DRAFT

Guidelines for Safe Handling of Nanoparticles in Laboratories

(Revised 03/31/05)

Background/Purpose:

Nanoparticles are currently defined as particulates having one dimension less than 100 nanometers (particles with diameters < 100 nm.) as well as being insoluble or poorly soluble in water. Particles in this size range readily become airborne and can remain airborne for very long periods of time. (However, electrostatic forces between particles produce a strong tendency for them to agglomerate into larger aggregates).

These particles, depending upon their effective size in the body and other physico-chemical characteristics, may have the potential to penetrate the alveolar membrane in the lungs and be transported to other parts of the body. Liquid solutions and/or slurries that contain nanoparticles, can produce airborne aerosols if agitated, splashed, or sprayed. These liquid aerosols containing nanoparticles can be inhaled, potentially depositing the nanoparticles deep within the lungs.

The potential for nanoparticles to penetrate the skin is unclear at this point so these materials should be handled in a manner that avoids skin contact.

Because of these issues, it is important to follow safe practices for handling and use of these materials. Of course, the inherent toxicity/hazards of the nanoparticle material/chemistry is also an important aspect of risk assessment and should be considered.

The text below offers general guidance. It is not possible to anticipate the particular circumstances of every work situation. Thus, it is important to consult with your group's or site's Health Safety & Environmental (HS&E) resource to prepare specific job safety analyses (JSAs) and safe practices for your particular work.

Also note that the safe practices below are based on experience handling nano materials in the laboratory. They will be updated as we learn more about the materials and/or as we do work on a larger scale beyond the bench.

Recommended General Safe Handling Guidelines For Laboratory Use:

1. Before working with or handling nanoparticles or nanoparticle-containing materials in a lab or pilot operation always conduct an exposure risk assessment with your local/site HS&E resource. They may also involve Business Unit or Corporate resources as needed.

   The exposure risk assessment includes an evaluation of:

   a. The physical form of the material (dry powder, liquid solution/slurry).
   b. The nanoparticle size range of the dry powder material or particles in the liquid solution/slurry, in nanometers. This information should be requested from suppliers.
   c. Potential routes of exposure to the body (inhalation, skin contact/penetration, eye contact).
   d. The chemical properties as they pertain to the material's toxicity.
   e. Work process procedures that could generate dust or liquid aerosol into the workplace air (e.g., pouring, agitating, grinding, vigorous mixing, etc.)
   f. Engineering controls available in the handling area (laminar flow hoods, chemical fume hoods, glove boxes, other local exhaust ventilation capability).

g. Any use of electrical/magnetic fields or temperature gradients applied to nanoparticles as part of the experimental work.
h. Risks of fire or explosion for dry powders.
i. Waste stream collection and disposal of materials containing nanoparticles (in solid, liquid, or air).

2. Whenever possible, receive and handle nanoparticles in slurries/solutions versus handling dry, powder materials.

3. Any handling, processing procedures, or processing equipment used with nanoparticle materials/mixtures, in a manner that could result in the generation of dust or liquid aerosols into the laboratory/pilot operation air, must be performed, (whenever feasible) within a validated, properly functioning <u>enclosing</u> exhaust hood. A low velocity, laminar– flow type hood, (e.g. Flow Sciences), traditional chemical "fume hood," or a "glove box" are preferred. At this time, we believe that a "downflow booth" will not provide adequate protection for working with nanoparticles without respiratory protection.

NOTE: A laminar flow or fume-type hood is recommended vs. a "dust hood" because particles of this small size range tend to behave more like gases or vapors.
Verify the effectiveness of the hood before using it. For example use a TSI P-Trak (or similar) instrument to determine if particles escape from the containment. The P -Trak, measures particles in the range 20 nm. to 1 micrometer. You are looking to see if there is an increased reading above background (e.g. > 10% above background).

4. If work that could result in the generation of nanoparticle dust or nanoparticle-containing liquid aerosols into the laboratory/pilot operation <u>cannot</u> be done in an enclosing exhaust hood (or completely "closed system"), you must consult your local/site HS&E resource. "Closed system" means that nanoparticle materials are inside a sealed container, closed pipes, or equipment, etc. without exposure points to open air.

Options for alternate engineering controls or PPE to be considered include:

a) Use of an <u>exterior</u> exhaust hood/open LEV (a flexible duct, with or without an attached portable hood, e.g., a "Nederman arm" or an "elephant trunk") that can be located closely above, or closely adjacent to, the potential dust or liquid aerosol source. <u>Normally, use of an exterior exhaust hood/open LEV must be supplemented with respiratory protection [see b) below].</u> Place the exterior exhaust hood/open LEV as close as possible to the potential source of nanoparticle dust/liquid aerosol generation. Enclose the source to the extent feasible (e.g. position a Perspex barrier around the source and sit the hood/LEV immediately above the source). The barrier is intended to help contain spillage.

   Always test the effectiveness of the exterior exhaust hood/open LEV for capturing the dust/aerosol source. Use a P-Trak to verify effectiveness. Use of smoke tubes provides a good visual indication if the hood/LEV is working effectively.
   Do not rely only on a one time assessment to determine capture effectiveness. The frequency and potential magnitude of aerosol generation will dictate the frequency of verifying the effectiveness of the hood/LEV.

b) Your HS&E resource will guide you in the choice of respirator for your specific situation.

   1.) When respiratory protection is needed, the <u>minimum</u> requirement is a Powered Air–Purifying Respirator (PAPR) equipped with P100/P3/HEPA filters used in conjunction with

either (1) a flexible hood that covers the head, shoulders and upper torso (with single or double "bib"), or (2) a tight-fitting full-facepiece.
NOTE: Do not use negative pressure half-masks or full-face respirators because very small leakages in the face-sealing area can allow nanoparticles to ingress to the breathing zone. A PAPR that does not include the full hood or tight-fitting facepiece as described above provides a low protection factor with more potential air ingress opportunity areas.

2.) When handling dry/powder nanoparticle materials outside of an enclosing exhaust hood or closed system, an air-supplying respirator [breathing air supplied from an air bottle or compressor source through an air-line, or a self-contained breathing apparatus (SCBA)] must be worn if:

a). nanoparticle charges are neutralized, or when work is done with nanoparticles in electromagnetic fields or thermal gradients,
b.) particle size range distribution data for these materials show that there are, or that there are likely to be, particles present that are smaller than 10 nanometers.

5. Impervious gloves should be worn for skin protection when handling all forms of nanoparticle materials/mixtures. Nitrile gloves are recommended for most dry and liquid applications. Other specific glove materials may be required depending upon the chemistry of the material being handled. Your local/site HS&E resource should be consulted for appropriate glove recommendations.
Note: Gloves should always be removed inside the enclosing hood or under the influence of local exhaust ventilation and placed into a receptacle or a sealed bag. This will help prevent particles/aerosols from becoming airborne into the breathing zone outside the influence of the hood.

6. Small spills of a few grams of dry/dried, or any size spill of liquid nanoparticle-containing material should be wiped up carefully without generating airborne material, e.g., with wet paper towels/wet cloths. Place towels/cloths in a sealed bag or bucket for disposal. Prevent dusting/aerosolization. Do not brush or sweep spilled dry/dried nanoparticles.

Although unlikely to occur, larger spills of dry/dried nanoparticle materials should be vacuumed using a HEPA filter-equipped vacuum cleaner, only if the exhaust can be routed to the outside of the building or into the exhaust duct of an enclosing hood, followed with a wet wiping of the surface with wet paper towels/wet cloths. Place towels/cloths in a sealed bag or bucket for disposal.
A PAPR or air-supplied respirator as described in 4.b. above must be worn during any large nanoparticle-containing material spill event and cleanup.

7. Dispose of laboratory scale nanoparticle-containing liquid or solid materials as hazardous waste if the chemical or mixture is regulated as such by applicable environmental regulations. Otherwise, dispose of nanoparticle-containing materials as special wastes (incinerate, chemically treat, or immobilize/encase). Waste disposal of larger scale wastes will be assessed on a case-by-case basis. Consult your local/site HS&E resource.