Main Focus

Nanotechnology environmental health & safety standards

By Steven Brown, Convenor of ISO/TC 229/WG 3, Environmental health and safety

The development and applications of new nanotechnologies have the potential to improve greatly the quality of life in areas such as medicine, water purification, environmental remediation and energy production. Some futurists predict nanotechnology will be the next disruptive technology because of the projected ability to impact and change so many areas of material science applications.

According to the US National Nanotechnology Initiative, nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers where unique phenomena enable novel applications.

Nanotechnology involves imaging, measuring, modeling, and manipulating matter at the 1 to 100 nanometer scale. At the nanoscale, the physical, chemical, and biological properties of materials differ in fundamental ways from the properties of individual atoms, molecules or bulk matter.

Nanomaterials currently under development are extremely varied in nature, chemical composition and potential applications. Because of their small size, nanoscale particles have unique properties such as unusual surface features which are highly reactive.

Since half of the atoms in a 5 nm particle are at the surface, these high-surface energies allow novel chemical reactions that are different from reactions with the same material in bulk form.

Nanomaterials can be classified according to their chemical make-up and can include classes of materials such as, but not limited to, oxides, metals, semiconductors, quantum dots, carbon nanotubes and fullerenes.

"The uniform application of ISO toxicology testing methods will expedite the development of a scientific knowledge base on nanomaterials."

There are over 300 products already in production that claim to contain nanomaterials. It appears that the potential new types and applications of nanomaterials are only limited by the material scientist's imagination.

Many of the emerging nanotechnologies involve the development of new materials which contain nanometer scale particles. As with the introduction of any new material or product into commerce, there is both the potential for positive societal benefits as well as the potential risk of harm to humans or the environment during the production, use and disposal of these new products.

However, with proper due diligence and effective life cycle analysis, the potential risks can be identified and addressed. The risks associated with nanomaterial production and use can be controlled through proper product design and implementation of effective manufacturing controls.

Due to the unique nature of nanomaterials, the current methodologies employed to conduct risk assessments, toxicological assessments and life cycle analysis of products containing nanomaterials may be ineffective or may not currently exist.

There are currently no standard test methods for human exposure measurements to nanoparticles. According to the US National Institute of Occupational Health, current research indicates that mass and bulk chemistry may be less important as an indicator of toxicity than particle size, surface area, and surface chemistry (or activity) for nanostructured materials.

Innovative measurement techniques and health hazard assessments are among the many standards that will need to be developed to evaluate adequately the use of nanomaterials.

Additional research is necessary to determine the toxicological properties of nanoparticles. Preliminary toxicological studies on nanomaterials indicate the potential for some nanomaterials to have harmful effects.

For example, studies show potential for nanomaterials to cause pulmonary inflammation, translocation from the lungs to other body organs, toxicity not predicted by the bulk material, enhanced bioavailability, altered clearance mechanisms and potential translocation of particles across cell membranes.

It is unknown if all nanomaterials will have new and unique health risks. Additional studies are needed to determine methods to assess nanoparticle toxicity, including the determination of which physical characteristics of nanomaterials will correspond to specific toxicological endpoints.

Potential physical characteristics that may influence biological effects include the following characteristics: total particle count, particle size distribution, total mass, particle surface area, particle surface charge, nanoparticle solubility in aqueous solutions and ability of the nanoparticle to aggregate or agglomerate.

In order to identify quickly if a specific nanomaterial under development may pose a health or environmental risk, a nanomaterial toxicity screening test is needed. Such a test would enable researchers and manufacturers to perform initial toxicity assessments and risk analysis on new nanomaterials.

The results of a screening test would help identify which physical and chemical parameters of a nanomaterial are indicative of a specific material's toxicity. The ability to determine rapidly the relative toxicity would also enable researchers to modify the nanomaterial under development to decrease its toxicity prior to manufacturing or release into the environment.

"The possibilities of nanotechnology are exciting and promise many benefits to mankind."

New nanomaterial analytical measurement techniques are needed in the following areas:

1) Metrology techniques to measure the physio-chemical properties of nanomaterials;

2) Analytical techniques to support *in vivo* and *in vitro* testing of nanomaterials;

3) Toxicity screening test to determine the effects of nanoscale particles on cellular membranes and ecological systems;

4) New analytical methods are also needed in order to differentiate the nanoparticles from ultrafine particle background levels that may be present in the ambient atmosphere.

In summary, environmental and human exposure assessments of nanomaterials will require new analytical techniques and instrumentation with corresponding ISO standards to provide guidance on their use and application.

About the author

Steven Brown is the Convener of the environmental health and safety Working Group of ISO/TC 229, *Nanotechnologies*. He is responsible for the development of ISO EHS standards and guidelines on the use of nanomaterials. Mr. Brown is employed by Intel Corporation where he is responsible for the safe introduction of new process chemistries and manufacturing technologies into Intel's global manufacturing facilities. He is a certified industrial hygienist with over 25 years' experience in aerospace and semiconductor industries.

Standardization of an accepted screening test will require the development of ISO standards on material characterization, sample purity assurance, sample preparation and toxicological testing methodologies for the various types of nanomaterials.

The uniform application of ISO toxicology testing methods will expedite the development of a scientific knowledge base on nanomaterials by ensuring all toxicity research is performed in a consistent and uniform manner.

Unfortunately, traditional methods of detecting, analysing and measuring micron-sized materials are ineffective in the measurement of nanoparticles.

The manufacturing and processing of nanomaterials presents the potential for release of nanomaterials into the environment. A basic understanding of the potential emissions routes, environmental distribution and transformation of nanomaterials within the environment is needed to prevent a negative environmental impact in the event these materials are released into the environment.

Analytical techniques and standards are needed to determine if manufactured nanoparticles undergo biotransformation when released into the environment or if they bioaccumulate over time.