

Working Safely with Nanomaterials

Workers who use nanotechnology in research or production processes may be exposed to nanomaterials through inhalation, skin contact, or ingestion. This fact sheet provides basic information to workers and employers on the most current understanding of potential hazards associated with this rapidly-developing technology and highlights measures to control exposure to nanomaterials in the workplace.

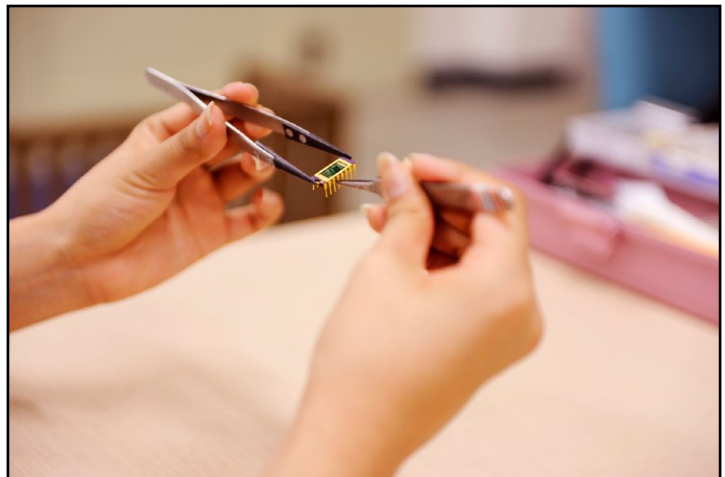
What are Nanotechnology and Nanomaterials?

Nanotechnology is “the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers (nm)” (www.nano.gov). A nanometer is one billionth of a meter, which is near-atomic scale. Engineered nanomaterials are assembled from nanoscale structures such as carbon nanotubes and filaments or from nanoparticles of materials such as titanium dioxide or cadmium selenide. Nanomaterials can have unique physical, chemical and biological properties that can enable their use in novel applications, such as making stain-free textiles using nanoscale additives or surface treatments or targeting drugs selectively to cancerous cells. The continued development of unique nanoscale structures has the potential to impact many industries, including electronics, healthcare, construction and consumer products.

As nanotechnology applications move from research laboratories to industrial and commercial settings, workers and employers should be aware of potential hazards posed by nanomaterials in their workplaces and employers should take appropriate measures to control worker exposure. This fact sheet reflects the current understanding of the health and safety issues relating to nanomaterials. Up-to-date information regarding this rapidly developing field of knowledge is available at www.nano.gov or at the Nanotechnology page on OSHA’s website (www.osha.gov/dsg/nanotechnology/nanotechnology.html).

Nanomaterials in the Workplace

Some examples of workplaces that may use nanomaterials include chemical or pharmaceutical laboratories or plants, manufacturing facilities, medical offices or hospitals, and construction sites. One way for workers to determine if their workplace is using nanomaterials is to ask their employer.



Semiconductor nanochip test package in a university nanotechnology laboratory.

Employers should check with manufacturers of chemicals and materials used in their workplace to determine if unbound engineered nanomaterials are present. The potential for nanomaterials to pose health or safety hazards is greater if the nanomaterials are easily dispersed (such as in powders, sprays, or droplets) or are not isolated or contained.

In workplaces where workers will be exposed to nanomaterials, the employer should provide information and training to their workers. This information and training should include at least the following:

- Identification of nanomaterials the employer uses and the processes in which they are used;
- Results from any exposure assessments conducted at the work site;
- Identification of engineering and administrative controls and personal protective equipment (PPE) to reduce exposure to nanomaterials;
- The use and limitations of PPE; and
- Emergency measures to take in the event of a nanomaterial spill or release.



An example of a nanoparticle is a buckyball or fullerene.

What We Know About Exposure to Nanomaterials

Information from research and animal studies on nanomaterials has identified some potential safety hazards and health effects.¹ Because nanotechnology is a rapidly emerging field, more information will likely become available about potential health and safety hazards associated with some nanomaterials. The health hazard potential depends on the particular nanomaterial and a person's exposure level. For example:

- Certain inhaled nanoparticles may be deposited in the respiratory tract and may cause inflammation and damage to lung cells and tissues; e.g., carbon nanotubes and nanofibers may be capable of causing pulmonary inflammation and fibrosis.²
- Titanium dioxide (TiO₂), which has many commercial applications (e.g., paint, paper, cosmetics, food), can be produced and used in varying particle sizes, including the nanoscale particle sizes (< 100 nm). NIOSH has determined that nanoscale TiO₂ particles have higher mass-based potency than larger particles, and that occupational exposure (by inhalation) to nanoscale TiO₂ particles should be considered a potential occupational carcinogen.³

¹ Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials, published by the National Institute for Occupational Safety and Health (NIOSH) in March 2009, DHHS (NIOSH) Publication No. 2009-125.

² See the NIOSH draft Current Intelligence Bulletin (CIB) – Occupational Exposure to Carbon Nanotubes and Nanofibers, published in November 2010 and accessible online at www.cdc.gov/niosh/docket/review/docket161A/pdfs/carbon-NanotubeCIB_PublicReviewOfDraft.pdf.

³ See CIB 63 – Occupational Exposure to Titanium Dioxide, published by NIOSH in April 2011 and accessible online at www.cdc.gov/niosh/docs/2011-160/pdfs/2011-160.pdf.

- Certain nanoparticles may penetrate cell membranes and may cause damage to intracellular structures and cellular functions.⁴
- Some nanomaterials may act as chemical catalysts and produce unanticipated reactions, creating a risk of explosions and fires.⁵
- Some types of nanoparticle dusts may be combustible and require less energy to ignite than larger dust particles (for instance, sugar or wood), creating a risk of explosions and fires.⁶

Current Occupational Exposure Limits for Nanomaterials

Few occupational exposure limits exist specifically for nanomaterials. Certain nanoparticles may be more hazardous than larger particles of the same substance. Therefore, existing occupational exposure limits for a substance may not provide adequate protection from nanoparticles of that substance. However, some specific exposure limits already exist. For example:

- OSHA recommends that worker exposure to respirable carbon nanotubes and carbon nanofibers not exceed 7.0 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) as an 8-hour time-weighted average, based on the National Institute for Occupational Safety and Health (NIOSH) proposed Recommended Exposure Limit (REL).
- OSHA recommends that worker exposure to nanoscale particles of TiO₂ not exceed NIOSH's 0.3 milligrams per cubic meter (mg/m^3) REL. By contrast, NIOSH's REL for fine-sized TiO₂ (particle size greater than 100 nm) is 2.4 mg/m^3 .

Because exposure limits for other nanomaterials do not exist yet, employers should minimize worker exposure by using the hazard control measures and best practices identified below and in the references noted under "Resources."

Assessing Worker Exposures to Nanomaterials

Employers should assess worker exposure to nanomaterials to identify the control measures needed and determine if the controls used are effective in reducing exposures by:

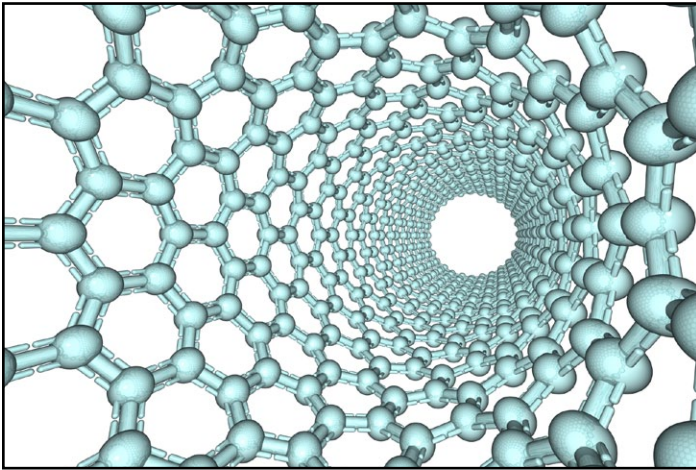
- Identifying and describing processes and job tasks where workers may be exposed to nanomaterials;
- Determining the physical state of the nanomaterials such as dust, powder, spray, or droplets;
- Determining routes of exposure (e.g., inhalation, skin contact or ingestion) of particulates, slurries, suspensions or solutions of nanomaterials;

⁴ See Approaches to Safe Nanotechnology from footnote 1.

⁵ See Approaches to Safe Nanotechnology from footnote 1.

⁶ See Approaches to Safe Nanotechnology from footnote 1.

- Identifying the most appropriate sampling method to determine the quantities, airborne concentrations, durations, and frequencies of worker exposures to nanomaterials⁷; and
- Determining what additional controls may be needed based on the exposure assessment results and evaluating the effectiveness of controls already in place. Employers should adopt the most effective controls available to limit worker exposure.



Model of carbon nanotubes, widely used in nanotechnology, electronics and optics.

Methods Employers Can Use to Reduce Worker Exposure to Nanomaterials

Because the research and use of nanomaterials continues to expand and information about potential health effects and exposure limits for these nanomaterials is still being developed, employers should use a combination of the following measures and best practices to control potential exposures:

Engineering Controls

- Work with nanomaterials in ventilated enclosures⁸ (e.g., glove box, laboratory hood, process chamber) equipped with high-efficiency particulate air (HEPA⁹) filters.
- Where operations cannot be enclosed, provide local exhaust ventilation (e.g., capture hood,

enclosing hood) equipped with HEPA filters and designed to capture the contaminant at the point of generation or release.

Administrative Controls

- Provide handwashing facilities and information that encourages the use of good hygiene practices.
- Establish procedures to address cleanup of nanomaterial spills and decontamination of surfaces to minimize worker exposure. For example, prohibit dry sweeping or use of compressed air for cleanup of dusts containing nanomaterials, use wet wiping and vacuum cleaners equipped with HEPA filters.

Personal Protective Equipment (PPE)

- Provide workers with appropriate personal protective equipment such as respirators,¹⁰ gloves and protective clothing.

Medical Screening and Surveillance

- Make available medical screening and surveillance for workers exposed to nanomaterials if appropriate.¹¹
- Review medical surveillance requirements under OSHA standards (e.g., [Cadmium](#), [Respiratory Protection](#)).

OSHA Standards that May Apply to Nanomaterial Hazards

Nanomaterial use may fall under either OSHA General Industry or Construction standards. OSHA's [Nanotechnology Safety and Health Topics Page](#) highlights some of the OSHA standards that may apply to situations where workers handle or are exposed to nanomaterials. The [General Duty Clause](#), Section 5(a)(1) of the *Occupational Safety and Health Act*, also may apply in situations where workers handle or are exposed to nanomaterials.

States with OSHA-approved [state plans](#) may have additional standards that apply to nanotechnology.

How OSHA Can Help Employers/Workers

OSHA offers free compliance assistance to employers and workers.

OSHA has compliance assistance specialists throughout the nation located in most OSHA offices. Compliance assistance specialists can

⁷ One sampling protocol available is the Nanoparticle Emission Assessment Technique (NEAT) that NIOSH developed to qualitatively determine the release of engineered nano-materials in the workplace (see the appendix of Approaches to Safe Nanotechnology from footnote 1). See also Working Safely with Engineered Nanomaterials and Nanoproducts (www.nanowerk.com/news2/newsid=26583.php).

⁸ See the Ventilation page (www.osha.gov/SLTC/ventilation/index.html) under Safety and Health Topics on OSHA's website for more information about ventilation standards and principles.

⁹ High-efficiency particulate air (HEPA) filter means a filter capable of trapping and retaining at least 99.97 percent of 0.3 micrometer diameter mono-dispersed particles. NIOSH research suggests that such a filter media may effectively remove nanoparticles, see Safe Approaches to Nanotechnology from footnote 1.

¹⁰ At a minimum, use HEPA filter equipped air-purifying respirators as specified by 29 CFR 1910.134; the equivalent NIOSH 42 CFR 84 particulate filters are the N100, R100, and P100 filters; see also Respiratory Protection for Workers Handling Engineered Nanoparticles, published on the NIOSH Science Blog on Dec. 7, 2011, and accessible online at <http://blogs.cdc.gov/niosh-science-blog/2011/12/resp-nano>.

¹¹ CIB 60 – Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles, published by NIOSH in February 2009 and accessible online at www.cdc.gov/niosh/docs/2009-116pdfs/2009-116.pdf.

provide information to employers and workers about OSHA standards and short educational programs on specific hazards. For more information, visit OSHA's website or call 1-800 321-OSHA (6742) to contact your local OSHA office.

OSHA's [On-site Consultation Program](#) offers free and confidential advice to small and medium-sized businesses in all states across the country, with priority given to high-hazard worksites. On-site consultation services are separate from enforcement and do not result in penalties or citations. Consultants from state agencies or universities work with employers to identify workplace hazards, provide advice on controlling hazards and complying with OSHA standards, and assist in establishing safety and health management programs. To find the On-site Consultation office nearest you, visit www.osha.gov/consultation or call 1-800-321-OSHA (6742).

Resources for Additional Nanotechnology Information

OSHA's [Nanotechnology Safety and Health Topics Page](#) provides information from a variety of other agencies and organizations.

What Rights Do Workers Have?

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- File a confidential complaint with OSHA to have their workplace inspected.
- Receive information and training about hazards, methods to prevent harm, and the OSHA standards that apply to their workplace. The training must be done in a language and vocabulary workers can understand.
- Call OSHA for free information or to ask questions.
- Receive copies of records of work-related injuries and illnesses that occur in their workplace.
- Receive copies of the results from tests and monitoring done to find and measure hazards in their workplace.
- Exercise their rights to a safe and healthful workplace without retaliation or discrimination.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For assistance, contact us. We can help. It's confidential.



**U.S. Department of Labor
www.osha.gov (800) 321-OSHA (6742)**