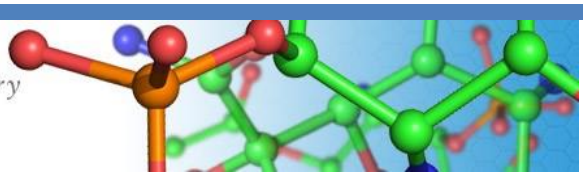
UNM | Department of Chemistry & Chemical Biology



Standard Operating Procedure

Nanoparticles

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 2885:2008(E), Nanotechnologies – Health and safety practices in occupational settings relevant to nanotechnologies. 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).

1.	**This standard operating procedure (SOP) is for a**

☐ Specific laboratory procedure or experiment
Examples: synthesis of chemiluminescent esters, folate functionalization of polymeric micelles

☐ Generic laboratory procedure that covers several chemicals
Examples: distillation, chromatography

☒ Generic use of specific chemical or class of chemicals with similar hazards
Examples: organic azides, mineral acids

2.	**Chemical Description**
	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. It is known that nanomaterials can travel further into the body via inhalation; nanomaterials can penetrate further into the human body if inhaled and even pass into the bloodstream and travel to other organs. Lack of data available on the hazards (human and environmental) posed by nanomaterials are still not fully studied. Nanoparticles may enter the body through three routes: inhalation, absorption and

	ingestion. Some nanomaterials (multi-walled carbon nanotubes - MWCNTs) have shown asbestos-like effects. Toxicological effects are unclear but are a function of: • Surface area • Number of particles • Electrical charge of the particle • Agglomeration of particles • Particle size • Solubility
3.	**Risk assessment**
	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.
4.	**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.
4.a.	Inhalation: Inhalation is the most important exposure route because it is the most concentrated, and produces the strongest effects. Inhaled airborne nanomaterials may deposit in different parts of the lungs. Inhaled nanomaterials may travel to other organs and lymph system via blood stream (also exposure via the olfactory bulb/nerve). Particles less than 5 microns (5000 nm) in size can penetrate deeply into the lungs where some clearance mechanism (cilia) are not present. In addition, smaller particles are likely to stay airborne for a longer period of time
4.b.	Absorption: Fewer studies done on absorption than on inhalation. Studies show different results. It is best to prevent eye and skin exposure.

4.c.	Ingestion: May occur after inhalation exposure when mucus is brought up the respiratory tract and swallowed. Poor work practice can result in hand-to-mouth transfer (e.g. eating or smoking in the work area). Ingested nanoparticles do translocate to other organs. Effects from nanomaterials testing: • Cancers, including mesothelioma • Rapid and persistent pulmonary fibrosis • Cardiovascular dysfunction • Transfer to different organs (e.g. the brain, heart, liver, intestine, lymph system) – via the olfactory nerve into the brain, via the lungs, via the skin • Affect cells: their shape and structure, damage cell membranes • Irritation responses (e.g. respiratory problems) • DNA and liver damage The risks to be assessed under EU chemicals-related occupational health and safety legislation, and some risk factors related to hazardous chemicals In red are the risk factors that need to be given particular attention when doing a risk assessment of the nanomaterials in the workplace

Risk	Some risk factors
Risks due to inhalation of the agent	• Toxicity of the nanomaterial • Physicochemical characteristics of the nanomaterial • Environmental concentration • Exposure time • Particularly sensitive workers • Inappropriate selection and/or use of RPE
Risks due to absorption through the skin	• Location and extent of the contact with the skin • Toxicity of the nanomaterial via the skin • Duration and frequency of contact • Particularly sensitive workers • Inappropriate selection and/or use of RPE
Risks due to contact with the skin or eyes	• Inappropriate selection and/or use of RPE • Inappropriate work procedure • Incorrect transfer procedure
Risks due to ingestion	• Toxicity of the nanomaterial • Potential toxicity of the nanomaterial • Incorrect personal hygiene habits • Possibility of eating, drinking or smoking in the workplace • Particularly sensitive workers
Risks of fire and/or explosion	• Physical state (ultrafine dust) • Pressure/temperature • Flammability/calorific value • Airborne concentration • Sources of ignition
Risks due to hazardous chemical reactions	• Chemical reactivity and instability of hazardous chemical agents • Inadequate cooling systems • Unreliable system for controlling key variables in the reaction (pressure, temperature and flow control)
Risks arising from installations which may have consequences on the health and safety of workers	• Corrosion of materials and installations • Deficient or non-existent facilities for controlling leaks and spills (retaining trays, protection against mechanical impacts) • Deficient or non-existent preventive maintenance

5. **Safety equipment**

5.a. 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 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 manufacturer 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.
5.b.	<u>Safe Work Practices:</u> 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. ➢ 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 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 processes unattended. ➢ 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. • Observe good chemical hygiene practices including hand washing, change of potentially contaminated gloves, and proper PPE removal.
5.c.	Personal Protection Equipment (PPE): **All PPE should be inspected for wear, cracks or tears** • Currently there are no generally acceptable 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. ➢ N95 have been recommended effective with respiratory protection with nanoparticles. This is a minimum level of protection. Air purification mask with particle filters may be used as well. All respiratory protection must be cleared medically, trained, and fit tested annually. ➢ Standard lab attire are required (e.g., long sleeved shirts, lab coats, long pants, and closed toed shoes) ➢ Long hair must be tied back ➢ Chemical goggles ➢ Chemically compatible gloves

5.d.	**Designated area**
	• Emergency Showers and Eyewashes: Any laboratory using nanoparticles must have an emergency eyewash station accessible within 10 seconds and located in the same room the hazard is being used. Emergency showers must be accessible within 10 seconds and can be located within the room or in the hall way. • Nanoparticles must be used in a Fume Hoods, marked with proper signage to warn others of the possible risk for contamination and exposure. Ensure that fume hood is working properly and have current certification (within last 12 months). Work areas should be cleaned and decontaminated routinely. • Fire Extinguisher ➢ A Class ABC fire extinguisher must be available within 10 seconds travel time from where Nanoparticles chemicals are used. ➢ If a Class ABC sand may be used for small fires • DO NOT attempt to extinguish large fires or if you are not comfortable to extinguish fires
5.e.	**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.
6.	**Transport, and storage, receiving requirements**
	• Avoid dust formation and control ignition sources. • Use proper PPEs, moving carts and precautions. • Store containers on shelves below eye level

7.	**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. • NEVER WORK ALONE
8.	**First Aid**
	• <u>Eye:</u> o **Rapid and immediate decontamination is critical.** o Flush with copious amounts of water for at least 15 minutes, lifting eyelids occasionally. o Remove contact lenses if easily removable without additional trauma to the eye. Do not interrupt flushing. o Get medical attention immediately. o Tell the lab PI and Teri Anderson (505-362-7833) o Provide the, medical treatment guide, SOP and SDS to emergency responders • <u>Inhalation</u> o In the event an accidental release of the nanoparticles occurs: ▪ Avoid breathing the dust ▪ Use gloves to clean up the spilled material ▪ Use wet methods (damp paper towel or other material) to collect the spill ▪ Avoid creating a dust ▪ Alert others in lab and evacuate area for those not protected by respirator

- Responder should immediately help victim to fresh air if it is safe to do so
- Call 911 and tell them you have a Nanoparticle exposure
- Tell the lab PI and Teri Anderson (362-7833)
- Provide the, medical treatment guide, SOP and SDS to emergency responders

- Ingestion:
  - Do not induce vomiting.
  - Call 911and tell them you have a nanoparticle exposure and give your exact location
  - Tell the lab PI and Teri Anderson (505- 362-7833)
  - Provide the, medical treatment guide, SOP and SDS to emergency responders
- Skin Contact:
  - If skin contact occurs, immediately drench in the safety shower with copious amounts of water for at least 15 minutes.
  - If possible to do so without further injury, remove any remaining jewelry or clothing.
  - Call 911 and tell them you have been exposed to nanoparticles and give your exact location
  - Tell the lab PI and Teri Anderson (505-362-7833)
  - Provide the, medical treatment guide, SOP and SDS to emergency responders
- Administer first aid as appropriate.
  - Alert people in the vicinity
  - Remain nearby to advise emergency responders.
  - Contact EHS, UNM Police, PI, and Chemical Safety Coordinator.
- **For any exposure**,
  - Double-bag contaminated clothing and personal belongings.
  - Get medical attention.
  - Even if the exposure is small, it is still important to be evaluated by a medical professional to determine if follow-up treatment is necessary.

9.	**Emergency procedures**

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.

- **Small liquid spills (<50 ml)**
  - If you do not feel comfortable cleaning up the spill, call Teri or EHS for help (never put yourself at risk!)

	○ Wear appropriate PPE (i.e., double gloves, lab coat, face shield and goggles). ○ Spills may only be cleaned with a spill kit and compatible wetting agent ○ Pick up (use plastic scoops) ○ Place in a sealed container for proper disposal as hazardous waste. Do not dump down the drain or into the trash. • If the spilled material is heated or is greater than 50 ml ○ Remove ignition sources ○ Evacuate the laboratory ○ Close the doors ○ Call Teri (505-362-7833) or Bobby (505-604-6102) or EHS (505-277-2753 or [afterhours] 505-951-0194) or UNM Police at 505-277-2241 or dial 911. • **Dry spills** ○ If you do not feel comfortable cleaning up the spill, call Teri for help (never put yourself at risk!) ○ Clean up spills in a manner that does not disperse, i.e., (preferably) wet method or HEPA ○ Reduce airborne dust and prevent scattering by moistening with water-do not flood ○ Pick up spill (use non-sparking equipment; do not use combustible materials such as corn whisks or brooms) ○ Place in a sealed container for proper disposal as hazardous waste. Do not dump down the drain or into a waste basket.
10.	**Waste disposal** *Identify amounts of waste anticipated and appropriate disposal procedures. Segregate waste by hazard class (for example, flammable, corrosive) and state (solid, liquid), label appropriately, and place in the laboratory's hazardous waste cabinet.*
	• **<u>Disposal of Nanoparticle solid contaminated material</u>** ○ Pipet tips, gloves and other contaminated debris should be collected as hazardous waste. ○ Bags are ok for dry solids, as long as the bags are sealed closed and labeled properly and there are no free-flowing liquids. ○ Sharps (needles) must go in puncture-resistant containers. ○ Do not place dry solids contaminated with chemicals in red or orange biohaz bags. • **<u>Disposal of and waste containing Nanoparticle acid</u>** ○ Nanoparticle compounds in manufacture's label may be disposed of as hazardous waste ▪ Containers must be in good condition or bagged to prevent spillage

- Lids must fit and be closed when not in use or for pick up
  - If Nanoparticles are part of a mixture may be disposed of as hazardous waste
    - Containers must be compatible with the mixture of waste
    - Containers must be in good condition
    - Containers must remain closed when not in use and for pick up
    - All secondary containers for waste must be labeled with the:
      - Hazardous Waste Label
      - Listing of Contents of the waste
      - Hazards of the mixture (EHS labels have boxes to check for these for ease of use)
- Fill out the Waste Pickup Request located at https://ehs.unm.edu/waste-management/index.html

Waste label templates are located at https://ehs.unm.edu/waste-management/index.html

11. **Training requirements**

List the general and laboratory-specific training required

☒ Hazard Communication
☒ Hazardous Waste Management
☐ Glove Box Training
☒ Basic Safety Training
☒ Other: _____Nanoparticle Training_____

Additional training requirements

List additional, local training requirements.

12. **Approval**

Standard operating procedures must be approved by the laboratory manager and directorate safety coordinator.

Laboratory manager *(name, signature, date)*: _____

Directorate safety coordinator *(name, signature, date)*: _____

Additional approvals

List subject matter experts consulted for approval:

Person consulted

Person consulted

Additional prior approvals required

List any tasks that require prior approval by the principal investigator or laboratory manager (for example, use of restricted chemicals and other higher hazard chemicals and running of higher hazard operations):

Task requiring prior approval

Task requiring prior approval