Research Needs Related to the Environmental, Health, and Safety Aspects of Engineered Nanoscale Materials

The National Nanotechnology Coordination Office on behalf of the Nanoscale Science, Engineering, and Technology (NSET) Subcommittee of the Committee on Technology, National Science and Technology Council (NSTC)

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These comments are hereby jointly submitted in response to the NNI January 4, 2007 public meeting on “Research Needs Related to the Environmental, Health, and Safety Aspects of Engineered Nanoscale Materials” held by the Nanoscale Science, Engineering and Technology (NSET) Subcommittee of the Committee on Technology, National Science and Technology Council (NSTC), addressing environment, health and safety (EHS) research generally and the NNI September 2006 report *Environmental, Health, and Safety Research Needs for Engineered Nanoscale Materials* specifically.

The NNI EHS report is lacking in several serious respects. First and foremost, an express primary purpose of the report was to identify specific EHS research needs related to understanding and managing the potential risks of nanomaterials and thereby informing and guiding research programs. Yet the document fails *to actually prioritize* these EHS research needs[1] or to make any sort of cohesive research plan or strategy. Rather, the document reads more like a partial scientific review of known and unknown risks of nanomaterials and a laundry list of needed information and research.

At times the report points out gaps that seem to cry out to be made into urgent research priorities. For example, the report notes that there is currently no federal program surveillance of nanomaterial releases into the environment,[2] yet this is not made a research priority. Similarly, the report notes that there are no studies on the effectiveness of personal protective equipment for manufacturing workers;[3] yet again this is not a research priority. The NNI report notes that research on nanomaterials properties’

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[1]NNI, *Environmental, Health, and Safety Research Needs for Engineered Nanoscale Materials*, p.8.

[2]*Id.* at 40.

[3]*Id.* at 47.

effects on skin penetration has "just begun,"[4] yet many skin-applied personal care products containing these nanomaterials are already on the market en mass. Still, this is not a research priority. Finally, the report notes that the lifecycle impacts of nanomaterials are "generally unknown,"[5] yet again, not a priority. There are many more examples throughout the report.

Instead there are a copious amount of "might be's," and "possible research approaches" throughout the report. And there are no final conclusions or recommendations.

This approach is wholly inadequate as a risk research framework. <u>Risk research prioritization and a corresponding risk research plan or framework is a basic and necessary step in order to protect human health and the environment</u>.

While prioritization and a strategic research plan are promised in the future, that this document continues to lack these foundational necessities betrays--as the House Science committee chairman said at the September 26, 2006 Congressional hearing--a lack of the "sense of urgency [that] is required."[6] The undersigned urge the panel to remedy that overarching failing <u>as soon as possible</u>.

We hereby recommend three major areas of EHS research high priority: nanomaterial worker and workplace health and safety in manufacturing, research and development, and academic settings; public health and safety with regard to nanomaterial consumer products; and the environmental impacts from nanomaterials.

Worker and workplace health and safety risks

First, with regard to worker and workplace health and safety risks: Exposures are occurring and protection is required. More than 2 million people work in the development, production or use of nanomaterials. Thousands of tons of nanomaterials are already being produced each year. Studies clearly document the hazard potential of engineered nanomaterials and the need for immediate protective action. Current federal approaches

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[4] *Id.* at 26.

[5] *Id.* at 53.

6 Weiss, *Nanotechnology Risks Unknown; Insufficient Attention Paid to Potential Dangers, Report Says*, Wash. Post, A12, September 26, 2006.

do not effectively manage workplace risks arising from thousands of new materials developed each year. A new paradigm is essential for worker health protection. Worker exposures should not be allowed unless safety has been demonstrated by producers.

Public health risks can be managed and research can occur in tandem, if a precautionary protective approach for workers is adopted. Research into the nature, extent and appropriate metrics of worker exposures is necessary for the identification of protective actions that need to be implemented in the workplace utilizing prudent resource allocation. Initiating precautionary protective measures combined with research into their efficacy serves multiple needs. Primary preventive methods such as avoiding hazardous feedstock, substitution with safer nanomaterials, employing closed processes & the generation of hazardous materials can be effective measures in protecting worker health. Likewise, additional preventive methods, such as use of local exhaust ventilation and work practice/administrative controls should be priorities for implementation and research as to their effectiveness. While the use of personal protective equipment represents the least desirable and effective option for protecting workers in the hierarchy of exposure control approaches, research on the effectiveness of protective equipment is also necessary.

In research and development (R & D) situations, both the basic materials being used and the nanomaterials that are reasonably expected to be developed must be considered and appropriate safety steps taken. Therefore, research is needed to assess the "under development" risks and optimize the analysis and decision-making that must occur in this sector in order to protect workers. Because considerable R & D occurs in private and public sector laboratories and in academic situations, research is needed to determine how to establish effective training as well as what that training must accomplish in the diverse workplaces where nanomaterials are being developed, tested, modified, and used in training.

Protecting both professionals and students provides unique challenges that must be met through research into effective communications and protections. In the area of education, both the teachers and students must be protected, and given the current federal advocacy for introducing this scientific field to children (e.g., NAS programs), it is imperative that this research be done. This involves research into how the necessary health and safety measures can be effectively communicated to this audience, the level of efficacy, and related steps to insure adequate protection of children and adults.

Research should focus on the efficacy of these various protective strategies, including best practices and policies for protecting worker health and safety, and the identification of ongoing exposures, emphasizing the idea that conducting research in tandem with taking protective actions is necessary. If workers are already exposed to likely hazards from engineered nanomaterials, it is critically important to use precaution by providing the best available protective equipment and workplace designs to mitigate exposures and study how well they are working. Future research can be guided, to some extent, by what we learn about the efficacy of the current best options.

Sufficient knowledge about the hazards of nanomaterials exists to justify implementing protective measures in the workplace to control exposures. Our lack of comprehensive research on hazards and risks must not be used as an excuse for inaction for protecting workers. Instead, research should be used now to identify and support development of protective practices and identify the most precautionary & efficient policy options. Substantial research should focus on protective strategies that can be implemented in 2007 and the near term to insure the health of workers.

Surveillance to determine who is most exposed and under what specific circumstances, in manufacturing, R & D, and educational settings should occur rapidly so that appropriate steps can be quickly taken to minimize exposure, and so that studies can be initiated to determine if harm has already occurred.

Nanomaterial Consumer Products

Worker health and safety is connected to public health and safety. Consumer products composed of nanomaterials have arrived and represent the crest of a product wave spanning many technologies. Hundreds of nano-products are already widely available, and are particularly prevalent in the personal care product sector. Nanomaterial commercialization continues at lightening speed: according to Lux Research's 2006 Nanotechnology Report, more than $32 billion in nano-products were sold in 2005 – 2X the total of 2004. Wilson Center's Project on Emerging Nanotechnologies Consumer Product Database lists more than 380 self-identified nano-products now on U.S. market shelves.

Nowhere are nanomaterials reaching the public faster than in personal care products. They are the Wilson Center Product Datebase's largest single category (125 products). A May 2006 Friends of the Earth Report found 116 cosmetics, sunscreens, and personal care products containing nanomaterials commercially available. These nanomaterials are "free", not fixed in product matrix, used daily and directly on the skin, and may be inhaled and are often ingested.

The most immediate concern is likely in "free" nanomaterials, or those used in liquids, or creams like cosmetics or sunscreens. "Fixed" nanomaterials are immobilized in a solid matrix (for example, tennis rackets reinforced with carbon nanotubes). The nanoparticles in these personal care products are "free," meaning they are not fixed in a matrix but rather suspended in the liquid or cream. Free particles are more easily dispersed and more quickly spread around. Free particles are also a form more conducive to being absorbed by organisms. These types of particles make up the largest percentage of the known nanomaterial consumer product market.

Because of this broad and intrusive exposure, these nanomaterials should be a very high research priority, in conjunction with regulatory and oversight action from responsible agencies. More specifically with regard to research priorities, dermal exposures and skin penetration of these nanomaterials used in personal care products should be at the top of the list.

Environmental Impacts

Third, environmental impacts must be an EHS research priority. These nanomaterials now being manufactured, marketed and purchased are inevitably ending up in the natural environment. Nanomaterials represent a new class of manufactured non-biodegradable pollutants, with pathways during development, manufacturing, transport, use, and disposal, as well as planned intentional release of some nanomaterials. The current wave of nano-products now available on market shelves includes an inordinate number of sunscreens, cosmetics, and other personal care products. These nano-products will and have been entering the environment on a continual basis, as they are disposed of after use (e.g., residual sunscreen in containers), washed off in showers, or directly dispersed from human skin into oceans, rivers, lakes, ponds, community and private pools. Nanomaterials used electronics, fuel cells, tires, and other goods will be worn off over a period of use or leak out at some point in use or after product disposal. In addition, some nanomaterials are being used in disposable materials like filters and electronics and will reach the environment through landfills or other methods of disposal. Finally, some nanomaterials will be introduced deliberately into the natural environment for environmental remediation purposes. For example, studies have indicated that iron nanoparticles could be used to clean up contaminated soil by neutralizing contaminants like DDT and dioxin.

Existing studies indicate potential serious environmental impacts and point to urgent need for further study. Potential environmental hazards and research priorities include:

*Mobility: The ability to persist; reach places larger particles cannot; move with great speed through aquifers and soils; settle slower than larger particles.

*Transportation: Nanomaterials have a large and active surface for absorbing smaller contaminants. Due to the bonding and mobility, fertilizers or pesticides could "hitch a ride" over long distances.

*Reactivity: Because nanoparticles tend to be more reactive than larger particles, interactions with substances present in the soil could lead to new and possibly toxic compounds.

*Durability and Bioaccumulation. Even in fixed form, nanomaterials are also "highly durable" and will remain in nature long after the disposal of their host products.[7] The longevity of nanomaterials theoretically will create accumulation that could upset ecological balances, even if that particular nanomaterial is harmless to humans.

*Degradation products: Many environmental contaminants of concern are the breakdown products of toxic or non-toxic parent compounds. It is essential to determine what degradation (including recombination) products will result from interaction with air, soil, water, biological materials, and other materials, under plausible conditions of use, storage, and disposal, prior to materials being introduced to commerce.

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[7] Andrew Maynard, *Nanotechnology: A Research Strategy for Addressing Risk*, Woodrow Wilson Internat'l Ctr. for Scholars, Project on Emerging Nanotechnologies, at 12 (July 2006).

Finally, nanomaterial environmental releases create unique management challenges. Even simply detecting engineered nanomaterials in the environment is a new challenge created by their unique physical and chemical characteristics. The methods and protocols needed to detect and measure nanomaterials are just beginning to be developed. Once detected, to remove them from water or air requires new filtering techniques. New protocols and cost-effective technologies for detecting, measuring, monitoring, controlling and/or removing nanomaterials are required and must be an immediate research priority. For example, engineered nanoparticles of iron have been investigated as part of environmental remediation technology. Field tests have shown that the engineered nanoparticles remain active in soil and water for several weeks and that they can travel in groundwater as far as twenty meters. However, the impact that the high surface reactivity of engineered nanoparticles used for remediation might have on plants, animals, microorganisms and ecosystem processes is unknown, as testing to determine the safety of these nanoparticles to environmentally relevant species has not yet been done. The basis of many food chains depends on the soil flora and fauna, which could be seriously impacted by injected manufactured nanomaterials. As a consequence, the U.K. Royal Society has recommended that the release of free manufactured nanoparticles into the environment for remediation be prohibited until more research is completed.[8]

Unfortunately, the NNI report devotes only four pages[9] to these important issues, without setting any research priorities.

A case study of the urgent necessity of such research and action can be seen with silver nanoparticles, which are being used in numerous products for their anti-microbial properties, yet these same enhanced properties are harmful to microorganisms and ecosystems. Due to concerns over the environmental impacts of silver nanoparticles, in February 2006 several public utilities and their national umbrella organization (NACWA) requested EPA regulate certain of these "silver ion" consumer products as pesticides under FIFRA. EPA has now said it will act with regard to at least one such product, a washing machine, although it has taken no action as of yet. Moreover a universe of products containing (or purporting to contain) silver nanoparticles exist and are widely available, including food storage,

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8 The Royal Society and the Royal Academy of Engineering, *Nanoscience and nanotechnologies: Opportunities and uncertainties*, London, July 2004, p.80.
9 NNI, *Environmental, Health, and Safety Research Needs for Engineered Nanoscale Materials*, at 29-33.

refrigerator lining, shoe lining, air filters and fresheners, drywall, paint, medical coatings, and wide range of other products.

Finally, with regard to the release of nanomaterials into the environment, the UK Royal Society and Royal Academy of Engineering seminal 2004 Report, upon which the NNI counts as a reference in its report, concluded that

> "Until more is known about their environmental impact, we are keen that the release of nanoparticles and nanotubes in the environment be avoided as far as possible. Specifically we recommend as a precautionary measure that factories and research laboratories treat manufactured nanoparticles and nanotubes as hazardous, and seek to reduce or remove them from waste streams."[10]

Conclusions

A recent article in *Nature* by Dr. Maynard and 13 others addressed the nano-safety "grand challenges" that must be tackled in the near future, including:
develop air and water detection/tracking; develop methods to evaluate nano-toxicity; and
develop systems for evaluating and models for predicting health and environmental impacts over product lifecycle.[11] The undersigned urge the committee to consider adopting research priorities and a research plan rooted in this solid underpinning.

Finally, the FY07 NNI Budget: only $44 million of the NNI's $1.3 billion is slated to go towards EHS research, a paucity that hampers the ability of the federal agencies to carry out a preventive and thorough research strategy, assuming the NNI develops such a framework. The undersigned, as well as

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10 See The Royal Society and the Royal Academy of Engineering, *Nanoscience and nanotechnologies: Opportunities and uncertainties*, London, July 2004, p. 31, available at http://www.nanotec.org.uk/finalReport.htm.
11 Maynard *et al.*, *Safe Handling of Nanotechnology*, 444 NATURE 267-269, (November 16, 2006).

parties from all sectors, have called for this number to be substantially increased, to at least $100 million annually. Relevant members of the committee should push for that to occur as soon as possible.

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