NANOMATERIALS SAFETY PROGRAM

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1.0 PURPOSE

The purpose of the University of Waterloo's Nanomaterials Safety Program is to outline the responsibilities and processes required to minimize the risk of working with nanomaterials.

2.0 SCOPE

This program covers all work with nanomaterials and outlines a set of rules that all individuals working with nanomaterials must abide by.

3.0 ROLES AND RESPONSIBILITIES

3.1 SUPERVISOR/PRINCIPAL INVESTIGATORS

The primary responsibility for the safety of workers, students, and the public lies with the principal investigator who is considered a supervisor under the Occupational Health and Safety Act in Ontario. They must complete the following:

- Identify all hazards associated with the use and manipulation of nanomaterials.
- Assess and control risks associated with the identified hazards.
- Communicate the hazards of working with and being exposed to nanomaterials and other laboratory substances required for the work conducted.
- Implement appropriate control measures to reduce the risk of working with these substances.
- Ensure workers and students are competent to perform the work assigned through training and any other means that the private investigators or Safety Office feels reasonable.
- Develop or authorize written standard operating procedures (SOPs) to outline how all processes with nanomaterials will be performed, before allowing work to begin.
- Train all workers on the SOPs that pertain to their work.
- Respond to worker reports of hazards promptly with appropriate action.
- Meet all legislative requirements and University policies associated with working with nanomaterials.
- Investigate unintentional exposures and incidents involving nanomaterials.

3.2 WORKERS, RESEARCHERS AND STUDENTS

- Report any hazards to their direct supervisor.
- Follow all procedures as written or required for the work they are performing.
- Follow all legislative requirements as deemed necessary for them to complete their work.

- Attend any training sessions deemed necessary by the University of Waterloo or their supervisor.
- Wear and use all personal protective equipment as required.

3.3 SAFETY OFFICE

- Provide a guidance manual (this document) on assessing and controlling the health risks of working with nanomaterials.
- Provide consulting services in the assessment and control of health risks.
- Provide exposure assessments.

4.0 ASSESSING RISK

Many of the health risks associated with nanomaterial use are unknown. For this reason, the University of Waterloo requires that a risk assessment be completed before the use of these materials. At a minimum, all risk assessments should:

- Be completed before work begins
- Identify the potential toxicity of the material (material properties)
- Identify the exposure potential (how it is being used, and in what form)
- Identify what engineering, process, and administrative controls to use

The flowchart in Figure 1 outlines the risk assessment process at the University of Waterloo.

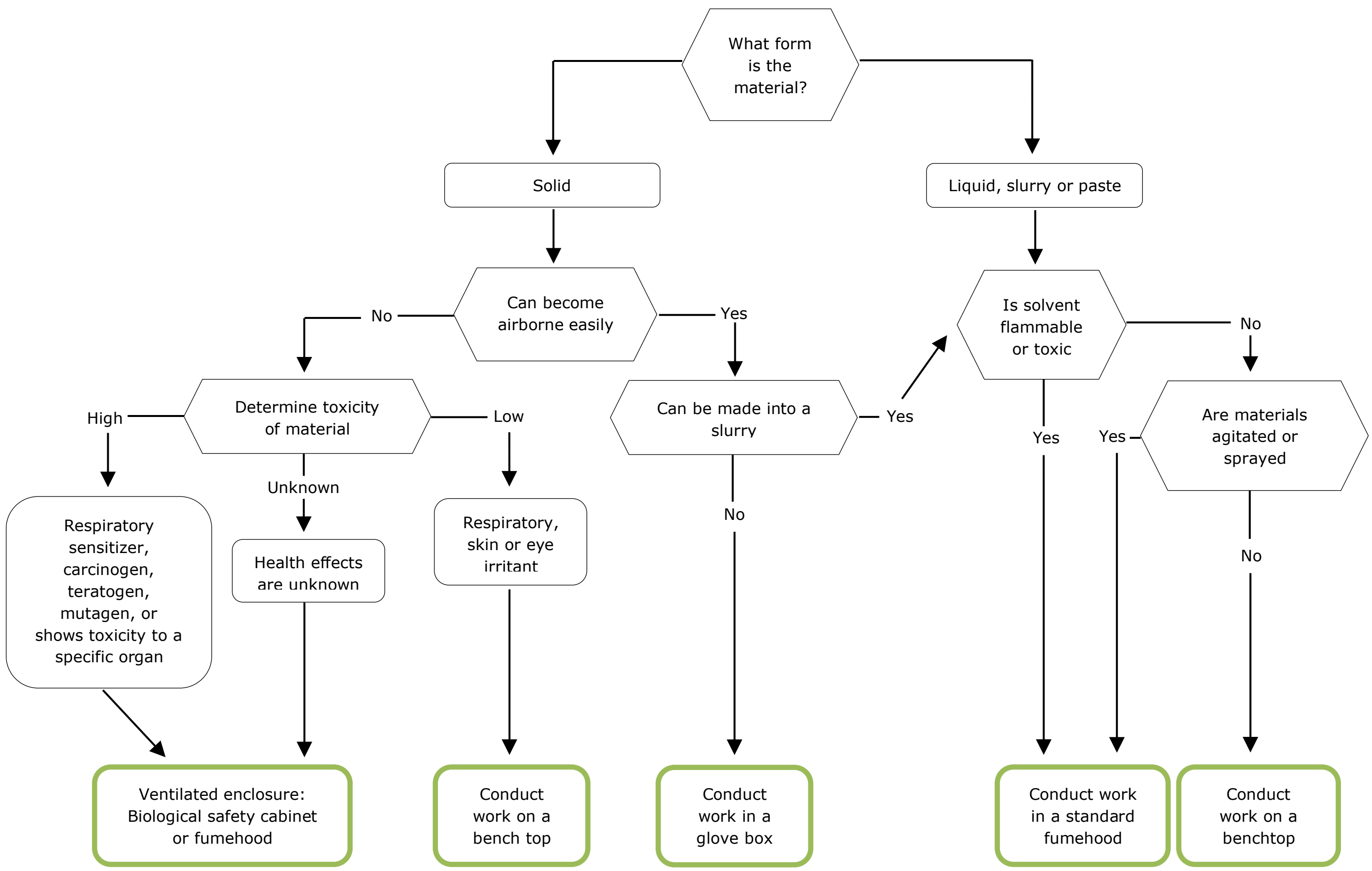


Figure 1: Nanomaterial handling decision tree

To use the process outlined in Figure 1, knowledge of the potential toxicity of the material is required. Keep in mind that if no toxicity information is available, you must assume the material will pose a health hazard, and you must handle the material in a HEPA filtered ventilated enclosure. To avoid being unnecessarily overprotective, it is in the best interest of the worker/researcher to understand the toxicity of the material they are working with.

Once the worker understands the toxicity information, they can proceed to assess how easily the powder will become suspended in air. If the material goes into the air easily (low density, ie. light and fluffy), it must be used in a ventilated enclosure (HEPA filtered glovebox or Biosafety Cabinet). For example, if the material easily floats off a scoop when you try to get some out of the container, it must be handled in a ventilated enclosure until moved into a liquid suspension or slurry. If you are unclear what is meant by "easily suspended in air", please watch our video on nanopowder handling recommendations.

For liquid suspensions or slurries, if the liquid used is toxic or flammable, the material cannot be used in a glove box, and can only be used in a fume hood or biological safety cabinet that is directly vented to the outdoors.

If you perform the risk assessment and are unclear about the result, please contact the Safety Office for a review. However, please keep in mind that for an accurate review of your material to occur, we will request the following information:

- Safety Data Sheets (SDS) for the nanomaterial and potentially the parent material
- The SDS for any other compound required for the work being conducted (like solvent)
- A summary of the experimental process (Standard Operating Procedure) that includes how the material is handled from its purchase to its ultimate disposal (cradle to grave)

5.0 CONTROL MEASURES

A completed risk assessment will outline the type of control required for each activity transpiring. In general, for handling nanomaterials, the following three main types of controls are expected.

- Engineering controls
- Administrative controls
- Personal protective equipment (PPE)

5.1 ENGINEERING CONTROLS

The following three basic types of engineering controls are recommended for handling nanomaterials.

5.1.1 HEPA FILTERED GLOVEBOXES

HEPA filtered gloves boxes are complete enclosures that provide a controlled environment to handle nanopowders. They have several features which make them appropriate to use when working with materials that are highly hazardous (ones that are respiratory or skin sensitizers, carcinogens, teratogens, mutagens or are reproductive toxins), or powders that become easily suspended in air.

These features include a sealed internal working compartment, a user-controlled HEPA filtered exhaust system, an antechamber for removal and placement of objects within the box, and an internal lighting system.

Figure 2 provides a schematic of a typical HEPA ventilated glovebox. The undergraduate Nano-engineering Laboratory uses units like this.

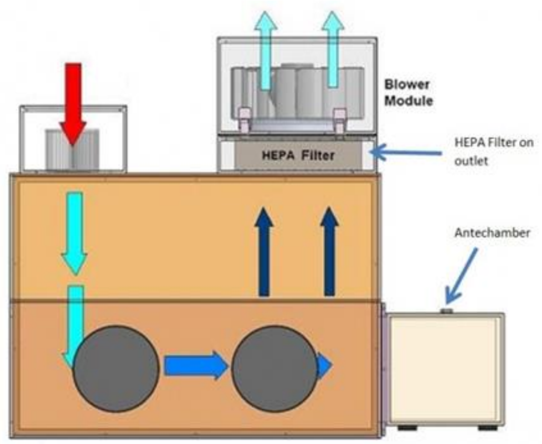


Figure 2: Image of a HEPA filtered glovebox to be used with highly toxic and/or highly aerosolizable powders

5.1.2 BIOLOGICAL SAFETY CABINETS

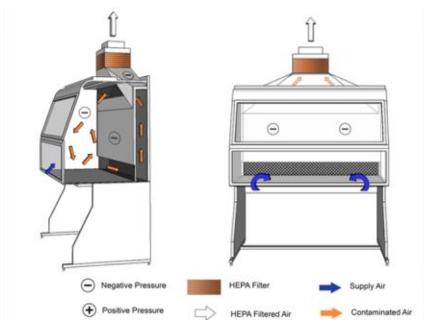
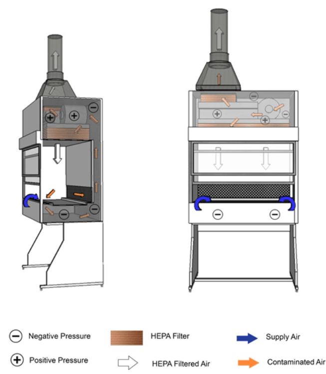
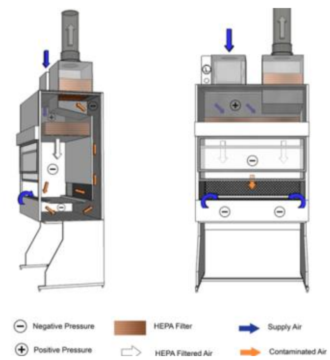
Biological safety cabinets (BSC's) are designed to protect the user from exposure to aerosolized hazardous particles. They are useful because they protect the user from exposure to an aerosolized particle, and they are not as cumbersome as a glovebox as they don't block line of sight, and a user will not have to use the oversized gloves. Air distribution within a BSC can vary depending upon the type of cabinet used.

Class I cabinets have airflow patterns similar to fume hoods and do not recirculate any air back into the laboratory.

Class II biosafety cabinets come in a variety of styles, with Class A2 and B1 cabinets recirculating some air back into the room and Class II B2 utilizing 100% fresh air.

In summary, any biosafety cabinet can be used for work with a nanopowder, however, only Class I or Class II B2 cabinets can be used for work that includes both nanomaterials and toxic or flammable liquids. Table 1 on the following page summarizes this.

Table 1: Summary of how various types of biosafety cabinets provide protection and their limitations

Class 1 Cabinet	Class II A1, A2, B1 Cabinet	Class II B2 Cabinet
Type of Protection: • From Powders: Yes • From flammables or toxic vapours: Yes  *Class I Cabinet*	**Type of Protection:** • From Powders: Yes • From flammables or toxic vapours: No  *Class II A2 Style Cabinet*	**Type of Protection:** • From Powders: Yes • From flammables or toxic vapours: Yes  *Class II B2 Style Cabinet*

Images from [Canadian Biosafety Handbook, Second Edition]

5.1.3 FUME HOODS

Fume hoods are basic ventilation enclosures with no filtration. They work by drawing laboratory air in and exhausting it out of the building. For most applications, this keeps whatever is being worked on inside the enclosure and away from the worker. In general, use fume hoods for work that involves nanomaterials that are relatively dense and hard to aerosolize in conjunction with toxic or flammable liquids. See Figure 1 for more information.

5.2 ADMINISTRATIVE CONTROLS

In most cases, administrative controls refer to the creation and use of standard operating processes that consist of:

- An equipment and materials list
- Pre-experimental processes (like results of risk assessment, instructions for creating stock solutions, prepping machinery or equipment, etc.)
- Step-by-step instructions on the actual processes conducted
- Post-experimental processes (wet wiping work area, wet wiping equipment, cleaning ventilated enclosures, etc.)
- Waste collection, disposal, and labelling practices
- Where to store items when finished work
- Dealing with emergency situations (accidental exposures, spills, etc.)

Work should not begin until an SOP has been developed and approved by the Supervisor or Principal Investigator.

5.3 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The minimum and mandatory PPE required by individuals working with nanomaterials include:

- Safety glasses with side shields or goggles
- Lab coat – ideally with no cuffs
- Nitrile or other compatible gloves
- Closed toed shoes

Do no use respirators as a permanent solution for working with nanomaterials. Respirator use requires proper training, fitting, and an understanding that by needing a respirator, the individual is already exposed to the compound. Conduct work in a ventilated enclosure if respiratory exposure is expected. Figure 1 outlines this process.

6.0 SAMPLE EMERGENCY PROCEDURES

6.1 SPILL PROCEDURE INSIDE CONTAINMENT

1. Use personal protective equipment appropriate for toxicity and physical properties of compounds
2. Notify occupants of laboratory
3. Use absorbent material with an appropriate solvent to wet wipe the area.
4. Place all cleaning materials, disposable PPE and waste in plastic bag
5. Seal and wipe the exterior
6. Place bag in secondary bag
7. Seal secondary bag and wipe exterior
8. Label nanomaterial waste with description for disposal (i.e. Nanomaterial contains nano-silver material)

6.2 SPILL PROCEDURE OUTSIDE CONTAINMENT

1. Evacuate occupants of laboratory, close laboratory door and secure area.
2. Contact UW Police at ext. 22222.
3. Provide the following information:
    a. Location of spill
    b. Material
    c. Quantity
    d. Assessment of risk
4. Remain with UW Police until spill team arrives.

7.0 RECORD OF REVISIONS

Date	Author/Editor	Change	Version
January 2021	Dhananjai Borwankar	• No changes	Nanomaterials Safety Program_v.2.0_JAN2021
January 2020	Dhananjai Borwankar	• Added section 7.0 Record of Revisions	Nanomaterials Safety Program_v.2.0_JAN2020
January 2019	Dhananjai Borwankar	• No changes	Nanomaterials Safety Program_v.2.0_JAN2018
January 2018	Dhananjai Borwankar	• Updated risk assessment worksheet and documentation requirements • Clarified that supervisors must authorize SOPs before they are used	Nanomaterials Safety Program_v.2.0_JAN2018