The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Office of Technical Assistance and Technology

The Big Picture: Safe Development of Nanotechnology

Proceedings from the workshop held in November 2007

Additional Sponsors:

Environmental Business Council of New England
Massachusetts Department of Environmental Protection
Massachusetts Department of Public Health
Massachusetts Division of Occupational Safety
Massachusetts Toxics Use Reduction Institute

Workshop Proceedings

The Big Picture: Safe Development of Nanotechnology
November 15, 2007
Marriott Courtyard, Marlborough, Massachusetts

Background

In April 2007, a Massachusetts Interagency Nanotechnology Committee was formed to discuss and gain a better understanding of the emerging field of nanotechnology. The collaborating agencies include the Massachusetts Department of Environmental Protection (MassDEP), Department of Public Health (DPH), Division of Occupational Safety (DOS), Office of Technical Assistance (OTA), and Office of Business Development (MOBD). The collaborating agencies have different authorities and bring diverse interests to Committee forums, allowing for more comprehensive discussions of the nanotechnology sectors in Massachusetts.

Massachusetts is currently a leader in nanotechnology, with approximately 100 companies working with nanomaterials and 11 major nanotechnology research centers across the Commonwealth. When the Interagency Committee first convened, the agencies had had little or no interactions with the nanotechnology sectors. The Interagency Committee developed a two-pronged strategy during initial meetings. The first goal was to start a dialog with Massachusetts' industries, consumer representatives, other government agencies, academia, and environmentalists to characterize the nanotechnology sectors in Massachusetts. The second goal was to use information from the dialog to obtain a better understanding of nanomaterial/nanoproduct manufacturing, product use, and disposal and to identify potential hazards of the technology as well as potential roadblocks to safe development in order to work with the sector towards preventing unintended consequences. The Interagency Committee agreed that a workshop would provide an opportunity to begin the necessary dialog with a goal of creating an alliance with the nanotechnology sector ensuring the safe development of nanotechnology in Massachusetts.

The Workshop

On November 15, 2007, a workshop, entitled "The Big Picture: Safe Development of Nanotechnology" was held. The Massachusetts Executive Office of Energy and Environmental Affairs' Office of Technical Assistance (OTA) co-sponsored the workshop with the Environmental Business Council of New England, the Massachusetts Department of Environmental Protection, Department of Public Health and Division of Occupational Safety, and the Massachusetts Toxics Use Reduction Institute. The purpose of the workshop was to start a discussion among industry, government and the public on developing appropriate strategies for assessing and managing the risks associated with the manufacture, use and ultimate disposal of nanomaterials. In the morning, nationally recognized experts presented basic information on nanoparticles and what is needed to address environmental, health and safety issues posed by the use of nanomaterials. Afternoon breakout sessions provided time for open discussions on issues such as worker safety, emissions and discharges, and product safety and disposition. These sessions provided time for participants to explore and discuss a range of issues and concerns associated with nanotechnology and to identify the next steps needed to develop the industry while protecting workers, the public, and the environment.

The nanotechnology workshop was a huge success, based on the evaluation forms. There were 125 participants from academia (researchers and environmental health and safety officers),

industry, environmental activists, insurers, attorneys, MA, NY, and NH state regulators and representatives from the US Environmental Protection Agency (EPA) Regions 1 and 2. Some of the general themes from the Workshop's Next Steps Session included support for continuing the day's dialog, to find ways to improve the involvement of industry in future interactive discussions, to identify and work to fill data gaps identified in the breakout sessions, and to enhance nanotechnology education and information exchange. More specific action items from the workshop are summarized in the descriptions of the breakout sessions and the workshop's next steps session.

Workshop Summary

Welcoming Address

Richard Bizzozero, Acting Director of OTA, State Senator Pam Resor, Philip Griffiths, Undersecretary for Energy and Environmental Affairs, and MassDEP Commissioner Laurie Burt provided welcoming addresses.

These speakers highlighted the fact that nanotechnology is an emerging technology that holds great promise for the future and can provide many benefits to society. There are exciting applications ahead, including many in the energy and environmental area such as making solar power more affordable, treating water to reduce contaminants and producing greener and safer products. Nanotechnology is vital to the economic future of Massachusetts, and State Officials encourage the growth of Massachusetts' nanotechnology companies and research endeavors. The goal is to promote innovation in this and related fields while preventing harm.

This meeting was intended to build a bridge to the future. Massachusetts previously built a strong partnership with the Biotechnology sector and similarly seeks a positive collaboration with the nanotechnology industry and research centers. We need to begin a public, transparent dialog, to learn from each other and to focus our efforts where necessary to ensure that the technology develops safely in Massachusetts. If it turns out that there are negative consequences of nanomaterials and/or nanoproducts in the environment or on human health, it will hinder advancing the technology. At this time, there are no plans for changing current regulations, or making new ones.

The Science of Nanotechnology

Dr. Andrew Maynard, Chief Scientist at the Woodrow Wilson International Center for Scholars project on Emerging Nanotechnologies focused on the 3 'R's – Risk, Response and Regulation. Dr. Maynard's presentation (www.mass.gov/envir/ota/events/ota_past_events.htm) covered the challenges of assessing the risk of nanomaterials, including the possible need to develop non-conventional approaches due to the novel properties of nanomaterials. The use of simple chemical properties of the constituent elements and compounds is not useful for nanomaterials, because the structures and size that give them novel useful properties also impact the way they behave in the environment and living systems. To demonstrate this, he showed images of various structures of nanoscale zinc oxide with many different shapes and likely many different properties. He also stated that biological activities occur on the nanoscale and so might be influenced by nanomaterials. To identify which nanomaterials are more likely to produce risks, one should consider the potential or likelihood for exposure. Information is needed on how these materials behave: as single particles, as agglomerates or suspensions, in formulations, and in products that may release nanoscale materials during production or use. Dr. Maynard also pointed

out that both end of life (disposal) fate and product misuse are factors that need to be considered in risk assessments.

Current Industry Perspective

Aatish Salvi, Vice President, Nanobusiness Alliance, the United States association for the nanotechnology industry, provided an overview of industry's perspective (www.mass.gov/envir/ota/events/ota_past_events.htm). Mr. Salvi pointed out that businesses using nanotechnology are extremely diverse in their uses of that technology and are from a wide range of industries. He also pointed out that nanomaterials themselves are extremely diverse in their properties, as diverse as "materials" in general, and cautioned against thinking of all nanomaterials as one single, monolithic class. He further cautioned that any "one size fits all" policy about nanomaterials or nanotechnology would likely not work. He also pointed out that we have been exposed to nanomaterials for thousands of years and that our ambient air contains many types of nanoparticles from cooking fumes, combustion, forest fires, dye and ink production, sea salt etc. Unlike the nanoparticles coming out of the tailpipe of a car or from road construction, he mentioned that the advantage of nanotechnology was that the nanomaterials being produced by businesses are "engineered" which means that we are able to control their properties and make them safer. Following from this, he posited that there is no reason to believe that engineered nanoparticles are likely to be any more or less hazardous than those we encounter every day, that engineered nanoparticles are less likely to be released into the environment and that we have existing knowledge from working with ultrafine particles and soot that is being applied by nanotech companies to ensure safety. He stated that any discussion of the potential hazards of engineered nanomaterials must be presented in the context of the hazards of nanoparticles to which we are already exposed through urban air and other sources. He pointed out that the uncertainties and concerns surrounding nanomaterials, such as the lack of fate and transport data, also apply to most other materials and chemicals which are more widely used by consumers today. In keeping with this he stated that nanomaterial developers and users should be treated the same as other developers of materials and chemicals and that regulations should not discriminate against them unduly. Mr. Salvi referenced the work that US EPA is doing on nanotechnology, including its soon to be launched EPA Nanoscale Materials Stewardship Program and recommended that Massachusetts' agencies track US EPA's work, and pass along such information to Massachusetts' nanotechnology companies, along with information on Best Management Practices (BMPs), while respecting the need for that confidential business information. He suggested that Massachusetts' agencies determine how nanomaterials relate to ultrafine particles and how our knowledge of dealing with ultrafines can apply to nanomaterials.

Policy Overview

The presentation by Martin Spitzer, Ph.D. and Former Professional Staff, House Committee on Science focused on the widening gap between the growth curve for nanotechnology products and the growth curve for health and safety knowledge, pointing out that the gap is now wide and will widen even further in at least the near future. He described the important role that nanotechnology, may have scientifically and economically, in the near future. Dr. Spitzer discussed scenarios where sufficient information on protecting human health and the environment may not exist, and how this could setback the nanotechnology industry's growth. He talked about the need for governance frameworks, and gave as an example the cosmetics industry, where a large number of nanotechnology products are already being sold to consumers, while the FDA doesn't have the scientific knowledge and tools, nor the regulatory authority to assure people the safety of these products or that the products work as advertised. Such scenarios

could threaten commercialization of nanotechnology and its path to success. Dr. Spitzer recommended the development of a systematic way to evaluate risk. Short and long-term research strategies must be developed and implemented to support this approach.

Systematic Approaches to Risk Assessment

Jo Anne Shatkin, Ph.D. Managing Director of the Conservation Law Foundation Ventures (CLF Ventures) presented information on systematic approaches to risk assessment (www.mass.gov/envir/ota/events/ota_past_events.htm). Dr. Shatkin focused on the importance of being proactive in reducing risks from nanotechnology and provided an overview of a risk assessment approach that takes into account the entire lifecycle of a product. This adaptive approach may be used to address environmental health and safety (EHS) risks, provide opportunities to engineer out hazards, and allow for the promotion of environmentally sustainable technologies. Understanding of the risk of nanotechnology products provides a competitive edge to the development of safe nano products.

Best Management Practices for Risk Management – The National Lab BMPs

Steve Hoey, Environmental Health and Safety Manager for the Center for Functional Nanomaterials, Brookhaven National Laboratory, explained that the Department of Energy (DOE) has funded five Nanoscale Science Centers of which Brookhaven is one. Research and development is conducted using small quantities of nanomaterials (i.e., one gram or less). This presentation (www.mass.gov/envir/ota/events/ota_past_events.htm) covered DOE's policies, procedures and requirements for work with nanomaterials, and research and development on engineering controls, worker safety, managing waste and transportation requirements. The speaker emphasized the importance of good risk communication, not only with direct workers, but also with auxiliary staff (e.g., janitors) and the public. What is perceived about the speaker's operation will influence the reputation of the safety handling of nanomaterials at other DOE facilities. Brookhaven has adopted a precautionary approach when working with nanomaterials, which presumes nanomaterials are treated as toxic until shown to be otherwise, and they start with good engineering, work flow and hygiene practices no matter what they're working with.

Panel and Open Discussion on Risk Assessment Frameworks and BMPs: Scope, Cost, Practicality, Stages, and Resources for Implementation

The panel members included: Igor Linkov, Ph.D. Research Scientist, US Army Engineer Research and Development Center; Michael Ellenbecker, Ph.D., Director, Toxics Use Reduction Institute; Kyle Cahill, Corporate Partnerships Program Manager, Environmental Defense; and Matthew Hull, Founder and President of NanoSafe, Inc. Each panel member provided opening statements about work that they were doing and protocols being followed (www.mass.gov/envir/ota/events/ota_past_events.htm) . Dr. Ellenbecker discussed the document *Interim Best Practices for Working with Nanoparticles* that was prepared by the Center for High-Rate Nanomanufacturing, located at the University of Massachusetts, Lowell. Dr. Linkov discussed multi-criteria decision analysis and environmental risk assessment. Kyle Cahill noted that Environmental Defense and Dupont have developed a risk assessment framework, and focused on the safe development of nanotechnology and the benefits of green initiatives www.nanoriskframework.org. Matthew Hull discussed the concept for the Nanosafe framework, which he developed. The framework provides a practical and integrated approach for proactively

addressing nanotechnology EHS issues in nanotechnology facilities. In the open discussion, attendees voiced supports that all of the EHS protection documents that exist or are being prepared should be brought together to better address nano risks. There was discussion of specific practices, such as the use of HEPA filters and information that may be available showing how they worked for nanomaterials. There was an acknowledgement that as new information develops, practices will evolve over time and that laboratories need to be flexible to incorporate new EHS changes. There was also a discussion of the need for research funds and possible funding sources.

Risk Communication As A Hurdle to Commercialization

The presentation by Michael Holman, Ph.D., Senior Analyst, Lux Research (www.mass.gov/envir/ota/events/ota_past_events.htm) described nanotech commercialization through a nanotechnology value chain – comprising nanomaterials, nano-intermediates and nano-enabled products – rather than a single "nanotech industry." With respect to nanotech environmental, health, and safety (EHS) risks, he described 3 aspects of EHS issues that need to be addressed: real risks, perceptual risk, and the regulatory environment. In his experience reviewing over 200 papers on EHS issues related to nanomaterials, most dealt with the hazard of the material versus the potential for exposure. He also noted that surveys indicate that consumers' knowledge of nanotechnology is low but their optimism about the benefits of nanotechnology is high. As a result, the perception of risks has not been solidified and can be influenced by what happens now. In terms of regulation, he mentioned US EPA is in the information-gathering mode.

Breakout Sessions

Workplace Safety – Moderator Dr. Charles Geraci, Nanotechnology Research Center and Chief, Document Development Branch, NIOSH.
(www.mass.gov/envir/ota/events/ota_past_events.htm)

This session acknowledged the fact that nanotechnology applications are rapidly rising and will eventually be used in everything, thereby changing things, as we currently know them. This expanding and evolving technology has highly diverse applications, and as a result, managing nanotechnology will be a big challenge.

Exposures to free nanoparticles will likely be greatest during their production and when they are being used in the production of the products that they are designed to enhance. Exposures during research activities are likely to be much lower.

Nanoscale particles have an extremely long settling time and can remain airborne for years, unlike much larger particles.

Monitoring methods use a variety of techniques and processes. Determining the overall mass concentration (e.g., milligrams of contaminant per cubic meter of air), a traditional industrial hygiene sampling metric, is not considered appropriate due to the extremely low mass of nanoparticles, and the belief that mass concentration may not be the appropriate predictor of risk. Direct reading instruments can provide information on the number of particles present and can identify the size distribution of particles. Area monitoring is relatively easy whereas personal monitoring is more difficult. Monitoring instruments are for the most part very expensive.

Monitoring protocols must also consider interference from existing nanoparticles (generated by mobile and combustion sources). Determining background levels is necessary to evaluate the potential exposure resulting from a given nano-manufacturing process.

Little is known about the degree of hazard from engineered nanoparticles, although there is some evidence of hazard from laboratory studies in animals, including impacts of nanoparticles at the cellular level and on the brain and respiratory system.

Facility Discharges and Emissions: How do you manage something that is hard to measure? Ed Kunce, Deputy Commissioner for Operations, MassDEP

This session tried to identify ways of managing discharges of nanoparticles to the environment over the course of their lifecycle. The group recognized that measurement tools are not readily available, although government and industries should avail themselves of instrumentation used in academic institutions like the University of Massachusetts, Lowell and that government and industry might work together to develop testing techniques.

Fate and transport issues were identified as key. Among those discussed was whether these particles have a propensity to agglomerate; when does agglomeration occur; and when and in what form are these particles toxic. Understanding the characteristics of nanoparticles would help environmental and health agencies evaluate the risk of the various discharge and exposure pathways, and would help prioritize efforts to develop measurement and health metrics. In addition, this could also factor into Best Management Practices, e.g., pre-treat discharges to allow for aggregation if the agglomerated nanoparticles are less harmful and/or more readily treated or captured.

For discharges to surface waters and wastewater treatment facilities, standard bioassays may help in identifying potential human health and /or aquatic toxicity issues. Ideally, a baseline study should be conducted before and after the discharges of nanomaterials. The affect of nanoparticles on microbial matter at wastewater treatment plants is an unknown.

Guidance on waste disposal would be helpful to have especially in order to identify what disposal option is preferable. Some participants thought that from an environmental perspective discharges to ambient air and emissions from incinerators would represent the pathway of greatest concern and priority, while disposal in landfills would be a lower concern and priority. This is based upon the assumption that nanoparticles in water or solid wastes would represent less of an exposure concern than particles in the air.

In recognition that testing procedures and health-based standards will take time to evolve, many thought that MassDEP should focus on identifying and serving as a clearinghouse on Best Management Practices (BMPs) that build upon Environmental Health and Safety practices, what the industry here and in Europe is doing, and academic research. As an example, one BMP may be to ensure that any air discharges from the laboratory or work space (hoods, vents) into areas proximate to home or schools are passed through an appropriate HEPA filter. The BMPs could address worker safety issues, environmental releases, best measurement techniques, pollution prevention (P2) opportunities, and waste management and disposal strategies.

The participants identified many information gaps beyond measurement techniques, fate and transport, and risk issues relative to exposure and toxicity of nanoparticles. Further information is desired on how nanotechnology is being managed internationally and in other states, which companies and organizations are part of the Massachusetts nanotechnology universe, and what

information should be provided to intermediate users of materials with nanoparticles and to the ultimate end-users of products with nanoparticle components. The issue of how best to communicate with nanopractioners as well as the downstream users (e.g., through product seals) was also raised. There was general agreement that education and outreach were important, especially at this early stage. Education needs to be directed toward government (state and local), the public at large, the nanotech industry, insurers (for liability issues), and venture capitalists. The environmental community also needs to be engaged, perhaps through advisory committees either on the state or regional level.

There was consensus that we are at the information gathering stage, and that although some regulatory options ranging from registrations to Environmental Results Program (ERP) certifications were identified by participants, these are premature. A better understanding of nanoparticles and products and their environmental and public health impacts, and the requirements of the nanotechnology industry are needed.

In summary, the workgroup discussed many possible follow-up activities and strategies that generally fall into the broad categories below:

- Development of testing techniques
- Application of bioassays to measure aquatic toxicity of nanomaterials
- Development of Best Management Practices and a Clearinghouse
- Education and outreach
- Environmental fate and transport research.

Product Safety and Disposition: Moderated by Seth Coe-Sullivan, Founder and Chief Technology Officer, QD Vision

There were approximately 16 participants in this breakout session: several regulators from New York, New Hampshire, EPA and Massachusetts, consultants, an insurance company representative, environmental activists and academia. This session started with a few examples: nanoparticles in fabric for clothing, washing machines equipped with time-released silver nanoparticles for antimicrobial properties, and nano-impregnated plastics. The session tried to focus on what the right questions are that need to be addressed in order to judge product safety and proper disposal. Similar questions could be asked for other nanomaterials or nanoproducts. The questions identified include the following:

- What happens when silver is released during the wash cycle? Does it stay on the clothing or partition to the wash water? What is the potential for human exposure? Do the silver nanoparticles remain in the wastewater and pass through the treatment plant causing downstream exposures, or do they concentrate in the sludge? If this occurs, would the silver nanoparticles eventually be a part of fertilizer sold for use in farming?
- Wastewater treatment plants test for metals. Will current monitoring and analytical methods distinguish silver nanoparticles from natural silver? Have the properties remained in the original form (silver nanoparticle antimicrobials) or changed? If changed, how?
- What happens to the bacteria when the silver nanoparticle antimicrobials from the washer are released into the waste stream? Will the silver nanoparticles alter the ecological system?
- Can silver nanoparticles (due to their size) travel to unexpected places?

Other related questions:

- For clothing, how long do nanoparticles remain in the fabric? For silver impregnated socks, does the silver leach out during the wash cycle? If all the silver nanoparticle additives lead to cleaner clothing, will people wash clothing less frequently? Will this reduction in water consumption be a potential benefit in places where water is scarce?

The discussion shifted to nanomaterials in plastic.

- Do the nanoparticles leach out of the plastic?
- Will the presence of nanoparticles alter the recycle-ability of plastics and alter the use and durability of the plastic? Are there worker risks?
- Can this plastic be destroyed or incinerated safely?
- Some plastics have other potentially harmful additives and properties (e.g. endocrine blockers in water bottles). What is the comparative toxicity?
- Is it possible to coat nanoparticles so that when they get into the environment, they are not bioavailable? Once nanoparticles get away from us, what does this mean for society?

Green science is one solution but it is expensive. Should we create incentives to bring about change? In Massachusetts currently, if you are a green product manufacturer, you get some sort of preference with the state when it comes to procurement choices at the state level.

Next Steps/recommendations:

1. The group unanimously thought that government funding was important. Funds for green design will save money in the long run especially on the R&D scale. Venture capitalists can partner with the green designers but should not be the "drivers" of the technology.
2. Because the insurance industry will pay for mistakes made, we must do our homework.
3. Nanomaterial products must meet government regulatory standards. What should these standards be or be based on?
4. Need to look at acute versus chronic risks to human health and the environment.
5. What is the ethical liability?
6. Education is needed, and encouraging incentives for green technology, shift the paradigm to "cradle to cradle," but who is responsible for lifecycle thinking?
7. What role is regulation? Some businesses might see "good" regulations as helpful. One option is to use an adaptive approach, develop a definition of nanotechnology and start with Dupont's recommendation. Is there a model regulation out there from industry and government such as Underwriter's Lab or International Standards Organization (ISO)? It could be a useful tool.

Next Steps and Concluding Remarks: Diane Mundt, Ph.D., Senior Manager, ENVIRON

A recommendation was made that the workshop participants continue to work together and make progress on many of the good ideas raised at the workshop breakout sessions. These include:

- Developing a government clearinghouse for information sharing. InterNano at the University of Massachusetts Amherst (beta.internano.org) provides community access to information on nanomanufacturing, as well as resources, such as reviews health and safety issues. InterNano could be a location for such clearinghouse information.
- Holding more meetings, workshops or seminars like today's workshop on selected topics. These forums would be designed to include input from industry.
- The National Science and Technical Institute (NSTI) will be meeting in Boston in 2008. This represents a learning opportunity and a chance to get Massachusetts state government on the agenda. Participants would like the continuing participation of

public health representatives. Other opportunities include educational sessions held by the national and local sections of the Society for Risk Analysis as well as Universities in the state with Nanotechnology centers.

- Continue with outreach to businesses and the public.
- Develop information on measurement methods and green-nano initiatives.
- Compile existing documents on monitoring, BMPs, and EHS protocols.
- Utilize, as feasible, the University of Massachusetts (Lowell) monitoring instrumentation to collect data on ambient levels in research and industrial facilities. Additionally, free monitoring is available from the National Institute of Occupational Safety and Health (NIOSH), upon request. NIOSH also has considerable information on safe handling of nanomaterials on their website: http://www.cdc.gov/niosh/topics/nanotech/safenano/
- Improve communication of research information to business, including EHS information. Products with EHS information may succeed in the marketplace to a greater extent than those without EHS information.
- Create a workgroup on needed research for green-nano development.
- Create a workgroup on needed research for life-cycle safety.
- Consider ways to encourage companies to participate in registries of "who is working with what materials, when and where" to both facility future research, as well as a mechanism to quickly provide feedback of new health and safety information
- Create a workgroup focused on improving communication between EHS personnel, scientists and engineers, and business/financial personnel within companies to facilitate discussion of potential nanoparticle risks and risk mitigation.
- Involve environmental experts and advocates in the public dialogue.

Continue to consider incentives, assistance, and appropriate protections for safe nanotechnology development.

Appendix A

The Commonwealth of Massachusetts

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November 15, 2007

To the Nanopractitioner:

We thank you for attending "The Big Picture: Safe Development of Nanotechnology". We are co-sponsoring this workshop because we think it is important to support the safe development of nanotechnology in Massachusetts. We feel strongly that engineering at the nanoscale holds tremendous promise for the future of our economy. Nanoscale technologies have the potential for new products and new product quality, some of it of great importance to Massachusetts' energy and environmental agenda.

This is an important opportunity for business and government to come together to share ideas that will support this emerging industry, learn from best practices, and allow the technology to be developed safely. It seems clear to us that uncertainties about possible new health and safety issues related to the dispersion of nanoparticles, if unaddressed, could pose challenges to the economic development we all want. We think it makes sense for us to learn about these matters, and to discuss the optimal response to these uncertainties with you, so that such challenges will not arise. We very much appreciate that you are here.

We encourage you to speak up, today, and make good use of the opportunity to ask questions, express your own views, and share insights and information. Please think about priorities and common needs, and possible future collaboration. We look forward to continuing to work with you and others in the industry to structure the most efficient and reasonable policies and programs for the safe and strong development of nanotechnology in the Commonwealth.

Sincerely,

Phil Griffiths, Undersecretary for Environment
Executive Office of Energy and Environmental Affairs

Laurie Burt, Commissioner
Massachusetts Department of Environmental Protection

John Auerbach, Commissioner
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Laura M. Marlin, Commissioner
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Appendix B

Interagency Nanotechnology Committee Members

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Appendix C

Speaker Biographies

The Big Picture: Safe Development of Nanotech Conference
November 15, 2007
Marlborough, Massachusetts

Richard Bizzozero
Acting Director, Office of Technical Assistance and Technology (OTA)

Rich Bizzozero has worked for OTA and the state's Toxic Use Reduction Act (TURA) program for more than 15 years, providing pollution prevention technical assistance to manufacturers across the state in a number of different industries. Rich has played key roles in several TURA initiatives and has worked collaboratively on many projects with other state and federal agencies. He has developed and lead numerous trainings on regulatory compliance and pollution prevention for industry as well as state and federal personnel. Rich earned a bachelor's degree in chemistry from the University of Vermont and a master's degree in plant and soil sciences from the University of Massachusetts.

Philip Griffiths
Undersecretary for Environmental Affairs, Executive Office of Energy and Environmental Affairs

Philip Griffiths currently serves as the Undersecretary for Environment in the Executive Office of Energy and Environmental Affairs for the Commonwealth of Massachusetts. As Undersecretary, he ensures that the policies and strategic priorities of the Governor and the Secretary of Energy and Environmental Affairs are implemented through the operations of the Department of Environmental Protection, Department of Conservation and Recreation, Department of Fish and Game, Department of Agricultural Resources, the Massachusetts Environmental Police and the Office of Technical Assistance.

Prior to his appointment as the Undersecretary, Phil served as Chief of Staff for the Executive Office of Environmental Affairs, and held several senior management positions during a ten-year career at the Department of Environmental Protection including Chief of Staff, Assistant Commissioner for Strategic Policy and Technology, and Director of the Geographic Information Systems (GIS) Program. Phil has also served as a website project manager for a variety of high-tech clients and was Special Assistant to the Secretary for Resources for the State of California.

Born in England, Phil grew up in Southern California and now resides in Watertown, Massachusetts with his wife, Maura Smith. He has a B.A. in History from Tufts University and a Masters in City and Regional Planning from the University of California at Berkeley.

Laurie Burt
Commissioner, Massachusetts Department of Environmental Protection

Governor Deval L. Patrick appointed Laurie Burt Commissioner of the Massachusetts Department of Environmental Protection (MassDEP). Ms. Burt started her new post in September 2007.

Laurie Burt was formerly a partner at the law firm Foley Hoag, LLP of Boston and Washington, D.C., where she started the firm's Environmental Practice Group and was the first woman to serve on its elected Executive Committee. Ms. Burt focused her practice on environmental litigation, compliance counseling, and land use, especially "Brownfields" redevelopment of contaminated sites in New England's urban areas and throughout the country. She previously served as a Massachusetts Assistant Attorney General in environmental enforcement before joining Foley Hoag. She is recognized in Best Lawyers in America for her work in Environmental Law.

Most recently, Ms. Burt was Vice President of the Boston Bar Association. She was also co-chair of the Appalachian Mountain Club's Board of Advisors and served as President of the AMC Board of Directors from 2000-2004. Her work with a number of local and national non-profit environmental and business groups has focused on issues such as national and regional climate change legislation.

Rick Reibstein
Senior Environmental Analyst, OTA

Rick Reibstein has worked at OTA since before its inception in 1990. He worked with the first technical assistance projects on toxics use reduction in the 1980's that helped convince the legislature to establish the ongoing technical assistance program we know today as OTA. He took some time off from OTA to work at EPA and DEP as an enforcement attorney, and he teaches environmental law and policy at BU and Clark Universities.

Morgan Mihok
Environmental Chemist and Nanotechnology Sector Lead, OTA

Morgan Mihok is an Environmental Analyst for OTA who specializes in providing pollution prevention and compliance assistance to Massachusetts companies in the textile, paper, nanotechnology, and biotechnology industries. She is currently heading OTA's work on nanotechnology. Morgan's laboratory research projects have included work in alternative fuel sources and chemical lithography. Prior to joining OTA, she worked in environmental consulting, focusing on chemical emissions and groundwater contamination. Morgan has a master's degree in Chemistry from Columbia University and a bachelor's degree in Chemistry from Penn State University.

F. Mark Modzelewski
Vice President of Strategic Opportunities, NanoDynamics

F. Mark Modzelewski the founder of Bang Ventures, an investment firm based in New York with offices in Cambridge, MA.

Mark is a seasoned technology entrepreneur, executive, investor and visionary. He Co-founded New Europe Ventures, a Polish-based Venture Capital firm, as well as the Benet Group, Leonardo BioSystems, Lux Research, and the NanoBusiness Alliance. He has served as a senior executive at NanoDynamics (and continues to advise the company), Opion, GolinHarris and NRW. In addition, he has consulted for companies ranging from NanoSys to Engelhard to Mastercard to Yahoo to eSpeed to Pixar to DaimlerChrysler.

Mark is a member of the Nanotechnology Technical Advisory Group to the President Council of Advisers on Science and Technology (PCAST). He is among the most well known figures in technology and was recognized by Forbes as a "powerbroker" and has been featured in Time,

Newsweek, US News, ABC, BBC, NY Times, Business Week, Fortune, Wall Street Journal, among others. Mark also appeared regularly as CNBC technology commentator and on occasion as a co-host of SquawkBox.

Before entering the private sector, Mark was an appointee in the Clinton Administration developing policy, legal and communication strategy efforts on issues ranging from Y2k preparedness, US mortgage and banking systems, the online transformation and integration of HUD and FHA programs, digital divide efforts, biotech and organic food standards, and regional economic development programs

He is a graduate of the U. Denver College of Law and Boston U.

Andrew Maynard, Ph. D.
Chief Scientist, Woodrow Wilson Institute

Dr Andrew Maynard is the Chief Science Advisor to the Project on Emerging Nanotechnologies—an initiative dedicated to helping business, government and the public anticipate and manage possible health and environmental implications of nanotechnology. His interest in nanomaterials started in the 1980's, while researching nanoscale atmospheric particles at the University of Cambridge in the UK. Through his work with the UK Health and Safety Executive, the US National Institute of Occupational Safety and Health and the US National Nanotechnology Initiative, he has led current science-based efforts to understand and manage the potential risks of nanotechnology. Dr. Maynard is considered one of the foremost international experts on addressing possible nanotechnology risks and developing safe nanotechnologies. As well as publishing extensively in the scientific literature, Dr Maynard is a well-known international speaker on nanotechnology, and frequently appears in print and on radio and television.

Aatish Salvi
Vice President, Nanobusiness Alliance

Mr. Salvi currently serves as the Vice President of the NanoBusiness Alliance, the U.S. association for the nanotech industry. At the Alliance he is responsible for overseeing the day-to-day operations of the alliance, chairing the Environmental, Health & Safety council and helping develop policy positions to create a better environment for nanotech commercialization. Mr. Salvi has been invited to keynote at number of nanotechnology focused conferences and events and has been a guest lecturer for classes at the Kellogg School of Management, Brown University and University of Massachussets, Amherst.

Prior to joining the Alliance, Mr. Salvi was a serial entrepreneur. His first startup venture was with Turbine Entertainment Software where he helped raise over $30 million in capital, hired and managed a 100 person team and oversaw the production of multiple multi-year projects with Microsoft and Vivendi Universal. His second was Driveitaway, Inc which he joined as its Sr. V.P. of Operations, helped raise $20 million in funding and close a global partnership agreement with the largest fleet leasing company in the industry. His experience as an entrepreneur in the high-tech sector gives him a unique perspective on the commercialization of nanotechnology. Mr. Salvi graduated with honors with a degree in Computer Science and a focus in Biochemistry from Brown University.

Martin Spitzer, Ph. D.
Former Professional Staff, House Committee on Science

Marty Spitzer joined the H.J. Heinz Center for Science, Economics and the Environment in January 2007. As a Senior Fellow he is providing strategic advice on a variety of current environmental issues, including nanotechnology, environmental performance measurement and climate change. Marty is also the Director of Legislative Affairs for the Center for Clean Air Policy, where he is helping develop and promote creative and effective climate change policy.

Both the Heinz Center and the Center for Clean Air Policy are highly respected, non-profit organizations that develop and promote innovative solutions to environmental policy and climate change through collaborative dialogue among business, government and environmental organizations.
Marty brings to both organizations his passion for solving problems collaboratively, linking the worlds of law, science, and policy, and developing programs that tap business drivers for environmental protection and sustainable development.

Until December 2006, Marty served as Professional Staff for the Science Committee in the U.S. House of Representatives, chaired by the recently retired Congressman Sherwood (Sherry) Boehlert (R-NY). Having joined the committee in 2001, Marty was also the lead or key staff person a lead staff person on a wide array of environmental science and policy issues, including climate change, nanotechnology, chemical and risk policy, sustainable development, and regulatory innovation. He also oversaw Science and Technology programs at the U.S. Environmental Protection Agency.

From 1996 to 1999 Marty served as Executive Director of the President's Council on Sustainable Development at the White House. Among his accomplishments, he organized an extensive public process to develop the Council's seminal report, "Towards a Sustainable America," and organized the public-private partnership that held the "National Town Meeting for a Sustainable America" in Detroit Michigan and communities across the country. Between 1990 and 2001, Marty served in various senior staff capacities at the U.S Environmental Protection Agency where he advanced innovative environmental policies such as improvements in environmental accounting in the private sector, recognition of leading companies through EPA's Performance Track program, and incorporation of pollution prevention into agency rules, permits, enforcement and research programs.

Marty earned his J.D. and Ph.D. in Policy & Management from the State University of New York at Buffalo. He earned a B.A. in Economics and History from Binghamton University.

Jo Anne Shatkin, Ph.D.
Managing Director, CLF Ventures

Jo Anne Shatkin, Ph.D., is Managing Director of CLF Ventures, a non-profit affiliate of the Conservation Law Foundation, New England's most influential environmental advocacy organization. CLF Ventures works at the intersection of business, stakeholder, and environmental issues to optimize environmental and economic performance, from project launch and business operation to responsible closure of surplus assets. Dr. Shatkin is a recognized expert in strategic environmental initiatives, human health risk assessment, technical communications, and environmental aspects of nanotechnology. She leads and provides expertise on projects and manages the day to day operations of CLF Ventures.

Dr. Shatkin has 19 years of experience in research and application of quantitative human health risk assessment for site redevelopment and remediation; drinking water and air quality, and environmental evaluations of emerging contaminants. Her specialty is the application and communication of innovative science-informed analysis to address complex emerging issues affecting businesses and communities.

She received her Ph.D. in Environmental Science and Policy in 1994 and her MA in Risk Management and Technology Assessment, both from Clark University, Worcester, Massachusetts and possesses a Bachelor of Science degree from Worcester Polytechnic University in Biology and Biotechnology. She is a research fellow of the George Perkins Marsh Institute at Clark University.

Dr Shatkin has been an active member of the Society for Risk Analysis since 1989, and recently founded the Emerging Nanoscale Materials Specialty Group of the Society for Risk Analysis, with 80 current members. Her forthcoming book, Nanotechnology: Health and Environmental Risks, is due to be published in early 2008 by Taylor and Francis Press. Jo Anne is a member of the Expert Nanotechnology Panel of the Council of Canadian Academies. She is past president of the New England SRA chapter; past Board Member and President of the Regional Environmental Council, past member of the Massachusetts Water Resource Authority Expert Risk Panel, and committee member of the Massachusetts Department of Environmental Protection Science Advisory Panel for Solid Waste.

Steve Hoey
EHS Manager, Center for Functional Nanomaterials, Brookhaven National Laboratory

Mr. Hoey is the Operations Manager for the Center for Functional Nanomaterials located at Brookhaven National Laboratory in New York. Mr. Hoey has over 27 years of ESH experience in the aerospace, defense and DOE R&D arena. He is the chair of the DOE NSRC ESH Working Group

He holds a Bachelor of Science Degree from Illinois State University in Occupational Safety and Industrial Technology and a Masters of Science Degree from the State University of New York Stony Brook in Environmental and Hazardous Waste Management.

Igor Linkov, Ph.D.
Managing Scientist, Intertox

Dr. Linkov is a Research Scientist at the US Army Engineer Research and Development Center and Adjunct Professor of Engineering and Public Policy at Carnegie Mellon University. Dr. Linkov has managed ecological and human health risk assessments and risk management projects. Many of his projects have included application of the state-of-the-science modeling and software tools (e.g., probabilistic and Bayesian Monte-Carlo, spatially-explicit modeling) to highly complex sites (e.g., Hudson River, Dow Midland, Natick Soldier Systems Command, Elizabeth Mine, etc.) and projects (e.g., insuring emerging risks, risk-based prioritization of remedial projects, developing performance metrics for oil spill response). He was instrumental in developing an integrated risk assessment and multi-criteria decision analysis framework that is now being widely applied by the US Army Corps of Engineers, including restoration planning for coastal Louisiana and Mississippi affected by the hurricane Katrina where a multi-billion dollar budget is at stake. Dr. Linkov is currently involved in several projects that examine factors responsible for nanotoxicology and nanomaterials risks. These projects investigate fate and transport of nanoparticles in the environment, ecotoxicology, assessment of nano-enabled product life cycle and risks. Dr. Linkov have organized three continuing education workshops in the area of nanomaterials health and safety and is organizing an international conference on "Nanomaterials:

Environmental Risks and Benefits" (Portugal, April 2008). Dr. Linkov was part of international and national panels on nanotechnology, including EPA Nanotechnology White Paper Peer Review Panel (2006) and Nanotechnology Grants Review Panel (2007), Environment Canada Nanotechnology Expert Panel (2007) and the City of Cambridge Nanotechnology Ordinance Advisory Panel (2007-2008). He serves as a Scientific Advisor to the Toxic Use Reduction Institute, a position that requires nomination by the Governor of Massachusetts. He is the recipient of the prestigious Chauncey Starr Award for exceptional contribution to Risk Analysis. Dr. Linkov has a BS and MSc in Physics and Mathematics (Polytechnic Institute, Russia) and a Ph.D. in Environmental, Occupational and Radiation Health (University of Pittsburgh). He completed his post doctoral training in Biostatistics and Toxicology and Risk Assessment at Harvard University.

Michael Ellenbecker, Ph.D.
Director, Toxics Use Reduction Institute

Michael J. Ellenbecker is an expert in toxics use reduction and industrial hygiene. Dr. Ellenbecker has been affiliated with TURI from its inception and has been its Director for three years. He manages a staff of fifteen and has guided the Institute's research program since 1989. Dr. Ellenbecker is co-author of 'Ventilation for Control of the Work Environment', the standard textbook for the design of industrial exhaust systems. He is also a Professor in the Department of Work Environment at the UMass Lowell, teaching industrial hygiene and cleaner production. Harvard-educated, Dr. Ellenbecker holds Doctoral and Master degrees in Environmental Health Sciences and Industrial Hygiene and is a Certified Industrial Hygienist.

As Director of TURI, Dr. Ellenbecker is leading efforts to provide health and safety support to the University's NSF-funded Nanoscale Science and Engineering Center for High-Rate Nanomanufacturing (CHN). The CHN, located at UMass Lowell, Northeastern University, and the University of New Hampshire, is committed to developing nano-scale products and materials in a way that is environmentally-appropriate and safe for workers.

Kyle Cahill
Corporate Partnerships Program Manager, Environmental Defense

Kyle Cahill focuses on bringing Environmental Defense's corporate partnership innovations broadly into new companies and industries. He collaborates with business to leverage new and proven best practices that provide distinct business benefits and produce significant environmental results.

Kyle is currently focused on the safe development of nanotechnology and green fleet management strategies with Fortune 500 companies. In his work, he has also done significant research and analysis on the intangible benefits of green initiatives.
Kyle previously worked in the corporate communications & public affairs practice at Edelman, world's largest independent public relations firm. There he counseled major companies on thought leadership strategies, investor relations and crisis communications. Prior to Edelman, Kyle conducted marketing strategies for major companies including Procter & Gamble, Sony, IBM, United Airlines and Reuters among others.

He earned his M.B.A. in corporate social responsibility from the Isenberg School at the University of Massachusetts, Amherst where he studied the influence of personal values on financial decision-making. He earned his B.A. in English Literature from Amherst College.

Matthew Hull
Founder and President of NanoSafe, Inc.

Matthew Hull is Founder and President of NanoSafe?, Inc., a start-up company headquartered in Blacksburg, VA that focuses on providing services for the safe development, manufacturing, and application of emerging nanotechnologies. For the last four years, Matthew has served as Principal Investigator at Luna Innovations Incorporated (Blacksburg, VA), where his research focused on developing technologies and strategies to protect human and environmental health. In 2003, Matthew developed the concept for the NanoSafe? framework, which provides a practical and integrated approach for proactively addressing nanotechnology environmental health and safety issues in nanotechnology facilities (particularly small and medium-sized enterprises). Hull has led research programs exploring applications and implications of engineered nanomaterials in environmental systems for agencies such as the US Department of Defense (DOD), EPA, NASA, NOAA, and the UK Department of Environment Food and Rural Affairs (DEFRA).

Currently, Matthew is a National Science Foundation IGERT/EIGER fellow in the Department of Civil and Environmental Engineering at Virginia Tech (Blacksburg, VA). His research is focused on understanding the interactions of engineered nanomaterials with living systems and seeks to develop biosensors for monitoring engineered nanomaterials in environmental media such as water, soils, and sediments. Matthew has an M.S. in Biology from Virginia Tech and a B.S. in Environmental Science from Ferrum College (Ferrum, VA).

Michael Holman, Ph.D.
Senior Analyst, Lux Research

Michael Holman is a Senior Analyst at Lux Research. He works closely with clients in the chemicals, specialty materials, and scientific instrumentation fields to help them understand and take advantage of the impact of emerging technologies on their industries. He has authored Lux Research framework reports on nanotechnology environmental, health, and safety (EHS) issues, nanotechnology tools, and international nanotech competitiveness. Michael is also an editor of the weekly Lux Research
Nanomaterials Journal, and leads development of Lux Research's definitive reference study on nanotechnology, The Nanotech Report.

Michael is also deeply involved in nanotech environmental, health, and safety (EHS) issues, speaking regularly with academics, regulators, non-governmental organizations, and other experts to understand the health and safety exposure of nanomaterials and the approaches that clients can take to minimize risk. He has helped train the FDA on nanotechnology as a part of the agency's Grand Rounds program, and was invited to address policymakers from the U.S. and EU at the Perspectives on the Future of Science and Technology program. Michael is also a member of the President's Council of Advisors on Science and Technology (PCAST) Nanotechnology Technical Advisory Group (nTAG).

Michael holds a Ph.D. in Chemistry from Columbia University, where he was a part of Columbia's Nanoscale Science and Engineering Center and Center for Nanostructured Materials, and a B.A. in Chemistry and Philosophy from Rice University.

Charles Geraci, Ph. D.
Coordinator, Nanotechnology Research Center and Chief, Document Development Branch, NIOSH

Dr. Charles (Chuck) Geraci is overall Coordinator of the NIOSH Nanotechnology Research Center and manages a number of Nanotechnology projects in the Institute, including the development of workplace guidelines contained in "Approaches to Safe Nanotechnology". HE also manages the NIOSH nanotechnology field team that is conducting visits to nanomaterial producers and users to characterize exposures, evaluate controls, and develop best practices. Dr. Geraci is also Chief of the Document Development Branch where he manages projects dealing with the development of recommendations to address worker health and safety in new or emerging technologies. He has over 32 years of Industrial Hygiene practice experience that has included the federal government, consulting, and private industry, including 10 years at the Procter & Gamble Company where he was an Associate Director of HS&E. Dr. Geraci earned a B.S. in chemistry from the University of Cincinnati and a Ph.D. in chemistry from the Michigan State University. He is Board Certified in both the Comprehensive Practice and the Chemical Aspects of Industrial Hygiene and is a Fellow of the American Industrial Hygiene Association. His research interests include development of exposure monitoring methods, evaluating the effectiveness of training, developing effective methods for risk characterization and management, and assessing the hazards and risks of new technologies. In his spare minutes, Chuck enjoys hiking, backpacking, canoeing, fishing, and completing home improvement tasks assigned by his wife.

Ed Kunce
Deputy Commissioner for Operations, Massachusetts Department of Environmental Protection

As Deputy Commissioner for Operations and Programs at the Massachusetts Department of Environmental Protection, Edward Kunce oversees decision making and related operations for all permitting, assistance, compliance and enforcement activities in DEP's three major bureaus--Resource Protection, Waste Prevention and Waste Site Cleanup--and supervises the field activities of the agency's four regional offices in Lakeville, Springfield, Wilmington and Worcester.

Kunce served previously as Director of DEP's Northeast/Metro Boston Regional Office, and prior to that worked in the private sector as an environmental consultant and in production management. He also served four years as a U.S. Army Engineer Officer.

Kunce has a Bachelor's degree from the University of Rhode Island, and has Master's degrees from Harvard University and Boston University.

Seth Coe-Sullivan, Ph.D.
Founder and Chief Technology Officer, QD Vision

Seth Coe-Sullivan is co-founder and Chief Technology Officer of QD Vision. He received his Ph.D. in Electrical Engineering from the Massachusetts Institute of Technology in May 2005, and his thesis work on incorporating quantum dots into hybrid organic/inorganic LED structures is the technology basis of QD Vision. His work spans quantum dot materials, new fabrication techniques including thin film deposition equipment design, and device architectures for efficient QD-LED light emission. Seth has over 20 papers and patents pending in the fields of organic light emitting devices, quantum dot LEDs and nanotechnology fabrication. He was awarded Technology Review Magazine's TR35 Award in 2006, naming him one of the top 35 innovators under the age of 35. In 2007, BusinessWeek named him one of the top young entrepreneurs under the age of 30.

Seth graduated in the class of 1999 from Brown University with an Sc.B. in electrical engineering. He then spent a year as a Staff Engineer at the Boston based research company Foster-Miller,

Inc., in the Emerging Technology division of the Materials Technology Group, before departing for MIT. Seth is honored to sit on Brown University's Engineering Advisory Council.

Diane J. Mundt, Ph. D.
Senior Manager, ENVIRON

Dr. Diane J. Mundt is a Senior Manager for ENVIRON International Corporation with over 20 years of experience in the application of epidemiological methods in the areas of occupational and environmental health, specializing in research and policy applications. She currently leads a team of scientists working in Nanotechnology occupational and environmental health issues. She also has particular expertise in the systematic evaluation of health effects of chemical compounds and an extensive background in the critical review and interpretation of epidemiological studies. Dr. Mundt received her doctorate from the University of Massachusetts, Amherst, and her Master of Science degree from Harvard University, School of Public Health.

Appendix D

Selected Resources: Websites

National Nanotechnology Initiative
http://www.nano.gov/

Environmental Law Institute publications
http://www.elistore.org/topics_list.asp?topic=Nanotechnology

Center for High-Rate Nanomanufacturing
www.nano.neu.edu/

UMass Amherst's InterNano – Information clearinghouse for nanomanufacturing R&D
http://beta.internano.org/

Nanotechnology Law Report (published by Porter Wright Morris & Arthur LLP)
www.nanolawreport.com/

General information about particle technology
http://nanoparticles.org/

Nanotechnology Now reports
http://www.nanotech-now.com/Past-Reports.htm

Nanoparticle Information Library
http://www2a.cdc.gov/niosh-nil/index.asp

European Nanotechnology Gateway
www.nanoforum.org/

Small Times
http://www.smalltimes.com/

Woodrow Wilson Project on Emerging Nanotechnologies
http://www.nanotechproject.org/

International Council on Nanotechnology
http://icon.rice.edu/

Massachusetts Nanotechnology Initiative
http://www.mtpc.org/mni/

NanoVIP.com – Nanotechnology: Massachusetts, Companies and Institutions
http://www.nanovip.com/nanotechnology-companies/massachusetts

ASTM International Committee E56 on Nanotechnology
http://www.astm.org/cgi-bin/SoftCart.exe/COMMIT/COMMITTEE/E56.htm?E+mystore

University of Wisconsin-Madison Nanotechnology Risk Resources
http://www.nsec.wisc.edu/NanoRisks/NS--NanoRisks.php

Selected Resources: Documents

NIOSH Safe Practices document
http://www.cdc.gov/niosh/docs/2007-123/pdfs/2007-123.pdf

EPA White Paper
http://www.epa.gov/OSA/pdfs/nanotech/epa-nanotechnology-whitepaper-0207.pdf

Swiss Re (Insurance company) perspective :
http://www.swissre.com/resources/31598080455c7a3fb154bb80a45d76a0-Publ04_Nano_en.pdf

Solicitation for proposals to create a National Center for the Environmental Implications of Nanotechnology (National Science Foundation):
http://www.nsf.gov/pubs/2007/nsf07590/nsf07590.htm

"Risk Mitigation Strategies for Manufacturers of Nanomaterials" :
http://www.reedsmith.com/_db/_documents/FDLI_Risk_Mitigation_Strategies_Nanomaterials.pdf

"Nanotechnology and the Environment: Will Emerging Regulations Stifle the Promise?"
http://www.wilmerhale.com/files/Publication/5faad09c-3d37-46ba-ae2e-0fd0acd4a1fd/Presentation/PublicationAttachment/10d017e2-53a6-4192-a0b8-1f7c1da97d16/nano_enviro_paper.pdf

"Guidance for Handling and Use of Nanomaterials at the Workplace":
http://www.baua.de/nn_49456/en/Topics-from-A-to-Z/Hazardous-Substances/Nanotechnology/pdf/guidance.pdf

"Nanoparticles: Actual Knowledge About Occupational Health and Safety Risks and Prevention Measures": http://www.irsst.qc.ca/files/documents/PubIRSST/R-470.pdf

"Limits and Prospects of the 'Incremental Approach' and the European Legislation on the Management of Risks Related to Nanomaterials":
http://www.innovationsgesellschaft.ch/images/fremde_publikationen/Incremental%20Regulatory%20Approach%20-%20Reg%20%20Tox%20%20and%20Pharmacol%20.pdf

"Workplace Airborne Nanoparticle Exposure Measurement at University Research Centers", powerpoint presentation:
http://www.cshema.org/conf07/presentations/43_CSHEMA_Tsai_Hallock_07.pdf

"TSCA and Engineered Nanoscale Substances":
http://www.lawbc.com/other_pdfs/00010729.PDF

NanoEthics: The Ethical and Social Implications of Nanotechnology:
http://www.nanoethics.org/wiley.html

"The Potential Risks of Nanomaterials: A Review Carried Out for ECETOC":
http://www.particleandfibretoxicology.com/content/3/1/11

"Nanotechnology: Assessing the Risks" – Andrew Maynard

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B82X8-4JW1D36-N&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=fc6ab8cb46f968a2341531f4518d4570

"Nanotech Environmental, Health & Safety: Progress and Priorities" – Aatish Salvi
http://www.nanobusiness.org/ehspolicy.php

NANO Risk Framework: Executive Summary
http://www.environmentaldefense.org/documents/6497_Nano%20Risk%20Framework%20Exec%20Summary.pdf