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Nanotechnology in Society: An Overview

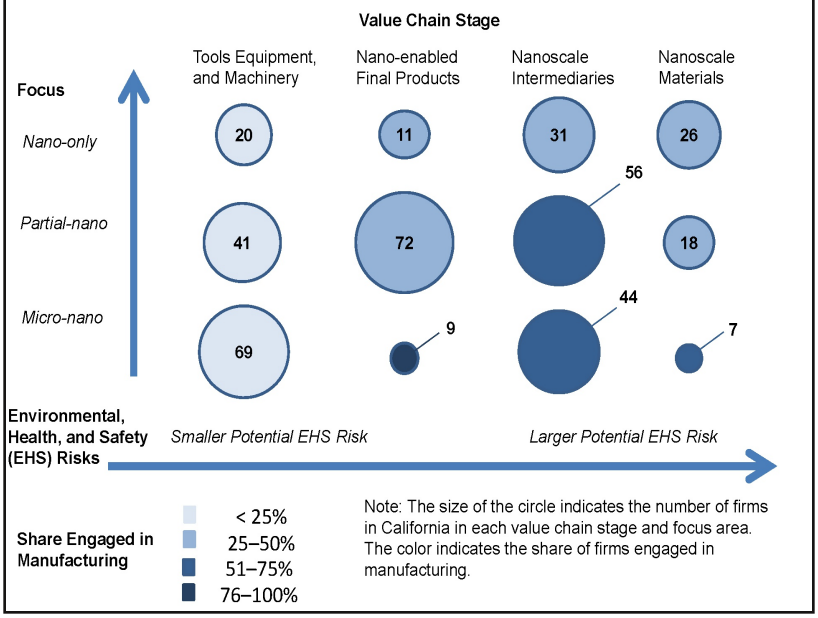
Nanotechnology refers to the manipulation of matter at the atomic or near-atomic scale. This allows for the deliberate engineering of materials and devices with specific properties that enable a range of new commercial, medical, and environmental applications (e.g., cancer treatments). This Short Subject provides an introduction to nanotechnology, offers information about potential risk, and discusses its regulation in the United States and California.

APPLICATIONS

Nanotechnology is defined by size and broadly refers to technologies at the scale of about 1 to 100 nanometers (nm) or just billionths of a meter. To put the size in perspective, a piece of paper is 100,000 nm thick. Engineered nanoparticles, as opposed to naturally occurring ultra-fine particles, have different properties and can be designed with different shapes, sizes, and chemistries than their larger, bulk-material counterparts.[1] For example, gold nanomaterials can appear red or purple, as the motion of the gold's electrons is confined at the nanoscale and the nano particles react differently with light compared to larger gold particles.

Such unique properties enable novel uses. Nanotechnologies, for example, could allow for more targeted cancer treatments that attack cancerous cells but leave intact surrounding healthy cells, unlike current, more invasive treatments. Nanotechnology has also been used to enhance water purification, such as the Lifestraw, which removes nearly all waterborne bacteria from drinking water. Nanomaterials are also used in a host of commercial products such as titanium dioxide nanoparticles for UV protection in sunscreen and ultra-light, extremely strong carbon nanotubes for lighter, durable materials and stain-resistant textiles. However, what makes nanomaterials unique—their novel properties—could also pose new and unknown risks.

Figure 1. California Nano-firms by Value Chain Stage, Focus, and Engagement in Manufacturing[2]



POTENTIAL RISK

As a preliminary step towards risk assessment, the National Science Foundation's California in the NanoEconomy project works to identify California firms that use nanotechnology.[2] Firms with employees most likely to come in contact with nanoscale materials are those that are entirely or partially focused on nanotechnology and engaged in manufacturing or research. Those engaged in manufacturing also have the greatest potential for environmental, health, and safety risks (Figure 1).

Two examples of potential risk are found in nano silver and carbon nanotubes. Nanosilver has been added to commercial products because the nanoscale enhances silver's anti-bacterial properties. Yet research suggests that textiles with nano silver, when laundered, release the nano silver into wastewater and the environment where it can accumulate. The long-term effects are unknown.[3] Carbon nanotubes are extremely durable, lightweight structures used for such things as bone tissue engineering. However, toxicological studies

A 2010 international survey of private nanotech companies found that less than half report having a nano-specific safety program, with many companies employing activities that NIOSH advises against.[7]

suggest chronic exposure to carbon nanotubes could cause adverse pulmonary effects similar to asbestos fibers, raising potential health concerns for workers involved in manufacturing.[4]

Regulation

Whether nanotechnologies as a class merit specific government regulation is a contested issue. Firms in the United States are not required to disclose if they use or import nanomaterials, and many nanomaterials have been regulated similarly to their bulk counterparts (e.g., nanoscale gold particles regulated as gold).[5] However, the United States Environmental Protection Agency (EPA) has been moving to collect more voluntary information about existing nanomaterials and to require information about new uses of nanomaterials not currently in the U.S. market. The EPA has authorization under the 1976 Toxic Substances Control Act to review and potentially regulate the life-cycle risks of some individual nanomaterials as new chemical substances.[5]

In 2010, the California Department of Toxic Substances Control formally requested manufacturers and importers to volunteer information about seven nanomaterials: carbon nanotubes, nano cerium oxide, nano silver, nano titanium dioxide, nano zero-valent iron, nano zinc oxide, and quantum dots.[6] This information is intended to help policymakers become familiar with existing risk assessment data and identify information gaps.

To minimize potential worker safety and health risks, the National Institute for Occupational Safety and Health (NIOSH) recommends that firms voluntarily adhere to nano-specific environmental, health and safety guidelines.[1] A 2010 international survey of private nanotech companies found that less than half report having a nano-specific safety program, with many companies employing activities that NIOSH advises against.[7] The institute has been moving to improve voluntary industry compliance through outreach.

In 2013, NIOSH recommended a new exposure limit for workers exposed to carbon nanotubes and carbon nanofibers based on research of toxicological data suggesting chronic exposure could cause "adverse pulmonary effects."[4] The long-term effect on exposed workers has yet to be seen.

Endnotes

1 National Institute for Occupational Health and Safety, Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials, (March 2009). http://www.cdc.gov/niosh/docs/2009-125/

2 Frederick, Stacey. California in the NanoEconomy. http://californiananoeconomy.org/

3 Massarsky, Andrey, *et al*. "Predicting the Environmental Impact of Nanosilver." *Environmental Toxicology and Pharmacology* 38, no. 3 (2014): 863-73.

4 National Institute for Occupational Health and Safety, Occupational Exposure to Carbon Nanotubes and Nanofibers, (April 2013). http://www.cdc.gov/niosh/docs/2013-145/pdfs/2013-145.pdf

5 United States Environmental Protection Agency, Control of Nanoscale Materials under the Toxic Substances Control Act www.epa.gov/oppt/nano/

6 Risk and Safety. www.californiananoeconomy.org/content/risk-safety

7 Engeman D. Cassandra, et al. "Governance Implications of Nanomaterials Companies' Inconsistent Risk Perceptions and Safety Practices." Journal of Nanoparticle Research 14, no. 3 (2012): 1-12.

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