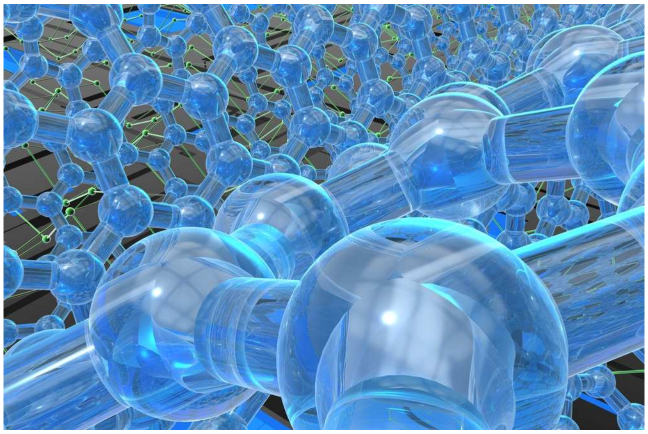
NANOTECHNOLOGY & NANOMATERIALS RESEARCH



Background

Nanotechnology is the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers. A nanometer is one billionth of a meter. While it is difficult to imagine just how small that is, here are some examples:

- A sheet of paper is about 100,000 nanometers thick.
- A strand of human DNA is 2.5 nanometers in diameter.
- A human hair is approximately 80,000 nanometers wide.

Nanotechnology relies on the ability to design, manipulate, and manufacture materials at the nanoscale. These materials are called nanomaterials.

Commercial processes and products that use nanomaterials are growing rapidly and these tiny products are increasingly found in paint, fabrics, cosmetics, treated wood, electronics and sunscreen. Nanomaterials exhibit unique properties different than chemical substances that are larger in size. Nanomaterials provide opportunities for the development of innovative products that provide advances in technologies and medicine. The US Environmental Protection Agency (EPA) is using scientific methods to research what nanomaterials are, how they act, travel and change over time.

Nanomaterials are very useful, but there is little research about how they affect human and ecosystem health.

To fill these research gaps, EPA's Chemical Safety Research Program, along with scientific collaborators worldwide, is researching how nanomaterials interact with biological processes important to human and ecosystem health.

This research is used by [EPA's Chemical Safety and Pollution Prevention Office] and others making chemical related policy decisions to better protect human health and the environment.

EPA's chemical safety research focuses on the following priority categories of nanomaterial research:

- Exposure and Characterizing Nanomaterials Properties
- Life Cycle Assessment of Nanomaterials
- Nanomaterials Risk Assessments
- Nanomaterials & Sustainability
- Enhancing Collaborative Research & Partnerships

Exposure and Characterizing Nanomaterials Properties

Nanomaterial properties such as reactivity, melting point, fluorescence, mechanical strength and electrical conductivity can be altered at the nano scale level which makes it hard to determine how these materials interact with humans and in the environment. EPA is:

- Researching how nanomaterials affect ecosystem and human health.
- Detecting, quantifying and characterizing nanomaterials.
- Assessing, ranking and predicting nanomaterial health effects using rapid, automated chemical screening called high-throughput testing methods.

Exposure and characterizing nanomaterial properties research will allow risk assessment of nanomaterials at multiple levels and will provide qualified and credible alternative testing methods that can be used to predict toxicity. Results from this research will be used to build a database that identifies what nanomaterial structures are more likely to result in toxicity and the types of structures that make up nanomaterials that are safer which can be used to design or engineer safer nanomaterials.

EPA is also assessing the potential effects of nano-titanium dioxide (used in cosmetic and sunscreen products), nano silver, carbon nanotubes, nano cerium oxide and

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nano copper on the health of ecosystems. Researchers are testing toxicity of nanomaterials in aquatic species, determining modes of exposure and how these materials can accumulate in both the marine and freshwater ecosystems.

These efforts will allow more sustainable development and usage of nanomaterials.

Life Cycle Assessment of Nanomaterials

EPA researchers are evaluating the life cycle of consumer products containing nanomaterials starting with raw material extraction and ending with the ultimate disposal. This research assembles a complete life cycle inventory for specified nano products. Using the principles of "green chemistry" and "life cycle assessment," researchers are developing more environmentally friendly methods to produce nanomaterials and crafting innovative technologies that minimize the impacts on health and the environment. The innovative technologies being developed by EPA researchers are being used in environmental remediation technologies and are being commercialized in collaboration with private companies.

Risk Assessments

EPA uses the comprehensive environmental assessment (CEA) approach to identify and prioritize research to support future assessments and risk management decisions.

A series of risk assessment case studies are in development pertaining to the product life cycle, how nanomaterials move in the environment, how they interact with important biological processes, determining how much nanomaterials people and the environment are exposed to and assessing the impacts of using particular nanomaterials in specific applications. Two case studies on nanoscale titanium dioxide (nanoTiO2) are available. One examines the use of nanomaterials for water treatment in the removal of arsenic, and the other looks at its use as an ingredient in topical sunscreens. A similar case study on nanoscale silver in disinfectant sprays is also available. Current efforts are focused on developing a case study on multiwalled carbon nanotubes (MWCNT) in flame-retardant coatings applied to upholstery textiles.

The case studies are developed using input from a diverse expert stakeholder group to support consideration of potential impacts in the environment as well as ecological and human health.

Sustainability

EPA has made significant progress in nanotechnology and sustainability research in the past five years. This research has developed alternative ways to apply nanomaterials to minimize environmental and health impacts.

The method uses a "bottom-up" approach to assemble nanomaterials at the molecular level. It avoids the use of hazardous reducing agents and instead employs benign metallic salts (such as iron), water, and polyphenols from plant materials to act as reducing or capping agent to prevent nanomaterials from collecting in larger clumps during production.

In 2008, EPA's nano research team designed a nanoparticle that has become very useful in cleaning up environmental contaminants, particularly families of chemicals that are harmful to humans called "Polychlorinated Biphenyls." Other real world applications in the works are nano zero valent iron which is an emerging option for the treatment of contaminated soil and groundwater and a nanomaterial called cerium oxide that is being added to fuel used in diesel buses to reduce emissions.

Collaborative Research Efforts

Collaborations are essential to the success of EPA's chemical safety research. EPA currently partners with different organizations ranging from industry, academia, trade associations, other federal agencies and non-governmental organizations. All partners have an interest in advancing nanomaterials research.

The United States government's efforts to assess nanomaterials are coordinated by the U.S. National Nanotechnology Initiative (NNI). NNI is a collaborative project of 25 agencies, including EPA.

In addition to research collaborations, EPA provides funding to external organizations to advance nanomaterials research. Solicitations for proposals to fund external research can be found at www.epa.gov/ncer/rfa/. EPA also offers opportunities for small business research grants and fellowships for both undergraduate and graduate students.

More information:
www.epa.gov/nanoscience/

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