# University of Arizona

## Nanomaterials Standard Operating Procedure

*[This is a template. Fill in all necessary blanks and delete all highlighted areas when complete. Add any sections necessary for your laboratory. This will be appended to your Laboratory Chemical Hygiene Plan.]*

**Title:**  **Click here to enter the title of your SOP.**

**Approval Holder (AH):** Click here to enter text **Approval #:** Click here to enter text

**Approval Holder Phone Number(s):** Click here to enter text

**Approval Safety Coordinator (ASC):** Click here to enter text

**Approval Safety Coordinator Phone Number(s):** Click here to enter text

**Department:** Click here to enter text

1. **Purpose**

This standard operating procedure (SOP) is intended to provide guidance on how to safely store, handle, use, and dispose of nanomaterials in Enter AH’s name’s laboratory. Laboratory personnel should review this SOP, as well as the appropriate Safety Data Sheet(s) (SDSs), before Describe the procedure or process this SOP will address. If you have questions concerning the requirements within this SOP, contact your Approval Holder (AH) or Approval Safety Coordinator (ASC).

1. **Scope**

*[Describe when this SOP applies and to whom this SOP applies.]*

1. **Hazard Description**

*[Describe the hazards presented by the procedure or process this SOP addresses. What makes it hazardous? Provide an example, if applicable.]*



Nanomaterials or nanoparticles are defined as materials with at least one external dimension in the size range from approximately one to 100 nanometers. Nanoparticles are objects with all three external dimensions at the nanoscale. Nanoparticles that are naturally occurring (e.g., volcanic ash or soot from forest fires) or are the incidental byproducts of combustion processes (e.g. welding, diesel engines) are usually physically and chemically heterogeneous, and are often termed ultrafine particles.

Engineered nanoparticles are intentionally produced and designed with very specific properties related to shape, size, surface properties, and chemistry. These properties are reflected in aerosols, colloids, or powders. Often, the behavior of nanomaterials may depend more on surface area than particle composition itself. Relative surface area is one of the principal factors that enhance reactivity, strength, and electrical properties.

Engineered nanoparticles may be bought from commercial vendors or generated via experimental procedures by lab researchers. Examples of engineered nanomaterials include fullerenes, carbon nanotubes, metal or metal oxide nanoparticles (e.g., gold or titanium dioxide), and quantum dots, among many others. Be aware that toxicity of nanomaterials may be greater than for the parent material, and that their greater surface area may make nanomaterials more flammable, explosive, or reactive than larger particles of the same composition. The risks of fire/explosion/reaction increase with the amount of nanomaterial.

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 1.0 micrograms per cubic meter (μg/m3) 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/m3) REL. By contrast, NIOSH’s REL for fine-sized TiO2 (particle size greater than 100 nm) is 2.4 mg/m3.
1. **Process & Hazard Controls**

*[Describe the steps needed to set up and complete the procedure or process in safe manner following the* [*hierarchy of controls*](https://www.cdc.gov/niosh/topics/hierarchy/default.html)*. Use as much detail as is necessary to ensure all laboratory workers can complete the procedure or experiment safely.]*

* 1. **Elimination/Substitution**
* Substitute by using a different form of nanomaterial such as a liquid vs a powder.

*[Describe any eliminations of hazardous chemicals or processes; alternatively, any substitutions with less hazardous alternatives that could be used to accomplish the task.]*

* 1. **Engineering Controls**

*[Describe any engineering controls (e.g. fume hoods, gas cabinets, local exhausts, blast shields, etc.) that are used to safely accomplish the task.]*

Every effort should be made to avoid releasing nanomaterials into the air. Since they can remain suspended for an extended period of time, any release poses a hazard to anyone entering the laboratory.

Perform all work with nanomaterials inside an enclosure such as a glove box, glove bag, or an enclosure made especially for nanomaterial or dry powder use. These enclosures are designed to operate at a much lower airflow than conventional fume hoods. Some nanomaterials, carbon nanotubes in particular, are difficult to handle in a chemical fume hood because the air flow is often too high to contain the material inside its container and can release back into the work area. Even fume hoods that are effective at containing bulk material may fail to contain nanomaterials, posing a risk to laboratory workers.

Any enclosure that vents into the room (such as a laminar flow hood or biosafety cabinet) or through the ventilation system must be equipped with a HEPA or ULPA filter. Work with RLSS and Facilities Management to develop a procedure for changing the filter without releasing nanomaterials into the room air such as a bag-in/bag-out technique.

* Dry Powder Nanomaterials:
	+ Chemical fume hood, glove box, nanomaterial handling enclosures, ventilated bagging or dumping stations and high efficiency particulate air (HEPA)- filtered local exhaust ventilation.
* Suspended in Liquids:
	+ Chemical fume hood, glove box, nanomaterial handling enclosure, local exhaust ventilation and ventilated spray booths.
* Physically bound/encapsulated:
	+ Chemical fume hood, glove box, local exhaust ventilation, downdraft table, wet cutting/machining, ventilated tool shroud and blasting cabinets.
	1. **Work Practices**

*[Describe any work practices (e.g. staggering schedules, additional cleaning measures for particulates, etc.) that are used to safely accomplish the task.]*

* When working with dry powders, sticky floor mats can help reduce the levels of nanomaterials in the air. Avoid contact with skin, eyes, and clothing. Wash hands before breaks and immediately after handling the product.
* Always wet-wipe areas where dry nanomaterials are used. Collect them in a double plastic garbage bags (clear), tape shut, affix with a completed waste card, and dispose as hazardous waste through Risk Management Services hazardous waste.
	1. **Personal Protective Equipment**

*[Describe the personal protective equipment needed to adequately protect laboratory workers when performing the process or procedure addressed by this SOP. Ensure to specify any personal protective equipment beyond the minimum (i.e. safety glasses, lab coat, gloves, long pants and closed-toed shoes).]*

* **Hand and Arm Protection**: Elbow-length, acid resistant gloves should always be used when creating, working with, or cleaning up aqua regia solutions.
* **Face and Eye Protection**: Safety goggles are a minimum protection; the use of a face shield with eye protection is strongly recommended to protect both the eyes and face from splashes.
* **Body Protection**: A 100% cotton lab coat should be used and can be combined with an acid resistant apron to prevent exposure to the body.
* **Respiratory Protection**: All respiratory protection requires RLSS assessment and approval; for exposures that require respiratory protection, contact RLSS at rlss-chem-support@arizona.edu.
	1. **Transportation and Storage**

*[Describe how to safely transport and/or store (e.g. ventilated cabinet, flammable cabinet, under inert blanket, etc.) the hazardous chemical(s) or processes.]*

* **Storage**
	+ Store all nanomaterial in well-sealed containers. Label the container with the chemical identity of the material and add the term “nano.”
* **Disposal**
	+ Collect nanomaterials in such a way that any powders will not escape and expose RMS staff during removal.
		- Bags with nanomaterials or contaminated items should be taped shut.
		- Waste buckets must be well sealed and marked.
		- Contact RLSS for additional measures, dependent upon the form and type of nanomaterials.
1. **Spills, Cleanup & Disposal**

*[Describe how to safely end the procedure or process, clean up the process or spills, and/or dispose of any waste generated.]*

Spill response should always follow the [University Chemical Hygiene Plan](https://rgw.arizona.edu/sites/default/files/cs-univeristy_chemical_hygiene_plan.pdf) Section 8.2. Do NOT attempt to clean spills of dry nanomaterials without respiratory protection (approved by RLSS).

**Exposure Response**

|  |  |  |  |
| --- | --- | --- | --- |
| **Inhalation** | **Ingestion** | **Skin Contact** | **Eye Contact** |
| May irritate the respiratory tract.  Conscious persons should be assisted to an area with fresh, uncontaminated air.  Seek medical attention in the event of respiratory irritation, cough, or tightness in the chest.  Symptoms may be delayed. | Rinse mouth. Do not induce vomiting. Seek medical attention immediately. | May cause skin burns.  Flush the skin with copious amounts of water for at least 15 minutes.  Seek medical attention immediately. | Aqua Regia is corrosive and irritating to the eyes.  Flush contaminated eye(s) immediately with copious quantities of water for at least 15 minutes.  Seek medical attention immediately. |

1. **Enter Additional Section Title**

*[Add as many sections as necessary to adequately describe how to safely perform the procedure or process addressed by this SOP.]*

The greatest risk of exposure is through inhalation of airborne nanomaterials. The amount of material released depends on the type of nanomaterial and how it is being manipulated.  The following table lists three common preparation techniques for nanomaterials and their potential for release of nanoparticles into the air:

|  |  |  |
| --- | --- | --- |
| **Form** | **Risk for release into air** | **Potential routes for Inhalation Exposure** |
| **Nanomaterial embedded into a solid matrix or tightly bound to a surface** | low | Mechanically working on the material such as cutting, sanding, drilling. |
| **Suspensions** | Moderate | Formation of aerosols through agitation such as sonicating, stirring, centrifuging of open containers holding suspensions |
| **Dry powder** | High | Any open handling of powder |

Once nanomaterials are released into the air, they can remain suspended for days or even weeks.

Exposure to nanomaterials can also occur through dermal contact, particularly damaged skin. There is evidence to support that nanomaterials can penetrate intact skin. Quantum dots in particular have been shown to penetrate intact skin. Follow the Safe Handling practices below to limit the risk of dermal exposure.

Exposure to nanomaterials through ingestion is unlikely but is possible. Ingestion can occur after inhalation, or through poor laboratory hygiene practices. There is evidence to support that nanomaterials can translocate to organs throughout the body after ingestion.

1. **References:**
* <https://www.osha.gov/sites/default/files/publications/OSHA_FS-3634.pdf>
* <http://www.cein.ucla.edu/p155.php?pageID=366>
* <https://www.cdc.gov/niosh/docs/2012-147/>
* <https://www.nano.gov>
* <https://www.cdc.gov/niosh/topics/nanotech/pubs.html>
* https://ehs.stanford.edu/subtopic/nanomaterials