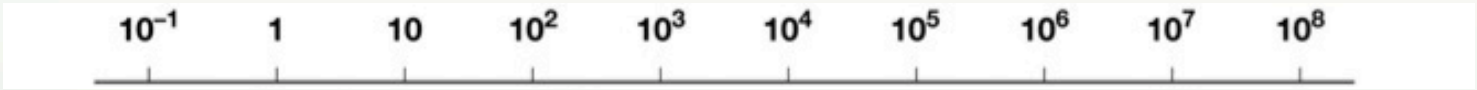
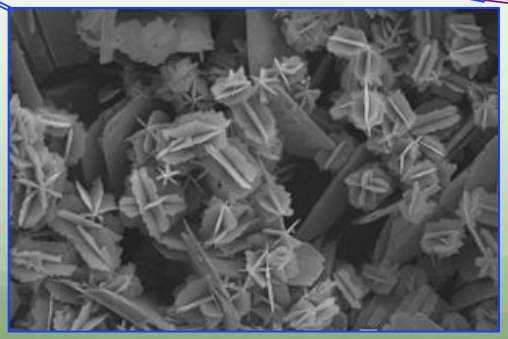
Guidelines for Handling Dry Materials

What is Today's Focus?

- Dry chemicals or materials that could pose a hazard due to physical and toxicological characteristics.
- Can be natural or manmade, but will focus on those found in lab spaces and machine shops.
- Includes materials across the size spectrum.



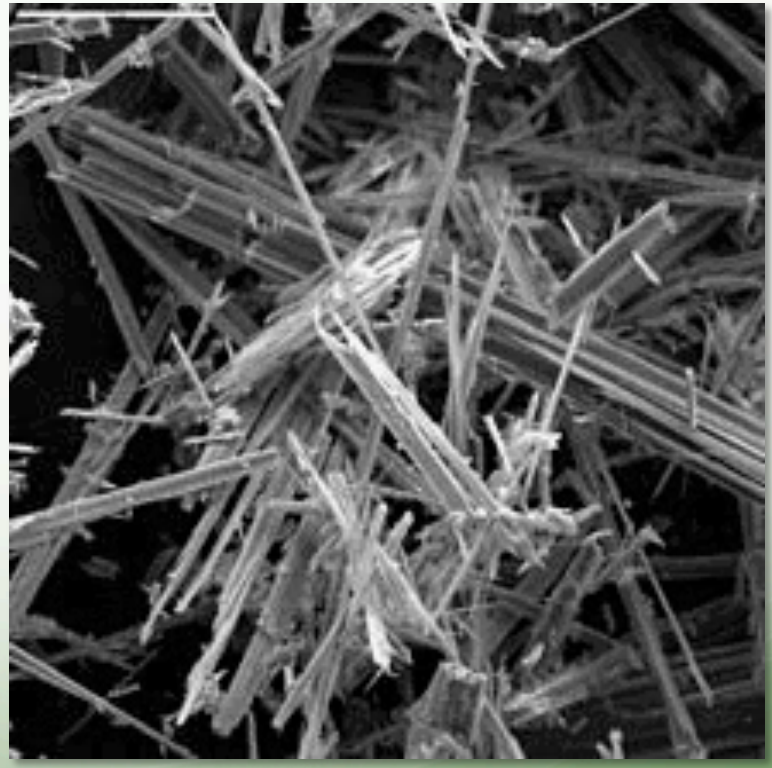


Uses in BE and DMSE

- Machining –
  - Groups work with "machine shop" tools that can create powders as materials are processed.
- Powders as product –
  - Some groups develop powders or nanomaterials.
- Dry chemicals as stock material –
  - Many chemicals come as a powder, then are suspended in an appropriate solvent based on the experiment.
- Nanoparticles as tools –
  - Quantum dots are used for imaging procedures.
- Others
  - The above is just a sample of the types of applications where dry chemicals are found at MIT.

Safety Concerns

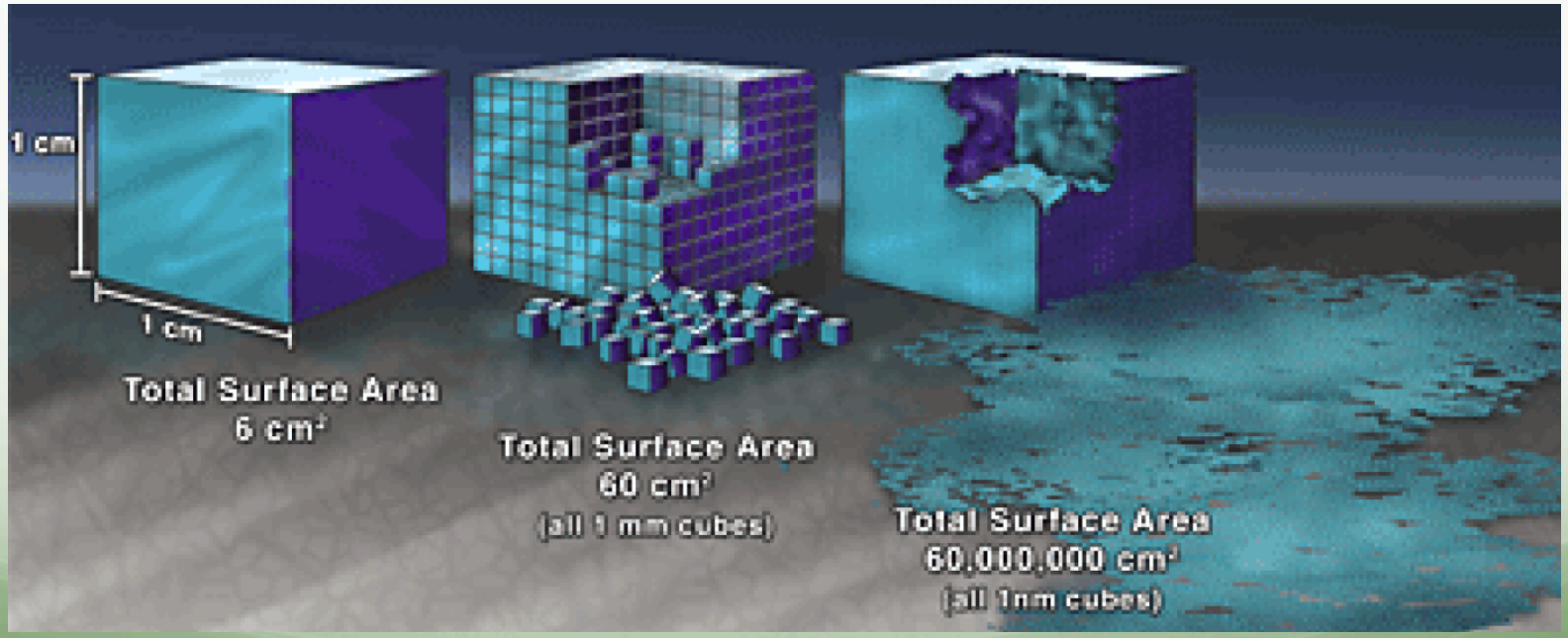
Safety concerns arise from a mixture of the properties of the material and the form it is in.



Safety Concerns: Toxicity

Some contributing factors in toxicity:

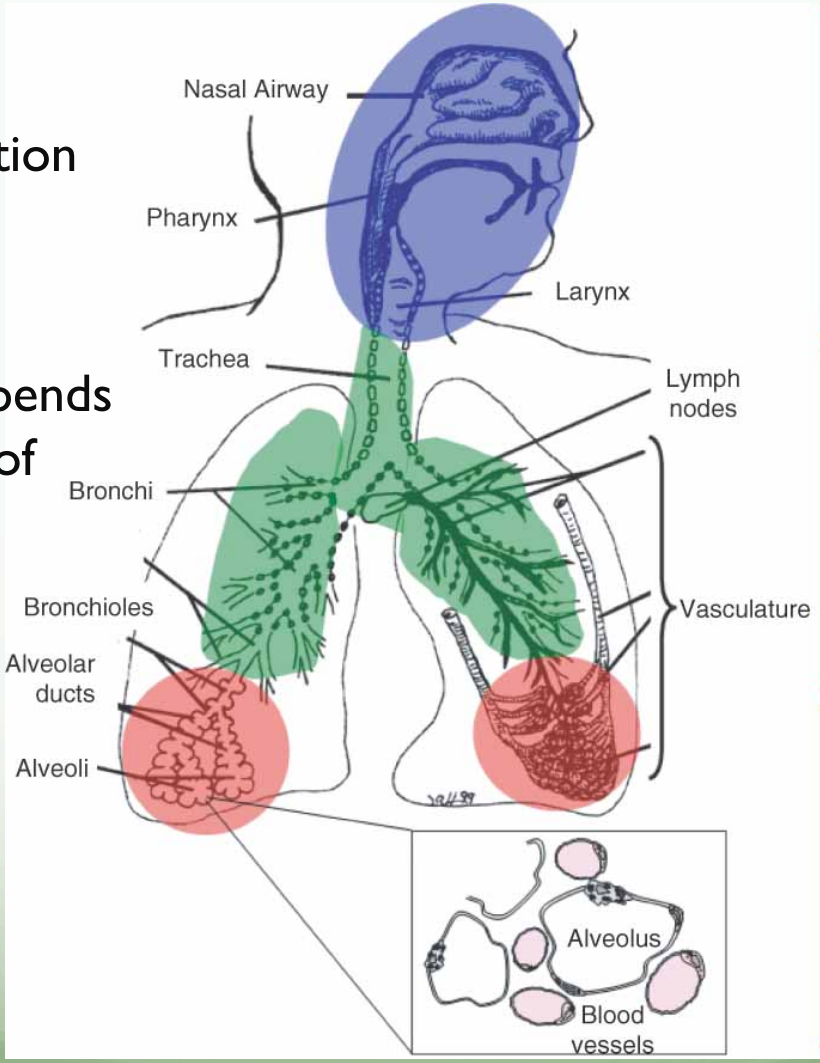
- Composition and Structure
- Solubility
- Reactivity
- Surface Chemistry
- Aggregation Potential
- Surface Area
- Shape
- Density
- Particle Size

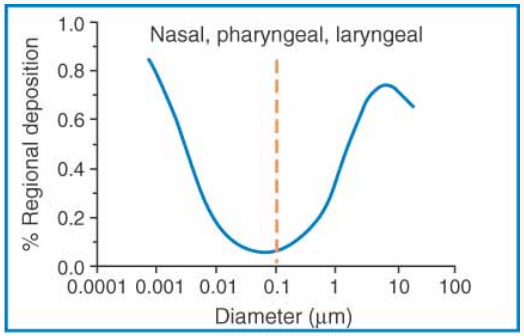


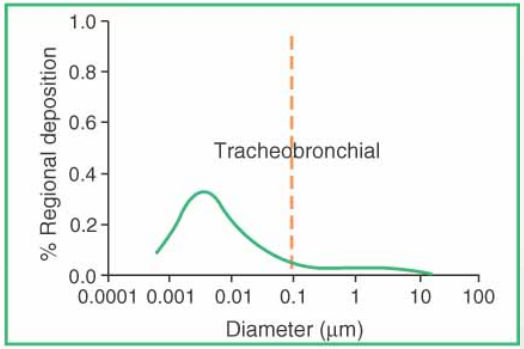
Source: Trudy E. Bell; graphics courtesy of Nicolle Rager Fuller

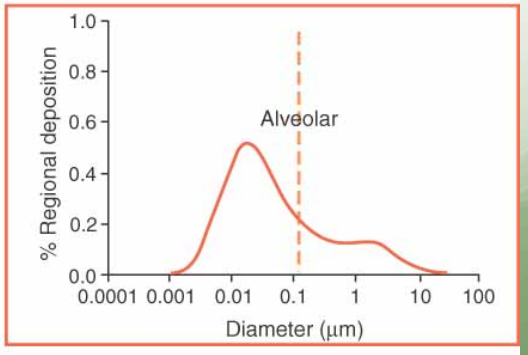
Safety Concerns: Toxicity

- Exposure pathways
  - Dermal absorption
  - Ingestion
  - Injection
  - Inhalation – depends in part on size of particle









Safety Concerns: Toxicity

- The toxicity of nanoparticles is greater than that of the same mass of larger particles (Micromaterials)
- Substance Specific Toxicity can be influenced by:
  - Surface area
  - Particle Size
  - Shape
  - Aspect Ratio for nano fibers
  - Solubility in Physiological Fluid
  - Ability to generate Reactive Oxygen Species(ROS)
- Materials may be acutely toxic or involve long-term toxicity (ex. Carcinogens).

Safety Concerns: Combustion

- Many materials, if in a fine enough powder, are combustible.
- Both carbon-containing and metal dusts can explode if they are aerosolized at a high enough concentration in presence of oxygen
- Because of the very large surface area, smaller particles may be more prone to explosion than an equivalent mass concentration of larger particles.
- The potential and severity of explosions can increase proportionally to the quantity of combustible materials being used.
- All researchers should avoid creating large, highly concentrated aerosols of combustible materials.

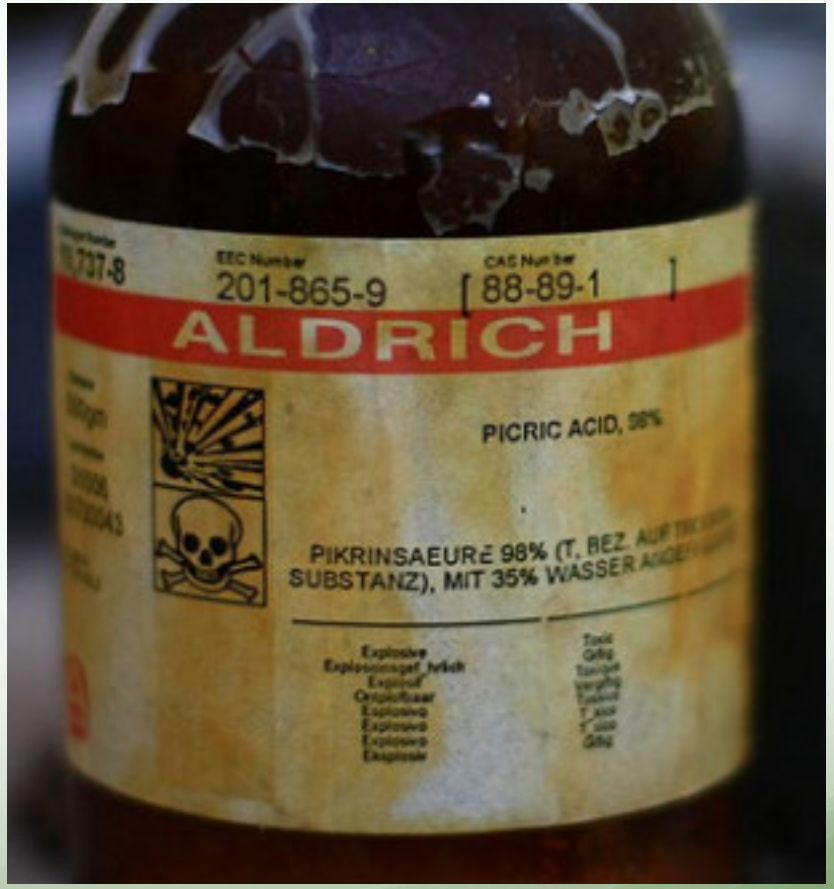
Safety Concerns: Combustion

Under the right circumstances even flour is combustible.

https://en.wikipedia.org/wiki/Dust_explosion

Safety Concerns: Combustion

Combustion with friction.

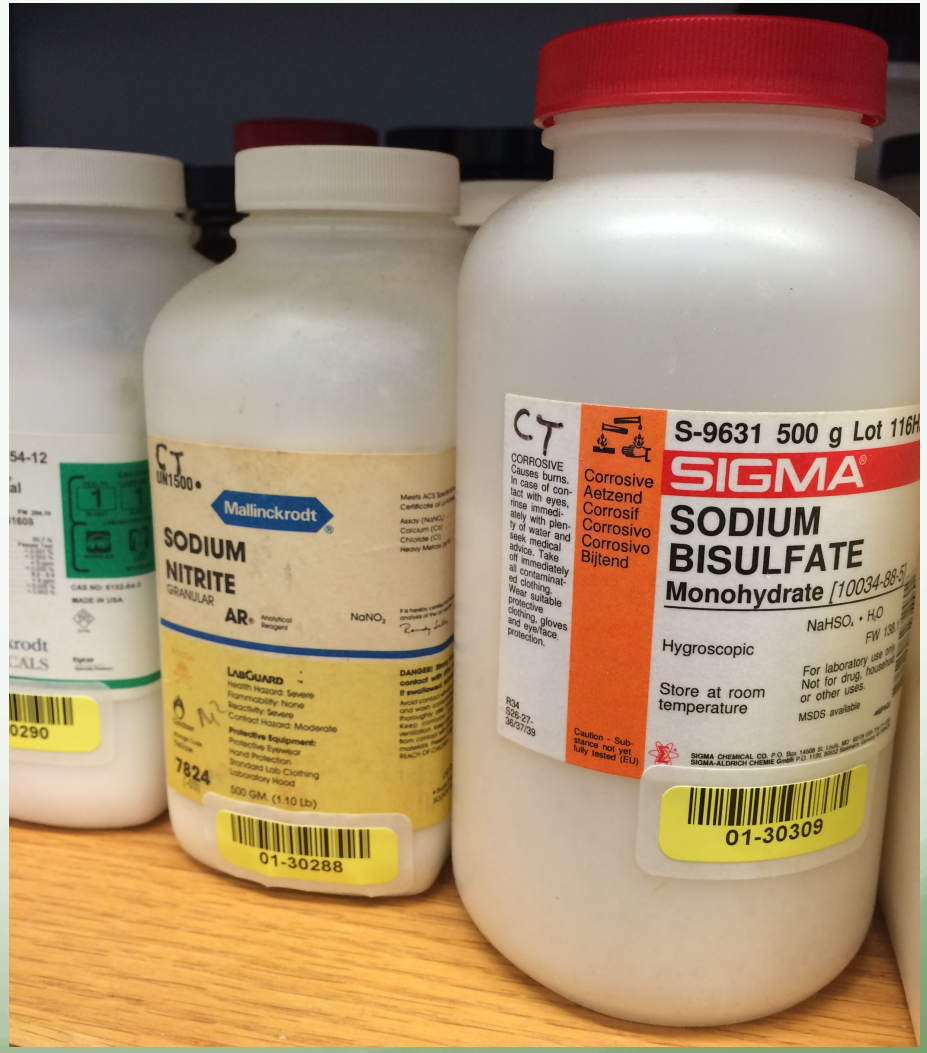


Safety Concerns: Reactivity

- Many materials react with air, water, or other materials.
- Results may include fire and/or gas production.
- Smaller particles of a given material can be more reactive.

Safety Concerns: Corrosive

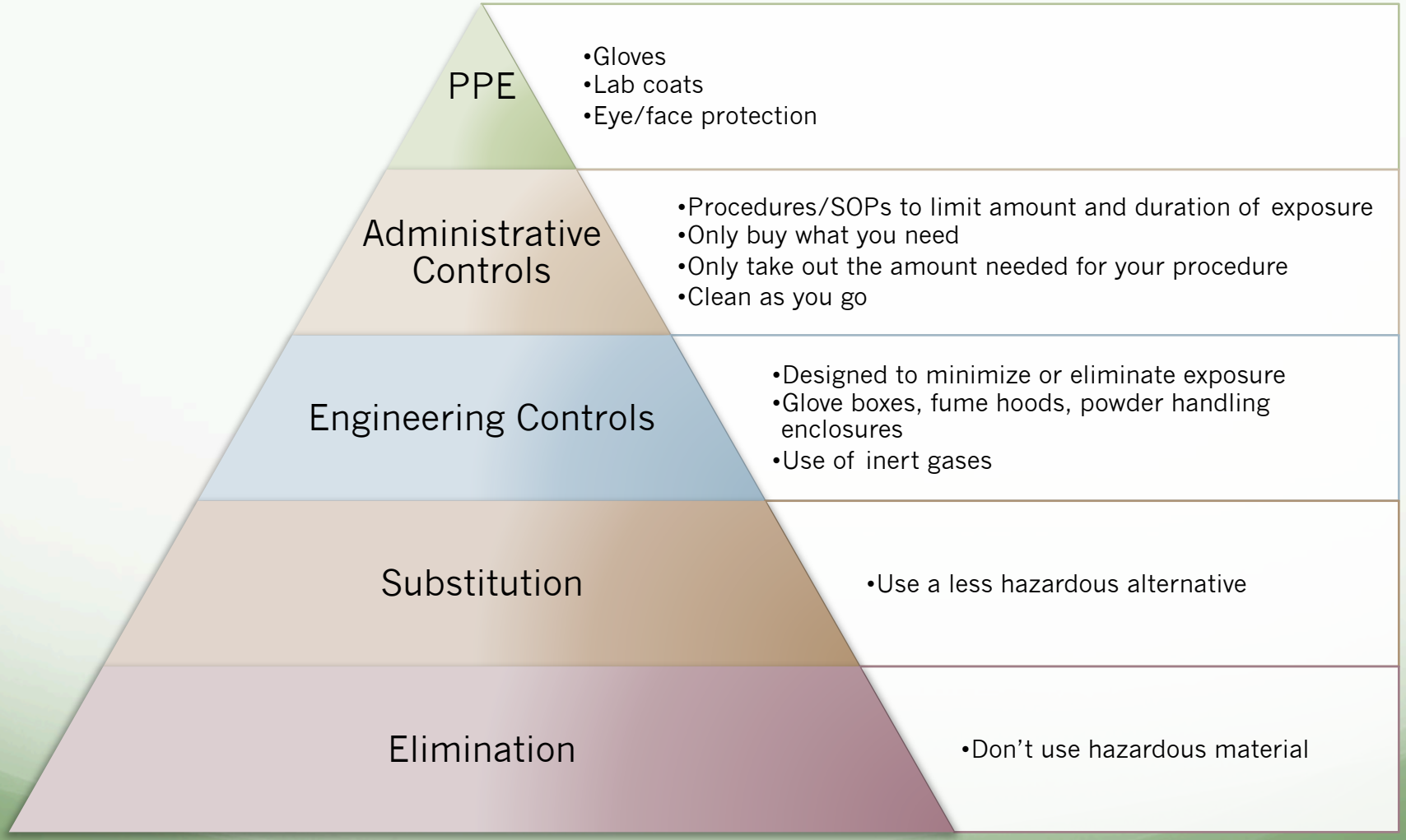
- Corrosive materials
  - Many dry chemicals used in labs are corrosive.
  - Random example – Sodium bisulfate
    - Causes severe skin burns and eye damage.
    - Irritating to skin, eyes, nose, and throat.
    - High concentrations may cause coughing, wheezing, shortness of breath, and fluid in the lungs.
  - Important to look at hazards before using chemicals on the shelf.



Safety Concerns

- Some operations can increase the risk of exposure:
  - Material handling
  - Synthesis and manufacturing process
  - Open and manual handling of bulk materials
  - Milling
  - Sonication
  - Grinding
  - High-speed blending

Mitigating Hazards



Mitigating Hazards: Handling

- Avoid manipulating materials on bench top
- If possible, don't use dry forms of materials.
- Keep materials sealed in a container when transporting or storing.
- Avoid generating aerosols (e.g., through sonication) on bench tops.
- Use appropriate laboratory exhaust and containment systems.

Mitigating Hazards: Handling

- Engineering controls can reduce or prevent the release of hazardous materials into the workplace
- General exhaust ventilation
  - Recommended ventilation rates for general laboratory range from 4 to 12 ACH,
  - Labs should have non-recirculating ventilation systems (preferably, 100% exhaust air)
  - Lab pressurization should be negative to the hallway
  - Prevents the migration of hazardous materials into adjacent rooms or areas through HVAC system
- Local exhaust ventilation
  - Chemical fume hoods
  - Vented enclosures
  - Special devices connected
  - Biological safety cabinets (BSC)
  - Powder-handling enclosures

Mitigating Hazards: Housekeeping

- Clean all working surfaces potentially contaminated with (e.g., benches, glassware, apparatus, exhaust hoods, support equipment) at the end of each day.
- Do not dry sweep or use compressed air.
- Bench top protective covering material may be used.
- Wash your hands before leaving the lab.
- Do not eat or drink in lab.

Mitigating Hazards: PPE

- Proper PPE depends on the characteristics of the material(s) your are using.
- PPE and proper clothing may include:
  - Lab coat – material based on hazard
  - Gloves – choice based on compatibility
  - Eyewear
    - Close-fitting safety glasses with side shields for low hazard, low exposure situations
    - Tight-fitting, dustproof (i.e., non-vented) safety goggles for higher hazard, higher exposure potential scenarios
  - Respirators – when engineering controls do not adequately reduce risk of airborne exposure
  - Long pants (without cuffs)
  - Long-sleeved shirt
  - Closed-toe shoes (low permeability material)
  - Disposable, over-the-shoe booties

Mitigating Hazards: PPE

- PPE selection must be based on many considerations, such as:
  - Chemical identity
  - Known toxicology of the nanoparticle
  - Quantity
  - Physical state
  - Existing exposure controls in place
  - PPE performance requirements and limitations
  - Other hazards present such as combustible dust
- A PPE assessment should be performed to determine the appropriate PPE for your work.
- Contact EHS for assistance in selecting the appropriate PPE.

Mitigating Hazards: Waste Management

- Be pro-active in identifying old, unneeded materials that can be discarded.
  - Reduces risk in lab
  - Frees up much-needed space
  - Reduces likelihood of paying for disposal of "unknowns"
- Many dry materials will need to go through the hazardous waste program for disposal.
- Contact EHS for questions regarding disposal.

Periodic Re-Evaluations

- Periodically review the work being done in your lab to determine if a re-evaluation is needed.
- Reasons for re-evaluating your setup may include:
  - Modification in process or material
  - Tasks are moved to a new location or employee
  - New equipment is designed or installed
  - Physical form changes (for example, powders rather than suspensions)
  - New toxicology data are obtained
  - Work related illness is reported

What Should You Do?

- Determine what dry materials are in your labs.
  - What procedures are in place?
  - Is there a need for the materials you have?
  - What is being done to reduce hazards?
  - Ask for guidance/assistance regarding specific lab setups and materials.
  - Can old/unneeded materials be removed?
  - Be careful!