Nanotechnology

Nanotechnology - Controls for Health Hazards

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What are the hazards of nanotechnology?

It is a difficult question to answer as each nanomaterial (like each chemical) can have its own unique effects. The effects of the nanomaterials are not only based on the chemical characteristics but the shape, size, crystal structures, surface coatings, surface texture, surface charge, surface reactivity, and other factors can all impact how the nanomaterial might affect our health. In addition, the nanomaterial may not have the same characteristics as its "normal" sized particles material.

Hazards of nanotechnology are described further in the OSH Answers document Nanotechnology – General.

How should exposure to nanotechnology be controlled?

To control these exposures, use the hierarchy of control principles. There are four main methods of control, which should be implemented in this order:

1. Elimination (including substitution)
2. Engineering controls

3. Administrative controls
4. Personal Protective equipment

The OSH Answers Hazard Control describes the general hierarchy of control process in more detail.

What characteristics of nanomaterials should be examined?

When performing a hazard identification and risk assessment, consider the following factors:

- characteristics of the material
- amount of material used or handled
- the state of the material (e.g., dry powder, in a solution/liquid, or contained within a solid material)
- degree of containment (e.g., are other controls used?)
- number of workers exposed
- duration of use (e.g., how much and how long is each worker exposed)is exposed to a hazard, the larger the dose of the hazard that may be absorbed into the body.

Because of the uncertainties about the toxicology of nanomaterials, steps need to be taken to reduce exposures to as low as possible. More information about the nanomaterial may be needed, such as what is known about the toxicological properties of that nanomaterial, or of the elemental components from which a particular nanomaterial is produced? (e.g., studies about humans, animals, or those done in a laboratory). What is known about the safety properties? Could these products be an explosion hazard?

Consider making a hazard map for any process using nanotechnology. Use a floor plan of your facility and indicate where there are hazards. You might target:

- physical hazards
- frequency of exposure
- level of exposure
- a specific chemical or agent
- workers or job titles most likely to be exposed

What are examples of elimination and substitution controls for nanomaterials?

First, determine if you can eliminate or substitute the nanomaterial. For example, determine if it is possible to:

- not use the nanomaterial at all (eliminate)
- replace the nanomaterial with a “normal” sized particle that has known information about its hazards and risks (substitute)
- use another form of the nanomaterial, such as a liquid instead of dry powder (substitute) that may not become airborne as easily

What are examples of engineering controls for nanomaterials?

Engineering controls are methods used to remove the product, or place a barrier between the worker and the hazard. Inhalation is the most common route of exposure to airborne nanomaterials in the workplace. Ventilation is a control measure that can be used to reduce worker exposure to nanoparticles generated through various work processes. Where ever possible, design the entire work process to be enclosed and ventilated appropriately.

Examples for nanomaterial work include:

- enclosures, which can be small for weigh scales or large enough to enclose the entire nanomaterial reactor
- local exhaust ventilation
- isolation devices, such as glove boxes
- use of air locks and sealed containers

What are common ventilation controls when working with nanomaterials?

Local exhaust ventilation should be used for controlling nanomaterial exposure. Local exhaust removes the contaminant at the source and prevents it from entering the general work area. In their Workplace Design Solutions documents regarding exposure to nanomaterials, the National Institute for Occupational Safety and Health (NIOSH) recommends:

- For operations when workers handle powders on a small scale (e.g., working with a quality assurance or control sample, or weighing out a specific amount for mixing), use local exhaust or ventilated enclosures such as fume hoods, glove boxes, isolators, and biological safety cabinets.
- For processes such as spraying or machining, equipment such as ball milling machines should have a ventilated enclosure and hinged doors for loading and unloading.

- Spray dryer production should have local exhaust ventilation.
- Extrusion operations should consider an exhaust hood and local exhaust ventilation, designed to enclose the source as much as possible.
- For processes such as bagging or packaging, a continuous liner system will help to reduce emissions. Specifically designed bag dumping stations (with ventilation) will help reduce emissions when transferring bags to process hoppers. Enclose the waste bag collection area as well.
- For large scale material handling and packaging, unidirectional flow or downflow booths can be used.
- When working with reactors, small reactors can be placed in a laboratory fume hood or enclosure, while larger scale reactors should consider using a custom built enclosure or vinyl curtains, both with adequate ventilation.
- Dry powder operations can use a properly sized and installed high-efficiency particulate air (HEPA) filter.

Each system must be carefully designed, installed, used and maintained in order to operate properly and to be effective.

- Use flow indicators or flow alarms to show the ventilation system is working properly.
- Make sure materials used to construct enclosures and ventilation systems are compatible with the properties of the nanomaterials used (e.g., explosive, corrosive), as well as the process (e.g., head loads).
- Seal joints to contain the nanomaterials and prevent any escape or leakage.
- Always consider access requirements for the operator, as well as maintenance personnel such that they can do the required tasks without reducing the control features (e.g., they can perform tasks with the enclosure doors closed, with the air flow away from their breathing zone, etc.).
- Maintenance and cleaning of work areas or reactors should be done by methods that reduce emissions, such as using a local exhaust ventilation unit, baffles and side shields, and making sure the worker is position such that the air flow is away from their breathing zone.

Exhaust hoods capture the contaminant released by the process. Each should:

- be designed specifically for the process it is controlling
- have a air capture velocity stronger than contaminant velocity and air current from the room
- have an appropriate flow rate to prevent fugitive emissions without removing the nanomaterials from the process stream

- use an airflow indicator or alarm to show that it is working
- use a bag in/bag out filter change out system to reduce the risk of exposure to maintenance personnel

Because a local exhaust hood removes air from the workspace, for each one installed in the workplace, the general ventilation system may need to be adjusted to increase replacement air to balance the exhausted air with an equal amount of supply air. This adjustment will prevent drafts, pressure differences, and other fan operation issues.

Note that general dilution is, in general, not recommended to control nanomaterial concentrations because:

- there are no established occupational exposure limits or TLVs for many nanomaterials
- some nanomaterial toxicology data show associations with adverse health effects
- calculating necessary contaminant control air change rates is challenging due to variable workplace operations

Please see the OSH Answers series on industrial ventilation for more general information about ventilation systems.

What are examples of administrative controls?

Administrative controls include work practices, education, training, and other measures.

- Establish a chemical safety/hygiene plan, including preventative maintenance, how to check the systems performance, and repairs.
- Establish regular housekeeping measures such as appropriate storage, work station clean up, etc.
- Make sure all workers have the education and training they require when working with nanomaterials, including any known hazards of the particular nanomaterial in use, and how to recognize if the equipment used (e.g., ventilation, personal protective equipment (PPE)) is not working properly.
- Label all containers.
- If using a fume hood, set a certification mark for the proper hood face velocity. Lower the sash when not working with the nanomaterials. Place nanomaterials and equipment as far back in the hood as possible.
- Conduct work station and spill cleanup by using a wet wipe method or with a vacuum that meets the hazards present, such as explosion-proof, and/or HEPA filter. Do not use a pressure relief valve that may bypass the HEPA filter and release nanomaterials into the air.

- Dispose of cleaning materials in a sealed bag to prevent further release of the nanomaterial.
- Limit time spent working with nanomaterials
- Use tools with long handles (e.g., a long handle will prevent a worker from needing to place their head into a barrel when scooping out nanomaterials)
- Use sealed or closed bags/containers, or cover all containers when not in use.
- Restrict access to areas where nanomaterials are used.
- Use liquid products where possible to help reduce airborne exposures.
- Use good lighting to help workers perform their tasks, and to help notice if dust is escaping.
- Post appropriate warning signs.
- Do not dry sweep or use compressed air to clean work areas.

What are examples of personal protective equipment when working with nanomaterials?

Personal protective equipment (PPE) is the last defence. Note that the American Industrial Hygiene Association (AIHA) cautions that PPE has not been widely tested for effectiveness against nanomaterials. Current testing only evaluates relative effectiveness such as percentage of penetration at this time. PPE selection should be re-evaluated periodically.

PPE may include:

- using nitrile or other chemically resistant gloves
- wear a lab coat or coveralls
- safety glasses, goggles or face shield
- respirators that are appropriate for the products used and tasks being done

All PPE should be inspected before use, and periodically for signs of wear. Dispose of gloves in a sealed plastic bag.

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