



NANOPARTICLE SAFETY

Purpose

This SOP summarizes current National Institute of Occupational Safety and Health (NIOSH) recommendations regarding potential exposures to nanoparticles in a laboratory setting (materials are handled on a small scale). Additional information is available on the NIOSH website under the term “Nanotechnology” in the A-Z Index. Another excellent source of information on potential hazards of nanomaterials and recommended control practices and strategies is ISO/TR 12885:2018(en), *Nanotechnologies – Health and safety practices in occupational settings*.

NIOSH recommends conducting a risk assessment prior to working with nanoparticles. The risk assessment should consider potential routes of exposure, physical hazards and toxicological data or reasonable assumptions for the specific nanoparticles in use, and task hazards. Risk of exposure should be reduced to the maximum extent practicable through use of engineering controls, administrative controls, and Personal Protective Equipment (PPE). The California Nanosafety Consortium of Higher Education has published a “Nanotoolkit” for “Working Safely with Engineered Nanomaterials in Academic Research Settings.” This publication provides an easy to use tool kit for academic researchers to quickly identify safe handling practices based on whether the work they propose is in a low, moderate, or high potential exposure category. All persons conducting research with engineered nanomaterial are strongly encouraged to review and implement the tool kit. The tool kit can be found online with a simple search or is available from EHS upon request.

Background

Nanoparticles are very small, ranging in size from 1-100 nm. Their very small size imparts unique physical and chemical properties that differ from the parent compound. Research regarding potential health effects of exposure to various nanoparticles is lagging behind growth of nanotechnology. However, several studies present strong evidence that:

- Biological effects of exposure to nanoparticles may be related to particle size, shape, solubility, ability of the particle to bind to biological proteins and receptors, and other factors.
- Nanoparticles have greater physical reactivity than the parent compound, often acting as a catalyst in chemical reactions, and presenting greater fire and explosion risk.

Routes of Exposure

Nanoparticles can be ingested, inhaled (if airborne), and absorbed or injected through the skin. Ingestion can occur with unintentional hand to mouth transfer or larger particles that deposit in

the mouth, nose, or throat which can be swallowed. Inhalation is the route of exposure of greatest concern. Animal studies suggest that inhaled nanoparticles can enter the bloodstream and translocate to other organs. At present, there are no specific occupational exposure limits for nanoparticles.

Higher Risk Tasks

The following workplace tasks can increase the risk of exposure to nanoparticles:

- Working with nanomaterials in liquid media without adequate protection (e.g., gloves).
- Working with nanomaterials in liquid during pouring or mixing operations, or where a high degree of agitation is involved.
- Generating nanoparticles in the gas phase in non-enclosed systems.
- Handling (e.g., weighing, blending, spraying) powders of nanomaterials.
- Maintenance and cleaning of equipment and processes used to produce or fabricate nanomaterials.
- Cleaning-up of spills or handling waste containing nanomaterials.
- Cleaning of dust collection systems used to capture nanoparticles. Machining, sanding, drilling, or other mechanical disruption of materials containing nanoparticles.

Hazard Elimination/Substitution

The first considerations in managing the risk associated with nanoparticles are hazard elimination, followed by substitution with a less hazardous product. In many cases, this will not be possible due to the nature of the work. When the hazard cannot be eliminated then the risk is managed through implementation of feasible engineering and administrative controls, as well as appropriate PPE.

Engineering Controls

The primary engineering control related to nanoparticle work is ventilation to prevent airborne exposures. Feasible ventilation controls must be used to minimize potential exposure to airborne nanoparticles. Other types of controls (administrative and PPE) are not a substitute for engineering controls.

- In general, labs that handle non-encapsulated nanomaterials outside of fully-enclosed systems must have non-recirculating general ventilation systems. Lab pressurization must be negative to the hallway. Lab doors must be kept closed at all times to maintain negative pressurization. This is typical of the design for most laboratory type spaces.
- Activities that are likely to release nanomaterials (e.g., opening sample tubes, needle aspiration of liquids containing nanomaterials, weighing of dry nanomaterials, cleaning of reaction chambers, etc.) should be performed in a glove box, glove bag, fume hood, biosafety cabinet, or other exhausted enclosure. When enclosure in a ventilated device is not feasible, an articulating fume extractor positioned close to the work zone and with sufficient capture velocity may be an acceptable alternative.
- Exhaust gases generated by furnaces, reactors, and similar equipment used to manufacture or process nanoparticles should be captured and directed outside of the building (local ventilation control).

Engineering controls are generally not required for nanomaterials that are encapsulated in a solid, nanocomposite, and surface coated material unless cutting or grinding is conducted.

Safe Work Practices

Appropriate safe work practices must be observed when handling nanomaterials that present risk of exposure.

- Conduct a risk assessment before engaging in work with nanomaterials. Review literature to identify physical characteristics and health hazards prior to handling nanomaterials. Review the work processes to be conducted and equipment to be used to ensure that work can be conducted safely in the intended area of use, with the intended equipment, and appropriate engineering controls (e.g., ventilation, etc.) are available and in working order.
- Observe standard good chemical hygiene practices, including but not limited to the following:
 - ✓ Minimize potentially contaminated areas by confining operations to designated areas of the smallest feasible size.
 - ✓ Do not engage in horseplay.
 - ✓ Keep work areas clean and uncluttered. Dry sweeping or air hoses are prohibited for use when cleaning work areas potentially contaminated with nanomaterials. HEPA vacuums or wet-methods are acceptable, although wet methods are preferred. Clean work areas at the end of each work shift. If using a HEPA vacuum, change the filter within a ventilated enclosure to prevent exposure to nanomaterials. Clean work areas when likely to be contaminated and at the end of each work shift.
 - ✓ Do not eat, drink, smoke, apply cosmetics, chew gum or store food, beverages, tobacco, cosmetics, or medications in laboratory areas. Do not use common glassware or utensils for food and chemical handling.
 - ✓ Do not mouth pipette.
 - ✓ Promptly and thoroughly clean up spills, leaks, and drips. It is recommended to handle solutions containing nanoparticles over disposable bench liners that have an impervious backing or trays to facilitate clean-up.
 - ✓ Avoid underestimation of the risk. Most nanoparticles have not been thoroughly evaluated for toxic effects.
 - ✓ Do not leave potentially dangerous processes unattended.
 - ✓ Handle and store glassware with care. Do not use cracked or chipped glassware. Properly dispose of damaged or broken glassware in broken glass/sharps receptacles, not the trash container. Dispose contaminated needles and other sharps in an appropriate sharps container.
 - ✓ The laboratory must be equipped with hand washing facilities and an emergency eyewash. Always wash hands and other exposed skin areas after removing PPE, prior to exiting the laboratory area, and before eating or drinking.
 - ✓ Notify EHS of suspected exposures. See EHS SOP, ***On-The-Job and Student Injuries***.

- The preferred method for nanoparticle manipulation is in solution. Once in solution, it may be handled on the lab bench using the same precautions as is necessary for other chemical solutions. However, any agitation, sonication, or other aerosol producing technique must be conducted in a ventilated enclosure.
- As appropriate to the characteristics of the nanoparticles in use and tasks conducted, implement additional control measures as warranted, such as use of walk-off mats, enhanced PPE, air curtains, worker decontamination, etc. Sticky mats at exits can help to reduce potential tracking of nanoparticles outside of the laboratory.
- Offices and general-purpose workstations may not be located inside laboratories that handle nanomaterials.
- Consider whether medical screening/monitoring is appropriate relative to the specific nanomaterials in use and exposure potential.

Personal Protective Equipment

Currently there are no generally established guidelines available based on scientific data for the selection of protective clothing or other apparel to protect against exposure to nanomaterials. The following PPE recommendations are consistent with conventional occupational hygiene practices and NIOSH nanotechnology publications and guidance.

- **Short pants/dresses and open-toed shoes are not appropriate laboratory attire.**
- **Lab coats must be worn. Impermeable coats with ribbed cuffs are the best choice.** Lab coats may not be taken to private homes and laundered, and they should not be worn or stored in “clean” areas outside of the lab. Alternatively, disposable lab coats can be used and then discarded when leaving the lab.
- Arm sleeves should be used where high levels of exposure or splashes of solutions containing nanoparticles are anticipated.
- Eye protection appropriate to the tasks performed is required. This may include safety glasses, face shields, and/or chemical splash goggles. Face shields and safety glasses do not provide sufficient protection against unbound, dry materials that could become airborne. In these cases, an inhalation hazard likely exists as well and a full-face respirator will be necessary to provide both eye and respiratory protection.
- Gloves should be worn when handling nanomaterials. Broken skin presents greater potential for exposure. Choose gloves only after considering the resistance of the glove to both the nanomaterial and any associated chemical. Situate the cuff of the glove over the ribbed cuff of the lab coat or other outer protective garment.
- If airborne contaminants cannot be effectively controlled through local ventilation, a full-face respirator may be needed. Persons intending to use a respirator must first be enrolled in UNL’s Respiratory Protection Program.
- Observe good chemical hygiene practices. Wash hands and exposed skin after removing PPE and before leaving the laboratory. Change disposable gloves frequently and when likely to be contaminated (e.g., after cleaning a reaction chamber, etc.).

Spill Management

Strategies used to mitigate and cleanup a nanomaterial spill are similar to those employed for releases of chemicals and biological agents. Primary considerations include preventing exposures and minimizing the impacted area. As with any spill/release, evacuation of the area and notification of response authorities is appropriate if the situation is an imminent hazard.

Wet cleaning methods are preferred to HEPA vacuum methods. For solid/powder nanomaterials, dampen the surface of the spill with a compatible liquid (soap/water, cleaning oil, etc.). Take care to dampen gently to avoid the production of aerosols. Wet wipe the affected area with a disposable cloth/wipe. Repeat cleaning of the area several times using fresh cleaning solutions and wipes. Seal used wipes in a bag to prevent aerosolizing of the nanomaterials upon drying. Dispose of used wipes via EHS. Use the same strategy for liquid materials, except use compatible disposable wipes or absorbent pads to first absorb the liquid.

Appropriate PPE must be worn when cleaning up a spill. Do not use energetic cleaning methods such as dry sweeping or compressed air.

Waste Management Disposal

The following guidance applies to the waste management of any of the following:

- Pure nanomaterials (e.g., carbon nanotubes)
- Items contaminated with nanomaterials (e.g., wipes, pipettes, culture plates, PPE, etc.)
- Liquid suspensions containing nanomaterials
- Solid matrices with nanomaterials that are loosely attached to the surface such that they can reasonably be expected to break free or leach out when in contact with air or water, or when subjected to reasonably foreseeable mechanical forces.

Dispose of nanomaterial liquids, powders, and contaminated papers, wipes, disposable PPE, etc. via EHS. Containerize all waste in double plastic bags that are sealed, or other sturdy, impervious, screw-cap containers. For disposal, clearly label the container to indicate the presence of nanomaterial and follow guidelines in SOP: **Hazardous/Radioactive Material Collection Procedures**.

Consult EHS on proper disposal of nanomaterials embedded in a solid matrix as there may be additional disposal requirements depending on the nature of the embedded material.