UF Environmental Health and Safety
UNIVERSITY of FLORIDA

Nanoparticle Safety Guidance

OBJECTIVE:

This guidance document is intended for all University of Florida personnel that create, use, or are exposed to nanoparticles.

This guidance document excludes nanoparticles generated as part of 3D printing. For additional information regarding nanoparticles and 3D printers, see the UF 3D printer policy.

RESPONSIBILITIES:

Environmental Health and Safety

- Development and periodic review of this guidance document.
- Provide consultation, upon request, to assist labs and research centers with implementing policies regarding the use of nanoparticles in research.

Principal Investigators/Supervisors

- Writing and implementing specific safety protocols to be followed by all employees in their research space based on the guidance provided in this document.
- Provide or assign safety training to employees and students who may be exposed to nanoparticles as a part of their employment.
- Provide the required personal protective equipment (PPE) to employees and ensure that it is used properly.

Employees and Students

- Complying with the safety procedures outlined **in this document** as well as the safety procedures established by the PIs and/or supervisors.
- Completing any training related to nanoparticle use as assigned by their PIs, supervisors, facility directors, and/or EH&S.
- Wearing the necessary PPE as identified in the safety procedures.

INTRODUCTION:

Nano-objects are any materials that have at least one dimension (length, width, height and/or diameter) between 1 to 100 nanometers (nm). Nanoparticles refers to material in which at least two dimensions measure between 1-100 nm. Nanoparticles may be dry particles, suspended in a gas (as a nanoaerosol), suspended in a liquid (as a nanocolloid or nanohydrosol) or embedded in a matrix (as a nanocomposite).

Nanoparticles suspended in gas pose the greatest risk due to the nature of gas and containment challenges. Nanoparticles in dry powder present the second highest risk due to the danger of inhalation and skin exposure. Nanoparticles within a liquid pose a lower risk though they increase the danger of skin exposure without adequate protection. Nanoparticles embedded in a matrix present the lowest risk due to their physical form although this can be highly dependent on the nature of the nanoparticles, such as nanoparticles with immunological properties.

There are many unknowns regarding the health risks posed by working with nanoparticles. Factors that influence health risks following exposure include:

- Magnitude and duration of the exposure
- Persistence of the material in the body

- Inherent toxicity of the material
- Susceptibility/health status of the person

Nanoparticle toxicity depends on the physical and chemical characteristics of the specific nanoparticle, including size, shape, surface charge, stability and chemical composition of the core and shell. Toxic effects attributed to nanoparticles include thrombosis due to platelet aggregation, inflammation of the respiratory tract, neurodegenerative disorders, stroke, and myocardial infarction.

ROUTES OF EXPOSURE:

Inhalation

Inhalation is the most common route of exposure to nanoparticles. Inhaled nanoparticles can be deposited in the lungs to greater extents than larger particles and can enter the bloodstream and translocate to other organs and tissues, including the brain, heart, liver, kidneys, spleen, bone marrow and nervous system. Nanoparticles suspended in a gas and dry nanoparticles present the greatest risk of inhalational exposure.

Ingestion

Nanoparticles may enter the gastrointestinal tract via ingestion. Ingestion may occur from unintentional hand-to-mouth transfer of materials. Once ingested, nanoparticles may be absorbed and transported to distant sites via the circulatory system.

Skin absorption

In some cases, nanoparticles have been shown to migrate through skin and circulate through the body. If the particle is carcinogenic or allergenic, even minute quantities may pose a health risk. Skin absorption is most likely to occur during handling of liquid suspensions of nanoparticles or dry powders.

Injection

Exposure by accidental injection (skin puncture) is also a potential route of exposure, especially when working with needles and other sharp objects or animals.

HAZARD IDENTIFICATION AND CONTROL MEASURES:

Prior to working with nanoparticles, a hazard assessment must be performed by the staff conducting the work. EH&S is available to assist with risk assessments upon request. The assessment must take into consideration the unique physical and chemical properties of the nanoparticle (which may not be of relevance to larger particles of the same material), the process by which the nanoparticle will be generated and/or used, and the availability of existing engineering controls (fume hood, glove box, biosafety cabinet, etc.). Additional administrative controls and PPE may be required if engineering controls are not suitable or available to contain/isolate the hazard.

Engineering Controls

Use exhausted enclosures (fume hoods, certified Class II biosafety cabinets, glove boxes or local capture exhaust hoods) for any work that may produce aerosols. Work at least 6 inches from the hood face/sash. To prevent disrupting air flow, keep fume hoods/BSCs free of excess materials (bring in only items required for the work being done) and avoid making fast/abrupt motions. Manipulations that may create aerosols include:

- Handling powders, weighing, mixing, preparing solutions.
- Synthesis of nanoparticles.
- Agitation of nanoparticle-containing liquids (pouring, mixing, shaking).

- Mechanical disruption of solids containing nanoparticles (cutting, grinding, etc.).
- Creating nanoparticles in gas phase.

Administrative Controls

- Review safety data sheets (SDS) for information regarding the nanoparticle(s) if they are available.
- Replace nanoparticles with less hazardous materials or use nanoparticles suspended in a liquid or embedded in a matrix whenever possible.
- Develop and implement written standard operating procedures (SOPs) for preparation and administration of specific nanoparticles. The SOPs must specify required engineering controls and PPE to be used.
- The PI or area supervisor must ensure that staff receive appropriate training, including specific nanoparticle-related health and safety risks, SOPs and steps to be taken in the event of an exposure, prior to allowing them to conduct work with nanoparticles.

Work Practices

- Use needle safe devices and injection techniques. Place needles and other sharp objects used with nanoparticles into a sharps container immediately following use. Do not bend, shear, or recap needles.
- Do not store or consume food or beverages in areas where nanoparticles are handled, processed, or stored to minimize exposure via ingestion.
- Wash hands frequently and thoroughly when working with nanoparticles to minimize exposure through ingestion or skin absorption. Always wash hands prior to eating or drinking after working with nanoparticles.
- Clean work surfaces upon completion of work using wet wiping methods or a HEPA-filtered vacuum cleaner.
- Label all containers with nanoparticles so that it is readily known that a nanoparticle hazard exists, i.e., carbon-based nanoparticles, gold nanoparticles, polymeric nanoparticles.
- Place nanoparticles in a labeled and sealed container, later placed inside a sealed secondary container for transport between rooms or buildings. Whenever possible, bind nanoparticles into a solid or liquid form prior to transport.

Personal Protective Equipment (PPE)

- Protective gloves - selection will depend on the chemicals being used for the procedure. Double-gloving may be required when working with specific nanoparticles. Reference the SDS and consult with EH&S as needed.
- Laboratory coat/disposable gown to provide coverage of street clothing and exposed skin.
- Eye protection – safety glasses. Tight fitting goggles must be used if engineering controls are not adequate.
- Respiratory protection – required if engineering controls are not adequate/available and a potential aerosol exposure exists. Contact EH&S for additional information regarding respirator use.

SPILL/EXPOSURE RESPONSE:

It is highly encouraged to have a nanoparticle spill kit in all spaces where nanoparticle research takes place. This kit should contain gloves, appropriate respirators (requires fit testing) such as N100/R100/P100, absorbent material, wet wipes and/or HEPA-filtered vacuum, sealable plastic bags, walk-off mat (i.e., sticky mat), and barricade tape.

Spills involving nanoparticles must be cleaned up immediately. Evacuate the laboratory and cordon off the area of the spill using barricade tape. Use wet cleanup methods or a HEPA-filtered vacuum cleaner. **Do not dry sweep or use conventional vacuum cleaners**. Collect spill cleanup materials in plastic bags, seal bags when finished, then deposit in a secondary bag which should also be sealed and wet wiped when finished. Dispose of as indicated in the next section.

Once spills have been cleaned up by trained staff, the incident must be reported to EH&S using the Injury/Incident Report Form. For large spills or those involving extremely hazardous nanoparticles, close off the lab space and contact UF EH&S Hazardous Waste Management at (352) 392-1591.

Exposures should be reported to EH&S using the Injury/Incident Report Form. Exposures should also be reported to AmeriSys (800-455-2079) to obtain authorization for any medical treatment required.

WASTE DISPOSAL:

Nanoparticles are potentially hazardous materials and should be handled and disposed of cautiously. Nanoparticle waste is NOT automatically regulated by the EPA as hazardous waste. To ensure proper management and disposal of nanoparticle related waste, a hazardous waste determination must be performed (contact EH&S HWM for assistance). If the nanoparticle material or associated chemicals meet the definition of hazardous waste, they must be packaged and labeled following standard EH&S Hazardous Waste management requirements. If nanoparticle waste is not EPA hazardous waste, it must be incinerated. Regardless of status, the following waste handling practices must be followed:

1) All waste substances/solutions/lab consumables that have been used in nanoparticle research must be deposited in a sealed container and double bagged.
2) All nanoparticle waste containers and/or bags must be wet wiped prior to disposal.
3) Needles and other sharp objects should be placed in a sharps container and disposed of as biomedical waste.

Never leave containers unsealed, unlabeled, and/or dump down the drain.

Equipment used with nanoparticles must be appropriately cleaned prior to being moved, disposed of, or repaired. The EH&S Equipment Decontamination Form must be submitted and approved to move, dispose, or repair such equipment.

NANOPARTICLE USE IN ANIMALS:

In addition to following all requirements listed in this guidance document, additional considerations for nanoparticle use in animals must be taken into consideration.

- Administration of nanoparticles to animals via injection can be done on a bench top. Animals must be restrained and/or sedated. Bench top must be covered with a plastic-backed absorbent bench paper during administration. Work surfaces must be thoroughly cleaned after dosing.
- If animals are exposed to nanoparticles via aerosol inhalation, a risk assessment must be conducted in conjunction with EH&S in advance.

- Cages should be opened, and animals handled only in an exhausted enclosure. If an animal transfer station (ATS) is used, an N100/R100/P100 or equivalent respirator must be worn in addition to standard PPE (gloves, lab coat/gown, safety goggles).
- The first cage change should occur no sooner than 72 hours after dosing. Cage waste disposal requirements for initial and subsequent cage changes should follow waste determination process as outlined above in consultation with EHS HWM.

RESOURCES:

3D Printer Policy – University of Florida EH&S

https://www.ehs.ufl.edu/about/policies/3d-printer-policy/

Approach to Nanomaterial ES&H

https://science.osti.gov/-/media/bes/pdf/doe_nsrc_approach_to_nanomaterial_esh.pdf

Guidance for Handling and Use of Nanomaterials at the Workplace

https://pubmed.ncbi.nlm.nih.gov/19755453/

Guidelines for Safety during Nanomaterials Research

https://www.ehs.washington.edu/system/files/resources/nanosafeguide.pdf

Interim Best Practices for Working with Nanoparticles Center for High-Rate Nanomanufacturing
http://eprints.internano.org/34/1/Best_Practices_for_Working_with_Nanoparticles_Version_1.pdf

Nanomaterials Safety Implementation Plan

https://www-group.slac.stanford.edu/esh/eshmanual/references/chemsafetyPlanNano.pdf

Nanoparticles Safety Guide

https://www.uth.edu/dotAsset/c6d9a7b4-bdc9-424b-b849-bd6cbadcc398.pdf

Nanotechnology Safety

https://ehs.unc.edu/lab/nano/

Respiratory Protection for Nanoparticles

https://blogs.cdc.gov/niosh-science-blog/2011/12/07/resp-nano/

Sukhanova A, Bozrova S, Sokolov P, Berestovoy M, Karaulov A, Nabiev I. Dependence of Nanoparticle Toxicity on Their Physical and Chemical Properties. *Nanoscale Res Lett*. 2018;13(1):44. Published 2018 Feb 7. doi:10.1186/s11671-018-2457-x