

The Current State of Affairs: NanoHealth & NanoSafety

By Neil J. Silins

In general terms, nanotechnology includes engineered structures, devices and systems that have a length scale of 1-100 nanometers (1 nanometer = 10^{-9} meters). At this scale, materials begin to exhibit unique properties that affect physical, chemical and biological behavior. A position paper published by the Council of State and Territorial Epidemiologists (07-EH-02) notes that the size, surface area, reactivity and other characteristics of these substances place them into a category of materials, which behave differently than similar compounds of conventional size. These properties raise significant concern about their effects on biological and ecological or environmental systems. Recent research suggests that nano-sized materials can penetrate deep into the lungs, the brain, easily travel through the skin and cause oxidative damage. Studies on fish suggest that at least one form of nanoparticles can cause brain damage. The extent of potential SH&E effects of nanomaterials seems poorly understood.

The number of consumer products using nanotechnology more than doubled, from 212 to 475, in the 14 months following the Project on Emerging Nanotechnologies' launch of the world's first online inventory of manufacturer-identified nanotech goods in March 2006. Clothing and cosmetics top the inventory at 77 and 75 products, respectively. A list of nanotechnology products that also includes bedding, jewelry, sporting goods, nutritional and personal care items is available for free at <http://www.nanotechproject.org>. While polls show most Americans know little or nothing about nanotechnology, in 2005, nanotechnology was incorporated into more than \$30 billion in manufactured goods. By 2014, Lux Research estimates \$2.6 trillion in manufactured goods will incorporate nanotechnology, or about 15% of total global output.

By 2015, the economic impact of nanotechnology worldwide is expected to be over \$1 trillion. Research and development is particularly significant in the fields of electronics, optoelectronics, magnetic applications, medical imaging, drug delivery and cosmetics. Nanotechnology is already marketed in a wide variety of products, including paints, sunscreen and cosmetics, sports equipment, stain-free clothing and automobile parts and equipment. It is estimated that a new commercial product containing nanomaterial is marketed every day, and the pace is accelerating. Note that the reported inventory of nanoproducts does not include nanotech consumer products that companies do not identify as such or nano raw materials and intermediates. Indeed, one of the significant difficulties seems to be the secrecy brought about by the intense competition in a rapidly evolving marketplace.

In a letter dated May 22, 2006 from ASSE to Assistant Secretary of Labor Edwin Foulke, Jr., ASSE President Jack H. Dobson, Jr., CSP wrote "As you begin leading OSHA's efforts, we urge you to consider the following thoughts ASSE has on the current activities of OSHA and the challenges the agency faces as it moves into the future... From all reports, nanotechnology will accelerate the challenges of recognizing, evaluating and controlling safety and health risks in U.S. workplaces. While our knowledge about those risks does not yet support enforcement measures, ASSE urges OSHA to reach out to employers and workers with guidelines and other opportunities to help them keep abreast of rapidly expanding research on such risks. NIOSH has done an excellent job of encouraging the direction of research in nanotechnology and keeping the safety and health community informed. OSHA needs to work hand-in-hand with NIOSH to ensure that any risks and controls learned can be quickly disseminated and OSHA can be prepared to move forward with protection standards if and when they become necessary."

J. Clarence Davies, Senior Advisor to the Project on Emerging Nanotechnologies at the Woodrow

Wilson International Center for Scholars, stated, “Every day that EPA does not exercise some kind of oversight on nanomaterials is another day when the American public involuntarily participates in a huge experiment to see whether nanotechnology poses any threat to health or the environment” in testimony given before EPA in August 2007. To many of us, a consensus on how to study the potential affects of nano anything is formulated one step behind the development of nanoproducts, the manufacturing processes and nanowaste and the introduction of nanoproducts into the marketplace, our businesses and our homes.

The National Nanotechnology Initiative (NNI) is the federal government’s coordinating body for nanotechnology research and development. Since 2001, NNI has spent approximately \$1 billion per year. Only about 4% of that amount has been dedicated to studying the potential health and environmental effects of nanomaterials in the last three years. This might seem inadequate given that an estimated two million workers are exposed to nanometer particles on a regular basis. In response to this apparent emphasis on development and production with passing lip service to health and safety, several organizations, including NNI, have either been assigned or taken on the responsibility of formulating systems for evaluating the health and safety ramifications of nanotechnology.

Researchers and other interested parties have recommended that federal funding be greatly increased. One of the stumbling blocks seems to be that, when dealing with a new type of material, one with potential effects and interactions on a level that is outside of the realm of “normal” science, knowing what to look for and how to evaluate its impact on health and safety may not be intuitive. In September 2006, NNI published a document titled “EHS Research Needs for Engineered Nanoscale Materials” (http://www.nano.gov/Prioritization_EHS_Research_Needs_Engineered_Nanoscale_Materials.pdf). This document identified five broad categories of EHS research and information needs, including 75 specific needs relating to risk assessment and management.

Following a public comment period, the Nanotechnology Environmental and Health Implications (NEHI) Working Group of NNI redefined the focus to five priorities within each of the five categories. These priorities, by category and taken directly from the report, are:

1. Instrumentation, Metrology & Analytical Methods
 - a. Develop methods to detect nanomaterials in biological matrices, the environment and the workplace.
 - b. Understand how chemical and physical modifications affect the properties of nanomaterials.
 - c. Develop methods for standardizing assessment of particle size, size distribution, shape, structure and surface area.
 - d. Develop certified reference materials for chemical and physical characterizations of nanomaterials.
 - e. Develop methods to characterize a nanomaterial’s spatio-chemical composition, purity and heterogeneity.
2. Nanomaterials & Human Health
 - a. Develop methods to quantify and characterize exposure to nanomaterials and characterize nanomaterials in biological matrices.
 - b. Understand the absorption and transport of nanomaterials throughout the human body.

- c. Establish the relationship between the properties of nanomaterials and uptake via the respiratory or digestive tracts or through the eyes or skin, and assess body burden.
 - d. Determine the mechanisms of interaction between nanomaterials and the body at the molecular, cellular, and tissular levels.
 - e. Identify or develop appropriate in vitro and in vivo assays/models to predict in vivo human responses to nanomaterials exposure.
3. Nanomaterials & the Environment
- a. Understand the effects of engineered nanomaterials in individuals of a species and the applicability of testing schemes to measure effects.
 - b. Understand environmental exposures through identification of principle sources of exposure and exposure routes.
 - c. Evaluate abiotic and ecosystem-wide effects.
 - d. Determine factors affecting the environmental transport of nanomaterials.
 - e. Understand the transformation of nanomaterials under different environmental conditions.
4. Health & Environmental Exposure Assessment
- a. Characterize exposures among workers.
 - b. Identify population groups and environments exposed to engineered nanoscale materials.
 - c. Characterize exposure to the general population from industrial processes and industrial and consumer products containing nanomaterials.
 - d. Characterize health of exposed populations and environments.
 - e. Understand workplace processes and factors that determine exposure to nanomaterials.
5. Risk Management Methods
- a. Understand and develop best workplace practices, processes and environmental exposure controls.
 - b. Examine product or material lifecycle to inform risk reduction decisions.
 - c. Develop risk characterization information to determine and classify nanomaterials based on physical or chemical properties.
 - d. Develop nanomaterial-use and safety-incident trend information to help focus risk management efforts.
 - e. Develop specific risk communication approaches and materials.

Davies stated in his testimony that “The current situation with respect to nanotechnology reminds me of the situation with respect to chemicals in 1971 when TSCA was first drafted. We had no idea how many new chemicals were manufactured each year, and the estimates ranged from 100 to 10,000....However, TSCA was enacted because there was a sense of urgency....Today nanomaterials require a sense of urgency.”

Much information regarding nanotechnologies is available from governmental agencies, independent research groups and manufacturers. Given the promise of new properties and the potential of nanotechnology, newsletters and magazines herald the investment opportunities that are currently available. What we need, however, from a health and safety perspective, is a framework to standardize and evaluate the potential impacts these materials might have on human health and the environment. It seems that nanoscience and nanotechnology will have a deep and lasting influence on worker safety and health and the environment. As safety

professionals, being part of the investigative process and participating in rulemaking are essential.

Resources & References

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