in better, more informed decisions.

Grieger, Hansen and Baun recommend that further attention be given to the assessment and development of standardized testing procedures, equipment, materials as well as the full characterization of nanomaterials in order to most effectively reduce uncertainties in the near term.

"This is based on the minimal presence of inherent stochastic variability in these knowledge gaps, as found in this analysis" says Grieger. "Research within these fields is also important due to the serious challenges that are created when comparing test results and drawing conclusions without adequate standardization and nanomaterial characterization."

She anticipates that the research fields involved in assessing the health and environmental risks of nanomaterials, and particularly those involved in the decision making processes in regards to nano-risks, increasingly open up to new methodologies and frameworks. This is due to the diversity of nanomaterials and products containing them and the fact that current assessment methods often struggle to keep pace.

"Also, in light of the general movement towards 'greener' engineering and production, I also anticipate that 'greener' initiatives will start to be incorporated into the production of at least some nanomaterials. Among other things, this may help consumer acceptance as well as reduce some potentially costly 'down stream' health and environmental assessments."

A series of expert forecasts provide an overview of the potential emerging risks at the workplace

WORKPLACE EXPOSURE TO NANOPARTICLES

The European Agency for Safety and Health at Work (OSHA) has published "Literature Review - Workplace exposure to nanoparticles" which reviews the most recent publications on nanoparticles and focuses on the possible adverse health effects of workplace exposure. The report presents the regulatory background and activities taken to manage this emerging risk. Among the top ten emerging risks, three have in common their physico-chemical state as insoluble particles or fibres: nanoparticles and ultrafine particles, diesel exhaust, and man-made mineral fibres. The experts agreed that nanoparticles and ultrafine particles pose the strongest emerging risk.

New toxicological reserch on titanium dioxide nanofilaments raises concerns.

Approaches to Safe Nanotechnology

From a risk and safety point of view it is impossible to draw any definite conclusions as far as today's nanomaterials are concerned. Although gaining steam, nanotoxicological research is still scarce; standards are just emerging; and scientific findings can be contradicting each other because the underlying assumptions and methodologies vary.

One initiative that tried to shed light on this issue is a recently completed global review of completed and near completed environment, health and safety research on nanomaterials and nanotechnology.

The resulting EMERGNANO report is a unique attempt to identify and assess worldwide progress in relation to nanotechnology risk issues. The review doesn't provide any new data or conclusions but is offeres a fairly comprehensiv identification, stocktaking and analysis of of research carried out worldwide on nanotechnology safety, including that relating to hazard, exposure, risk assessment and regulation.

Hundreds of projects were assessed

The EMERGNANO project, conducted under the umbrella of the SAFENANO initiative, identified more than 670 projects from around the world, and after careful selection assessed more than 260 unique, relevant projects completed, close to completion or in progress since 2004. The final report provides a comprehensive listing of projects, alongside detailed evaluation of their outputs.

The authors caution, though, that they "were unable to identify significant output from many of the studies involved in the program, including studies which had already been completed. We accept, in relation to this, that we have not captured all of the information available on these studies and it is quite likely that there is some information that we have not been able to identify by the various routes through which we attempted to do so."

Ever since its October 2005 report "Characterizing the potential risks posed by engineered nanoparticles" in which it described a set of 19 Environmental, Health and Safety (EHS) research objectives (ROs), the UK government has been very active in research pertaining to the environmental, health and safety issues relating to engineered nanoparticles. The approach used in this review and analysis was to:

- Develop a comprehensive and categorised list of potentially relevant studies, active since 2004;
- Compile information about status, duration, funding, objectives, methods and output relating to these studies through dialogue with project leaders;
- Based on preliminary review, allocate (map) the studies to the 19 ROs being considered;
- Through a multidisciplinary panel of expert reviewers (the authors of this report), chosen to cover the range of scientific disciplines represented in this activity, carry out an appraisal of the contribution of each study in relation to 19 ROs, the extent to which the RO is likely to be met, and the gaps remaining;
- Undertake a risk assessment appraisal identifying the need for control or management of risk, including an appraisal of whether there is sufficient information to invoke the precautionary principle for one or more nanomaterials;
- And through a workshop and dialogue reach a consensus view about the remaining gaps and future priorities.

Important progress was identified

With regard to the research objectives, the assessment reveals some important progress made across the four main thematic areas of characterisation, exposure, toxicology and ecotoxicology spanned by the 19 ROs. This includes:

- For characterisation and reference materials, identification of candidate materials and minimum characterisation specifications for development of reference nanoparticles for toxicological and other investigations is underway. Some commercial reference materials are now beginning to emerge.
- For exposure assessment and control, recent research has conclusively shown that filters, such as those used in respiratory protective equipment and in air cleaning systems, are highly effective in removing nanoparticles from the air.
- For toxicology, lack of mass balance toxicokinetics for any nanoparticle and the patchy nature of the published toxicokinetic data has proven a severe impediment to identifying extra-pulmonary hazards. In addition, testing to date has focussed on a very limited number of particle types and sizes, making it impossible to know whether all NP behave in the same way toxicokinetically, or whether (as seems more likely) a structure activity relationship will emerge that highlights certain sizes and surface chemistries as factors enhancing or limiting potential of any nanoparticle to translocate or be toxic;
- In ecotoxicology, work to date has improved understanding of kinetics of nanoparticle uptake in invertebrate and vertebrate models, and has related this to toxicity. In addition, recent studies which focus on microbial organisms help to provide information on nanoparticle effects at both an individual organism and greater community level.

Currently, EMERGNANO represents the best available picture available of current strategic nanorisk research. As such, the review presents an excellent basis for assessing progress of these and other studies in the future.

Impressive as this study's scope is, the crucial statement by the authors is this: "After assessing study quality and completeness, we did not identify a sufficient body of evidence to make a qualitative risk assessment feasible for any category of nanomaterial." Given the speed of nanotechnology commercialization, this is scary. It should prompt regulators and other governing bodies to seriously step up their funding for relevant research.

Researchers are exploring design methods that will lead to safer and more effective nanoparticles

NEW DESIGN METHODS COULD LEAD TO SAFER NANOMATERIALS

In a research review published in the July issue of the journal *Nature Materials*, researchers provide a comprehensive overview of current knowledge on the physical and chemical properties of nanomaterials that allow them to undergo interactions with biological molecules and bioprocesses.

"What we have established here is a blueprint that will serve to educate the first generation of nanobiologists," says Andre Nel, leader of the team and chief of the division of nanomedicine at the David Geffen School of Medicine at UCLA and the California NanoSystems Institute.

"Based on our rapidly improving understanding of nano-bio interactions, we have done a thorough examination of the literature and our own research progress to identify measures that could be taken for safe design of nanomaterials," he said. "Not only will this improve the implementation and acceptance of this technology, but it will also provide the cornerstone of developing new and improved nanoscale therapeutic devices, such as drug-delivering nanoparticles."

The review article spotlights several important research advancements:

- A classification of the interactions when nanomaterials contact and bind to biological systems will help scientists understand how man-made materials may react when exposed to cells, tissues and various life forms in different natural environmental contexts.
- When nanomaterials enter a biological fluid — for example, blood, plasma or interstitial fluid — the materials' surface may be coated with proteins. Understanding how these protein layers change the properties of the nanomaterials and the ways in which they interact in the body can provide valuable information on how to alter the protein coatings to allow for targeted delivery of nanomaterials to specific tissues, such as in cancer treatments.
- Physicochemical properties such as size, charge, shape and other characteristics could greatly affect the ability of nanomaterials to enter a cell; this could determine whether a material can be useful in nanomedicine applications or could cause harm if taken in by life forms in an ecosystem or food chain.
- Nanoparticles can elicit a wide range of intracellular responses, depending on their properties, concentrations and interactions with biological molecules. These properties and their relationships to cellular function can induce cellular damage or induce advantageous cellular responses, such as increased energy production and growth.

Based on the link between certain nanomaterial properties and potential toxic effects, the team asserts that scientists can reengineer specific nanomaterial properties that are hazardous while maintaining catalytically useful function for industrial use.

UPCOMING EVENTS

LOOKING AT THE RISKY SIDE OF NANO

4th International Conference on Nanotechnology – Occupational and Environmental Health

August 26-29, 2009, Helsinki (Finland)

The Conference will discuss global health and safety issues surrounding engineered nanoparticles and nanotechnologies, especially in connection with occupational and environmental health. The conference will also provide insights into the latest research results and actions to assure the safety and thereby the future success of nanotechnologies.

4th International Conference on the Environmental Effects of Nanoparticles and Nanomaterials

September 6-9, 2009, Vienna (Austria)

This conference is the fourth in a series of very successful meetings in London and Birmingham. It will include a public talk "Talking About Risks of Nanotechnologies: The State-of-the-Art and beyond."

Society for the Study of Nanoscience and Emerging Technologies First Annual Conference

September 8-11, 2009, Seattle, WA (USA)

The event invites all discussions of anthropological, cultural, economic, ethical, historical, philosophical, political, and sociological aspects of nanosciences and emerging technologies.

International Conference on the Implications of Nanotechnology

September 9-10, 2009, Washington, DC (USA)

This conference brings together leading researchers from around the world working on nanotechnology risk assessment, nanotoxicology, ecosystem impacts, transport and transformation of nanomaterials, and nanomaterial detection.

Transatlantic Regulatory Cooperation – Securing the Promise of Nanotechnologies

September 10-11, 2009, London (UK)

This international conference brings together regulatory experts from the US and EU to debate the opportunities and challenges of greater transatlantic cooperation in regulating nanomaterials risks.

NanoEurope 2009

September 28-30, Berlin (Germany)

It is important that the effects of engineered nanomaterials are well understood, and that any risks are managed in a comprehensive and transparent manner. The "Safety" theme at the event will address toxicological studies of nanomaterials, as well as considering risk management and regulatory issues.

Rusnanotech 09

October 6-8, 2009, Moscow (Russia)

The conference will include a track on "Certification, metrology, standardization and technical regulation for safety and quality in nanoindustry."

IN SHORT – PAPERS, INITIATIVES & UPDATES

PAPER: Nanoparticle Characteristics Affecting Environmental Fate and Transport Through Soil

The objective of the present study is to identify changes in properties of nanoparticles released into the environment with a case study on aluminum nanoparticles. Aluminum nanoparticles commonly are used in energetic formulations and may be released into the environment during their handling and use. To evaluate the transport of aluminum nanoparticles, it is necessary not only to understand the properties of the aluminum in its initial state but also to determine how the nanoparticle properties will change when exposed to relevant environmental conditions doi: 10.1897/08-341.1

REGULATION: Norway's Companies Asked to Declare Nanomaterials

The Norwegian Pollution Control Authority (SFT) establishes a scheme for Norwegian businesses to report their use of nanomaterials in chemical products. This is in line with recommendations from the Norwegian Board of Technology. Information about nanomaterials in chemical products will be incorporated as a separate topic in declarations to the Norwegian Product Register, administered by the SFT. The scheme is not strictly mandatory.

REGULATION: Significant New Use Rules on Nanomaterials From EPA

EPA is promulgating further significant new use rules (SNUR) under section 5(a)(2) of the Toxic Substances Control Act (TSCA) for 23 chemical substances which were the subject of premanufacture notices (PMNs). The required notification will provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs. EPA is issuing these SNUR for specific chemical substances which have been subject to the premanufacture notice process (PMN) under TSCA. PMN applies to new chemical substances only and allows EPA to perform a premanufacture review of the concerning substance. Among the concerning chemical substances are many non-nanomaterials, but also different modifications of single-walled and multi-walled carbon nanotubes, carbon black, and (mixed) metal oxide containing film coating additives. EPA Federal Register Notice of June 24, 2009 (Volume 74, Number 120)

PAPER: Novel Method for the Direct Visualization of In Vivo Nanomaterials and Chemical Interactions in Plants

In vivo nanoparticle visualization is needed to support applications in drug delivery to plant biology where real-time monitoring is essential. Techniques are sought that do not require the addition of molecular tags or nanotags to enhance detection, because these may modify the surface properties or behavior of the nanomaterials. Here two-photon excitation microscopy coupled with plant, nanomaterial, or chemical autofluorescence is used to detect and visualize multiwalled carbon nanotubes(MWCNTs), titanium dioxide, and cerium dioxde in living wheat tissues. The potential of the technique to track chemical-nanomaterial interactions in living tissues is then demonstrated, using phenanthrene as a model compound. doi: 10.1021/es900065h

INITIATIVE: Nanotechnology And The Environment: Mismatch Between Claims And Reality

Two international coalitions of NGOs, the European Environmental Bureau and the International POPs Elimination Network (IPEN) Nanotechnology Working Group, have challenged industry claims about the potential environmental benefits provided by nanotechnology products. The groups have published a paper that lays out their case. (pdf download)

PAPER: The Impacts of Aggregation and Surface Chemistry of Carbon Nanotubes on the Adsorption of Synthetic Organic Compounds

The role of surface functionalization of CNTs on synthetic organic compounds (SOC) adsorption was investigated by using commercially available CNTs because these are the types of CNTs that will be produced at large quantities and will likely to enter the environment. In addition, the role of the physicochemical properties of SOCs on their adsorption to CNTs was examined by using SOC molecules with different planarities and solubilities. doi: 10.1021/es900453e

PAPER: Silver Nanoparticle Impact on Bacterial Growth: Effect of pH, Concentration, and Organic Matter

Silver nanoparticles are widely used as antibacterial agents. This antibacterial property carries with it a potential environmental risk once these nanoparticles are discharged into the environment. This study investigated the impact on *Pseudomonas fluorescens* over a 24 h exposure of well characterized Ag NPs at pH values of 6-9, in the presence and absence of Suwannee River humic acids (SRHA). doi: 10.1021/es803259g

PAPER: Titanium Nanomaterial Removal and Release from WastewaterTreatment Plants

The authors report for the first time the occurrence, characterization, and removal of nano- and larger-sized titanium at wastewater treatment plants. doi: 10.1021/es901102n

STUDY: U.S. Scientists and Public Differ on Need for Nanotechnology Regulation

According to the study, the public tends to focus on the benefits — rather than potential environmental and health risks — when making decisions about nanotechnology regulation, whereas scientists mainly focus on potential risks and economic values. Leading U.S. nanoscientists believe regulations are most urgently needed in the areas of surveillance and privacy, human enhancement, medicine and the environment. At the same time, this group feels that other areas, including machines and computers, have little need for further regulation. Data for the study came from survey questionnaires filled out by 363 of the most highly cited and most active U.S.-affiliated scientists in the nanotechnology field. The survey, conducted between May and June of 2007, was administered by the University of Wisconsin Survey Center. It was the first nationally representative study of nanoscientists. doi: 10.1007/s11051-009-9671-5

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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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