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

nanoRISK Insider Report

OPTIMIZING THE BENEFITS OF NANOTECHNOLOGY WHILE MINIMIZING AND CONTROLLING THE RISKS

Notwithstanding the mixed news that individual investors have been getting from their nanotechnology stock portfolios, industry as a whole is pressing ahead with incorporating nanotechnologies in their products and processes. But it appears that safety measures - due to a lack of information – are lagging behind..

PROTECTING NANOTECHNOLOGY WORKERS

Unlike many other areas of science, nanosciences are capable of influencing a wide sweep of industrial and medical processes, from cleaner energy applications, to smart materials and revolutionary medical applications. It is increasingly difficult to know which products use nanotechnology or incorporate nanomaterials; nanotechnology consumer product directories give an idea where nanomaterials are used but are increasingly useless in helping to understand the full extent of nanotechnologies penetrating industrial manufacturing processes.

Some consumer companies embrace 'nano' wholeheartedly and advertise their 'revolutionary' face creams, tennis rackets and car waxes; some, after increased scrutiny, have become very quiet about their nanotechnology activities (especially the large cosmetics and food companies); and some even change their company name to something that doesn't include 'nano' ('cleantech' or 'greentech' has become the new nanotech).

Combine this technological shift that is taking place in industries across the board with the still existing lack of conclusive answers about the toxicity of nanomaterials, and you get a worrisome mix of industry pushing ahead unconstrained, a regulatory environment where key constituencies are ill prepared and underfunded to address the issues with the speed required, and public opinion that covers the whole range from activists calling for a complete moratorium on all things nano to snake-oil salesmen who promise nanotechnology stock tips that will make you a gazillionaire. Oh, and apparently now you can also add to this mix certain religious types in the U.S. who find nanotechnology is morally not acceptable.

This leaves industry workers who potentially are exposed to nanoparticles in their workplace between a rock and a hard place: their companies are at the leading edge of industry, shifting to nanotechnologies in their manufacturing processes to gain competitiveness and create tomorrow's high-tech jobs. On the other hand, even with the best intentions from their employers, there are no sufficient guidelines, regulations or best practices that ensure sufficient worker protection. The problem is that it is very hard to protect against a risk that is neither clearly defined nor understood.

Lack of Information

Many companies that want to take active steps in implementing safety protocols to assure their workers' safety have almost nowhere to turn. We wrote about this problem, and what companies pro-actively are doing about it, in a previous nanoRISK newsletter ("Collaboration is key to protecting nanotechnology workers", Aug/Sept 2007) where we highlight the specific steps that three proactive companies (Altairnano, QuantumSphere, QD Vision) are undertaking to assure their employees' safety.

Some government agencies, like NIOSH (National Institute for Occupational Safety and Health) in the U.S. are taking an active stance in helping industry to address potential safety concerns by exchanging information among companies about best practices and safety guidelines for nanomaterials. Other countries that are very active in nanotechnology have similar initiatives, but many countries don't.

A recent survey that was published in *Environmental Science & Technology* exemplifies the issue: The authors,

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The OECD has prepared an overview of its work on nanotechnologies for Forum VI of the Intergovernmental Forum on Chemical Safety (IFCS). This event will be held in Dakar, Senegal, September 15-19, 2008.

NANOTECHNOLOGY AT THE OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

OECD

A recent paper, titled "Nanotechnologies at the OECD" (*http://www.who.int/entity/ifcs/documents/standingcommittee/nano_oecd.doc*), describes the two activities of OECD related to nanotechnolo-gies: i) the activities of the Working Party on Manufactured Nanomaterials (WPMN); and ii) the Working Party on Nanotechnology (WPN).

WPMN projects:

Project 1: An OECD Database on Human Health and Environmental Safety Research

The WPMN is developing a Database of Research into the Safety of Manufactured Nanomaterials. This database is intended to hold details of completed, current and planned research projects on safety, which are to be updated (electronically) by delegations. Although this database is still a prototype, it already includes over 200 records which have been migrated from the database of the Woodrow Wilson Center. The database will be accessible online for editing and/or adding new records. This database is intended to be a resource for (amongst other things) each of the other projects of the WPMN. The public launch will be in 2008.

Project 2: Research Strategy(ies) on Human Health and Environmental Safety Research

The WPMN is developing a research strategy. This work is based on the knowledge that large sums of money are being devoted to R&D for future applications of nanotechnology. By contrast, it appears that relatively small sums are being made available for human health and environmental safety research. The objective of this project is to strengthen the international cooperation on safety research related to manufactured nanomaterial through: i) identifying priority research areas; ii) considering mechanisms for co-operative international research; and iii) to draw recommendations on research priorities for the short, medium and longer term.

With this in mind, the WPMN has developed a comprehensive list of research themes on environment and human health safety. An analysis (based on the research priorities provided by delegations) on gaps in research currently being undertaken, from which it will draw a set of preliminary recommendations on priorities or needs for research for consideration during 2008.

Project 3: Testing a Representative Set of Nanomaterials

This project is built around the concept that much valuable information on the safety of manufactured nanomaterials (MNs), as well as the methods to assess safety, can be derived by testing certain nanomaterials for human health and environmental safety effects. The objective of this project is to develop a programme to create an understanding of the kind of information on intrinsic properties that may be relevant for exposure and effects assessment of nanomaterials through testing.

As a result of the background work undertaken so far, the WPMN has selected a priority list of MNs for testing (based on materials which are in commerce or close to commercialisation). The WPMN also agreed a minimal base set of endpoints or effects for which these NMs should be tested. As a follow-up, the WPMN launched a "sponsorship programme" at the end of 2007 for the testing of specific MNs. The sponsorship programme is an international effort to share the testing of those manufactured nanomaterials selected by the WPMN. The first phase of the programme will test each nanomaterial for a minimal base set of endpoints (phase 1 of the project). This will produce Dossier Developments Plans for each nanomaterial tested. This work is being supported by the development of a guidance manual for sponsors of the testing programme. In addition, it is expected that this will identify those cross-cutting issues or tests, that will need further consideration (phase 2).

Project 4: Manufactured Nanomaterials and Test Guidelines

It is important to know whether existing test guidelines (used for "traditional chemicals") can be successfully applied to MNs. Some information on this question will be derived from the work on testing MNs implemented by sponsors as a part of Project 3. In parallel, this project is reviewing existing test guidelines [especially the OECD Test Guidelines (TGs)] with view to establishing whether they are suitable for MNs. A preliminary review of Test Guidelines related to physical chemical properties has been finalised and work is planned to review non-OECD testing methods including international and national standards. This project is also reviewing Test Guidelines related to: effects on biotic systems; degradation and accumulation; and health effects.

The WPMN may also begin work on the preparation of guidance documents for testing MNs to address specific issues such as how to prepare and administer materials in appropriate doses for in vivo and in vitro studies.

Project 5: Co-operation on Voluntary Schemes and Regulatory Programmes

A number of countries have put "voluntary schemes" or "stewardship programmes" in place to assess the safety of MNs. This project is analysing these programmes with the aim of: i) identifying common elements, which encourage industry and other entities to submit existing information and data and/or generate new data on risk assessment and risk management of nanomaterials; ii) preparing recommendations to countries on approaches and elements to consider for information gathering initiatives; iii) to identify current and proposed regulatory regimes and how they address information requirements, hazard

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identification, risk assessment and exposure mitigation/ risk management of MNs; and iv) to share information on existing or proposed guidance documents on practices to reduce occupational or environmental exposure to MNs.

Accordingly, an Analysis of Information Gathering Initiatives has been completed. Amongst other things, it addresses the similarities and differences identified in these national initiatives. This analysis also includes a number of considerations and recommendations on approaches and elements for consideration by those countries wishing to launch similar initiatives.

In addition, a Comparison of Regulatory Regimes for Manufactured Nanomaterials has been completed. This exercise identified how current and proposed regulatory regimes address the risk assessment of MNs. In addition, a "template" form has been suggested to identify the various components of regulatory regimes which are or may be applicable to NMs.

As a result of this project, the WPMN has decided to undertake an additional activity on "International Sharing and Comparison of Data on Manufactured Nanomaterials". The concept behind this proposal is to share, amongst member countries, information on MNs, reported through national information gathering initiatives, including voluntary programmes. A centralised list with summary level data is being prepared. This list will be held on the WPMN password-protected site, and it will include contact information in the relevant countries to enable delegations to exchange information on a bilateral basis.

Project 6: Co-operation on Risk Assessment

This project aims at identifying existing risk assessment schemes and is currently reviewing them to establish if they are suitable for the assessment of MNs. This project aims to: i) compile information on risk assessment approaches for chemicals that may be applied to MNs; ii) analyse current risk assessment approaches as these apply to MNs; iii) prepare recommendations for addressing and filling identified gaps.

Accordingly, this project is currently compiling existing risk assessment strategies and methodologies for chemicals that are being currently used for - or may be extended to include - MNs. At the same time, supporting tools will be identified that are currently available which offer the potential to strengthen and enhance risk assessment.

Project 7: The Role of Alternative Methods in Nanotoxicology

This project has been established to: i) assess available in vitro methods and evaluate how they might be used in an overall assessment plan for hazard testing of MNs; ii) prepare an analysis by comparing in vivo and in vitro studies through testing MNs (human and ecotoxity endpoints); and iii) to produce a guidance document for the longer term and for more

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UPCOMING EVENTS
LOOKING AT THE RISKY SIDE OF NANO

Nanotechnology – A Contributor to Reducing Animal Experiments?
May 28-29, 2008, London (UK)
This two-day conference, the first of its kind in Europe, will examine the role nanotechnology could play in improving or refining the development of alternatives to animal testing whilst maintaining safety.
http://www.nano.org.uk/newsletter/animals/

2nd World Congress on Risk – Risk and Governance
June 8-11, 2008, Guadalajara (Mexico)
This is the second of a series of World Congresses on Risk that are important, logical steps to further develop the field of risk analysis and its applications.
http://www.sra.org/events_2008_world_congress.php

11th International Inhalation Symposium – Benefits and Risks of Inhaled Engineered Nanoparticles
June 11-14, 2008, Hannover (Germany)
The symposium will cover the main areas of current concern and active research in the context of inhaled engineered nanoparticles: Relevant physico-chemical characteristics; Measuring methods for airborne particles; Emerging biological test systems; Bioavailability; Pulmonary and systemic toxicity; Mechanisms of toxicity; Use in therapy and diagnosis; Potential sources of human exposure; Potential risks.
http://www.inis-symposium.com/index.html

Environmental and Biological Risks of Nanobio-technology, Nanobionics and Hybrid Organic-Silicon Nanodevices
June 18-20, 2008, St. Petersburg (Russia)
NATO Advanced Research Workshop. New aspects organization, interrelations and interactions of the live organisms and the artificial technical systems for design of the hybrid systems; Analysis of the potential risks of nanobiotechnologies and perspectives of the bionic approach to creation of intellectual technical systems.
http://www.spbcas.ru/nanobio/arw/index.html

Environmental, Health and Safety Aspects of Nano-technology: A Workshop for Reporters
July 20-22, 2008, Madison, WI (USA)
Journalists interested in exploring benefits and risks issues of nanotechnologies are invited to apply for this two-and-a-half day course.
http://mrsec.wisc.edu/Edetc/reporters2008/

Summerschool Ethics of Nanotechnologies
August 24-29, 2008, Enschede (The Netherlands)
The EthicSchool is open to young researchers from a wide variety of academic backgrounds. Participants will develop competence in ethical deliberations, enabling them to make useful contributions to responsible nanotechnology development, as stimulated by the European Commission's Code of Conduct, the Responsible NanoCode, and other initiatives.
http://www.ethicsschool.eu/home.php?page=summer_n

PROTECTING NANOTECHNOLOGY WORKERS …

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Kaspar Schmid and Michael Riediker from the Institute of Health Economics and Management at the University of Lausanne in Switzerland, evaluated the use of nanoparticles, the currently implemented safety measures, and the number of potentially exposed workers in all types of industry in Switzerland (*"Use of Nanoparticles in Swiss Industry: A Targeted Survey". Environ. Sci. Technol., 42 (7), 2253–2260, 2008*).

Although this study was limited to Switzerland, and it is not entirely representative as it was targeted to certain sectors, it stands to reason that its findings are indicative of the current state of nanoparticle use and safety 'best practices' across industries and countries.

Nanoparticles Already Widely Used in Industry

The survey showed that nanoparticles are already used in many industrial sectors; not only in companies in the field of nanotechnology, but also in more traditional sectors, such as paints. Schmid and Riediker write that "Forty-three companies declared to use or produce nanoparticles, and 11 imported and traded with prepackaged goods that contain nanoparticles. The median reported quantity of handled nanoparticles was 100 kg/year but the distribution ranged from 'several grams' to 1000 tons. The production of cosmetics, food, paints, powders,and the treatment of surfaces used the largest quantities of these nanoparticles. Generally, the safety measures were found to be higher in powder-based than in liquid-based applications."

The key finding in this study was that the respondents had many open questions about best practices, which shows that regulators and industry bodies are badly lagging behind, and points to the need for rapid development of guidelines and protection strategies.

The study identified 15 different types of nanoparticles in use in Swiss industry. Silicon dioxide and titanium dioxide were the two predominant nanoparticle-types. Eight other types of nanoparticles were used by only one company. Large-scale usages (several tons per year) were found for iron oxides, titanium dioxide, silver, aluminum oxide, zinc oxide, and carbon black nanoparticles.

The table above shows the protection measures used by the interviewed companies (the sum of the lines does not equal the number of the identified companies because several companies applied more than one protection type).

The study notes that "most of the companies working with nanopowder used several types of protection-measures and many of those working with nanoliquids used only personal protective equipment. The following protection types were found: separation (the application of closed environments like closed machines or separated rooms); airflow (the use of a fume cupboard or a suction device); filter (the use of some form of air filtering system); and personal protective equipment (the use of masks, gloves, eyeglasses, etc.)."

Few other protection types were indicated. All companies with nanoparticle-powders used protection measures, most of them used several types of protection. Seven of the 22 companies with liquid-only applications provided only respiratory personal protective equipment. Two companies with a liquid and a solid application type did not use any protection at all.

Another finding was that most of the protection measures seemed to have been conceived to be adapted to the perceived risk of the application type. For liquid or solid applications, most persons in charge assumed that nanoparticles would not become airborne. Consequently, they did not apply airways protection measures.

Schmid and Riediker write that "almost all contacted safety managers answered our questions about nanoparticle applications and protection measures. Many of them gave detailed information about their EHS [Environmental Health and Safety] approach even though the predominant message was 'I am very interested in the topic of nanoparticles and EHS, but I don't know enough'."

What this study shows is that large-scale use of nanoparticles is already a reality in many industrial sectors. It also reaffirms the fact that there is not enough information available to corporate personnel dealing with nanotechnology EHS issues and what is available is not easily accessible, especially for smaller and mid-size companies.

Protection Measures Used for the Different Application Types, Reported by Interviewed Companies

application type versus protection type	number of companies identified	separation	airflow	filter	personal protective equipment	other protection	no protection
liquid	22	3	3	3	12	1	2
liquid and powder	2	1	2	2	2	0	0
powder	15	9	11	8	11	2	0
solid	2	1	0	0	1	0	1
type not declared	1	1	0	0	0	0	0
type not known	1						
total	43	15	16	13	26	3	3

Protection measures used for different application types as reported by interviewed companies (Reprinted with permission from American Chemical Society)

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general use on the use of alternative approaches, including in vitro methods, for the hazard evaluation of MNs.

As a first step, a report is being prepared including: i) a list of in vitro endpoints on human health and ecotoxicity; ii) the kind of information that the in vitro tests will provide; iii) a list of validated in vitro tests that might be used for testing NMs; and iv) a background document on the feasibility for validating further in vitro methods and to consider the development of further in vitro tests.

Project 8: Exposure Measurement and Exposure Mitigation

The objective of this project is to exchange information on guidance documents for exposure measurement and exposure mitigation and to develop recommendations on future work that needs to be undertaken. Specifically, the project aims to address: 1) exposure in occupational settings; 2) exposure to humans resulting from contact with consumer products and environmental releases of MNs; 3) exposure to environmental species resulting from environmental releases of MNs including releases from consumer products containing MNs. The WPMN recognizes that exposure measurement and exposure mitigation information developed for incidental nanoscale particles is highly relevant to this project and thus it will be considered.

WPN projects

Project A: Statistics and Measurement

The objectives of this project are twofold. The first objective is to overview of the current status, importance and development of nanotechnology using currently scantly available and internationally comparable science, technology and innovation indicators and statistics. This overview will draw on available national and international sources, including member government reports. It will also draw on private sources, where relevant, and assess the quality and comparability of such indicators and statistics. This overview will be published as an OECD report entitled "Nanotechnology at a Glance". The report will be a building block for further efforts in developing internationally comparable statistics and indicators.

The second objective of this project is to develop a framework for internationally comparable and validated statistics, according to agreed definitions and classifications, supported by possible firm-level model surveys. This objective will be undertaken in conjunction and subsequent to the first objective and will involve cooperative work with OECD's Working Party on National Experts in Science and Technology Indicators (NESTI).

Project B: Nanotechnology Impacts on Companies and the Business Environment

The overall objective of this project is to contribute to an improved understanding of the current and potential specific implications of nanotechnology for innovation and economic growth and for policymaking in these areas. The project foremost uses qualitative case study approaches for achieving its objectives. The primary source of information about the impacts of nanotechnology on companies and business environments will be face-to-face interviews with the relevant company representatives using a pre-designed questionnaire. In addition to the qualitative company case studies will also be complemented with a questionnaire on broader characteristics and developments of science, technology and innovation policies across countries.

This questionnaire will highlight challenges and opportunities of policymaking in this field and is also intended to facilitate a policy dialogue. The results of the project will be presented in a final report to the WPN. Project outcomes may also be discussed at a Workshop to be held in 2008 to which business leaders, policymakers, and other experts will be invited.

Project C: International R&D collaboration

This objective of this project is to map research infrastructures, science and technology agreements across countries in order to increase the awareness of countries about opportunities for international R&D collaboration and thereby facilitate this cross-country activity. The information collected in this project can also provide insights about the development of nanosciences and technologies, and assess whether new types and patterns of R&D collaboration at the global level are emerging due to the specificities of this field.

Project D: Communication and public engagement

The objective of this project is to gather experiences from member countries on communication and outreach activities related to nanotechnology in order to support public engagement and foster a dialogue among stakeholder communities (including industry, researchers, policy makers, and the public). The OECD secretariat is currently developing, together with this project steering group, a questionnaire which will be sent to countries delegates and specialists in the area of emerging technologies agencies, to know more about actual and foreseen activities in communicating around nanotechnology and engage the general public in the debates. Combined with other available material and a dedicated workshops this questionnaire will be used for identifying and supporting further good practices in this area..

Project E: Policy Dialogue

The first objective of this project is to develop an inventory of current S&T policies covering OECD member countries and some non-member countries that can form the basis of a synthesising report on the nature, organization, objectives and recent changes in S&T policies related to nanotechnology across countries. The inventory will be based on information that has been identified from public sources

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and on a dedicated questionnaire which has been sent out to the WPN delegates. The synthesising report will contribute to highlighting common challenges and opportunities of S&T policies in nanotechnology across countries and constitute one basis for a policy dialogue.

The second objective of this project is to facilitate a policy dialogue. As suggested above the synthesising report could form a basis for the dialogue. The other facilitating activity will take the form of one or two workshops in summer or autumn 2008. This workshop will involve OECD member and non-member delegates, as well as invited S&T policy experts and a number of other key stakeholders.

Project F: Global Challenges: Nano and Water

The objective of this project is to examine nanotechnology developments, opportunities and diffusion barriers in the area of water purification. The access to affordable and clean water is a major global challenge, especially for developing countries. Nanotechnology offers a range of interesting technologies such as enhanced membranes, filters, catalysts, sensors etc. that can provide concrete solutions in this context. Nonetheless the further development and diffusion of these technologies are still in an early phase, and might face various barriers to adoption. This project will undertake expert interviews and focused analyses in this field to help address some of the key challenges in delivering policies that can unlock the potential that nanotechnology can have.

This project has recently received additional funding and is presently in an intensive design and start-up phase with scheduled expert panel interviews in February as well as preparations for a workshop session at the Nanotechnology in Northern Europe 2008 conference to be held in September 23-25 in Copenhagen. This project also hopes to contribute to the fifth World Water Forum conference to be held in March 2009 in Istanbul.

The objectives of a new survey were to how industry responds to the properties of engineered nanomaterials they are dealing with in terms of risk assessment procedures and precautionary measures.

Majority of Companies Using Engineered Nanomaterials Do Not Perform Any Form of Risk Assessment

The researchers from EMPA and ETH Zurich, found that the majority of 40 companies surveyed in Germany and Switzerland who are working with nanoparticulate materials (NPM) did not perform any form of risk assessment.

Twenty-six companies (65%) indicated that they did not perform any risk assessment of their nanomaterials and 13 companies (32.5%) performed risk assessments sometimes or always. Fate of nanomaterials in the use and disposal stage received little attention by industry and the majority of companies did not foresee unintentional release of nanomaterials throughout the life cycle.

Furthermore, no factors were identified that could provide any explanation of why some companies conducted risk assessment and why others did not. Of the 13 companies conducting assessments, companies reported that a conclusive evaluation was possible and 5 reported that it was not possible. Although no further information was given by the companies, a majority of the companies perceived their current risk assessment procedures as sufficient to evaluate NPM risk, even though no standardized procedures for NPM exist.

The authors suggest that their results may have detected a lack of any systemic approach among industry players in regard to assessing the risks of nanoparticulate material.

Consequently, developing proactive risk management strategies appears to be an urgent task for minimizing the risk of harm to the environment and the public health. How much responsibility the individual firm should take in a globalized market is an issue of considerable debate in policy.

Nevertheless, it may be necessary for regulators to take measures to ensure that engineered nanomaterial risks are properly assessed by industry. A first step could be to initiate an NPM database with information on the properties of the different NPM produced and handled in industry. Such a database would assist in categorizing NPM with respect to, e.g., chemical properties, toxicity, and consumer use. The database could have an international scope such as the European Union.

Since the voluntary reporting scheme in place in the UK has received very few contributions from industry, a legally enforced information duty of NPM producers seems therefore to be the most effective solution to ensure quality and coverage, the authors say. Actively initiating risk management strategies may also help industry address any public concern related to the possible risks of NPM.

Only 24 out of 40 companies gave complete information on the size distribution of their NPM – it would be interesting to know if they couldn't or just didn't want to. Of the particle information that was provided, the researchers found that the nanomaterials in their sample exhibited such a diversity of properties that a categorization according to risk and material issues could not be made.

Source: *Aasgeir Helland, Martin Scheringer, Michael Siegrist, Hans G. Kastenholz, Arnim Wiek, and Roland W. Scholz. (2008). Risk Assessment of Engineered Nanomaterials: A Survey of Industrial Approaches. Environ. Sci. Technol., 42 (2), 640–646*

IN SHORT – PAPERS, INITIATIVES & UPDATES

PAPER: Nanoparticles affect pollutant toxicity

New research suggests that C60 nanoparticles (fullerenes), when released into water systems, may interact with other common pollutants in aquatic environments with important consequences for their toxicity to plant and animal life. Other organic (carbon-based) chemicals are known to have an effect on the toxicity of pollutants to plant and animal life. But nanoparticles like C60 have unique and altered properties compared to larger particles, and so they may have a very different effect on the toxicity and availability of pollutant molecules. The nanoparticles themselves may also be inherently toxic. Researchers from the Technical University of Denmark and the University of Copenhagen, Denmark tested the effect of four common pollutant chemicals: atrazine, methyl parathion, pentachlorophenol (PCP) and phenanthrene on green algae and freshwater crustaceans. The researchers found that when C60 nanoparticles were present, they affected the availability of the toxic chemicals to the organisms. C60 made phenanthrene more toxic to algae at lower concentrations, for instance, but made it less toxic to the crustaceans. C60 made PCP less toxic to both algae and crustaceans. The C60 had little effect on the toxicity of the other two pollutants tested. Nanoparticles also affected how quickly and how much of the pollutant was taken in by the organisms. Clumps of the C60 itself also stuck to the crustaceans' bodies and inside their digestive systems. The authors recommend that nanoparticle risk assessment take into account not just the toxicity of the particles themselves, but also the possible interaction with other environmental contaminants. They also suggest that further research into the effects of nanoparticles' different phases (in particular their behaviour in water as they form suspensions or clumps of molecules know as aggregates) is also relevant to their potential toxicity in the aquatic environment.

Source: *A. Baun, A., Sørensen, S.N., Rasmussen, R.F., Hartmann, N.B., and Koch, C.B. (2008). Toxicity and bioaccumulation of xenobiotic organic compounds in the presence of aqueous suspensions of aggregates of nano-C60. Aquatic Toxicology. 86 (3): 379-387*

PAPER: Nanomaterials' impact on anaerobic microbial communities

Another impact study of fullerenes. Major environmental receptors of nanomaterials will be soil, sediment, and biosolids from wastewater treatment. Analysis of anaerobic microbial activity and communities provides needed information about the effects of nanoparticles in certain environments. In this study, biosolids from anaerobic wastewater treatment sludge were exposed to fullerene in order to model an environmentally relevant discharge scenario. Findings suggest that C60 fullerenes have no significant effect on the anaerobic community over an exposure period of a few months. This conclusion is based on the absence of toxicity indicated by no change in methanogenesis relative to untreated reference samples.

Source*: Leila Nyberg, Ronald F. Turco, and Loring Nies (2008). Assessing the Impact of Nanomaterials on Anaerobic Microbial Communities. Environ. Sci. Technol., 42 (6), 1938–1943*

PAPER: A conceptual framework for occupational risk management as applied to engineered nanomaterials

This article reviews a conceptual framework for occupational risk management as applied to engineered nanomaterials and describes an associated approach for controlling exposures in the presence of uncertainty. The framework takes into account the potential routes of exposure and factors that may influence biological activity and potential toxicity of nanomaterials; incorporates primary approaches based on the traditional industrial hygiene hierarchy of controls involving elimination or substitution, engineering controls, administrative controls, and use of personal protective equipment; and includes valuable secondary approaches involving health surveillance and medical monitoring.

Source: *Paul Schulte; Charles Geraci; Ralph Zumwalde; Mark Hoover; Eileen Kuempel (2008) Occupational Risk Management of Engineered Nanoparticles. Journal of Occupational and Environmental Hygiene, Volume 5, Issue 4, pages 239 – 249*

PAPER: Human health implications of nanomaterial exposure

This review presents the current state of knowledge regarding the potential routes of human exposure to nanomaterials and their biological health effects. Although anthropogenic nanosized particles emitted in the environment are known to produce adverse human health in susceptible populations, much remains to be explored. Exposures can occur from direct exposure or from the use of commercial products made of nanomaterials. Safe manufacturing guidelines for prevention of exposures and recommendations on safe handling and use need to be established on a proactive basis.

Source: *Thilo Papp; Dietmar Schiffmann; Dieter Weiss; Vince Castranova; Val Vallyathan; Qamar Rahman; Human health implications of nanomaterial exposure. Nanotoxicology, Volume 2, Issue 1 March 2008 , pages 9-27*

PAPER: Differential cytotoxicity exhibited by silica nanowires and nanoparticles

Researchers found that silica nanowires are nontoxic at concentrations below 190 µg/ml but exhibit considerable cytotoxicity at higher concentrations. It appears that apoptotic pathways are not activated. Instead, cytotoxicity appears to be primarily due to increased necrosis in cells exposed to high concentrations of nanowires. In contrast to what was seen with silica nanowires, analysis of silica nanoparticles revealed very little cytotoxicity even at the highest concentrations tested. These results indicate that structural differences between silica nanomaterials can have dramatic effects on interaction of nanomaterials with cells.

Source: *Abulaiti Adili; Saskia Crowe; Miles F. Beaux II; Timothy Cantrell; Pamela J. Shapiro; David N. McIlroy; Kurt E. Gustin; Differential cytotoxicity exhibited by silica nanowires and nanoparticles. Nanotoxicology, Volume 2, Issue 1 March 2008 , pages 1-8*

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OPTIMIZING THE BENEFITS OF NANOTECHNOLOGY WHILE MINIMIZING AND CONTROLLING THE RISKS

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