NANOTECHNOLOGY FACT SHEET

Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials, and devices. The technology promises scientific advancement in many processes and practices such as medicine, consumer products, energy, materials and manufacturing. Nanomaterials (NMs) are defined as materials that have a length scale between 1 and 100 nanometers. At this size, many materials exhibit unique properties that affect physical, chemical, and biological behavior. Researching, developing, and utilizing these properties is at the heart of this technology.

The global nanomaterials market was valued at $3.4 billion in 2014 and is expected to reach $11.8 billion by 2020 showing a compound annual growth rate of 23.1%. North America will remain the market leading region for several years as it has significant ongoing Research & Development activities in nanomaterials.)

The increasing production and use of NMs may lead to greater exposures of workers, consumers, and the environment, and the unique scale-specific and novel properties of the materials raise questions about their potential effects on human health and the environment.

Workers within nanotechnology-related industries have the potential to be exposed to uniquely engineered materials with novel sizes, shapes, and physical and chemical properties. Occupational health risks associated with the manufacture, use, and disposal of NMs are not yet clearly understood. Information on dominant exposure routes and potential exposure levels is poorly known.

There are strong indications that particle specific surface area, surface chemistry, and other surface properties are responsible for observed responses in cell cultures and animals. Studies suggest that some NMs can move from the respiratory system to other organs. Research is continuing to understand how these unique properties may lead to specific health effects.

NMs are already in industrial and consumer products, including drug-delivery systems, stain-resistant clothing, solar cells, cosmetics, and food additives. It is the nanoscale-specific properties of NMs (for example, their electronic, optical, or chemical-reactive qualities) that are key to research and commercial applications.

Critical gaps in knowledge are related to the unique properties and environmental, health, and safety (EHS) risks of NMs, with major challenges for the field, including 1) great diversity of nanomaterial types and variants, 2) lack of capabilities to monitor rapid changes in current, emerging, and potential NM applications and to identify and address the potential consequences for EHS risks, 3) lack of standard test materials, analytical techniques for complex media, and 4) poor understanding of toxicological profiles, exposure scenarios and adequate models for investigating EHS risks, leading to great uncertainty in describing and quantifying nanomaterial hazards and exposures.

The diverse properties of nanomaterials make them challenging from the perspective of risk assessment. The variety of NM types and the variation within types make it difficult to define their composition, structure, and properties without extensive characterization, and NM transformations in environmental or biological matrices complicate the characterization process. The countless assemblages of atoms and structures and the plethora of inorganic and organic macromolecular coatings affect NM surface chemistry and thus their behavior in the environment and in organisms. Depending on the environment where a nanomaterial is present (for example, lung fluid, surface water, or air), its surface properties may change, affecting its behavior, so that making predictions about such behavior and potential effects is challenging. Because of the variety of NMs with differing properties, it is difficult to identify materials or classes of materials that may behave similarly with respect to fate, transport, toxicity, and risk.

Significant research is still required on nanomaterials in the environment, including identifying and quantifying nanomaterial releases and the populations and environments being exposed, understanding processes that affect both potential hazards and exposure, examining nanomaterial interactions in complex systems ranging from subcellular to ecosystems, and supporting an adaptive research and knowledge infrastructure to advance research.

References

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