Editorial

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Biographical notes: Srikanth S. Nadadur is Health Scientist Administrator and Programme Director for Nanotechnology Environmental Health and Safety (Nano-EHS) and Environmental Cardiopulmonary Health Extramural Research Programmes, National Institute of Environmental Health Sciences (NIEHS). He has more than 25 years of research experience in molecular biology and toxicology. He is currently overseeing nano-EHS research efforts by NIEHS Centers for Nanotechnology Health Implications Research (NCNHIR) consortium, involving more than a dozen academic institutions across the USA. He is also a member of the Trans-NIH Nano Task Force and an agency representative to the Nanotechnology Environmental and Health Implications (NEHI) subcommittee, National Nanotechnology Initiative (NNI). With other federal agency partners, he had contributed to the human health sections of the NNI 2011 Strategy document for Nanotechnology-Related Environmental, Health and Safety Research for federal research coordination in the USA.

The advances in material sciences have allowed manipulation of matter at the molecular/nanoscale level to use the novel properties and functions that are not observed at the macro level for materials with similar molecular composition. This process has led to the exploitation of nanotechnology in diverse applications ranging from electronics, energy, cosmetics, construction, paper, textiles, transport, therapeutic applications and environmental remediation. The latest advances in nanotechnology use small amounts of engineered nanomaterials (ENMs) in nanocomposite structures in which the mechanical, electrical, thermal, optical, electrochemical, and catalytic properties will differ markedly from those of the component materials. Sustainable exploitation of nanotechnology applications promises production of cleaner energy, inexpensive clean water that positively contributes to savings in raw materials, and reduced environmental pollution. This rapid development and introduction of ENMs and nano-enabled products necessitates a strong research programme to understand potential health and environmental impacts of ENMs. The global market for nanotechnology-enabled products is predicted to reach $2.6 trillion by 2014 (Hullmann, 2007). Currently, more than 60 countries are actively pursuing an accelerated development and commercialisation of nanotechnology-based products, which account for about 2,300 consumer products in the market ranging from sunscreen creams to stain-resistant fabrics, and even children's toys.

The USA (http://www.nano.gov/node/681) and European nations have integrated environmental health and safety research into their national research strategies to guide safer development and use of nanotechnology. The ongoing research is leading to the understanding that some of the physicochemical properties that can be manipulated (size, surface area, surface charge, aspect ratio, and crystallinity) for beneficial technological applications pose additional complexities and diversity that do not allow categorisation of ENMs as one group of substances. The fundamental toxicological inquiries using in vitro cell culture systems and animal models to understand possible biochemical and physiological effects from the perspective of nanoparticle ‘size’ implicate oxidative stress and inflammation in the cytotoxic response (Nel et al., 2006). On the other hand, the mechanical strength and excellent physicochemical properties of carbon nanotubes suggest them to be bio-persistent with potential to induce pulmonary injury, fibrosis, frustrated phagocytosis and differential toxicity response in animal models, depending on the presence of contaminating metals used in the synthesis process (Shvedova et al., 2009; Wang et al., 2011; Murphy et al., 2011). For example, with diverse surface and functional modifications about 50,000 different types of carbon nanotubes can be produced, and assessing their toxicological properties and potential health risks is a daunting task for the regulatory purposes. As a near infinite number of ENMs can be generated, the conventional toxicological approaches of screening one compound at a time may not provide the needed scientific input for toxicity and health risk assessment. Incorporation of systematic high throughput in vitro screening approaches to deduce biological response signatures associated with specific physicochemical properties may allow a hazard ranking approach for detailed analysis in animal models for predicting potential health effects (Meng et al., 2009).

Inhalation, oral, dermal and ocular exposures are the four major routes for ENMs from occupational and environment. Knowledge gained from the ambient particulate matter research efforts on ultrafine particulates that may also include particles in nanoscale size, guided experimental studies to understand pulmonary toxicity of ENMs. The rapid increase in the use of ENMs in food preservation and food packaging had been recognised in the national nanotechnology environmental health and safety strategies. Given the diversity of nanomaterials, consumer products, and potential routes of exposure, it is not possible to cover the complete spectrum of nanotechnology environmental health and safety in one issue. So, this special issue is aimed at providing an overview on diverse rational approaches being used by investigators to address critical scientific issues and gaps to understand environmental health and safety of ENMs.

Xia et al., Heideman et al., and Tanguay et al. review the potential benefits of high to medium throughput in vitro and in vivo approaches and their integration to gain fundamental understanding of biological response to diverse metal oxide and CNT nanoparticles. Worden et al. provide an overview on the use of bilayer lipid membranes that mimic cell membranes to characterise ENM-biomembrane interactions that can provide fundamental understanding of these interactions. The hydrophobic CNTs can be made more hydrophilic by surface functionalisation, which can influence their fate and transport in the environment, as well as their bioavailability (Mitra et al.). The in vitro investigation on 24 commercially available MWCNT in a macrophage-like differentiated THP-1 cell line reports that, depending on contaminating metals (nickel) and cell uptake mechanisms influence the inflammatory response and downstream molecular events (Holian et al.). The hydrophilic and biologically available functionalised CNT toxicity evaluation on an in vitro co-culture system of intestinal epithelial cells combined with proteomic approaches observed CNT-specific molecular and cellular functional alterations with little overlap across CNT type and in the absence of overt toxicity (Witzmann et al.). Bergin and Witzmann review the published literature on potential toxicity outcomes from the ingestion of a variety of nanometals, metal oxides, carbon-based nanoparticles, and polymer/dendrimers. This issue also includes the increasing need for development of green synthesis methods to develop silver nanoparticles and their potential therapeutic use against antibiotic resistant strains (Banu and Rathod).

A strategic research programme on nanotechnology environmental health and safety is critical in achieving success for the sustainable development and marketing of new generation ENMs. This can be achieved by incorporating collaborative multidisciplinary coordinated research programme such as Nano EHS currently implemented by NIEHS to identify potential health or environmental risks while also fostering the technological advancements for a larger public and economic benefit.

The statements, opinions or conclusions presented here do not necessarily represent the statements, opinions or conclusions of NIEHS, NIH or the US Government.

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