# Nanomaterials & Nanotechnology

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Research Safety
*Office of Research*
UNIVERSITY OF GEORGIA

## I. Purpose & Scope

This document is meant to provide best practices and university guidelines for laboratory work involving the use of manufactured nanomaterials. Since nanotechnology is a rapidly expanding area of research, new studies are published regularly that explore toxicity and possible routes of exposure to workers. Toxicity hazards posed by nanomaterials can vary widely depending upon the type being used. Certain nanomaterials can present health hazards not displayed by the items in their bulk form. Due to the lack of human studies for most nanomaterials, current recommendations are primarily based on in vitro or animal studies.

## II. Nanomaterial Sources and Composition

The World Health Organization (WHO) uses the term nanomaterials as an all-encompassing term including nano-objects, nanoparticles, and nanotubes from all sources. These are all materials that have at least one primary dimension less than 100 nanometers (nm). For the purposes of this SOP, "nanomaterials" will be used to mean all of these items – including all variations of these materials both naturally occurring and anthropogenic.

Nanomaterials can be naturally occurring (such as volcanic ash), unintentional byproducts (such as automobile exhaust and industrial air pollution), or intentionally created (engineered or manufactured). The types of nanomaterials of most concern in a research laboratory setting are manufactured nanomaterials (MNMs).

MNMs can be spheres, rods, or tubes, and be handled as dry powder, attached to polymers, or placed into solution or suspension. Specific MNM hazards will depend on the shape and composition of the nanomaterial.

## III. General Health & Safety Considerations

**A.** Health hazards posed by MNMs can be caused by inhalation, ingestion, or skin absorption; for most, the highest risk route of exposure is inhalation.

- For this reason, exposure control should focus on preventing inhalation exposure with the aim of reducing it as much as possible by utilizing either localized ventilation or, in the absence of appropriate engineering controls, respiratory protection.

**B.** There are currently no specific regulatory occupational exposure levels (OELs) for MNMs in the workplace, and overall, toxicity is not well understood for the majority of them.

- Some have undergone more extensive evaluation and for which recommended exposure levels are available from theNational Institute for Occupational Safety and Health (NIOSH). These include titanium dioxide and carbon nanotubes which have shown adverse pulmonaryresponses in exposed mice and rats.
- Appendix I of this SOP contains a table from the WHO that classifies the hazardous properties of common MNMs.

**C.** When determining the likelihood of exposure, it is important to consider whether the MNMs will be used in either an open or closed system. Open systems inevitably lead to more possibilities for exposure, and a risk assessment should be done prior to working with nanomaterials in an open system. Contact the Office of Research Safety for assistance with a risk assessment.

**D.** In some cases, the manufacture of commercially available nanomaterials involves the use of chemicals that are known to be hazardous. Be sure to obtain and review the safety data sheets (SDSs) for all MNMs purchased from outside vendors.

- Users should be aware that SDSs may not always provide complete information due to the item's novelty. For this reason, it is always best to err on the side of caution when handling these items.

## IV. Best Practices for Reducing Exposures

**A.** When possible, utilize nanomaterials that are in solution or suspension, orembedded in a matrix as this will reduce the generation of airborne particles subject to inhalation. Use of MNMs in dry or powder form should be limited as most inhalation exposures have taken place when handling them in this form.

**B.** Always utilize the smallest amount of MNMs necessary for a particular reaction or process.

**C.** When research involves work with MNMs for which toxicity is not yet known or is incomplete, it is always prudent to assume that the material is toxic.

**D.** To reduce dermal exposure it is recommended that any MNMs be handled with double nitrile gloves and the outer glove be removed within a fume hood or some other localized exhaust ventilation system. Additionally, placing the outer glovesinside of a bag or other sealed container will reduce the possibility of inhalation exposure.

**E.** When the production of airborne MNMs is possible, such processes must be performed inside of a general purpose chemical fume hood, HEPA-filtered local capture hood, or glovebox.

**F.** When work with MNMs is necessary outside of proper engineering controls such as fume hoods or glove boxes, users should be fit tested with a NIOSH-approvedHEPA-filtered respirator and be enrolled in the university's Respiratory Protection Program. You must contact the Office of Research Safety to enroll in this program.

**G.** Surface contamination with nanomaterials is always a concern and can often go undetected. For this reason, it is a best management practice to wipe down all work surfaces and equipment regularly even if no contamination is suspected. A dampened cloth or paper towel will usually be sufficient.

## V. Spills & Waste

**A.** Any spill of MNMs should be cleaned up immediately. If lab personnel are uncomfortable or unprepared to clean up the spill themselves, theyshould contact the Office of Research Safety. If a lab chooses to clean the spill themselves, the following guidelines must be followed at a minimum.

- Double nitrile gloves, lab coats, and safety glasses must be worn.
- The area should either be vacuumed with a HEPA filtered vacuum dedicated specifically for nanomaterials or wet wiped, or both.
- For spills that might involve airborne nanomaterials, proper respiratory protection must be worn. If lab personnel are not enrolled in the Respiratory Protection Program, they must not attempt to clean up the spill themselves. Instead, contact the Office of Research Safety.
- Do not brush or sweep spilled or dried nanomaterials.
- If possible, place sticky mats at the room exit to reduce potential spread. Foot traffic must be reduced or eliminated in the area of the spill until proper cleanup procedures have taken place.

**B.** Waste resulting from either routine work with MNMs or from a spill must be treated as chemically hazardous waste unless the lab can definitively determine that the waste is non-hazardous. This includes all wipes, bench paper, gloves, and other potentially contaminated lab debris. For assistance with a waste determination and for help with waste disposal, contact the Environmental Safety Division.

## VI. Contacts

Environmental Safety Division: 706-542-5801
Office of Research Safety: 706-542-5288

## VII. References

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, National Research Council, 2011

WHO Guidelines on Protecting Workers From Potential Risks of Manufactured Nanomaterials, World Health Organization, 2017

Protecting Workers During the Handling of Nanomaterials, National Institute Occupational Safety and Health (NIOSH), 2018.

# APPENDIX I: CLASSIFICATION OF HAZARDOUS PROPERTIES OF NANOMATERIALS

| MNM | Acute toxicity | Skin corrosion/ irritation | Serious eye damage/eye irritation | Respiratory or skin sensitization | Germ cell mutagenicity | Carcinogenicity | Reproductive toxicity | Specific target organ toxicity (single exposure) | Specific target organ toxicity (repeated exposure) |
|---|---|---|---|---|---|---|---|---|---|
| Fullerene ($C_{60}$) | No[a] | No | No | No | No | No data[b] | No data | No data | No |
| SWCNT | No | No | No | No | Cat 2B[c] (L)[d] | No data IARC[e] 3 | No data | No data | Cat 1 (L) |
| MWCNT | No | No | Cat 2A (H)[g] | No | Cat 2 (H) | MWCNT–7: Cat 2 (M)[f], IARC 2B Other MWCNTs: IARC 3 | No | No data | Cat 1 (M) |
| AgNP | No | No | No | Cat 1B (M) | No | No data | No | No data | Cat 1 inhalation (H) Cat 2 oral (H) |
| AuNP | No data | No data | No data | No data | No data | No data | No data | No data | Cat 1 inhalation (H) |
| $SiO_2$ | No | No | No | No | No | No data | No | No data | Cat 2 inhalation (H) |
| $TiO_2$ | No | No | No | No | No | No data; IARC 2B | Cat 2 (L) | No data | Cat 1 inhalation (H) |
| $CeO_2$ | No | No data | No data | No data | No data | No data | No data | No data | Cat 1 inhalation (M) |
| Dendrimer | No data | No data | No data | No data | No data | No data | No data | No data | No data |
| Nanoclay | No data | No data | No data | No data | No data | No data | No data | No data | No data |
| ZnO | No | No | No | No data | No | No data | No | No data | Cat 1 inhalation (M) |

AgNP: silver nanoparticles; AuNP: gold nanoparticles; $CeO_2$: cerium dioxide; MWCNT: multi-walled carbon nanotubes; $SiO_2$: silicon dioxide; SWCNT: single-walled carbon nanotubes; $TiO_2$: titanium dioxide; ZnO: zinc oxide.

[a] No: no hazard class assigned based on data.

[b] No data: no studies available in OECD dossier.

[c] GHS categories: Cat 1 usually implies serious and/or irreversible damage; Cat 2 milder or reversible damage. Within a category A implies more serious and B milder damage.

[d] L: low level of evidence.

[e] IARC refers to the International Agency for Research on Cancer categories of confidence in carcinogenicity: IARC Cat 2B = possibly carcinogenic; IARC Cat 3 = not enough evidence to draw conclusion.

[f] M: moderate level of evidence.

[g] H: high level of evidence.