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Nanoparticle Safety and Health Guidelines

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PURPOSE

The purpose of this document is to outline safety and health guidelines for the safe handling and disposal of nanoparticles utilized or generated during research projects. This document is intended to provide guidance for small scale laboratory projects.

DEFINITIONS AND BACKGROUND

The ASTM Committee on Nanotechnology has defined a nanoparticle as a particle with lengths in two or three dimensions between 1 and 100 nanometers (nm). Nanoparticles can be composed of many different base materials and may be of different shapes including: nanotubes; nanowires; and crystalline structures such as fullerenes and quantum dots[1].

Nanoparticles present a unique challenge from an occupational health perspective as there is a limited amount of toxicological data currently available for review. However, some studies have shown that existing exposure control technologies have been effective in reducing exposure to nanoparticles. As such, the accepted exposure control hierarchy was utilized in the development of this document.

EXPOSURE PATHWAYS AND COMMON TASKS THAT COULD RESULT IN EXPOSURE

The primary routes of exposure for nanoparticles are inhalation, dermal absorption, and ingestion. Nanoparticles or nanomaterials used in laboratory experiments will likely be in one of three forms: a powder, in suspension, or in a solid matrix. The form of the nanoparticles or nanomaterial will play a large role in the exposure potential. For example, a nanoparticle in powdered form will present a larger inhalation hazard potential than a nanoparticle in suspension.

Some common tasks that present some potential for exposure include[2]:

- Working with nanoparticles in suspension without gloves;
- Working with nanoparticles in suspension during pouring or mixing where agitation is involved;
- Generating nanoparticles in the gas-phase;
- Handling nanoparticle powders;
- Maintenance on equipment used to produce nanoparticles;
- Cleaning up spills or waste material;
- Cleaning dust collection systems; and
- Machining, sanding, grinding, or mechanically disturbing nanomaterial which can generate an aerosol.

METHODS OF EXPOSURE CONTROL

The established hierarchy of exposure controls for nanoparticles is consistent with existing exposure control options for hazardous chemicals. The exposure control methods are summarized in Table 1.

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Table 1: Exposure Control Methods*

Control Method	Process, Equipment, or Job Task
Elimination	Change of Experimental Design to Eliminate the Hazard
Substitution	Substitution of a High Hazard with a Lower Hazard (chemical)
Engineering	Isolation/enclosure, Ventilation (Fume Hood)
Administrative	Work Practice Procedures, Chemical Hygiene Plan Policies
Personal Protective Equipment (PPE)	Gloves, Goggles, Clothing, Respirators

*Table adopted from NIOSH document entitled, "Approaches to Safe Nanotechnology"[2]

Each of the control methods should be evaluated prior to beginning work on any project involving nanoparticles. The evaluation should include the completion of a hazard assessment. Forms to document the hazard assessment are available on the REM website (https://www.purdue.edu/ehps/rem/forms/allforms.html). The ideal control method involves the elimination of the hazard (i.e. automated process which eliminates occupational exposure potential), or the substitution of a less hazardous material. If the hazards associated with a specific nanoparticle research project cannot be controlled with elimination or substitution, the following control options should be considered.

Engineering Controls

As previously discussed, the physical form of the nanoparticle will greatly influence the exposure potential. The inhalation exposure risk increases from nanoparticles in a solid matrix to nanoparticles in suspension to aerosolized nanoparticles. Additional factors that will influence the exposure risk include the quantity of material used or generated and the frequency and duration of exposure. Engineering controls that should be considered for use in laboratory scale nanoparticle research projects include source enclosure/isolation and local exhaust ventilation systems. Projects or processes involving the generation of nanoparticle aerosols and nanoparticles in suspension should be performed in a chemical fume hood, externally ducted biological safety cabinet, or glove box to limit the inhalation exposure potential.

Administrative Controls

Administrative controls that should be considered and/or implemented during a laboratory scale nanoparticle research project focus on employee training and proper work procedures. Some administrative controls that should be considered include:

- Providing known information to workers and students on the hazardous properties of the nanomaterial precursors or products;
- Education of workers and students on the safe handling of nanomaterials;
- Restricting access to areas by using signs or placards to identify areas of nanoparticle research;
- Transport dry nanomaterials in closed containers;
- Handle nanoparticles in suspension on disposable bench covers;
- Always perform nanoparticle aerosol generating activities in a fume hood, externally ducted biological safety cabinet, or glove box; and
- Clean the nanomaterial work area daily at a minimum with a HEPA-vacuum or wet wiping method.

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PPE and Laboratory Protection

General PPE recommendations for working with nanomaterials are consistent with PPE recommendations for working with chemicals in the laboratory. PPE recommendations include:

- Wear latex or nitrile gloves when handling nanoparticle powders and nanoparticles in suspension (glove changes should be performed frequently);
- Wear chemical splash goggles when working with nanomaterials in suspension or dry powdered form;
- Wear lab coats. Lab coats should be laundered on a periodic basis. Do not take lab coats home for laundering;
- Wear commercially available arm sleeves in situations where dermal contact with nanoparticles in powder or in suspension are expected;
- Wear closed-toe shoes (if necessary cover shoes with commercially available booties); and
- Consult with REM regarding the use of respiratory protection if an inhalation exposure hazard exists. The need for and selection of an appropriate respirator should be determined by REM in accordance with the University's Respiratory Protection Program.

WASTE DISPOSAL, DECONTAMINATION, AND SPILL PROCEDURES

Waste Disposal Procedures

Since the toxicology and environmental fate of nanoparticles is still largely unknown, all nanoparticle waste (solid material and liquids) should be conservatively managed as hazardous waste. This also includes any debris (i.e. PPE, plastic) that has become heavily contaminated with nanoparticles. All nanoparticle waste must be placed in an appropriate container and labeled. The label should indicate all constituents in the waste using a percent format; nanoparticles can be listed as "trace". To have the waste picked up by REM staff, complete a Hazardous Materials Pickup Request Form. Refer to the Handling and Disposal of Chemicals Guidelines for more information regarding the management of hazardous waste.

Decontamination and Spill Cleanup Procedures

All spills involving nanoparticles should be treated like a hazardous material spill and cleaned up immediately. If the spill presents an emergency situation, evacuate the area and dial 911. If the spill does not present an emergency situation but assistance is needed with cleanup, contact REM at 49-40121. Refer to the Handling and Disposal of Chemicals Guidelines for more information regarding spill cleanup procedures.

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REFERENCES

1. ASTM E2456-06, “Standard Terminology Relating to Nanotechnology.

2. NIOSH [2009]. Approaches to Safe Nanotechnology. Managing the Health and Safety Concerns Associated with Engineered Nanomaterials. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. [www.cdc.gov/niosh/docs/2009-125/].

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