Guidelines on Working with Nanomaterials in the Laboratory

Scope

This document is intended to be applied in situations where employees or students work with nanomaterials in the laboratory at UofT.

Introduction

Nanomaterials present special hazards around their usage in the laboratory versus larger particle sized (>100nm) materials of identical chemical composition. The macroscale material is referred to as the parent compound. Nanoscale materials have been found to be usually more toxic than the parent compound (1). The properties of the material may be amplified or even changed fundamentally, for example the reactivity of sufficiently fine gold nanoparticles (5). In addition some powdered nanomaterials aerosolized via simple means such as pouring or otherwise dispensing can behave in a fashion more similar to vapours – they tend to follow the airstream more than the parent compound and do not as readily settle out. Nanoparticles can readily pass into the deep lung and from there can in some cases pass into the bloodstream (6). These factors make nanomaterial exposure via inhalation more likely than for the parent compound and with potentially more severe health consequences including systemic effects.

For most nanomaterials used in the lab there will be minimal or no safety and toxicology information available for the nanoscale version of the parent material. As a result the hazard of the nanomaterial must often be extrapolated from the properties of the parent material.

For some uses of nanomaterials a High Hazard Permit may be required. In many, lower risk uses, a permit may not be needed. Please consult with the Office of Environmental Health and Safety (EHS) for further information.

Responsibilities

Principal Investigator (PI)

The Principal investigator is responsible for ensuring that work conducted with nanomaterials is approved and is responsible for reviewing, or having approved by a delegate, any risk assessment conducted, and hazard controls proposed. The PI must also ensure the work procedures to mitigate the hazards are appropriately implemented.

Department

It is the responsibility of Directors and Department Heads to ensure employees and students are aware of these guidelines where labs are working with nanomaterials.

Student/Staff Member That Will be Working with Nanomaterials

The person working with nanomaterials is responsible for seeking approval of the PI or delegate, and to submit to the PI or delegate a detailed description of the activity, as well as the hazard controls and work procedures currently proposed.

Risk Assessment

In order to conduct work safely the activity should be placed into one of the following categories:

Risk Level	Description	Mitigation
High Risk	**Handling of solid nanomaterials.** The potential for release is significant as nanomaterials can disperse in air to an extent that is similar to vapours. Examples: Generating nanomaterials; Weighing powdered nanomaterials; Non-wetted cleaning of furnaces or reactors and; Cleaning or removing filters used for nanomaterials. Note if larger quantities of powders are being used, please consult with EHS.	Minimum: use a fume hood, EHS approved ductless hood†, or A2 biosafety cabinet‡. Use of a glove box recommended for materials with the highest possibility of exposure, the highest toxicity of the macro scale material or for a nanomaterial known to be highly toxic. Examples include, but are not limited to, carbon nanotubes or As, Be, Cd nanoparticles. For detailed assessment of the risks of a particular material the Lawrence Livermore National Laboratory CB Nanotool should be used (4, 7).
Moderate Risk	**Nanomaterials suspended in a liquid.** Examples of activities: Sonication, spraying, any other aerosol generation. **Physically bound nanomaterials such as composites or films.** Power grinding, sanding, cutting or drilling.	Use fume hood, EHS approved ductless hood†, or A2 biosafety cabinet‡.
Low Risk	**Nanomaterials suspended in a liquid.** Examples of activities: Pipetting small quantities, cleaning up a wet spill, and brushing out a coating. **Physically bound nanomaterials such as composites or films.** Examples of activities: Manual cutting, sanding or drilling of nanocomposites.	Possible to be conducted on the benchtop with appropriate post activity wet cleanup if required. Use of a ventilated enclosure may simplify post activity cleanup.

Note: EHS staff are available for assistance with risk assessment after an assessment of activities and likelihood of exposure.

†Ductless hoods may not be able to capture all chemicals that may be used with the nanomaterials.

‡Biosafety cabinets can only be used with powders or aqueous solutions – they do not capture vapours.

PPE

All activities with nanomaterials should be conducted with basic PPE as outlined in the UofT Lab Coat Guidelines and the General Laboratory PPE Assessment Tool.

Training

All persons working with nanomaterials must have current WHMIS and Chemical Safety training and/or refresher up-to-date. Workplace specific training for the specific class of nanomaterials and the specific way they are being used must be provided by the PI.

The training should be documented. Documentation can be a simple as a written note in a notebook or an email. Training can be informal such as with a demonstration, verbal, or written instructions and could be delegated to a representative of the PI - for instance the lab manager.

Waste Disposal

All nanomaterials must be disposed of as chemical waste. Powdered materials or dispersions should be double bagged and disposed of in rigid sealed, labelled containers for example a green pail labelled with "nanomaterial waste". Nanomaterial waste streams should not be mixed.

References

1) IRSST, Report R-599, Best Practices Guide to Synthetic Nanoparticle Risk Management, January 2009
2) NIOSH, Nanotechnology Research Centre, Controlling Health Hazards When Working with Nanomaterials: Questions to Ask Before You Start, DDHS (NIOSH) Publication No. 2018-103, February 2018
3) California Nanosafety Consortium of Higher Education, Nanotoolkit, Working Safely with Engineered Nanomaterials in Academic Research Settings, April 19, 2012
4) Lawrence Livermore National Laboratory, CB Tool ver. 3.01, accessed Sep. 2019
5) Mélanie Au, Jérôme Rose, Jean-Yves Bottero, Gregory V. Lowry, Jean-Pierre Jolivet, and Mark R. Wiesner, Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective, Nature Nanotechnology, Advance Online Publication, September 2009
6) NIOSH, General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories, Publication Number 2012-147, May 2012
7) Zalk, David M., Paik, Samuel Y., Swuste, Paul, Evaluating the Control Banding Nanotool: a qualitative risk assessment method for controlling nanoparticle exposures, Journal of Nanoparticle Research, iss. 7, vol. 11, p.1685, June 27, 2009

Appendix 1: SOP Template

Note: Part of this document was reproduced from the Nano toolkit - Working Safely with Engineered Nanomaterials in Academic Research Settings with authorization from the author.

Lab Name

SOP Name

Nanomaterial Form (circle)

Solid	Suspended in Liquid	Physically Bound

Brief Description of Activity to be Conducted

Results of Risk Assessment

High Risk	Moderate Risk	Low Risk

Engineering Controls to be Used

Glove box	Fume hood, biosafety cabinet, ductless enclosure	Bench top

Additional Work Practices to Follow

High Risk	Moderate Risk	Low Risk
-Follow PPE Risk Assessment Tool for appropriate PPE -Clean all surfaces potentially contaminated with nanomaterials with wet wiping methods -Use sticky mats or antistatic paper in work area	-Follow PPE Risk Assessment Tool for appropriate PPE -Clean all surfaces potentially contaminated with nanomaterials with wet wiping methods	-Follow PPE Risk Assessment Tool for appropriate PPE