"In the long term, nanotechnology will demand a revolutionary re-thinking of occupational health and safety" ***John Howard, MD, NIOSH***

Introduction

Welcome to the course ***Working Safely with Nanotechnology OHS_HS240***. This course is designed to teach those working with nanomaterials how to work safely with them and to stay healthy as well as protect co-workers.

Objectives

At the end of this course, you should be able to:

1. Select the valid concerns that OH&S has and describe how these might affect you in your daily work.
2. Review the various control measures necessary for safe Laboratory Operations and apply them in your area.
3. Select several safe work practices that should be applied to areas working with nanomaterials.
4. Choose the items necessary for a nanomaterials spill kit, and demonstrate how to clean up a nanomaterial spill correctly.
5. Describe the process for proper labeling and disposal of nanomaterials.

Terms and Definitions

Term	Definition
Nano	Greek for dwarf; very small; minute; super tiny; 1 nanometer (nm) = 0.000000001 meter (m); 1 nm = 10^{-9} m; 1nm = one billionth meter
Nano Measures	
Nanometer	One billionth of a meter
Nanosecond	One billionth of a second
Nanoliter	One billionth of a liter
Nano-object	Material with one, two, or three external dimensions in the size range from approximately 1-100 nm.
Nanoplate	A nano-object with one external dimension at the nanoscale

Nanoparticle	A nano-object with all three external dimensions at the nanoscale (e.g., Fullerenes, Quantum Dots)
Nanofiber	A nano-object with two external dimensions at the nanoscale (e.g., nanotube defined as a hollow nanofiber and a nanorod as a solid nanofiber)
Nanomaterial	Nano-objects incorporated in a larger matrix or substrate
Nanotechnology	"Nanotechnology is the understanding, manipulation, and control of matter at dimensions of roughly 1 to 100 nanometers to produce new materials, devices, and structures." *OSHA definition*

Current Occupational Health and Safety Concerns

Nanoparticles: Big Potential or Big Threat?

Do nanomaterials present new safety and health hazards? What are the risks? How can the benefits of nanomaterials be realized while minimizing the potential risk? What will be the effect of chronic exposure to scientists in labs?

Current studies of animals exposed to different nanomaterials are useful in predicting potential human health effects.

Laboratory animal studies involving carbon nanotubes (CNT) and carbon nanofibers (CNF) indicated that CNT and CNF could cause adverse pulmonary effect including:

- inflammation,
- granulomas[1]and
- pulmonary fibrosis[2].

These animal study findings are significant to human health risks. Similar lung effects have been observed in workers in dusty jobs exposed to comparable materials that were inhaled. In animal studies where carbon

[1] Granulomas are a small group of cells that form when the immune systems attempts to fight off a harmful substance, but cannot remove the substance from the body.

[2] A condition where tissue deep in the lungs becomes scarred. The tissue can get thick and stiff making it hard to breathe. This may also cause the blood not to receive enough oxygen.

nanotubes (CNT) were compared with other known fibrous materials (e.g., silica, asbestos, untrafine carbon black), the CNTs were of similar or greater strength.

Based on research reviewed by the Centers for Disease Control's (CDC) National Institute for Occupational Safety and Health (NIOSH), nanomaterials can:

Increase chemical toxicity as compared to larger particles of similar composition,

Be deposited in the respiratory tract in greater proportion by inhalation compared to larger particles of the same material,

Cross cell membranes and cause oxidative damage as well as impair functions of cells in culture, and

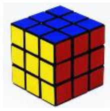
Penetrate healthy, intact skin, and move (known as translocation) to other organs.

In this course, it is Occupational Health and Safety's (OH&S) responsibility to give you the information on how to handle the nanomaterials in the laboratory safely so that you and your co-workers will be protected. It is **your responsibility** to use that information every day to stay healthy and safe.

Why Are Nanomaterials Potentially More Toxic?

There are three elements that scientists think make nanomaterials potentially more toxic than other chemicals.

1. **Size:** Nanomaterials are materials with at least one external dimension in the size range from approximately 1-100 nanometers. Due to their very small size, nanomaterials are capable of crossing cell membranes and reach the blood and various organs (translocation).
2. **Greater Surface to Volume Ratio:** Relatively more molecules of the chemical are present on the surface making it more toxic than larger particle of the same composition.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Surface = 3^2 X 6 = 54	Surface = 2^2 X 6 = 24	Surface = 1^2 X 6 = 6
Volume = 3^3 = 27	Volume = 2^3 = 3	Volume = 1^3 = 1
Surface/Volume = 2	Surface/Volume = 3	Surface/Volume = 6

3. **Shape:** The health effects of nanoparticles are likely to depend on shape.[i]

When materials are nanosized, both physical and chemical properties change. The following changes can occur:

- Color
- Melting temperature
- Crystal structure
- Chemical reactivity
- Electrical conductivity
- Magnetism
- Mechanical strength

Other Dangers and Concerns – Fire and Explosions

When the particle size decreases, it can increase combustion potential and combustion rate. This leads to the possibility of relatively inert materials becoming highly reactive in the nanometer size range.

When using combustible nanomaterials, the potential and severity of explosions increases proportionally to the number of materials used.

Exposure, Severity, and Routes

We know there are potential hazards when working with nanomaterials, but what are the limits?

The NIOSH proposes the following recommended exposure limit (REL):

- 1 $\mu g/m^3$ elemental carbon as an 8-hr Time Weighted Average (TWA) respirable mass airborne concentration for carbon nanotubes and carbon nanofibers
- 0.3 mg/m^3 for ultrafine titanium dioxide

Respirators may be necessary if expected exposures are above this level – especially for ultrafine titanium dioxide.

Potential for Exposure

Below are situations that could increase your potential for exposure:

- Working with nanomaterials in liquid media without adequate personal protective equipment (PPE)
- Handling nanomaterials in powder form
- Working with nanomaterials in operations where a high degree of shaking or moving is involved
- Cleaning dust collection systems used to capture nanomaterials
- Generating nanomaterials in the gas phase in non-enclosed systems
- Performing maintenance on equipment
- Carrying out processes used to produce or fabricate nanomaterials
- Machining, sanding, drilling of nanomaterials, or other mechanical disruptions of nanomaterials

Severity of Exposure

Cleaning up spills or waste material

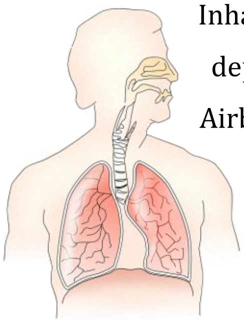
How will you know the severity of your exposure? That depends. The following factors must be taken into account to determine the severity of exposure.

1. The amount of material being used
2. Whether the material can be easily dispersed (in the case of a powder) or form airborne sprays or droplets (in the case of suspensions)
3. The degree of containment
4. Duration of use

Routes of Exposure

Nanomaterials are so small that it is sometimes difficult to know if you have been exposed or not. In order to maintain the health and safety of those yourself and those around you, you should know the routes of exposure and use controls for protection.

Inhalation

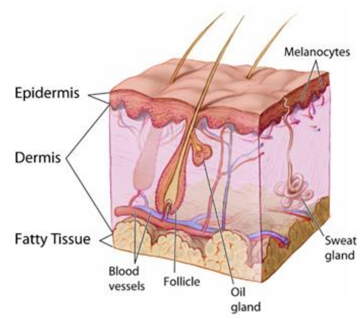


Inhalation is the most common route of exposure to airborne particles in the workplace. The deposition of nanoparticles in the respiratory tract is determined by the particle's shape and size. Airborne nanomaterials that are inhaled can be deposited in the respiratory tract as well as entering the blood stream and translocating to other organs. Studies have shown that, when inhalation occurs, the inhaled nanomaterials can induce certain cancers and cause cardiovascular dysfunction and/or rapid and persistent pulmonary fibrosis.

- Inhalable - 100 μm diameter: can be breathed into the nose or mouth
- Thoracic - 10 μm diameter: can penetrate the head airways and enter the airways of the lung
- Respirable - 4 μm diameter: can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs[ii]

Skin absorption (Dermal)

Even though we don't know everything about nanomaterials, we know that the appropriate PPE ***must*** be worn when working with them.



Various nanoparticles have the potential to:

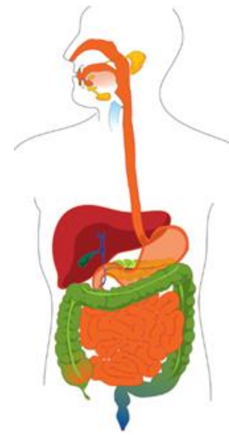
- Inhibit cell proliferation (iron oxide, nanotubes, TiO_2, silver)
- Affect cell morphology (silver, nanotubes)
- Initiate irritation response (quantum dots, nanotubes)
- Damage cell membrane (fullerenes)
- Induce DNA damage (cobalt chrome alloy)

Ingestion

Ingestion of nanomaterials usually occurs when:

- Poor work practices result in hand-to-mouth transfer

- Particles that are cleared from the respiratory tract via the mucociliary escalator are accidentally swallowed



In some studies, ingestion of various nanomaterials has the potential to:

- Cause liver damage (silver)
- Trigger immune response in intestinal dendritic cells (TiO_2 and SiO_2)
- Be cytotoxic to human intestinal cells (TiO_2, SiO_2 and ZnO)
- Damage DNA of human intestinal cells (ZnO)
- Be genotoxic to liver and lungs (C_{60} and SWNT)

Translocation after Ingestion

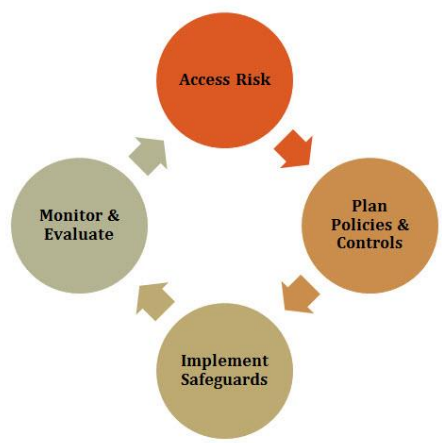
Studies have shown that ingested nanoparticles do translocate to other organ systems. For example, single-walled carbon nanotubes (SWCNT) that were placed into the stomachs of rats via gastrogavage were later discovered to have translocated to the rats' liver, brain and heart.[iii]

Risk Assessment and Management

Risk assessment and management is difficult in nanotechnology especially since standard, acceptable levels of exposure have not yet been determined for all the nanomaterials. Potential dangers depend on several factors such as size, shape, chemical composition, and solubility.

When choosing the appropriate controls to manage risk in the laboratory, the following factors should be taken into consideration:

- Scale of handling operations,
- Physical properties of materials being handled (particle size, wet or dry process),
- Work environment (lab environment, nearby activity),
- Equipment requirements (size of equipment/keeping enclosed), and
- Level of protection required.



Monitoring and Medical Surveillance

Monitoring is a key part of the safety program that seeks to protect workers against nanomaterial particulate exposures. Monitoring is classified as personal, area, or biological. Personal monitoring is the most common, but area and biological monitoring also serve important purposes in ensuring occupational health. Air samples may be collected by placing sampling devices directly on the worker (personal sampling) or by placing a sampling device in the work area. Personal sampling is a measure of the exposure concentration for the evaluation of the exposure level to workers and area sampling measures the environmental concentration for the evaluation of the clean level in the work environment.

Medical Surveillance Program Oversight

Qualified healthcare professional who is informed and knowledgeable about potential workplace exposures, routes of exposure, and potential health effects related to nanomaterials should have oversight of the medical surveillance program.

What Biological Tests Are Available?

There is **no clinical test** to measure:

- Transdermal nanoparticle absorption
- Transneural nanoparticle absorption
- Gastrointestinal nanoparticle absorption
- Respiratory nanoparticle absorption

Currently, other respiratory tests are unsuitable for detecting early effects of exposure to nanomaterials.

Who Should Participate in the Surveillance Program?

- Workers exposed to concentrations of carbon nanotubes (CNT) or carbon nanofibers (CNF) in excess of the REL (i.e., at above 1 μg/m3 EC as an 8-hr TWA).
- Workers exposed to more than 0.3 mg/m3 for ultrafine titanium dioxide
- Workers in areas or jobs that have the potential for intermittent elevated air- borne concentrations of any kind of nanomaterials.

Screening Elements: Initial Evaluation

People working with nanomaterials should have an initial (baseline) evaluation done by a qualified health-care professional that consists of the following:

- An occupational and medical history, with respiratory symptoms assessed by use of a standardized questionnaire, such as the American Thoracic Society Respiratory Questionnaire
- A physical examination with an emphasis on the respiratory system
- A spirometry test
- A baseline chest X-ray (digital or film-screen radiograph)
- All baseline chest images should be clinically interpreted by a board certified physician.
- Other examinations or medical tests deemed appropriate by the responsible health-care professional

Screening Elements: Periodic Evaluation

This is an image of a respirable dust sampling (top right) and pre-weighed cassettes for gravimetric sampling (bottom).

Evaluations should be conducted at regular intervals to ensure consistent care and health due to the nature of work. Periodic evaluations should be conducted:

- Post-incident as deemed appropriate by the responsible health-care professional
- Based on data gathered in the initial evaluation ongoing work history
- Periodic analysis of the medical screening data to identify trends or patterns

Changes in symptoms such as new, worsening, or persistent respiratory symptoms, and when process changes occur in the workplace (e.g., an unintentional "spill")

Standard Operating Procedures

Every laboratory that contains nanomaterials should have written standard operating procedures (SOP). Those procedures should contain the following information:

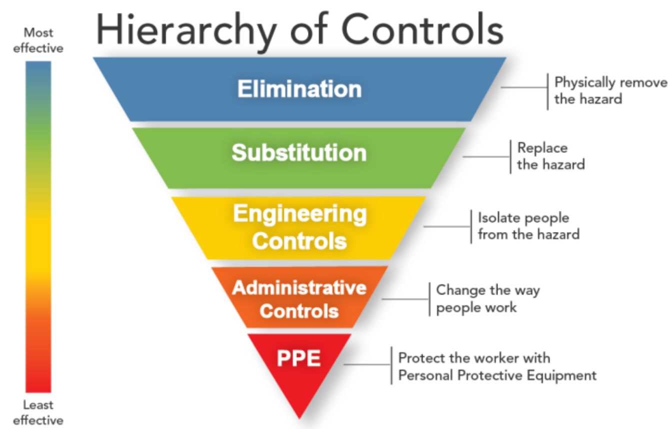
- Contact information for the PI, supervisor, manager, OH&S, etc.
- Experiment overview
- Risk assessment
- Controls used in the lab
- Engineering/ventilation controls
- PPE required
- Emergency safety equipment available in the area
- Step-by-step operating procedures
- Decontamination procedures
- Spill and accident procedures
- Waste disposal
- Training requirements
- General
- Lab specific
- Required approvals

NIOSH Hierarchy of Controls

This chart of the hierarchy of controls should be used to reduce the risks involved when working with nanomaterials.

Controls are usually placed:

1. At the source (where the hazard "comes from")
2. Along the path (where the hazard "travels")
3. On the worker (PPE)



Elimination and Substitution

Elimination is the most desirable approach in the hierarchy of controls. This is not possible when the study involves the nanomaterials themselves. Substitution of a nanomaterial may be difficult since it was likely chosen for its particular properties.

Engineering Controls

Engineering controls protect workers by removing hazardous conditions. This is not the same as elimination. It is one of the most effective and applicable control strategies for most nanomaterial processes.

Engineering controls are divided into two broad categories: ventilation controls and non-ventilation controls. Examples of ventilation controls are fume hoods, biological safety cabinets, and directional laminar flow booths.

Examples of non-ventilation controls are glove bag containment, guards and barricades, material treatment (water spraying of dust).

Fume Hoods for Nanomaterial Usage

Ventilation controls (fume hoods and biosafety cabinets) were covered in the recently updated Biosafety Cabinets and Fume Hoods (OHS_BIO304) course. OH&S strongly recommends using fume hoods when working with nanomaterials. Please follow all of the procedures as directed in the course.

Special Fume Hoods for Nanomaterial Use

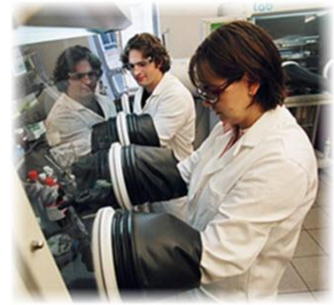
New fume hoods specifically designed for nanotechnology are being developed primarily based on low-turbulence balance enclosures. They have face velocity alarms to alert the user to potentially unsafe operating conditions.

One advantage of these devices is that they operate at much lower flow rates and velocities than the chemical hoods. The internal turbulence is reduced significantly, lessening the potential for loss or ejection of the nanomaterial.

The use of bench-mounted weighing enclosures, as seen here, is common for the manipulation of small amounts of material.

Newer nano hoods based on pharmaceutical weigh-out enclosures may be a reasonable alternative to larger fume hoods when only small-scale, benchtop manipulation of powders is needed.

Glove Boxes: Alternatives to Conventional Chemical Hoods



Glove box isolators typically provide a greater level of worker protection. The primary advantage of using a glove box is that it fully isolates a small-scale process and provides a high degree of operator protection.

Glove boxes do have some disadvantages. For example:

- Cleaning the glove box may be difficult.
- Reduced access and limited operational scale may prevent you from performing the tasks that you desire.
- Transferring materials into and out of the glove box can be dangerous if not handled carefully.
- Glove box enclosures are sometimes used under positive pressure with an inert atmosphere. This can increase the possibility of airborne releases from the enclosure due to leaks.

Biosafety Cabinets

Biosafety cabinets (BSC) may be appropriate for use with dry powders. Caution must be taken. The airflow patterns inside a cabinet create complex turbulence patterns that may adversely affect the ability to handle nanomaterials without loss.

Remember when using BSC, consideration should be given how to clean the cabinet after use, how to maintain the BSC during required maintenance such as filter change-outs, and proper exhaust configuration.

Administrative Controls

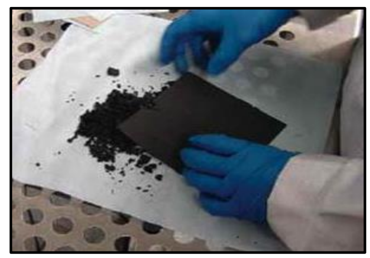
Administrative/work practice controls involve changes in workplace policies and procedures. The following controls are suggested to reduce risks.

Personal

1. Do not eat or drink in the areas where nanomaterials are handled.
2. Use hand-washing facilities before eating, smoking, or leaving the worksite.
3. Know where emergency showers are located, and use them in case of contamination.
4. Keep a change of clothes in case there is inadvertent contamination.
5. Bag and label contaminated clothing and send it out to be laundered. Do not take the contaminated clothing home.

The Lab

1. Educate workers on the safe handling of nanomaterials to minimize the likelihood of exposure.
2. Provide information on the hazardous properties lab workers are using.
3. Limit access to the laboratory (e.g., key cards).
4. Keep laboratory doors closed.
5. Remember to use local exhaust in all areas of material handling.
6. Use 100% fresh supply air. Do not recirculate room air.
7. Choose space that is isolated as much as possible from the rest of the lab.
8. Implement additional control measures (e.g., use of a buffer area, decontamination facilities for workers if warranted by the hazard) to ensure that nanomaterials are not transported outside of the work area.
9. Apply bench top protective covering.
10. Substitute nanomaterial slurry for a dry powder form, when possible, to reduce worker exposure.
11. Add water or use wet paper with dry powders when possible to control the release of nanomaterials.
12. Cover all containers when not in use.
13. Avoid dry sweeping (i.e., using a broom) or compressed air to clean work areas.
14. Ensure work areas and designated equipment (e.g., balance) are cleaned at the end of each work shift, at a minimum, using either a HEPA-filtered vacuum cleaner or wet wiping methods.
15. Dispose of all waste material in compliance with all applicable federal, state, and local regulations.



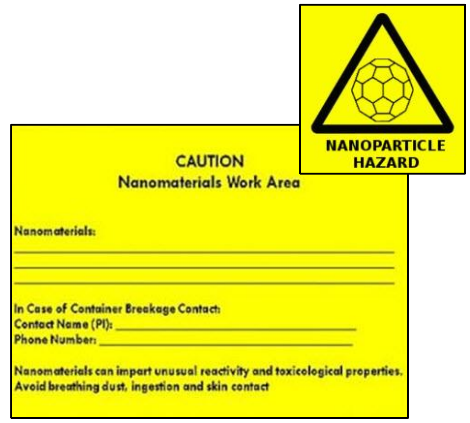
Shown here is crumbling carbon nanofiber paper on wet paper.

Use of Special Flooring: Sticky Mat

Consider using a walk-off mat such as a "sticky mat" at access/egress points to reduce the likelihood of spreading nanoparticles outside the laboratory.

Signage, Labeling, and Storage

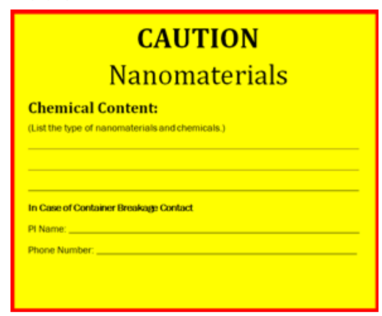
Door Signs

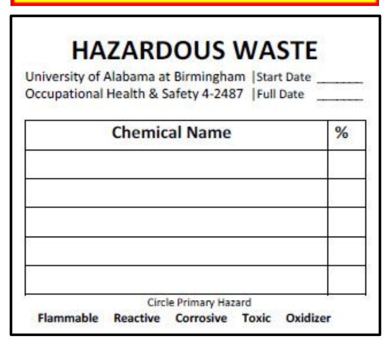


Appropriate signage indicating the hazard, PPE requirements, and any other pertinent information should be posted at entry points to areas where nanomaterials are handled or stored. These are for your health and safety. These should be read and followed.

Labeling and Storage

Before you begin working with nanomaterials from original or transferred containers, read the hazardous properties listed on the original container or in the Safety Data Sheet (SDS). If you do not have a SDS, order one.

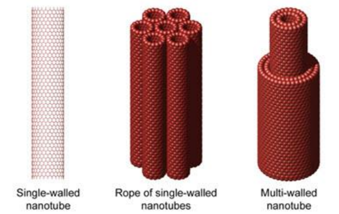




- Get a nanomaterial label like the one shown here and fill in all of the information.
  - If you do not use this label, your label must include the word "nano" and indicate the chemical content and form.
  - Ensure that every line is completed in case the container spills, breaks, or is opened so that others will know what to do.
  - Place the label on the container so that it is visible.
  - Add a Hazardous Waste label like the one shown here to the bottle along with the yellow label. The chemical hazards take precedence over the nanomaterial hazards. Both completed labels should be on the containers.
    - Both sets of labels are available on the OH&S website. The templates are designed for Avery Labels #5164.
- Keep liquids and dry particles in closed, tightly sealed, labeled, unbreakable containers whether they are suspended in liquids or in dry particle form.
- Use secondary containment (e.g., Ziploc® bags) for dry powders.

As of 2015, regulations have not yet caught up with nanomaterial hazards. Manufacturers are required only to list the hazards of the original material. For example, carbon nanotubes (CNT) are described as "carbon."

Personal Protective Equipment (PPE)



The size of the nanoparticle may be a factor in determining appropriate PPE.

National Institutes of Health (NIH)

When working with nanomaterials, personal protective equipment (PPE) offers the least amount of protection against worker exposures. It should be used when engineering and administrative controls are not feasible or effective in reducing exposures to acceptable levels. It is the last line of defense after engineering controls, work practices, and administrative controls.

Does this mean that you should not wear it? Absolutely not! You should always wear PPE as to act as a barrier between you and the hazard.

PPE should never be the only method used to reduce exposure because it may "fail" (stop protecting the worker) with little or no warning. For example: "breakthrough" can occur with gloves, clothing, and respirator cartridges.

Recommended PPE

Below are items you must have when working with nanomaterials.

- Long pants and a long-sleeved shirt
- Closed-toe shoes (Disposable, over-the-shoe booties may be necessary to prevent tracking nanomaterials from the laboratory.)
- Lab coats
  - Non-cotton (polyester) laboratory coats may be worn. We prefer that you wear a disposable gown where possible since all re-useable protective clothing should be laundered.
    - Make sure the gown sleeves are inside the gloves to protect the wrist area from exposure.
    - Keep all non-disposable clothing in the laboratory/change-out area to be laundered.
    - Place the clothing in closed bags before sending to the laundry service for cleaning.
    - Label the laundry bag with a nanomaterial hazardous waste label.
- Safety glasses or goggles and, in some cases, face shields are required to eliminate the chance of the nanomaterials getting into the eyes, nose, or in the facial area.
- Gloves must be worn when working with nanomaterials. Recommended types are:
  - Nitrile (most generally used)
  - Neoprene

   - Polyvinyl chloride (PVC)
   - Latex
- Respirators may be required for some nanomaterial operations. If you wear a respirator, you are required to:
   - Have a medical evaluation
   - Go through a fit testing to ensure the right fit
   - Participate in a brief training session on how to properly wear the device
   - Take part in the respirator maintenance program

PPE Requirements Imposed by the Environmental Protection Agency (EPA)

When working with certain multiwall carbon nanotubes, the EPA requires:

- Use of gloves impervious to nanoscale particles and chemical protective clothing, and
- Use of a NIOSH–approved full-face respirator with an N-100 cartridge while exposed by inhalation in the work area.

When working with siloxane modified silica nanoparticles, use impervious gloves or a NIOSH-approved respirator with an assigned protection factor (APF) of at least 10.

Emergency Procedures and Spills

Spill Kit

A nanomaterial spill kit should be readily available in or near each laboratory working with nanomaterials. A nanomaterial spill kit may contain the following:

- Caution tape
- Nitrile or other chemically impervious gloves
- Disposable laboratory coat with elastic wrists
- An N95 or P-100 for which you have been fit tested annually
- Absorbent material (e.g., kitty litter, Vermiculite, etc.)
- Pre-moistened wipes

- Sealable plastic bags (e.g., Ziploc® bags)
- Walk-off mat (sticky mat)
- HEPA-filtered vacuum (labeled as "nanomaterial use only")
- Spray bottle with water
- Nanomaterials and hazardous waste (if needed) label – Both are located on the website.
    - This is the same as the one used for labeling and/or waste containers.
- Hazardous waste containers with leak proof caps

Everyone in the laboratory should be prepared for contamination, spills, and other emergencies that could occur when working with nanomaterials. The following steps should be taken in case of a spill.

- Evacuate the lab if necessary.
- Restrict access to only those individuals with appropriate PPE, training, equipment, and authorized response to enter the affected area.
- Use the UAB Spill Kit Procedures Job Aid on the website regarding spills of hazardous materials along with the following additional requirements:
    - Clean the spilled material using wet-wiping methods.
    - Use only designated HEPA vacuums to vacuum nanomaterials.
        - Avoid dry sweeping or the use of compressed air.
    - Apply absorbent materials/liquid traps for liquid spills containing nanomaterials.
    - Collect and dispose of spill cleanup materials as nanomaterial-bearing waste.

Disposal

The following waste management guidance applies to nanomaterial-bearing waste[3] streams consisting of:

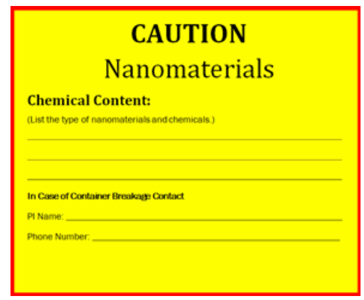
- Pure nanomaterials (e.g., carbon nanotubes)
- Items contaminated with nanomaterials (e.g., wipes, PPE, bench paper). Any material that comes into contact with nanomaterials becomes nanomaterial-bearing waste (e.g., gloves, other PPE, wipes, blotters). It must be managed as hazardous waste.
- Liquid suspensions containing nanomaterials

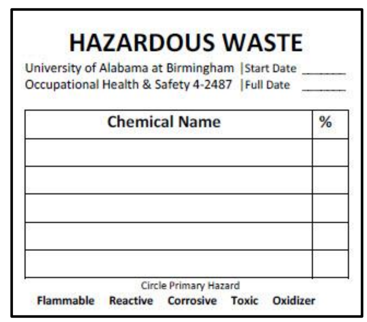
[3] Waste stream definition: The flow or movement of waste material from the point of generation (your lab) to final disposal (incinerator, landfill, etc.)

- Solid matrixes with nanomaterials that are easily crumbled, or have a nanostructure loosely attached to the surface, such that they can reasonably be expected to break free or leach out when in contact with air or water, or when subjected to mechanical forces. This does not apply to nanomaterials firmly bond in a solid base that will not release nanoparticles to water or when broken.

Any material coming into contact with nanomaterials becomes nanomaterial-bearing waste (e.g., gloves, other PPE, wipes, blotters).

- ***Never put nanomaterial-bearing waste into the regular trash or down the drain!*** There is a difference between nanomaterial bearing waste[4] and embedded nanomaterial waste[5].
- Collect nanomaterial-bearing waste in closed, tightly sealed, labeled, unbreakable containers.
- Label the container with both a nanomaterial and hazardous label (if it contains a hazardous chemical) like the ones shown here.
    - Label the container when the first piece of waste is placed in it.
    - If the nanomaterial waste stream has any chemical hazards associated with it, which takes priority over nanomaterial hazards. For example, if the nanomaterial is dispersed in a flammable liquid, then label as flammable. If the liquid is corrosive, then label as corrosive. If the nanomaterial is made of toxic metals, label toxic.





- Keep the container in a laboratory fume hood until it is ready for disposal. The container must remain sealed unless adding waste to it.
- When the container is full:
    - Secure the lid.
    - Remove it from the hood.
    - Place it in a second sealed container in a satellite accumulation area (SAA).
    - Complete the Hazardous Waste Manifest. Make sure that if clearly states NANOMATERIALS.

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[4] Nanomaterial-bearing waste may have the nanomaterials come loose or completely out and go into the environment. These must be disposed of as hazardous waste.

[5] Nanomaterials that are embedded, we assume will not become come loose or out. These do not have to be disposed of as hazardous waste.

- Check the date on your transcript for the last time you completed the Hazardous Waste Handling OHS_CS055 course if you are completing the manifest.
- It must be within the last 365 days before you can send the manifest, or it will be returned.
- Send the manifest to UAB OH&S Support Facility.

Regular Waste Stream

Nanomaterials embedded in a solid material that cannot reasonably be expected to break free or leach out when they contact air or water can be placed in the regular waste stream (trash). We assume that these nanomaterials ***will not*** come out of the material and go into the environment.

> If you have questions, please call OH&S at (205) 934-2487.

Conclusion

This concludes the Working Safety with Nanomaterials OHS_HS240 course. Please take the assessment at this time. 90% or higher is required to pass.

You may take the assessment two times. If you fail all attempts, you will fail the course and have to take it again.

When everyone in your area/laboratory has completed this course, please notify OH&S so that the other half of the course can be set up. Someone from OH&S will come to your lab for inspection and further, live training.

You will not receive credit for this course until the person from OH&S confirms the completion of the live portion of this course.

> For further assistance or information contact UAB OH&S at 205-934-2487 or visit the OH&S **website**.

Want to Learn More?

OH&S has many training courses available to all UAB active employees and students. This includes topics such as in-depth radiation training, biosafety, bloodborne pathogens, chemical safety, controlled substances, building life safety, hazardous and medical waste, universal waste, PPE, hazardous communication, etc.

We have a decision tree to assist you in choosing the right course to match the knowledge/skills you may need at work every day as well.

If you have any questions or comments, please feel free to contact OH&S.

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[i] Orr, Galya, Sustainable Nano website, 2013, "Surfing Particles: taking a ride using living cell machinery," http://sustainable-nano.com/2013/04/30/surfing-particles-taking-a-ride-using-living-cell-machinery/

[ii] World Health Organization, "Hazard Prevention and Control in the Work Environment: Airborne Dust," http://www.who.int/occupational_health/publications/en/oehairbornedust3.pdf

[iii] Kulinowski, Kristen M., Introduction to Nanomaterials and Occupational Health, "Module 2: What Workers Need to Know about Nanomaterial Toxicology," https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CDAQFjAD&url=https%3A%2F%2Fnanohub.org%2Fgroups%2Fgng%2FFile%3A1-Introduction_to_Nanotechnology_and_Nanomaterials.pptx&ei=XuI3VZLOHZTbsATQlYGQBw&usg=AFQjCNFngipwOQrfz0rQeBcBNttYJv8Rpw&sig2=v28fu948hqCv09vZE4ygJg&cad=rjt