Guidelines for the Use of Nanoparticles

1. Background

The following document provides guidelines concerning the work with nanoparticles within laboratory facilities. These guidelines provide information about the properties of commonly used nanoparticles/nanomaterials, their health and safety hazards and ways to protect oneself from potential laboratory exposures. Emergency procedures for dealing with accidental spills or nanoparticles exposure are also included.

WARNING: Since nanotechnology is an emerging field, many of the hazardous effects are not completely understood with many nanoparticles. Since these materials are relatively new, they are to be considered toxic and handled cautiously using "precaution principles" until adequate amount of data on the hazards of these nanomaterials has been collected for health and environment safety information.

2. What is Nanotechnology?

Nanotechnology is a broad name given to a wide range of technologies and materials that create, manipulate, or use particles that have one thing in common - their size.

Nanotechnology (or nanoscience) involves materials that are extremely small and have dimensions roughly between 1 and 100 nanometres (nm). A nanometre is 1 billionth of a metre. To give you an idea of the scale of nanoparticles:

- A piece of paper is about 100,000 nm thick.
- A human hair is about 70,000 to 80,000 nm.
- A red blood cell is about 7,000 nm.
- A virus is about 10 to 100 nm.

While the exact definition of nanotechnology may vary, most research and studies have concentrated on particles with a dimension of less than 100 nm.

3. What Makes Nanoparticles Unique?

Nanoparticles can have characteristics that are very different from when they are in their larger (or "normal") form. Often, nanoparticles will be stronger, lighter, more reactive, or conduct electricity in a different way.

It is important to note that a nanoparticle can have different properties than the same material at a macro level. Nanoparticles have a higher surface area in proportion to their mass. An increased surface area typically means the particle will be more reactive (such as having an

increased biological activity by mass when compared to larger particles). This effect can be either be a positive or negative quality. It is a positive quality when the particle displays antioxidant activity, or has the ability to carry drugs to specific organs or cells. But, it can be a negative quality when the effect can increase toxicity, increase the oxidative stress of a cell, or destroy the cell.

4. Health and Safety Concerns

Although insufficient information exists to predict the health hazard posed by the exposure to nanoparticles, current research indicates that exposure via inhalation and skin contact can result in these particles entering the body. Results from human and animal studies show inhaled nanoparticles can deposit in the respiratory tract. Animal studies also show nanoparticles can enter the bloodstream and translocate to other organs. Nano particles have the greatest potential to enter the body if they are in the form of individual particles, agglomerates of nanoparticles, and particles from nanostructured materials that become airborne or come into contact with the skin.

It is a difficult question to answer as each nanoparticle (like each chemical) can have its own unique effects. The effects of the nanoparticles are not only based on the chemical characteristics - the shape, size, surface texture, surface charge and other factors can all impact how the nanoparticles might affect our health. In addition, the nano-sized particle may not have the same characteristics as its “normal” particles (including when the nanoparticle created from the same chemical or material). Nanoparticles are also being studied for their ability to cause fires or explosions, or if they can play a role as a catalyst (a substance that causes or accelerates a chemical reaction).

According to NIOSH the following workplace tasks may increase the risk of exposure to nanoparticles:

- Working with nanoparticles in liquid media without adequate protection (e.g., gloves) will increase the risk of skin exposure.
- Working with nanoparticles in liquid media during pouring or mixing operations, or where a high degree of agitation is involved, will lead to an increased likelihood of inhalation and respirable droplets being formed.
- Generating nanoparticles in the gas phase in non-enclosed systems will increase the chances of aerosol release to the workplace.
- Handling nano structured powders will lead to the possibility of aerosolization.
- Maintenance on equipment and processes used to produce or fabricate nanoparticles will pose a potential exposure risk to workers performing these tasks.

- Cleaning of dust collection systems used to capture nanoparticles will pose a potential for both skin and inhalation exposure.

4.1 Health Hazard

Nanoparticles appear to enter the body the same way other particles - through inhalation, ingestion or absorption through the skin. While there is no cut off in size that makes particles toxic or non-toxic, some studies have shown that as particles become smaller, there is an increased likelihood of injury to occur.

In all cases, more studies are needed to determine the health concerns for humans. How a nanoparticle enters the body and the effect it may have depends on many factors including:

- Surface area
- Mass
- Solubility
- Composition / chemistry
- Charge
- Shape
- Aggregation

Current research indicates the following:

a) Respiratory

Nanoparticles can be deposited in all areas of the respiratory tract depending on the size and composition of that particular nanoparticle. They can also enter the blood and lymph circulation systems and be distributed throughout the entire body. When in the blood system, they can be taken up by the liver, spleen, bone marrow, heart and other organs.

b) Skin

Nanoparticles can also cross the skin and possibly reach other organs. There are indicators that particles can accumulate around hair follicles and when the follicle opens, the particles can reach deeper levels.

c) Nerves

There is also some animal study evidence that the nanoparticles may be able to enter the body though nerves, usually the olfactory nerves and bulbs in the nose (the "nerves of smell"), and move along the axons and neurons of the central nervous system.

d) Digestive system

While this area is not as well researched, early studies have shown nanoparticles tend to pass through the gastrointestinal (GI) tract and are eliminated quickly. Again, this effect is dependent on the properties of the specific nanoparticle.

5. Control Procedures

While the health risks from exposure to nanoparticles are not known, the work practice and engineering control procedures to prevent exposure are well understood. Standard laboratory practices regarding the use of hazardous chemicals and gases must be followed. The following engineering, work practice and ventilation controls are required when handling nanoparticles to reduce potential exposure and ensure safe conditions in University of Lethbridge laboratories.

a) Lab Personal Protection and Hygiene

- Lab coats must be worn. Lab coats must be laundered. Lab coats should not be taken to private homes and laundered.
- Arm sleeves are required where high levels of exposure or splashes of solutions containing nanoparticles are anticipated.
- Safety glasses are required when working in any lab.
- Gloves (disposable nitrile) must be worn when handling nano materials. Because skin penetration is a concern gloves must cover the wrist and any skin on the arm exposed by the lab coat.
- Appropriate personal clothing is required in all laboratories including those that work with nanomaterials. Long pants and closed toed shoes are required.
- Respirators may be required for activities that cannot be controlled using ventilation (i.e. fume hood). All respirators users must be fit-tested for respirator. Please contact Safety Services.
- Hand washing facilities must be provided in all labs. Hand washing must be performed after handling nanomaterials.

b) Lab Contamination and Cleaning

Avoid lab contamination by selecting from the following control procedures:

- Restrict the handling of nanoparticles to areas well within the lab.
- Handle dry nanomaterials in a fume hood, biological safety cabinet, glove box or a vented filtered enclosure. **Do not work** on the open bench with dry nanoparticles.
- Transport dry nanoparticles in closed containers.

- Handle solutions containing nanoparticles over disposable bench covers.
- Aerosol producing activities (such as sonication, vortexing and centrifuging) may not be conducted on the open bench. Perform these activities in a fume hood, biological safety cabinet, glove box or a vented filtered enclosure.
- Clean bench tops after each work activity.
- Have emergency protocols in place for spills. Spills of dry nanoparticles must be cleaned with a HEPA vacuum. Dry sweeping must not be used.
- Daily vacuuming of benches and floors with a HEPA vacuum should be performed in labs that handle nanoparticles.

c) Ventilation Controls

- Labs that handle nanoparticles must have non-recirculating ventilation systems (preferably 100% exhaust air) with ventilation rates of 6-12 air changes per hour. Lab pressurization must be negative to the hallway.
- Activities that are likely to release nanoparticles (borosilicate tubes, weighing of dry nanoparticles) shall not be performed on the open bench. These activities shall be performed in a fume hood (or other vented enclosure), biological safety cabinet, glove box or a vented filtered enclosure.
- Exhaust from all furnaces used to produce nanoparticles must be trapped and connected to a local exhaust source.

d) Waste Disposal

All solutions and solid materials must be disposed of as hazardous waste following established University of Lethbridge guidelines.

6. Resources

a) Nanomaterial Safety Guidelines, Concordia University

b) OSHA:Working Safety with Nanomaterials
https://www.osha.gov/Publications/OSHA_FS-3634.pdf

c) CCOHS: Nanotechnology- General
https://www.ccohs.ca/oshanswers/chemicals/nanotechnology.html