

Safe Use of Nanoparticles – Standard Operating Procedure

Augusta University - Environmental Health and Safety Division

PURPOSE

To provide health and safety guidance to faculty, staff, students and visitors working with nanomaterials at Augusta University.

REASON FOR PROCEDURE

To provide a framework for anticipating, recognizing, evaluating and controlling the potential hazards associated with nanotechnology; however, the procedure is not intended to provide stand-alone guidance, it should be used in conjunction with consultation with the appropriate safety offices (Biological, Chemical, Radiation and Industrial Hygiene) depending on the nature of the nanomaterials used.

There are many unknowns as to whether the unique properties of engineered nanomaterials pose health concerns. The potential health and safety risk following exposure to a substance is generally associated with the following:

- Magnitude and duration of the exposure;
- Persistence of the material in the body;
- Fire and/or explosion;
- Inherent toxicity of the material; and
- Susceptibility or health status of the person.

There are limited data regarding the health and safety risks related to nanomaterials. As such, this document is to provide recommendations for practicing prudent health and safety measures when working with nanomaterials. EHS recognizes the limitation of creating a set of procedures that will cover all situations. Consult with EHS prior to project initiation.

AFFECTED STAKEHOLDER AND ORGANIZATION(S)

All Augusta University organizational elements, as well as faculty, staff, and students.

DEFINITIONS

Nanoparticle – A substance with dimensions less than 100 nanometers in size.

Nanotechnology – The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.

Nanotubes - A sheet of graphene rolled up into a seamless cylinder with a diameter on the order of a nanometer.

INTRODUCTION

Nanotechnology involves the manipulation of matter at nanometer scales to produce new materials, structures, and devices. Nano-objects are materials that have at least one dimension (e.g., length, width, height, and/or diameter) that is between 1 and 100 nanometers. A nanometer, or nm, is 1×10^{-9} meters or one millionth of a millimeter or a billionth of a meter. The term nanoparticles typically refer to materials in which all three dimensions are in the nanoscale. In this document, the term nanoparticles or nanomaterials will refer to purposefully created, engineered particles with at least one dimension between 1 and 100 nanometers.

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 also exist in several structures, such as nanotubes, nanoplates, and nanofibers.

EXPOSURE RISKS

The most common route of exposure to a nanomaterial is through inhalation. The deposition of discrete nanomaterials in the respiratory tract is determined by the particle's aerodynamic or thermodynamic diameter. Particles that are capable of being deposited in the gas exchange region of the lungs are considered respirable particles. Discrete nanomaterials are deposited in the lungs to a greater extent than larger respirable particles. Deposition increases with exertion (due to an increase in breathing rate and change from nasal to mouth breathing). It also increases among persons with existing lung diseases or conditions. Based on animal studies, discrete nanomaterials may enter the bloodstream from the lungs and translocate to other organs.

Ingestion is another route whereby nanomaterials may enter the body. Ingestion can occur from unintentional hand-to-mouth transfer of materials. This can occur with traditional materials and it is scientifically reasonable to assume that it could happen during handling of materials that contain nanomaterials. Ingestion may also accompany inhalation exposure because particles that are cleared from the respiratory tract via the mucociliary escalator may be swallowed.

A few studies suggest that nanomaterials may enter the body through the skin during exposure.

PROCESS & PROCEDURES

1. **Engineering Controls.** The following engineering controls should be used when handling nanomaterials:
 - a. Use of a chemical fume hood or a ducted biosafety cabinet is required for all tasks with potential of aerosolizing nanomaterials in either liquid or powder form (i.e. vortexing, sonicating, pipetting, weighing).
 - b. If heavy usage of aerosolized nanoparticles is in use, a proper decontamination, or buffer, area should be utilized to ensure the nanomaterials are not transported outside of the working area, such as the anteroom area in the BSL2+ facility.
 - c. Safety caps or sealed rotors will need to be used for centrifuging nanomaterials. The buckets and/or tubes will need to be opened only in a chemical fume hood or a ducted biosafety cabinet.
 - d. Hand washing facilities shall be available.
 - e. Laboratories and other spaces where nanomaterials are used or stored must be equipped with an eyewash station.
2. **Administrative Controls.** All work involving nanomaterials requires approval from the appropriate safety committee (Biological, Chemical and Radiation) depending on the nature of the nanomaterials. The PI will need to ensure that he/she:
 - a. Has an Institutional Chemical Safety Committee (ICC) number
 - b. Has listed the nanomaterials on their chemical inventory
 - c. *If the nanomaterials involve biological hazards*, that they are listed on a Biosafety Protocol Application or Amendment.
 - d. *If the nanomaterials involve radiation hazards*, that they are listed on a Radiation Safety Protocol Application or Amendment.
 - e. Has a written set of Standard Operating Procedures indicating the safety measures that will be employed to address the risks of working with nanomaterials.
 - f. Laboratory personnel shall receive the appropriate training, including specific nanomaterial-related health and safety risks, standard operating procedures, and steps to be taken in event of an exposure incident, prior to working with nanomaterials.
 - g. The laboratory where the nanomaterials will be used will need to be inspected by EHS. A site-specific risk assessment will be performed to determine the potential hazards

associated with the experimental procedures involving nanomaterials and the availability of containment measures for risk mitigation.,

- h. Exposures involving nanomaterials or any other acutely hazardous material shall be reported to Environmental Health and Safety, as soon as possible, after medical attention has been sought if necessary. Clothing contaminated with nanomaterials should be removed immediately. Do not take contaminated work clothes home – contaminated clothing may require disposal as hazardous waste.
3. **Special Practices.** The following special practices are to be employed in addition to standard/prudent practices for handling materials dispersed via aerosolization.
- a. Limit the amount of material present in the lab or being worked with at any given time to only the amount necessary to perform the experiments.
 - b. Traffic past the chemical fume hood or ducted biosafety cabinet where nanomaterials are being used should be minimized.
 - c. Needles used for nanomaterial injection shall be disposed in an approved sharps container immediately following use. The sharps container should be placed in the chemical fume hood or ducted biosafety cabinet where the sharps will be used.
 - d. Needles used for nanomaterial injection should never be bent, sheared, or recapped.
 - e. Bench paper utilized during preparation of nanomaterial stock should be lined with an impervious backing to limit potential for contamination of work surfaces in the event of a minor spill.
 - f. Work areas should be cleaned at the end of each work shift using wet wiping methods (absorbent material dampened with soap and water following by a disinfectant if necessary for the agent that the nanoparticle is carrying). Dry sweeping or pressurized air should never be used to clean work areas.
 - g. Bench tops, chemical fume hood interiors, biological safety cabinet interiors, equipment, and laboratory surfaces with potential for nanomaterial contamination should be routinely cleaned. Cleanup should be conducted in a manner that prevents worker contact with nanomaterial wastes.
 - h. The disposal of all waste material should occur in a containment device and be bagged upon exiting the containment device. Powdered materials shall be wetted prior to disposal.
 - i. Laboratory personnel shall be instructed to use extreme caution when performing injections involving nanomaterials since accidental needle stick presents an exposure threat.
 - j. The storage and consumption of food or beverages in workplaces is prohibited where nanomaterials are handled, processed, or stored, since exposure may occur via ingestion.
 - k. Wash hands carefully before eating, drinking, applying cosmetics, smoking, or using the restroom.
4. **Personal Protective Equipment (PPE).** The following PPE is required when handling nanomaterials:
- a. *Protective Gloves* - Glove selection is best determined by a risk assessment and the chemicals used for the procedure. Nitrile or rubber gloves, which cover hands and wrists completely through overlapping sleeve of lab coat when working with nanomaterials, may provide adequate protection. Wearing two sets of gloves (“double gloving”) is advised whenever performing tasks involving nanomaterials and other hazardous substances.

- b. *Eye Protection* - Safety glasses or goggles are required for eye protection when working with nanomaterials
 - c. *Protective Clothing* – Impervious laboratory coats or disposable gowns that provide complete coverage of skin shall be worn when working with nanomaterials.
 - d. *Respiratory Protection* - If engineering controls are not adequate or are not available, if nanomaterials will need to be handled on the open bench and the potential to inhale nanomaterials exists, respiratory protection is required (a minimum of a half face particulate respirator with P100 filters is required). Anyone required to utilize respiratory protection shall contact Employee Health and Wellness (706-721-3418) for medical clearance, fit testing and training.
5. **Use of nanoparticles in animals.** *If the nanomaterials will be introduced into animals*, this shall be reviewed and approved by the Institutional Animal Care and Use Committee. The standard engineering controls and PPE recommended above should be employed. If manipulation of nanomaterials will need to occur outside of containment, double gloves, gown, safety goggles or safety glasses, and a minimum of a half- face respirator with P100 filters will need to be worn. Additionally:
- a. Animals shall be appropriately restrained and/or sedated prior to administering injections and other dosing methods.
 - b. Nanoparticles in suspension should be injected in a chemical fume hood or a ducted biosafety cabinet; however they may be injected into an animal on a bench top covered with absorbent paper. Absorbent paper should be changed after each experiment and disposed as nanoparticle waste. Dispose of the syringe in an approved sharps container.
 - c. If an oral preparation is being administered via a syringe or other feeding device, a fume hood or ducted biosafety shall be used. If administration is by food, use of a microisolator cage is recommended.
 - d. If being administered as an aerosol, a chemical fume hood or a ducted biosafety cabinet shall be used.
 - e. Exposed animals shall be housed under BSL-2 conditions. Downgrading may be considered on a case-by case basis.
 - f. All bedding and waste shall be bagged and incinerated.
 - g. All potentially contaminated carcasses, bedding and other materials shall be disposed of through incineration.
 - h. Any surplus nanoparticle stocks shall be disposed of as hazardous waste.
6. **Spills.** Anyone attempting to manage any spill involving hazardous agents shall wear the appropriate PPE described above. OSHA advises typically standard approaches to cleaning nanomaterial powder and liquid spills include the use of HEPA-filtered vacuum cleaners, wetting powders down, using dampened cloths to wipe up powders, and applying absorbent materials or liquid traps. At a minimum, the following procedures are required when managing an accidental spill of nanomaterials:

For spills involving wet nanomaterial suspensions

- a. *Small spills (typically involving less 5 ml of material)* of nanomaterial-containing solutions should be covered and absorbed with absorbent material. Areas affected by liquid spills should be triple cleaned with soap and water following removal of absorbent paper. . Following completion, all cloth and other spill clean-up materials with a potential for nanomaterial contamination shall be disposed of as hazardous waste.
- b. *For larger spills* of nanomaterials, contact the Environmental Health and Safety at 706-721-2663 for assistance.

For spills involving dry nanomaterial (i.e. powders)

- a. *Small spills inside of the chemical fume hood or a ducted biosafety cabinet (typically involving less than 5 mg of material)* of nanomaterial containing powder should be wet-wiped with cloth/gauze that is dampened with soapy water. Affected surfaces should be thoroughly wet-wiped three times over with appropriate cleaning agent and with a clean, damp cloth used for each wipe down. Following completion, all cloth and other spill clean-up materials with a potential for nanomaterial contamination shall be disposed of as hazardous waste.
 - b. *For spills outside of the chemical fume hood or a ducted biosafety cabinet*, contact the Environmental Health and Safety at 706-721-2663 for assistance.
 - c. *For larger spills* of nanomaterials, contact the Environmental Health and Safety at 706-721-2663 for assistance.
7. **Wastes.** Surplus stocks and other waste materials containing greater than trace contamination shall be disposed of through the Chemical Safety Office. Due to the fact that certain nanomaterials may be unaltered during metabolism, all potentially contaminated animal carcasses, bedding, and other materials shall be disposed as Biohazardous waste (through incineration). All potentially contaminated materials used in the laboratory should be disposed of in the biohazard containers (bagged and/or wetted).

FORMS AND RELATED DOCUMENTS

Aitken, R.J., Creely, K.S., Tran, C.L. Nanoparticles: An Occupational Hygiene Review. Research Report 274. Prepared by the Institute of Occupational Medicine for the Health and Safety Executive, North Riccarton, Edinburgh, England. 2004.

Approaches to Safe Nanotechnology. Department of Health and Human Services, Center for Disease Control, National Institute for Occupational Safety and Health. 2009.

General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories, Center for Disease Control, National Institute for Occupational Safety and Health. 2012.

Nanomaterials Safety Program. University of New Hampshire. Office of Environmental Health and Safety. 2007-2011.

Nanotechnology and Nanoparticles – Safe Working Practices Information. Virginia Commonwealth University. Office of Environmental Health and Safety. 2007

Occupational Safety and Health Act of 1970 (29 U.S.C. 654). Section 5(a) (1).

APPENDICES:

Augusta University Safety or Compliance
Committees or Offices: Biological Safety Office:
<http://www.augusta.edu/services/ehs/biosafe/>

Chemical Safety Office:
<http://www.augusta.edu/services/ehs/chemsafe/>

Radiation Safety Office:
<http://www.augusta.edu/services/ehs/radsafe/>