# Nanomaterials Health and Safety

MIT Environment, Health and Safety Office

# MIT EHS Training

This training is part of MIT's Environment, Health and Safety Management System (EHS-MS).

The EHS-MS encompasses all areas of the Institute: all departments, labs and centers and all students and staff. We all have a role and responsibility to insure that MIT is safe in all aspects of our work.

MIT is committed to being at the forefront in achieving, maintaining, and surpassing regulatory compliance.

Learn more about the EHS-MS, MIT EHS policy, and the central EHS office services at: [www.ehs.mit.edu](http://www.ehs.mit.edu)

# Objectives of this Course

By the end of this course, you will be able to:

- Define engineered nanoparticles (ENP) and understand some of the many types and their characteristics
- Understand what we know about the special health, safety, and environmental hazards of ENP
- Know how to control personal and environmental exposure to ENP
- Know how to safely manage waste and ship ENP

# Course Introduction

This web course is primarily focused on free or unbound engineered nanoparticles (ENPs) that may present an inhalation, skin, or ingestion hazard to researchers in laboratories.

It takes about 30 minutes to complete this web course. You can start and stop as many times as you like without having to repeat course materials.

If you have any questions about this course or handling nanomaterials, call the EHS Office at 2-EHSS or email us at environment@mit.edu.

# How to Use This Course

- This course will automatically advance through the slides.
- You also have the option to advance the course at your own pace by clicking the buttons at the bottom of the screen.  You can go forward or backwards to review slides.
- You can download slides at the end to save a pdf of additional sources of information at MIT or other institutions.
- You can download complete information about references cited in the slides by clicking the Reference Information button at the end.

# What is Nanotechnology?

Nanotechnology is the manipulation of materials at the nanometer scale to produce new particles, structures, and devices. A nanometer is one billionth of a meter ($1 \times 10^{-9}$ m). The term "nano" refers to things or processes on a scale between 1 to 100 nm.

*An Engineered Nanoparticle (ENP) is an intentionally synthesized particle (in contrast to naturally or incidentally created) with at least one dimension between 1 to 100 nm.*

ENPs can exhibit very different properties from their respective micron sized bulk materials, including greater strength, conductivity, fluorescence, and reactivity. ENPs are the basis of a new engineering and biological revolution.

# What are ENPs?

ENPs can be composed of many different base materials (carbon, silicon, metals such as gold, selenium, and cadmium).

ENPs can have many different shapes such as nanotubes, nanowires, fullerenes (hollow spheres), and crystalline structures such as quantum dotes.

Many more of the atoms in ENPs are on the surface, resulting in greater reactivity than bulk materials. Government agencies such as the EPA, OSHA, and NIOSH are investigating the health, safety and environmental effects of ENPs.

**ENPs under evaluation by the EPA**

- Carbon nanotubes and nanofibers
- Fullerenes
- Titanium and zinc oxides
- Nanosilver
- Cerium oxide, indium tin oxide
- Dendrimers
- Cadmium and selenium quantums dots
- Nanoceramic particles and nanoclays
- Nanowires
- Silica

# Nanoparticles can be natural or man-made

| Natural Nanoparticles | Man-made Incidental or Industrial Nanoparticles |
|---|---|
| • Volcanic ash<br>• Forest fire smoke<br>• Dust storms<br>• Ocean spray | • Combustion products (power plants, automobiles, diesel exhaust)<br>• Cigarette smoke<br>• Welding fume<br>• Metal working aerosols<br>• Mining dust |

Particles in the nm size range occur in nature and as an incidental byproduct of existing industrial and combustion processes.

Humans have always been exposed to nanoscale particles from natural sources and are well adapted to certain levels of exposure to particles that reach the deep lung.

Human activity has increased the variety and amount of nanoparticles that we are exposed to. Some can cause harm and have chronic health effects that develop over years if above safe levels.

# Characteristics of Nanoparticles: greater surface area and number and stay suspended longer in air

| Particle Diameter and Mass in Air | Particle Surface Area | Particle Number in cc of air | Residence Time in air |
|---|---|---|---|
| 20 nm<br>(10 mg/$m^{3)}$ | 3000 $um^2$/ml | 2.6 x $10^6$ | Agglomerate and then remain suspended for days to weeks |
| 2 um or 2000 nm<br>(10 mg/$m^{3)}$ | 30 $um^2$/ml | 2 | Gravitational settling occurs rapidly |

Nanoparticles have greater surface area than micron size particles. For the same mass concentration, 2 nm particle has 300 times the surface area and one million times the particle number compared to a 2 um particle.

When released into air, nanoparticles first agglomerate and then can remain suspended for days to weeks before contacting surfaces and sticking to them.

# Background Concentrations of Ambient Ultrafine (nm) Particles

| Location or Activity | Particle Concentration |
|---|---|
| Outside City of Cambridge Air | 5000 – 10,000 particles/cc of air |
| Inside MIT Labs and Offices | 1000 – 10,000 particles/cc of air |
| Pollution Episodes | $3 \times 10^6$ particles/cc of air of air |
| Cooking | $1 \times 10^6$ particles/cc or air of air |

Air pollution researchers refer to nanoparticles in the 1 to 100 nm size range as ultrafine particles. There is a background concentration of ultrafine particles in ambient air due to combustions sources such as cars, household heating systems, and power plants.

Outside urban air has background particle concentrations of 5000 – 10,000 particles per cc of air. During pollution episodes, concentrations may increase to millions of particles per cc of air. Cooking (sauteing , frying) may generate particles numbers of up to one million particles per cc.

# Nanoparticles are inhaled and deposit in lungs



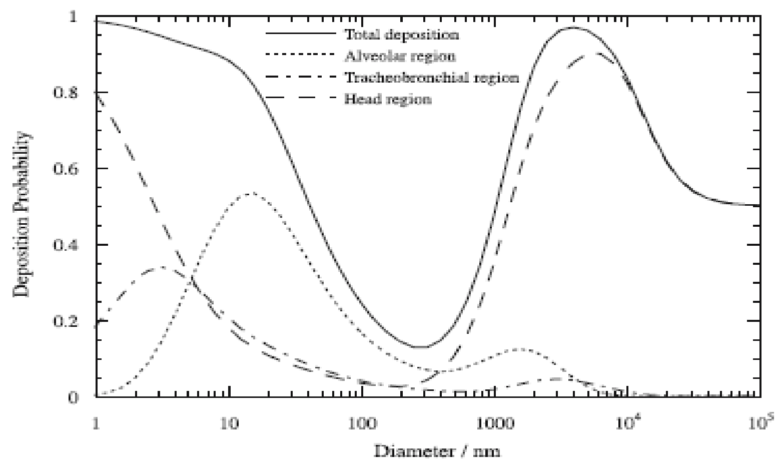
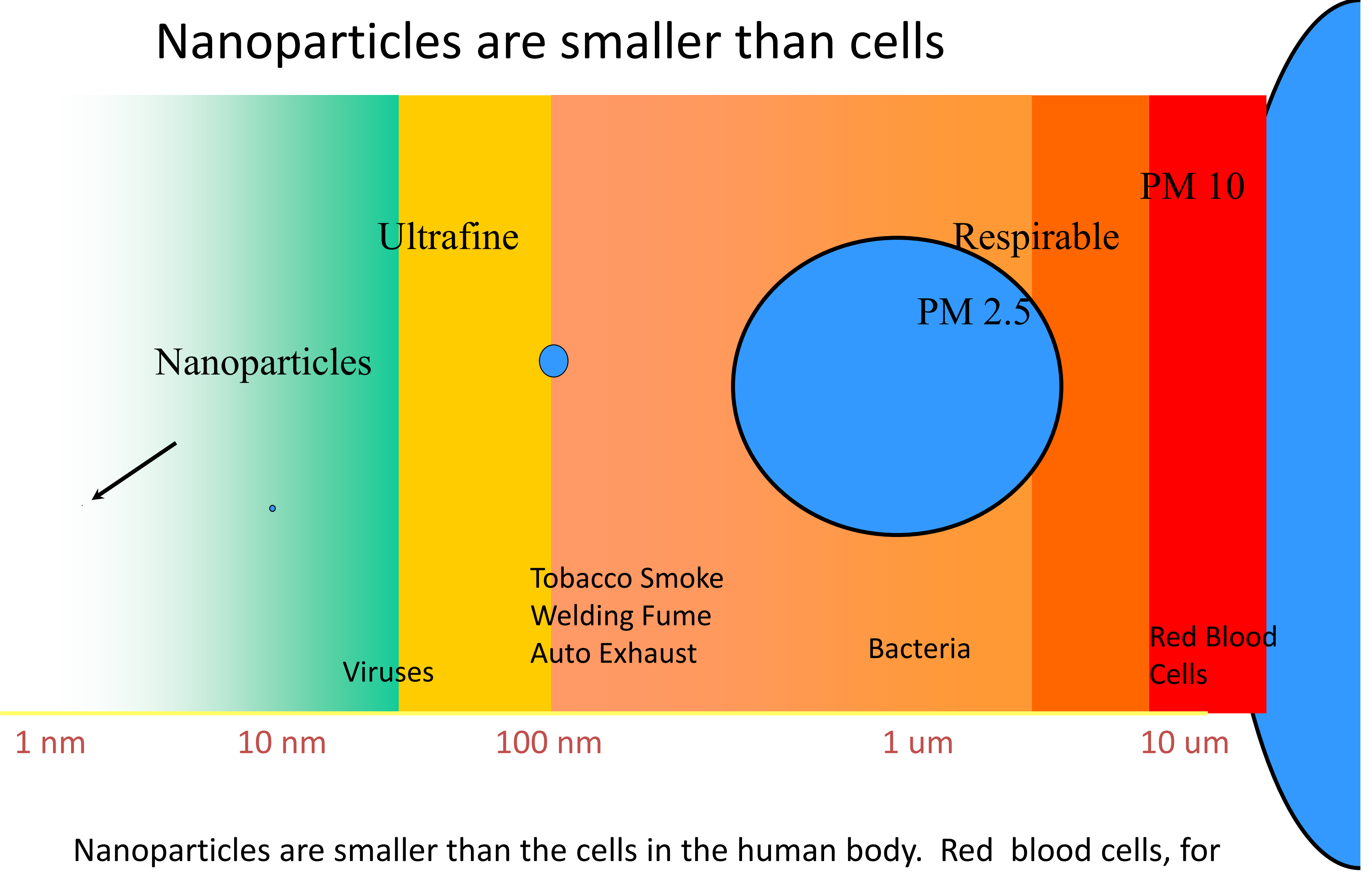



*Figure 2.* Modeled total particle deposition probability in the respiratory tract, and deposition probability in the alveolar region (ICRP, 1994). Deposition has been modeled assuming an adult breathing through their nose at 25 l/min (light exercise), and exposed to spherical particles with a density of 1000 kg/m$^3$.

If released into air, nanoparticles in the 1-100 nm range can be inhaled into upper airways and into the alveoli, or gas exchange range region in the deep lung. Once in the lung, nanoparticles deposit onto surfaces. About 90% of all inhaled nanoparticles are deposited somewhere in the respiratory tract. About 50% deposit in the alveolar or gas exchange region of the deep lung, as indicated in the above figure.

# Nanoparticles are smaller than cells




Nanoparticles are smaller than the cells in the human body. Red blood cells, for example, are 6-8 um (6000 – 8000 nm) in size.
ENPs are the same size are organelles within the cells, such as mitochondria and DNA. They are the same size as viruses and are easily taken up by cells when they come in contact with them.

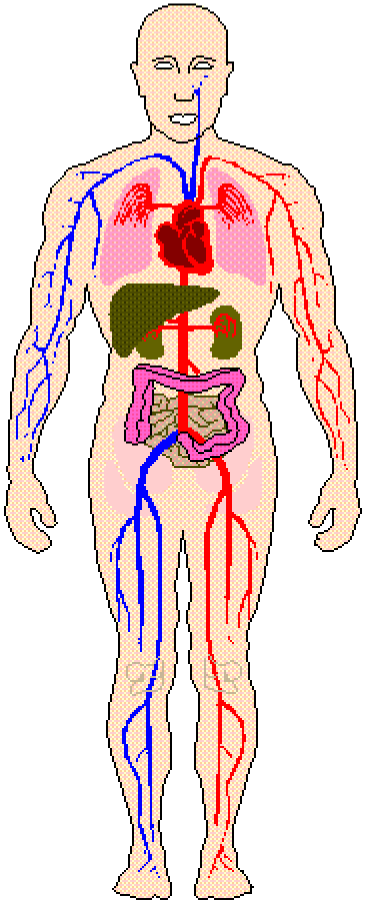
# Engineered Nanoparticles can be more toxic than micron size material

Traditional toxicology studies found that toxicity was related to the type of particle and the amount or mass of particle to which an organism was exposed.

Nanotoxicology is a new field in which studies have found that toxic effects are also related to the size of the particles. Some ENPS in the 1 to 100 nm range have been found to be more toxic that the same mass of larger, micron size material.

*For example, the same mass of 20 nm titanium dioxide nanoparticles produced 43 fold more lung inflammation in animals than 250 nm titanium dioxide particles. The increased inflammation is believed to be due to the much greater surface area of the small particle for the same mass of material. (Oberdorster et al 2004).*

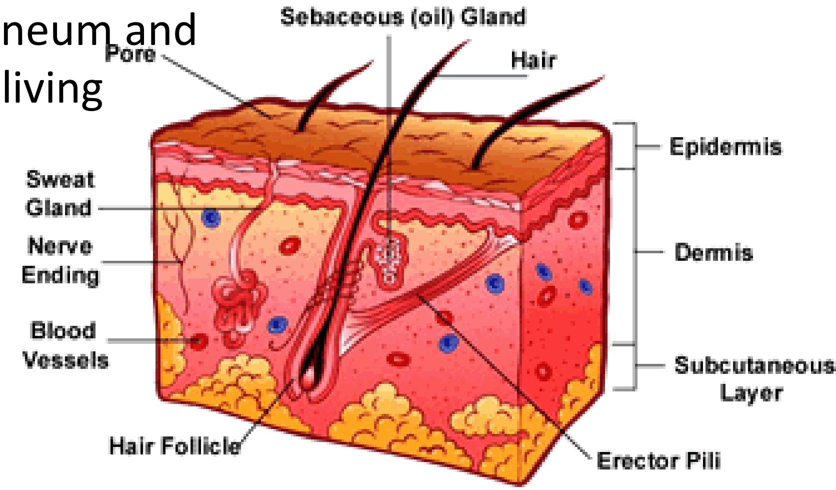
*This has been observed with different types of ENPs such as aluminum trioxide, carbon black, cobalt, and nickel but it is not observed in all cases.*



# ENPs may possibly penetrate the skin

The possibility that ENPs may penetrate skin is being actively investigated but has not been demonstrated in whole animal or human studies to date.

One study of nm titanium dioxide found that it penetrates the outer dead layer of skin called the stratum corneum and deeply into hair follicles but did not reach the living dermis layer below (Ladderman et al 1999).




A study of quantum dots found that they did not penetrate the mouse skin unless the skin was abraded (Zhang et al 2008). A second study found that quantum dots did penetrate intact, unabraded pig skin (in an in vitro bioassay). The eliptical shape of particles used in this study was hypothesized to facilitate penetration between skin cells (Rymen-Rasmussen et al 2006)

# Cadmium based materials are highly toxic at all sizes

| Study Results | Type of Cell |
|---|---|
| CdSe quantum dots were cytotoxic when oxidized by air or UV light.  Toxicity was partially prevented by ZnS coating (Derfus et al 2004). | Rat liver cells |
| CdSe quantum dots were toxic to all cell types tested; coating with albumin did not prevent toxicity (Shinohara et al 2004). | Monkey kidney cells<br>Human HELA tumor cells<br>Human liver cells |

Cadmium has been used in the synthesis of quantum dots which are nanocrystals about 6 nm in diameter.  They are increasingly used for bioimaging in research because of their very bright  and long-lasting fluorescent properties.

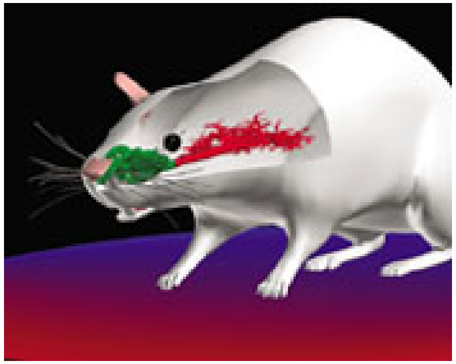
*From industrial studies, it is known that micron size cadmium is very toxic to human kidneys and lungs and is a suspected human carcinogen.  Preliminary testing of quantum dots containing cadmium have shown very toxic effects on many cell types in culture.*

Coating with protein did not prevent toxicity.  Coating with ZnS partially prevented toxicity. Additional research with coatings of different material types will need to be done before imaging in humans can be done.

# Fullerenes: Acute Toxicity Studies

- Fullerenes are composed completely of carbon molecules in the form of hollow spheres linked by hexagonal rings. Spheres of 60 molecules (C60) are also called buckminster fullerenes or buckyballs.

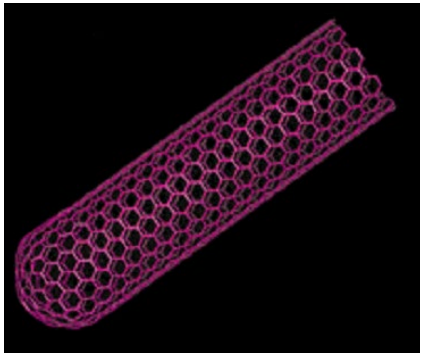
- They were first discovered in 1985 and have had more extensive toxicity testing than most other ENPS
- Acute toxicity studies found fullerenes to have low oral toxicity but moderate toxicity when injected into animals (Chen et al 1998).
- A study in a small number of mice looked at reproductive toxicity and found embryo death at moderate doses (Tsuchiya et al 1996).
- Single dose instillation studies found moderate lung inflammation but less than that produced by CNTs and quantum dots. An OEL of 0.39 mg/m3 was recommended (Shinohara et al 2011).



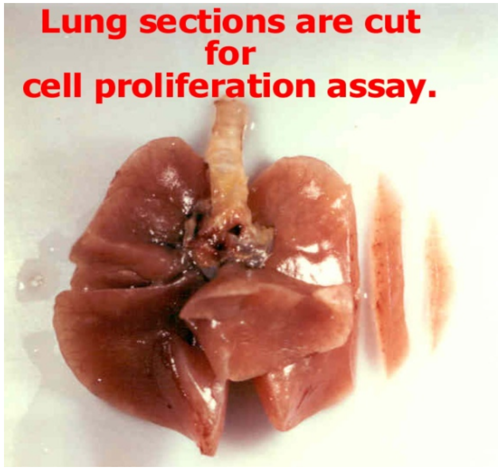
- More studies are needed to determine the safety of fullerenes if they are to be used for drug deliver in humans.

# Carbon Nanotube Toxicity

Carbon nanotubes (CNT) can have either single or multiple layers of carbon arranged in a cylinder. Typical dimensions for a single walled carbon nanotubes (SWCNT) are 1-2 nm in diameter and 100-1000 nm in length. Multiwalled carbon nanotubes (MWCNT) have several concentric layers.



CNTs may behave like nonbiodegradable fibers in the lungs. They have properties and toxicity very different from bulk carbon or graphite. They have great tensile strength and are potentially the strongest, smallest fibers known.




Preliminary single dose tests of lung toxicity in animals showed inflammation, granulomas, and fibrosis, or thickening and scarring of lung tissues (Lam et al 2004; Shvedova et al 2005; Muller et al 2005).

# Recent Development of Occupational Exposure Limits (OELS) for CNTs and Titanium Dioxide

Comparison of New Nano OELs to Existing OELs for Known Toxic Dusts:

| Material | OEL |
|---|---|
| Nano CNTs and Carbon Nanofibers (proposed) | 1 ug/$m^3$ |
| Nano Titanium Dioxide (<100 nm) | 100 ug/$m^3$ |
| Titanium Dioxide (>100 nm) | 1500 ug/$m^3$ |
| Beryllium | 0.05 ug/$m^3$ |
| Cadmium | 2 ug/$m^3$ |
| Crystalline Silica | 25 ug/$m^3$ |

In November 2013, NIOSH, which is the federal agency that researches occupational diseases, proposed an OEL for CNTs and carbon nanofibers (NIOSH 2013) . Based on the subchronic animal studies, NIOSH proposed an OEL of 1 ug/$m^3$ as an average over an eight hour day. The proposed OEL is in the same range of OELS for dusts known to be very toxic to human lung, such as beryllium, cadmium, and crystalline silica. NIOSH has also developed and adopted an OEL specifically for nano-sized TiO2 that is fifteen times lower than the OEL for larger TiO2 particles (NIOSH 2011).

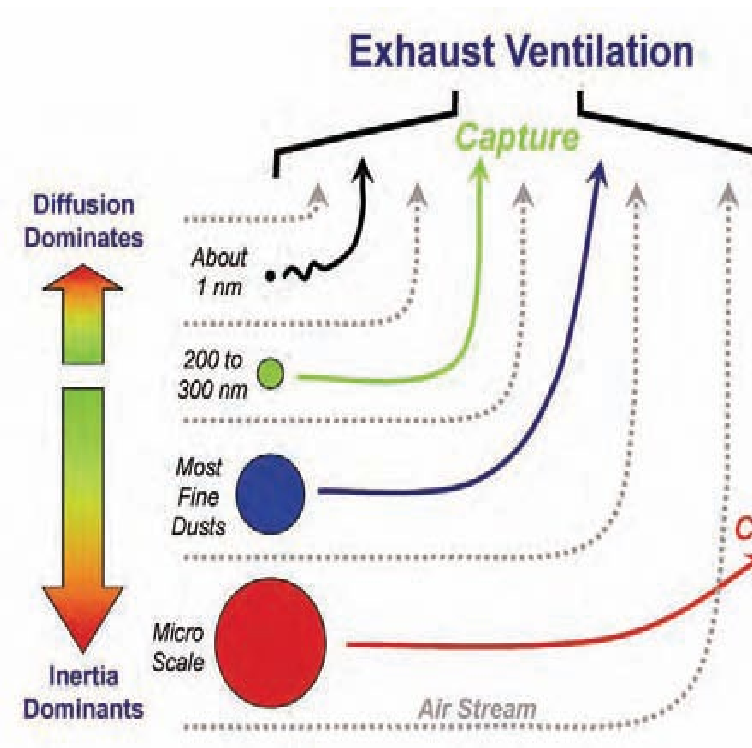
# Exposure to Engineered Nanoparticles in the Lab

# Probability of ENP Release and Exposure in the Lab

- The probability of ENP release and dermal and inhalation exposure depends upon the physical state of the nanomaterial.
- Nanomaterials in order of least to most exposure potential are the following:
  - Solid material with embedded nanostructures
  - Solid material with nanostructure bound to surface
  - Liquid suspensions of nanoparticles
  - Free nanoparticles (dry, dispersible single particles or agglomerates or gaseous phase)

# Aerosol Physics of Engineered Nanoparticles

- ENPs are in the size range of minimum settling. They can remain suspended in air for several days until collected on surfaces of captured by moving air streams.
- Nanoparticles follow air streams and are easily contained and collected by exhaust ventilation such as fume hoods or nanoenclosures.
- Nanoparticles are efficiently collected by HEPA (High Efficiency Particulate Air) filters by diffusions and electrostatic processes (Kim *et al* 2007)
- Nanoparticles are efficiently collected by HEPA filters used in respirators (Shaffer et al 2009)

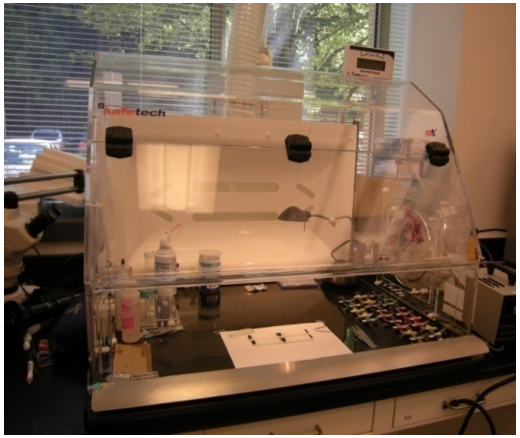


# Lab Practices which can cause Dermal and Inhalation Exposure

- The following are examples of lab practices which can cause skin or inhalation exposures, or both:
  - Working with ENPs in liquids without gloves  of adequate protection.
  - Working with ENPs in liquid media during pouring, vortexing, sonicating or where a high degree of agitation is involved can lead to release of respirable and inhalable droplets.
  - Handling ENPs in powder form can lead to aerosolization and skin exposure also.
  - Generating ENPs in the gas phase in non-ventilated or non-enclosed systems can cause releases in the lab.
  - Maintenance on processes used to fabricate ENPS or equipment such as furnace tubes can produce dermal or inhalation exposure

# Nanoparticle Work in the Lab: How to Reduce Exposure Risk

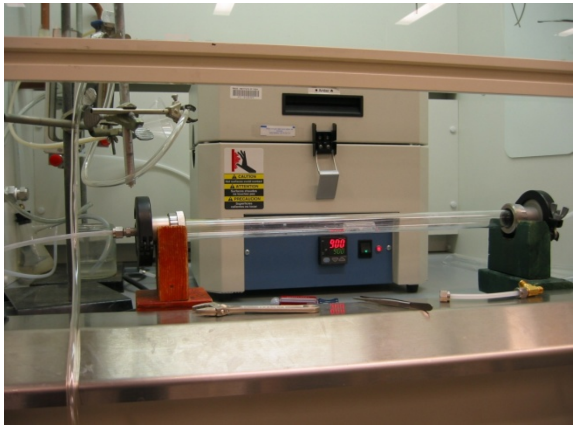
- Nanoparticles should be synthesized in closed or exhausted systems such as reactors, furnaces, fume hoods, glove boxes or other vented enclosures.
- All post-synthesis handling of dry ENPs should also be done in ventilated enclosures.
- Exhaust from vacuum pumps from closed reactors should be vented into the laboratory  local exhaust system.
- Transfer of ENPs, such as during weigh operations, should be within vented enclosures.
- Careful attention should be paid to opening reactors and furnaces using adequate purging.
- Processing or manipulation on the lab bench should be avoided.

# Use of Fume Hoods and Other Exhausted Enclosures to Control ENP Exposure

# Fume Hoods for Nanoparticle Work

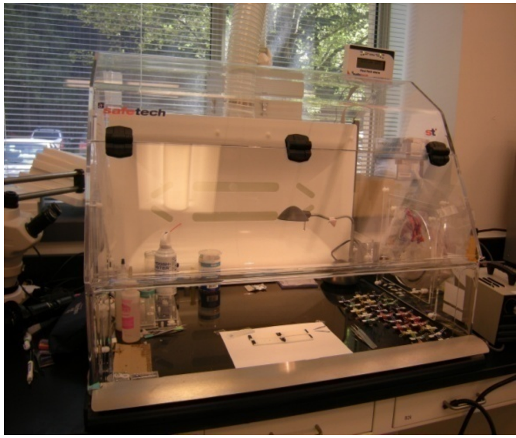
- Fume hoods are the most common enclosure used to reduce exposure to ENPs.
- They can be used to enclose furnaces which synthesize ENPS, weigh balances, and subsequent processing steps such as mixing, sonication, and assembly
- For furnaces which synthesize ENPs, fume hoods will capture flammable gasses and solvents used for synthesis as well as particles.
- Follow good work practices when using fume hoods:
  - Keep equipment 6” behind sash
  - Keep sash below chin or as low as possible when used
  - Move arms in and out slowly to prevent air inside hood being dragged out



CNT Furnace in Fume Hood

# Nanoenclosures for Weigh Balances and ENP Handling

- Several manufacturers have developed enclosures for weigh balances and ENP processing in which air currents do not disturb equipment or particles being handled
- These enclosures are designed to contain well at lower air current velocities.  They have slots designed to minimize air current disturbances on the floor of the enclosure.
- Manufacturers have tested the containment of these enclosures with nanoparticles and found acceptable containment.
- These enclosures can be connected to the lab exhaust system or to an HEPA filter with internal fan.  If the HEPA filter is used, the air is cleaned and exhausted back into the lab.
- Solvents cannot be used in the enclosures if the exhaust recirculates back into the lab.
- HEPA units must be tested with an aerosol annually to insure adequate filtering of nanoparticles.
- Contact the EHS Office for recommended vendors for these enclosures.



Nanoenclosure for assembly and weigh operations

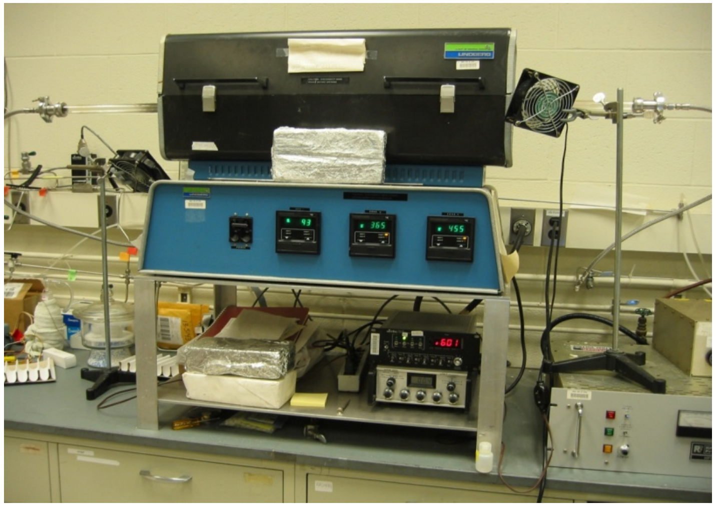
Stand alone HEPA filter and fan

# Biosafety Cabinets for Nanoparticle Work

- Biosafety cabinets (BSCs) have HEPA filters on incoming and outgoing air. They provide clean air for handling processes as well as exhaust. They were designed for work with viruses and bacteria but can also be used for ENP work.
- Only Class II Type B1 or B2 BSCs which exhaust into lab ventilation can be used for ENP work.
- About 60% of the air inside a BSC is recirculated within the BSC for energy conservation before venting to the outside.
- Only minimal amounts of solvents can be used in BSCs because of air recirculation.
- Contact the EHS Office if you have questions about the type of BSCs in your lab and their suitability for ENP work.

# Furnaces and Reactors for ENP Synthesis

- Enclosed furnaces and reactors can provide enclosure for ENP synthesis provided there are no leaks in any associated tubing and furnace and that ENPs remain firmly attached to substrates during removal.
- The best setup is placing furnaces or reactors inside a fume hood.
- Removal of free, unbound ENPs from furnaces always requires local exhaust ventilation.
- Exhaust gasses should be run through bubblers or filters to remove particulate. A 47 mm diameter quartz filter on the exhaust can filter out aerosolized CNTs (synthesized using aerosol catalyst)
- Furnaces and enclosures should be thoroughly purged of all gasses before opening.
- Maintenance on equipment, such as cleaning of furnace tubes, should be done in a fume hood.



# Glove Boxes and Custom Enclosures

- Glove boxes provide good containment for ENP handling under controlled or inert atmospheres.
- For large equipment or machining processes, specialty designed local exhaust ventilation drops can be used at emission points.
- Custom designed enclosures for large equipment can be fabricated by outside vendors. Contact the EHS Office for vendor information.

# Best Handling Practices for Handling Nanomaterials in the Lab

# Prevent Inhalation Exposure During Transport in Lab

- Nanomaterials removed from furnaces, reactors, or other enclosures should be put in sealed containers for transport.
- If nanomaterial is bound or adhered to substrate, the substrate can be removed and put in transport container.
- If nanomaterials are unbound and easily dispersible (such as CNT synthesis using aerosolized catalyst), the removal should be done using exhaust ventilation or glove bag connected to a HEPA vacuum.


Carbon nanotubes can be released when removed from a High Pressure CO furnace

# Prevent Skin Exposure to Nanomaterials

- For dry powders, use a sturdy glove with good integrity; disposable nitrile gloves are acceptable.  Nitrile gloves have been tested with viruses in the nm size range and provide an acceptable barrier.
- For liquid suspensions, chose a glove with good resistance to the solvent in use.
- If skin contamination is likely, use double gloves and change whenever contaminated.  Gloves with long gauntlets or sleeves are good for protecting exposed skin between hand and lab coat.
- Change gloves frequently or whenever contamination occurs.
- Use lab coats to protect your clothing from ENPS.  Use non-woven, disposable lab coats from materials such as Tyvek.  ENPs can penetrate woven cloth lab coats.
- For eye and face protection, use safety glasses, goggles, or face shield, depending upon your process.

# Prevent Contamination in the Lab

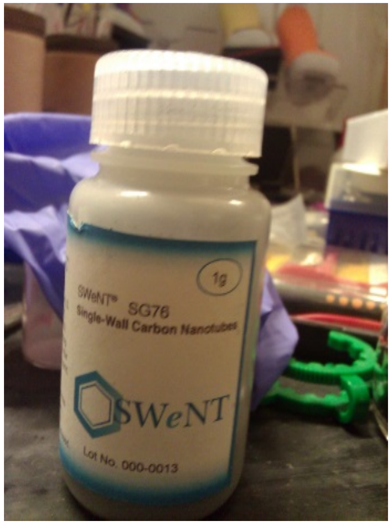
- Wet wipe surfaces of fume hoods or other enclosure after each use or at the end of the day.
- Bench liners can also be used to prevent surface contamination.
- Contaminated bench liners and wipes must be disposed of as hazardous waste.
- Never use compressed air or dry sweep for cleanup because this will disperse ENPs.
- Never use a shop vacuum or regular vacuum cleaner for cleanup because their filters are not fine enough to contain ENPs. Use only a HEPA vacuum with a HEPA filter on the exhaust to prevent dispersal into lab air.


# HEPA Vacuums for Cleanup and Spills

- HEPA vacuums have been designed and tested by manufacturers to remove 99.97% of 300 nm particles.  Their capture of 100 nm particles is even greater.
- The HEPA filter on the exhaust collects ENPs and prevents blowing them around the lab during cleanup.
- They have been used extensively in semiconductor manufacturing clean rooms for particulate cleanup.
- A vendor recommended by the EHS Office is Nilfisk.
- The EHS Office has a HEPA vacuum for loan to labs on a trial basis.

# Container Labels and Signs for ENP Work

- Label all nanomaterial containers with the words “nano” or “nanoscale”, such as “nanoscale titanium dioxide”.  If possible, give the actual size or range, such as 20-40 nm.
- Post signs in areas where easily dispersible nanomaterials are in use: indicate hazard and proper procedures for handling.



# Prevent Exposure During Spill Cleanup

- Prepare a Nanoparticle Spill Kit containing: nitrile gloves, wipes or absorbent materials, disposable P100 respirators, sealable plastic bags, tacky mats if large amounts of ENPs are used.
- Have respirators obtained from the EHS Office on hand if you anticipate spills outside of exhausted enclosures
- Minor Spills: use wet wiping with water or lab detergent for solid materials; use absorbent wipes for suspensions.
- Major Spills: use a vacuum with HEPA filter on the exhaust. The EHS Office has a HEPA vacuum that is available for emergencies.

# Use HEPA Respirators for Spill Cleanup Outside of Fume Hood

- Both disposable and reusable HEPA respirators are available for spill cleanup of ENPS.
- Both respirator types have been tested with nanoparticles and show excellent protection.
- Respirators cannot be shared; each person must obtain their own.
- Respirators must be obtained from the EHS Office to select the correct size (S, M, L) and tested to insure that it fits properly.  See the EHS web site for more information.

Disposable  HEPA Respirator

Reusable HEPA
Cartridge Respirator

# Proper ENP Waste Management Applies to

- Nanomaterial-bearing waste streams consisting of:
  - Pure nanomaterials (e.g., carbon nanotubes)
  - Liquid suspensions containing nanomaterials
  - Solid matrix with nanomaterials that are friable or nanostructure is loosely attached to the surface
  - PPE, wipes, items contaminated with nanomaterials

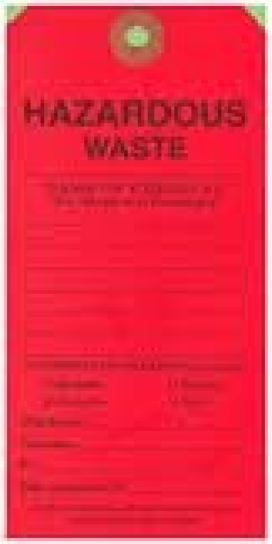
- Does not apply to nanomaterials embedded in a solid matrix that cannot reasonably be expected to break free or leach out.

**BUT….**

- Would apply to dusts and fines generated from cutting or milling such materials.

# ENP Waste Collection and Storage

- DO NOT dispose of nanomaterial-bearing waste in the regular trash or down the drain
- Collect paper, wipes, PPE and other items with loose contamination in a plastic bag or other sealing container
- Close and place into a second plastic bag or other sealing container when full
- Label outer bag or container with a red tag
- Follow SAA labeling and container requirements as with traditional hazardous waste



# Proper Labeling of ENP Waste

- Clearly indicate on waste label "nano-sized particles" and the makeup (e.g., cerium oxide).

- Also consider the base material and carriers/solvents
  - ***Heavy metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver***

  - ***Carriers/solvents: flammable, toxic, corrosive, reactive (e.g., toluene, trichloroethylene, ethers)***

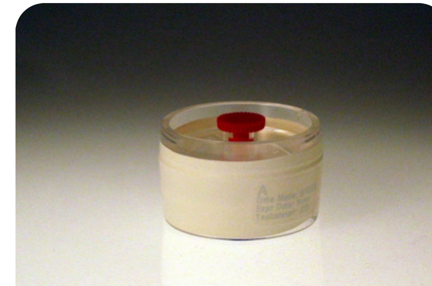
- *Powdered* carbon = flammable solid = hazardous waste

- Unsure? Contact the EHS Office for a waste determination

# Exposure Assessment for Nanomaterials

# Air and Surface Monitoring for Nanomaterials

- Air monitoring and wipe sampling of surfaces are used to assess potential exposure to nanomaterials.
- Surface contamination is assessed by wiping a designated area (general 10 cm2) with moistened filter paper and subsequent chemical analysis.
- Air monitoring can measure particle numbers in air (particles/cc) or particle mass (ug/m3).
- Specialized air sampling equipment is required to measure particle number and particle size distributions in air.
- Lab operations not done in exhausted enclosures and with the potential to release particles should be evaluated and possibly monitored.
- These include working with dry particulate outside of a fume hood, removing loose CNTs from furnaces, machining or cutting composites containing embedded nanoparticle, electrospinnig or spinning, vortexing or sonicating outside an enclosure, and others.



37-mm Quartz Fiber Filter for Air Sampling

TSI Condensation Particle Counter

# Studies of Lab Procedures that can Release ENPs

- Several studies have measured release of ENPs from lab operations that generate aerosols
- Transferring and weighing 200 g of carbon fibers on an open bench top without exhaust ventilation produced elevated particle counts as measured by CPC and visualized by SEM (Methner *et al.* 2012)
- Sonicating fullerenes of hydroxylated MWCNTs in aqueous solution with surfactants without an enclosure produced elevated particle counts (Johnson *et al* 2010).
- Drilling or cutting composites containing MWCNTs produced elevated nanoscale particle counts as measured by FMPS (though free MWCNTS were not detected by SEM). Wet cutting suppressed the release of nanoscale particles (Bello *et al*. 2009)

# Material Safety Data Sheets (MSDSs) and Other Information Sources

# Current MSDSs for Nanomaterials are often wrong

Sigma-Aldrich.

www.sigmaaldrich.com

**SAFETY DATA SHEET**

Version 6.1
Revision Date 01/15/2020
Print Date 01/18/2020

**SECTION 1: Identification of the substance/mixture and of the company/undertaking**

**1.1 Product identifiers**

| | | |
|---|---|---|
| Product name | : | Carbon nanotube, single-walled |
| Product Number | : | 704113 |
| Brand | : | Aldrich |
| CAS-No. | : | 308068-56-6 |

**1.2 Relevant identified uses of the substance or mixture and uses advised against**

| | | |
|---|---|---|
| Identified uses | : | Laboratory chemicals, Synthesis of substances |

**1.3 Details of the supplier of the safety data sheet**

| | | |
|---|---|---|
| Company | : | Sigma-Aldrich Inc.<br>3050 Spruce Street<br>ST. LOUIS MO 63103<br>UNITED STATES |
| Telephone | : | +1 314 771-5765 |
| Fax | : | +1 800 325-5052 |

**1.4 Emergency telephone number**

| | | |
|---|---|---|
| Emergency Phone # | : | +1-703-527-3887 |

**SECTION 2: Hazards identification**

**2.1 Classification of the substance or mixture**

**GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)**

Germ cell mutagenicity (Category 1B), H340

For the full text of the H-Statements mentioned in this Section, see Section 16.

**2.2 GHS Label elements, including precautionary statements**

| | |
|---|---|
| Pictogram | |
| Signal word | Danger |
| Hazard statement(s) | |
| H340 | May cause genetic defects. |
| Precautionary statement(s) | |
| P201 | Obtain special instructions before use. |
| P202 | Do not handle until all safety precautions have been read and understood. |

- Currents MSDSs often refer to information developed for larger micron sized particles.
- For example, the pictured MSDS for fullerene refers to carbon black which it describes as a nuisance dust.
- MSDSs for CNTs have cited occupational exposure limits for graphite, a micron size dust.
- A recent study of MSDSs for nanomaterials showed that 60% cited information related to the bulk micron size material.
- Nanomaterial MSDSs should indicate that ENPs may have different or more toxic properties than bulk materials and cite available information for the specific nanoparticle, if any has been developed.
- Because toxicity information about ENPS is rapidly changing and expanding, researchers should search scientific literature about specific nanoparticles they are working with.

# Additional Information Sources

Searchable electronic databases for nanoparticle toxicity include the following:

- International Council on Nanotechnology (ICON) maintains a database on environmental safety and health of ENPs that can be searched by particle type and time period: http://icon/rice.edu
- National Center for Biotechnology Information (NCBI) or Pub Med maintains a database which covers medical and biotechnology literature and which can be searched using terms such as nano, particle type, toxicity, etc: http://www.ncbi.nlm.gov/entrez

# Information Sources, con't

Other web sites offer information on best practices:

- ICON has developed a WIKI in which users post information on best practices for working with ENPs, both in labs and in industry. See Good Nano Guide on ICON web site: http://icon.rice.edu
- NIOSH maintains a website with background information, results of exposure assessment studies, and best practices for research labs, see *General Practices for Working with Engineered Nanomaterials in Research Laboratories, NISOH Publication 2012-147:* *www.cdc.gov/niosh/topics/nanotech/*
- From the California Nanosafety Consortium of Higher Education: *Nanotoolkit: Working Safely with Engineered Nanomaterials in Academic Research Settings (2012):* *http://ehs.ucla.edu/NanoToolkit.pdf*
- From the UK Nanosafety Partnership Group: *Working Safely with Nanomaterials in Research and Development (2012):* *http://www.safenano.org/Portals/3/SN_Content/Documents*

# MIT EHS Office Information Sources

More information is available on the MIT EHS Office web site:

- Nanomaterial Toxicity: https://ehs.mit.edu/chemical-safety-program/chemicals/
- EHS Office Direct: call 452-3477 or email environment@mit.edu for an evaluation of your laboratory procedures