C08 Safe Handling of Engineered Nanomaterials

1. Introduction

The term 'nanomaterial' is used generally to describe a material that has at least one dimension smaller than 100 nanometers (nm). Nanomaterials may be naturally occurring (such as in volcanic ash), produced as unintentional by products (such as in auto emissions) or intentionally created or engineered. The latter groups comprises the so called engineered (or manufactured) nanomaterials which may in turn to be used to produce 'nano-enabled products' showing enhanced functionality.

These very small particles often possess different properties than larger particles of the same composition, making them of interest to researchers and of potential benefit to society. Because of these differences, nanomaterials offer new and exciting opportunities in industry such as agriculture, electronics, medicine and pharmaceuticals technology, food processing, construction, automotive industry, textiles, health care and cosmetics. A growing number of innovators are harnessing the unique properties of nanomaterials into their research.

Nanomaterials can be spheres, rods, tubes, and other geometric shapes. The small particles may be bound to surfaces or substrates, put into solution or suspension, attached to a polymer, or in a few cases handled as a dry powder. Various nanomaterials can be created in the laboratory under experimental procedures, and some can be purchased from commercial vendors. In most research, the amount of material used is small, generally less than one gram.

Although nanomaterials have many beneficial properties, there are limited information about their associated health hazards. Particular care regarding the management of these materials must therefore be taken while research continues.

The purpose of this document is to provide personnel at the Science Park with general guidelines for safe handling of engineered nanomaterials in the laboratories.

2. Potential Health, Safety and Environmental Hazards

2.1 Health Hazards

Health concerns regarding the use of nanomaterials originate from the recognition of several unique attributes of them. The ultra-small particle size permits the particles to be carried deeply into tissues. The particles may be deeply respired into the lungs; may pass through the blood-brain barrier; or translocate between organs. The molecular structure of nanomaterials and the relatively greater surface area confer on these particles different chemical reactivities than for larger structures made from the same elements or molecules. Some evidence suggests that nanoparticles may be more toxic to tissues than larger molecular structures. Examples include the followings:

a) Carbon nanotubes and nanofibers may be capable of causing pulmonary inflammation and fibrosis by depositing in the respiratory tract.

b) The nanoscale TiO_2 particles, used in many commercial application such as paint, paper, cosmetics and food, have higher mass-based potency than larger particles. The occupational exposure (by inhalation) to nanoscale TiO_2 particles should be considered a potential occupational carcinogen.

There are four possible routes of workplace exposure to nanomaterials including **inhalation, ingestion, skin absorption and injection**. The physiological effects and potential hazard due to exposure will depends on size, dose, reactivity and structure of the nanomaterials.

2.2 Fire and Explosion Hazards

Because of the surface-to-volume ratio increases as a particle becomes smaller, nanomaterials may be more prone to explosion than an equivalent mass concentration of larger particles. Both carbon-containing and metal nanopowders can explode if they are aerosolized at a high enough concentration and if oxygen and an ignition source are present. Researchers should avoid creating concentrated aerosols of combustible nanoparticles. Decreasing the particle size of combustible materials can increase combustion potential and combustion rate, leading to the possibility of relatively inert materials becoming highly reactive in the nanometer size range. Some nanomaterials are designed to generate heat through the progression of reactions at the nanoscale. Such materials may present a fire hazard that is unique to engineered nanomaterials. One example is aluminum powder; particles bigger than 80 nm are known to be inert when exposed to air. On the opposite, particles less than 80 nm are known to be very reactive and can cause explosion. Another example is nanoscale Al/MoO_3 particles that can ignite more than 300 times faster than corresponding micrometer-scale material.

2.3 Environmental Hazards

There are limited publications on the effects of engineered nanomaterials on animal and plants in the environment. However, nanomaterials entering the environment resulting from accidental release from production facilities, landfills or wastewater treatment plants may become toxic to microorganisms in the soil and groundwater. This may in term affect other plants and animals following the food chains.

3. Nanomaterials Hazard Control Measures

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To ensure the health and safety of laboratory users, the management of each concerned laboratory shall observe the following hazard control measure requirements:

3.1 Risk assessment - Though some nanomaterials have been used safely for decades, other manufactured forms are new and have characteristics that are not yet fully defined. Laboratory Person In-Charge should identify the risk and the corresponding control measures needed by:

a) Identifying and describing processes and job tasks where workers may be exposed to nanomaterials.
b) Determining the physical state of the nanomaterials such as dust, powder, spray, or droplet.
c) Determining routes of exposure (e.g., inhalation, skin contact or ingestion) of particulates, slurries, suspensions or solutions of nanomaterials.
d) Identifying the most appropriate sampling method to determine the quantities, airborne concentration, duration, and frequencies of lab personnel exposures to nanomaterials as far as possible.

3.2 Facility and Building Services Requirements - The following requirements should be met for providing adequate environment or facility for laboratory users working inside:

a) General exhaust - Laboratory should be maintained under negative pressure relative to the corridor so that airborne nanomaterials, if any, will not spread to the outside.
b) Local exhaust - The small size and low inertia of particulate means they can move in the air more like a gas than normal particles. Therefore, correctly designed and well maintained local exhaust ventilation with a filtration mechanism for nanomaterials should be available. This includes biological safety cabinet (BSC), fume hood and glove box equipped with high efficiency particulate air (HEPA) filters. Because air is recirculated in Class II type A and BI biological safety cabinets, tasks involving volatile materials should not be performed in these cabinets.
c) Laboratory design - Set up a designated area for work with nanomaterials and suspensions away from entrances and high traffic areas. A designated area may be an entire laboratory, a section of a laboratory, or a containment device such as fume hood or BSC. Work surfaces where nanomaterials are handed should be smooth, impermeable and free of joints and cracks for easy cleaning.
d) Signage - Post signs indicating hazards and personal protective equipment requirements at entry points to the laboratory or areas where nanomaterials are handled.

e) Waste storage – Waste nanomaterials should be treated as chemical waste. A designated area and labeled container for waste should be assigned following the requirements for storing chemical waste.

f) Emergency facilities - Emergency shower, eyewash station, firefighting equipment, spill kit and first-aid kit shall be available at appropriate location in the laboratory.

3.3 Training of Personnel - All personnel working with engineered nanomaterials should receive training before working with nanomaterials. The training should address the hazards associated with nanomaterials and procedures to prevent exposure, appropriate nanomaterials handling and storage procedures, proper use of personal protective equipment (PPE), cleaning of contaminated surfaces or clothing, and proper disposal of nanomaterials.

3.4 Good Work Practice - A list of good work practice should be developed for the laboratory include:

a) Purchase and Use - Purchase and use the lowest concentration or quantity that meet your research needs. Use nanomaterials in solution or suspension if possible, to reduce the risk of dispersing dry nanomaterials during handling.

b) Labeling and Storage - Nanomaterials should be stored in labeled containers that indicate their chemical content and form (include the term 'nano' in the descriptor). Liquid or dry particles should always be stored in unbreakable, tightly sealed containers. Secondary containment should be used when appropriate. Cover all containers when not in use. Nanomaterials must not be stored with incompatible chemicals.

c) Transport - Transport of dry nanomaterials should be in closed container. Handling solutions containing nanomaterials over disposable covers.

d) Cleaning Process - Clean bench tops using a cleaning solution after each work activity. Spill of dry nanoparticles must be cleared up using HEPA vacuum cleaner or by wet-wiping. Dry sweeping must not be used.

e) Personal Hygiene - Wear proper PPE during work with nanomaterials. The minimum requirement includes safety glass, lab coat, nitrile or other compatible gloves and closed toed shoes. Dedicated clothing shall be either laundered by husbandry staff using in-house facilities or by professional laundry services. Dedicated clothing must not be taken home. Wash hands before leaving the work area and after removing gloves. Do not eat or drink in the areas where nanomaterials are handled.

4. General Safety Practices for Handling Nanomaterials

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Laboratory personnel shall adopt the following health and safety practices when handling nanomaterials in the laboratories:

a) Wear proper PPE and clothing. Avoid getting nanomaterials in eye, mucous membranes, on skin or in respiratory tract. Do not handle nanomaterials with your bare skin. Wash your hands before leaving the laboratory.
b) Ensure you well understand and strictly follow the safety procedures of specific task or experiment. Only trained personnel are permitted to work in these areas while nanomaterials are being used.
c) Make yourselves familiar with the hazards of nanomaterials and other precursor materials involved by reading the Material Safety Data Sheet (MSDS).
d) Perform works in HEPA-filtered fume hood or BSC. If neither is available, laboratory personnel should wear appropriate respirator or N95 mask. The use of respirator requires proper training and fitting test.
e) If weighing dry powders is necessary and the weighing balance cannot be located in fume hood or BSC, take a container then add the material to the container in a hood. Seal the container before returning to the balance to weigh the powder.
f) Aerosol producing activities such as sonication, vortexing and centrifugation should not be conducted on the open bench.
g) Keep nanomaterials which may become dispersed in air away from ignition sources to avoid fire or explosion.
h) If other hazardous chemicals are involved in the experiments associated with nanomaterials, work carefully in compliance with all necessary chemical safety requirements.
i) If heating in a closed vessel (e.g. hydrothermal or solvothermal reactor) is not avoidable, use vessel and other associated equipment designed and certified for that purpose and built-in with the necessary safety devices such as pressure relief valve or rupture disc.
j) All waste nanomaterials should be kept in proper waste containers with labels for pickup by a licensed chemical waste collector following the requirements of the Waste Disposal (Chemical Waste)(General) Regulation (Cap. 354C). Waste should never be poured down the drain or placed in trash bins.
k) Equipment used to create or handle nanomaterials should be cleaned or evaluated for potential contamination prior to disposal or reuse.
l) Regular cleaning of bench tops, floors and other surface should be implemented. Cleaning solution should be compatible with the vehicle in which the nanomaterials are suspended.

5. Emergency

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Laboratory Persons In-Charge should address the potential hazards of the engineered nanomaterials involved and the necessary safety measures to all concerned laboratory personnel. Suitable preparedness and arrangements should be in place to ensure that all laboratory personnel take appropriate actions in case of emergency.

In the event of minor spillage of nanomaterials, it is important that nearby personnel are alerted so that exposure to airborne nanoparticles is minimized. Window and doors should be kept closed. Always wear appropriate PPE when cleaning up a spill. For spills that might result in airborne nanomaterials, proper respiratory protection should be worn. Cleaning up powder spills should use HEPA vacuum cleaner or wet wipe the area with towels. Liquid spills can typically be cleaned by applying absorbent in the spill kit.

In case of larger scale of spillage:

a) Alert other people and evacuate the area immediately.
b) Leave the laboratory and close the door.
c) Report the incident to HKSTP following the “General Laboratory Emergency Procedures” in the SHE Handbook.
d) Stay away from the laboratory and wait for assistance. Do not allow people to enter the laboratory or go to the nearby areas.