Guidelines for Working with Engineered Nanomaterials

Engineered nanomaterials, 1-100nm in size, are increasingly used in research for a variety of applications. However, as mentioned in NIOSH's *publication General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories*, experimental animal studies indicate that potentially adverse health effects may result from exposure to nanomaterials and that the toxicity of these particles is greater than the toxicity of the same mass of larger particles of similar chemical composition. In addition to particle size, the other properties which are important in understanding the toxic effects of nanomaterials include size distribution, agglomeration state, shape, crystal structure, chemical composition, surface area, surface chemistry, surface charge, and porosity.

Researchers who use engineered nanomaterials in the course of their work may be exposed to these materials through inhalation, dermal contact and/or ingestion, depending on how they are being used and handled. Examples of potential exposures in research include exposures from leaks in equipment which synthesize nanomaterials, from mechanical grinding of bound nanoparticles, during material transfers, the weighing or mixing of dry powders, and during aerosol generating activities of liquid suspensions such as sonification or spraying.

There is still much research needed to understand the impact of nanotechnology on health, but at this time, and in the absence of exposure standards, the limited evidence available suggests caution when potential exposures to nanoparticles may occur. Researchers should follow the handling guidelines listed below to prevent inhalation and dermal exposures.

Selection of Nanomaterials:

Whenever possible, handle nanomaterials in solutions or attached to substrates to minimize airborne release.

Engineering Controls:

- Whenever there is the potential for inhalation exposures, including all handling of dry powders* or if aerosolization of liquid suspensions is possible, use local exhaust ventilation (LEV), which includes:
    - HEPA filtered exhausted enclosure
    - Fume hoods (with HEPA filtered exhaust if possible): Follow good fume hood use practices and work 6" inside the hood, with sash below the chin. Remove arms slowly from hoods to prevent currents which might draw materials outside the hood, and do not block the back baffles.
    - Glove box
    - Biological safety cabinet: following the same practices for fume hood use
- During grinding operations, use glove boxes or other fully enclosed systems to prevent airborne release
- To contain devices or equipment which may release nanoparticles, i.e., tube furnaces and or chemical reaction vessels, use fume hoods or other local exhaust ventilation

*If a balance cannot be located in a fume hood, BSC or HEPA filtered enclosure for weighing powders, tare the weighing bottle with a stopper, add the nanomaterial into the weighing bottle and stopper the bottle inside the fume hood/BSC/exhausted enclosure, then return the bottle to the balance for final weighing.

- When performing maintenance activities, such as cleaning or repairs to equipment used with nanomaterials, use fume hoods or other local exhaust ventilation

Administrative Controls:

- Hygiene:
  - Wash hands frequently, particularly before eating, drinking, or leaving the laboratory, to minimize potential exposure through ingestion and dermal contact.
  - Do not eat or drink, or store food and beverages, where nanomaterials are used or stored since this practice increases the likelihood of exposure by ingestion.
  - Remove gloves when leaving the laboratory.
- Labeling and Signage:
  - Store in a well-sealed container, preferably one that can be opened with minimal agitation of the contents.
  - Label all chemical containers with the identity of the contents; include term "nano" in descriptor (e.g., "nano-zinc oxide particles" rather than just "zinc oxide"). Include hazard warning and chemical concentration information, if known.
  - When leaving operations unattended, post signs to communicate warnings and/or precautions
- Cleaning:
  - Wet wipe all work surfaces regularly.
- Transporting:
  - Transport nanomaterials, within or outside buildings, in sealed secondary containers.
- Safety Equipment:
  - Know the location and proper use of emergency equipment, such as emergency eyewashes and showers, fire extinguishers, and fire alarms.

Personal Protective Equipment:

- At a minimum, nitrile exam style gloves, lab coats, safety glasses, long pants, and closed-toe shoes must be worn. In addition to exam style nitrile gloves, a utility grade glove may be required if the nanomaterial is suspended in liquid. Also, goggles and face shields may be appropriate dependent on the nature of the materials and procedure.
- If it is necessary to wear a respirator, due to a lack of engineering controls or during activities with higher nanomaterials exposure potentials (e.g., emergencies), EHS must be contacted to select the appropriate respirator and provide training and fit testing to the researchers as necessary, in accordance with OSHA regulations.

Training:

- Researchers must complete EHS's "Safety in the Chemical Laboratory" training and lab-specific training relevant to the nanomaterials and associated hazardous chemicals used in the process/experiment. Information on completing the "Safety in the Chemical Laboratory" course can be found at ehs.yale.edu.
- Lab-specific training should include a review of these guidelines, the relevant Safety Data Sheets, and the lab's Standard Operating Procedure for the experiment.

Standard Operating Procedures:

- Prepare a Standard Operating Procedure (SOP) for operations involving nanomaterials. The SOP should be tailored to be specific to the proposed experimental procedure.
- Consider the hazards of the precursor materials in evaluating the process.
- Special consideration should be given to the high reactivity of some nanopowders with regard to potential fire and explosion. [Pritchard 2004].

Disposal:

- Manage all nanomaterial-containing waste as hazardous waste. This includes lab matting and other lab debris. Place in a tightly closed container, label with a hazardous waste label/tag and provide as much information on the nanomaterials as possible (i.e., nano zinc oxide particles).

Spills:

- For spills inside fume hoods or other LEV, follow these procedures:
    - Use wet clean-up methods if possible. A dedicated HEPA vacuum may be used if necessary – Contact EHS
    - Do not dry sweep or use conventional vacuum cleaners
    - Collect spill cleanup materials in a tightly closed container
    - Manage spill cleanup debris as hazardous waste
- For spills outside exhausted enclosures, biosafety cabinets or other filtered exhaust enclosures, contact EHS for assistance at 203-785-3555.