Toxics Use Reduction Institute

Best Practices for Working Safely with Nanoparticles in Laboratories

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Center for High-Rate Nanomanufacturing

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The NSF Nanoscale Science and Engineering Center for High-rate Nanomanufacturing

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Michigan State University

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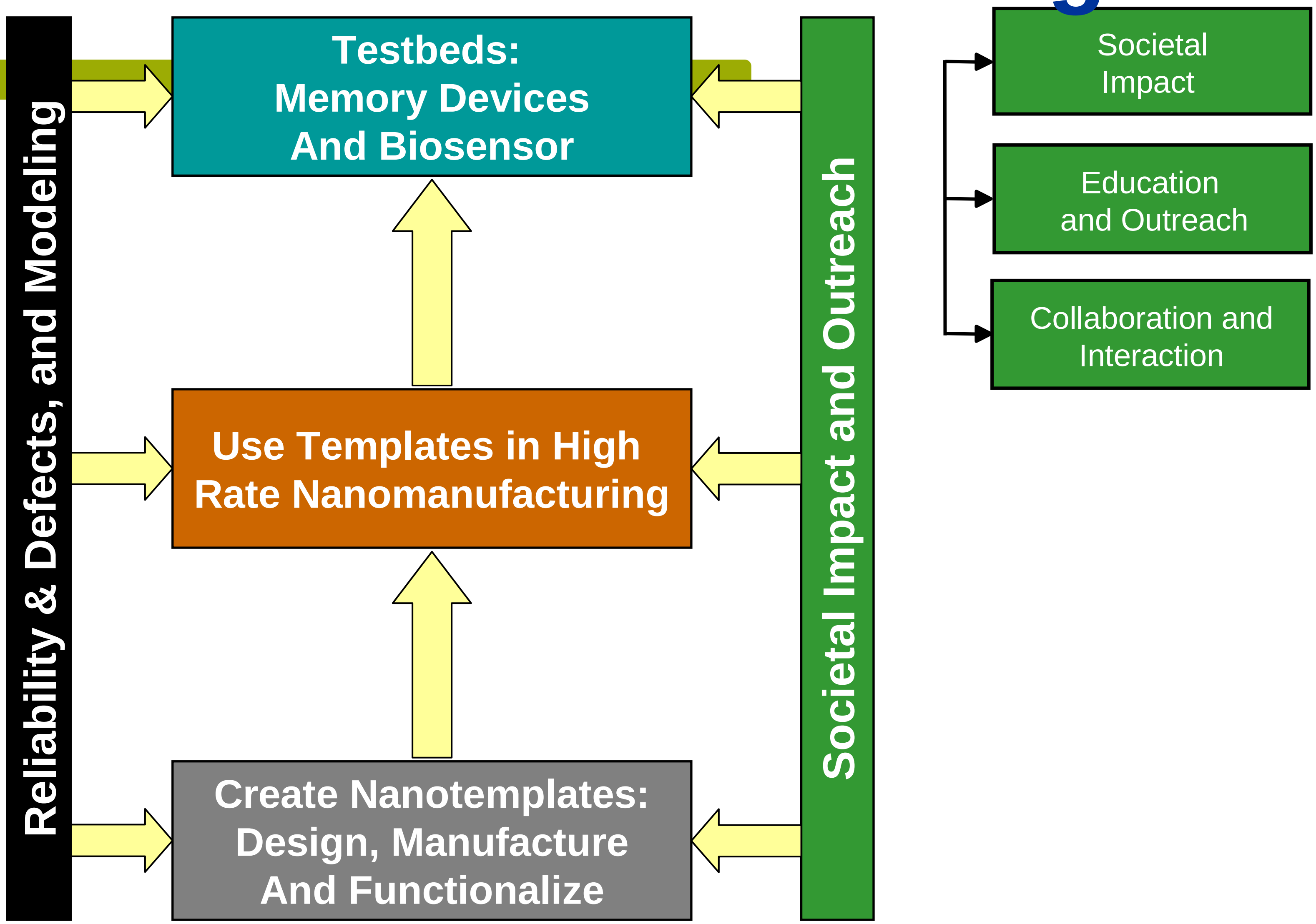
CHN Pathway to Nanomanufacturing



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Need for Best Practices Document

- Health and safety of NSEC lab personnel is of primary importance
- Significant nanoparticle exposures were measured in various CHN labs
- Poorly designed/operated engineering controls were documented
- Administrative procedures needed improvement

Need, Cont.

- NSEC labs must not adversely affect the environment
- Other research labs are looking for guidance
  - Lack of government regulation
  - Consistency of approach is desirable
- In response," Interim Best Practices for Working with Nanoparticles" was written
- Available at http://nsrg.neu.edu/environmental/

NIOSH Project

- Based on our previous work, NIOSH awarded us a contract for a new document
- Ellenbecker and Tsai, “Safe Practices for Working with Engineered Nanomaterials in Research Laboratories” under preparation
- Will be completed this summer

Resources Used

- Guidance documents prepared by
  - U.S. DOE National Laboratories (http://www.bnl.gov/cfn/)
  - MIT
  - NIOSH
  - ICON
- Discussions with our university EH&S offices
- Research/monitoring in our labs
  - Examples shown this afternoon

Document Outline

1. Introduction
2. Basic Premises
3. Occupational Hygiene Resources Available to CHN Researchers
4. Routine R&D Laboratory Operations
5. Management of Nanomaterials
6. Management of Nanomaterial Spills

2. Basic Premises

- Relatively little known about the toxicity of nanoparticles
- Enough known about engineered nanoparticles to cause concern
- The precautionary approach must be followed, i.e., limit exposure to nanoparticles until we know that certain exposures are acceptable

3. Available Occupational Hygiene Resources

- Three university EH&S offices described
- Capabilities of the CHN EH&S team described

4. Routine R&D Laboratory Operations

- Basic Principles
- Control Preferences
- Ventilation Design Principles
- Administrative Controls

Basic Principles

- Laboratory operations should be carried out in a manner that minimizes the risk of exposure to nanoparticles from inhalation or dermal contact
- Nanomaterials in dry powder form pose the most risk for inhalation exposure
- Nanomaterials suspended in a liquid present less risk for inhalation exposure, but may present more risk from skin contact

4. Routine R&D Laboratory Operations

- Basic Principles
- Control Preferences
- Ventilation Design Principles
- Administrative Controls

Control Preferences

- Follow a graded approach
- Preferable to keep particles:
  a. Fixed in a matrix;
  b. Next, bound in a solution; and
  c. As a last resort, free particles
- Follow the standard OH hierarchy of hazard controls for nanomaterials

Occupational Hygiene Hierarchy of Controls

- **Engineering controls**
  - – Substitution
  - – Isolation
  - – Ventilation
    - General exhaust ventilation
    - Local exhaust ventilation
- **Administrative controls**
  - – Worker training
  - – Medical monitoring
  - – scheduling

Hierarchy of Controls, Cont.

- **Personal protective equipment**
  - Respirators
  - Protective clothing
    - Gloves
    - Aprons
    - Goggles
    - Etc.

4. Routine R&D Laboratory Operations

- Basic Principles
- Control Preferences
- Ventilation Design Principles
- Administrative Controls

Ventilation Design Principles

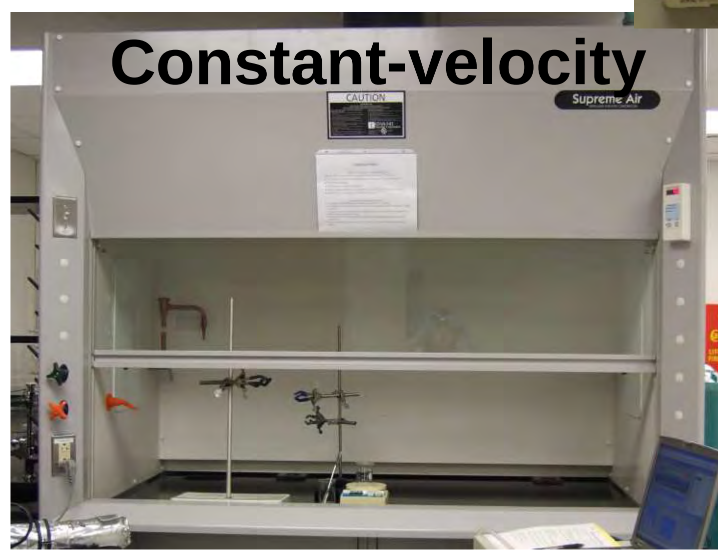
- All ventilation systems should be evaluated and approved by the university health and safety office.
- Under no circumstances should laboratory personnel design their own ventilation system and/or modify an existing system.
- Ventilation system should be maintained on a routine basis by the appropriate university maintenance personnel.

Fume Hoods


By-pass

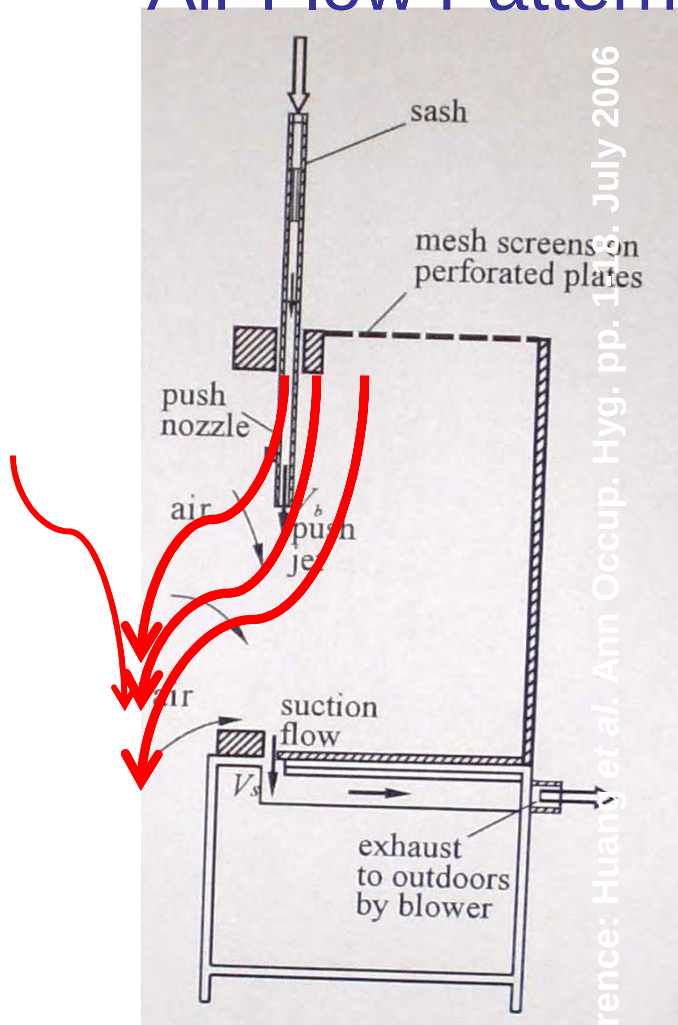

98


Conventional
HAZARDOUS WASTE
SATELLITE ACCUMULATION AREA


Constant-velocity
CAUTION
Supreme Air

Air Curtain Hood

Air Flow Pattern



CNT Furnace in Fume Hood

Fume Hood Performance

- Detailed information on proper hood use is provided
- Most important variables are
  - Hood design (constant velocity, air curtain hoods are best)
  - Face velocity (80 – 100 ft/min)
  - Sash position
  - Laboratory conditions
  - Work practices in hood

Alternatives may be Better

Nanopowder handling enclosure

Local Exhaust Ventilation

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4. Routine R&D Laboratory Operations

- Basic Principles
- Control Preferences
- Ventilation Design Principles
- Administrative Controls

Administrative Controls

Housekeeping

- Practice good housekeeping in laboratories where nanomaterials are handled.
- Clean all working surfaces potentially contaminated with nanoparticles at the end of each day using a HEPA vacuum pickup and/or wet wiping methods.
- Do not dry sweep or use compressed air.

Administrative Controls

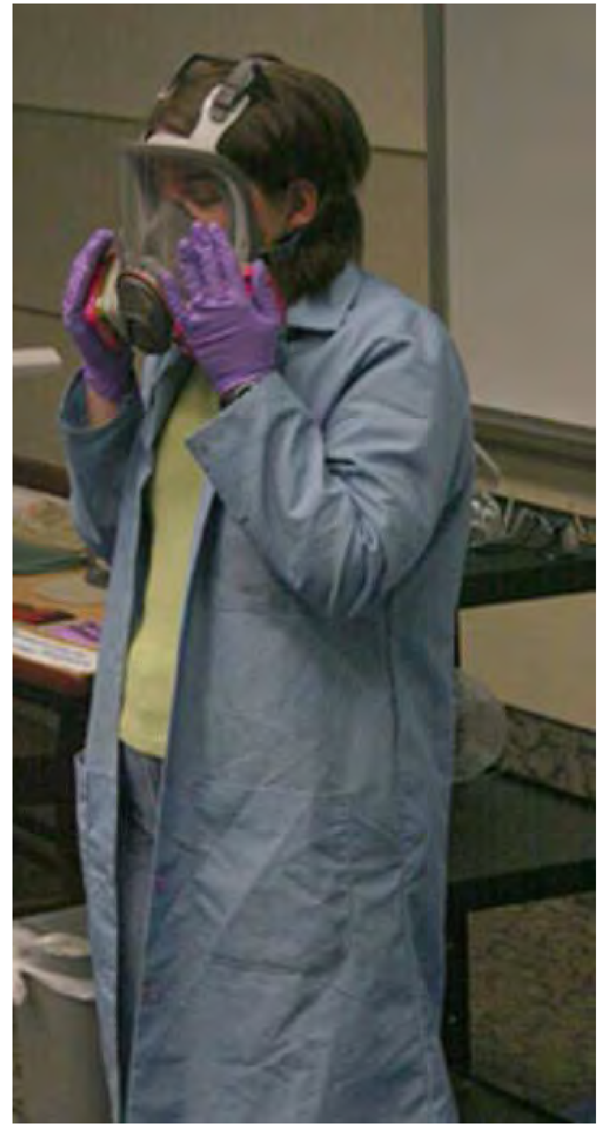
Work Practices

- Transfer nanomaterial samples between workstations in closed, labeled containers.
- Do not allow nanoparticles or nanoparticle-containing materials to contact the skin.
- If nanoparticle powders must be handled outside a fume- or exhausted laminar flow-hood, use appropriate respiratory protection.
- Vacuum up dry nanoparticles only if the vacuum cleaner has a tested and certified HEPA filter.

Administrative Controls

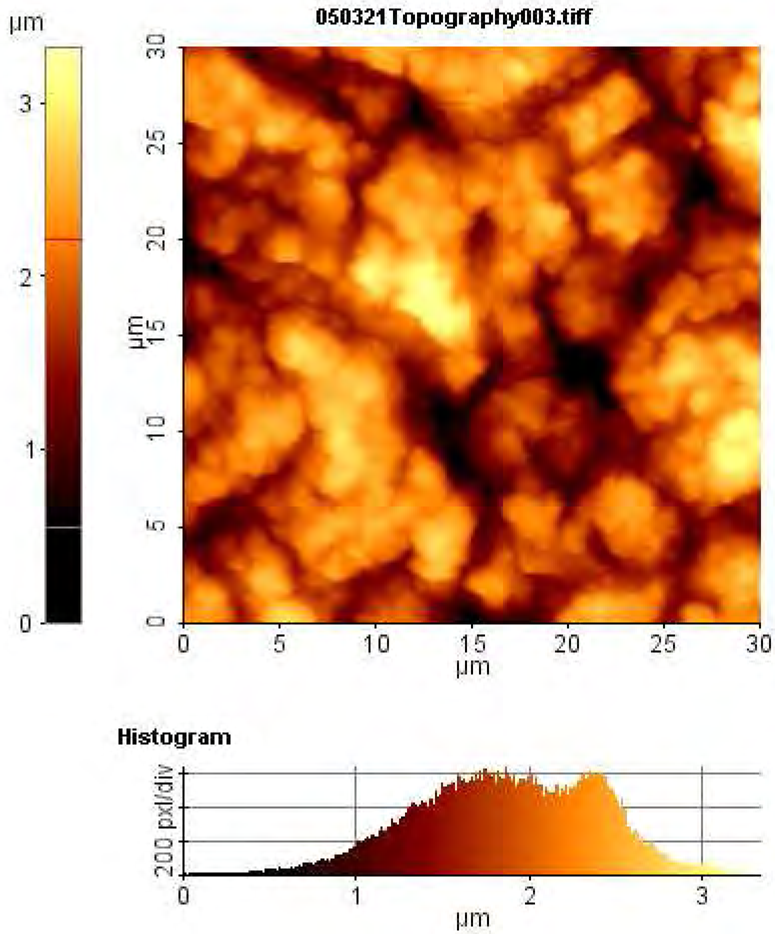
Clothing and Personal Protective Eqpt.


Playtex
market-style
Latex
nitrile

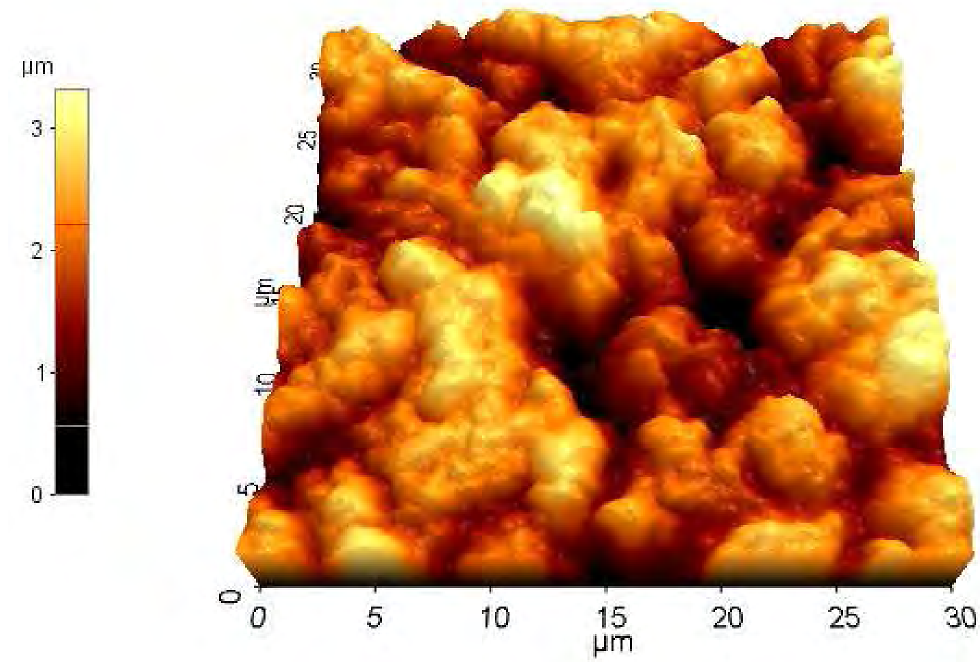



www.china.cn

Surface porosity of a yellow latex glove by a non-contact AFM

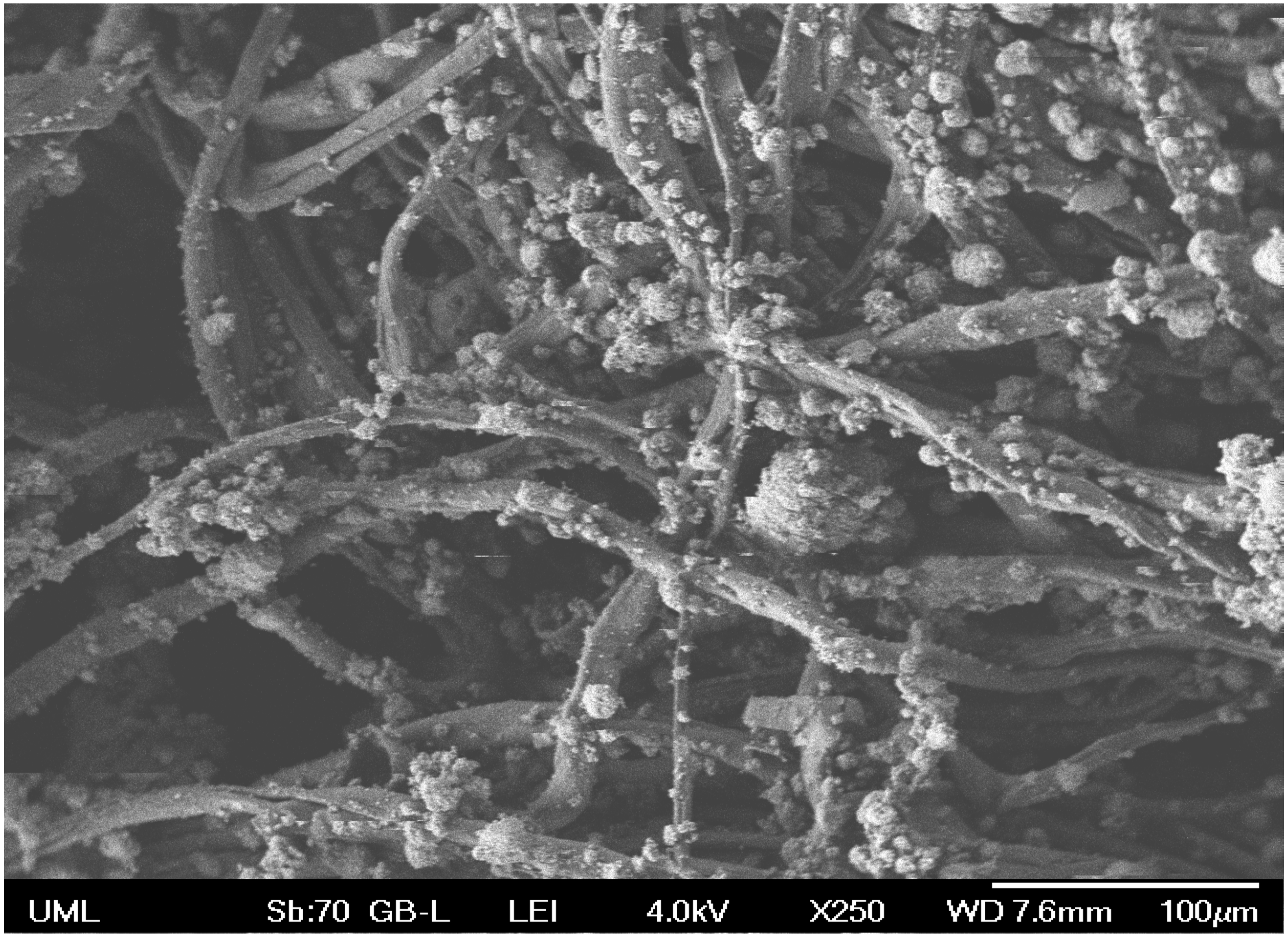


Height information

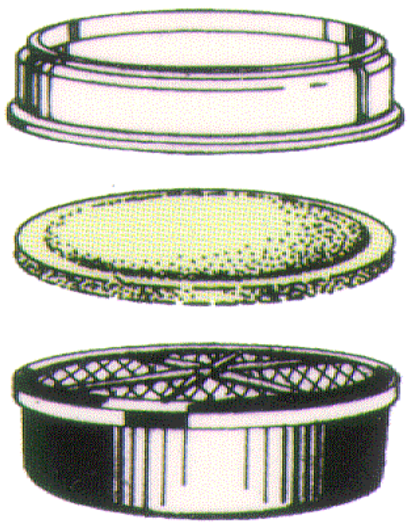


by Dr. Jun Lee

Clean Side – Cotton Glove

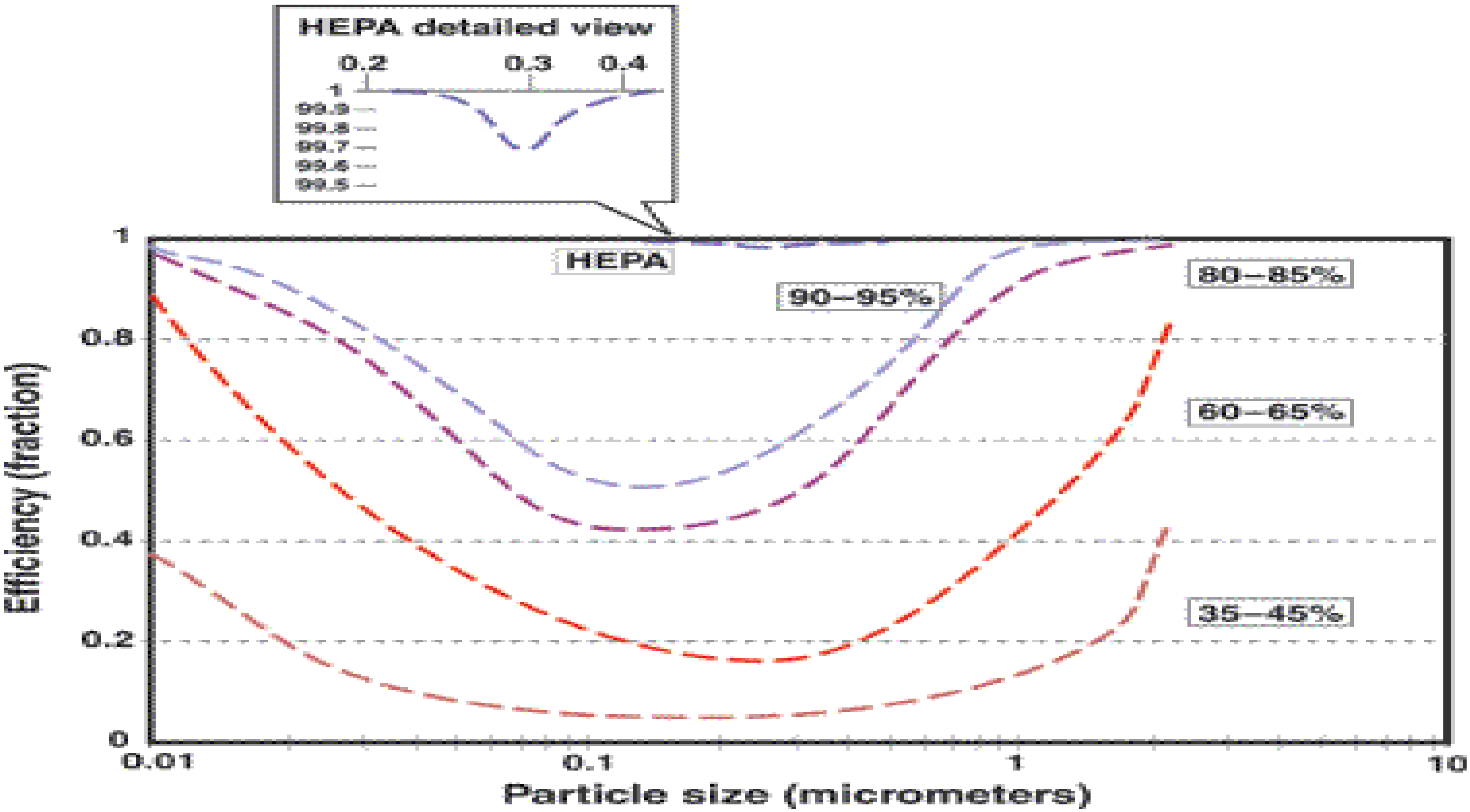



QuickLatch
8100
P100
8051
8058-P100




ECI
CVN95

HEPA Filter Collection Efficiency

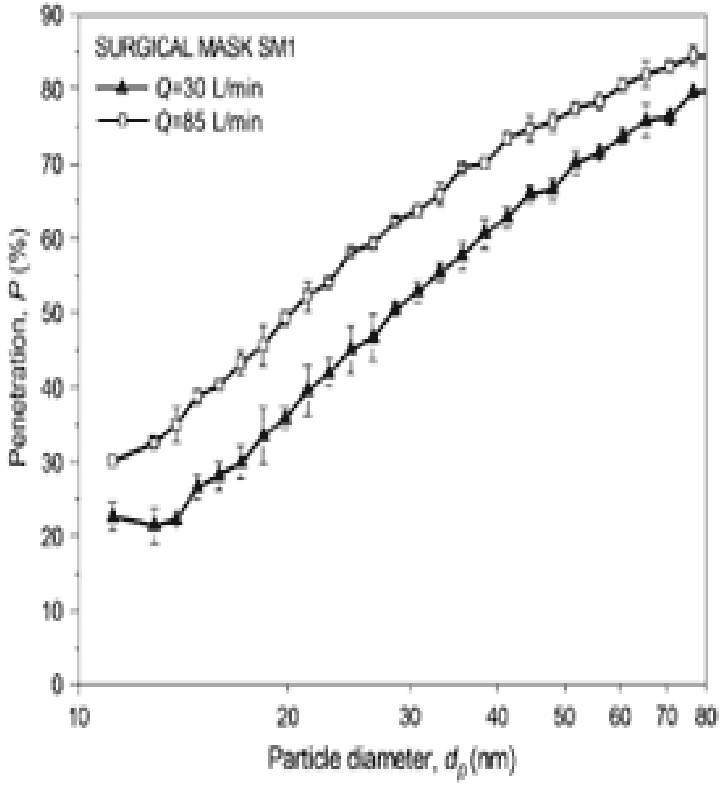


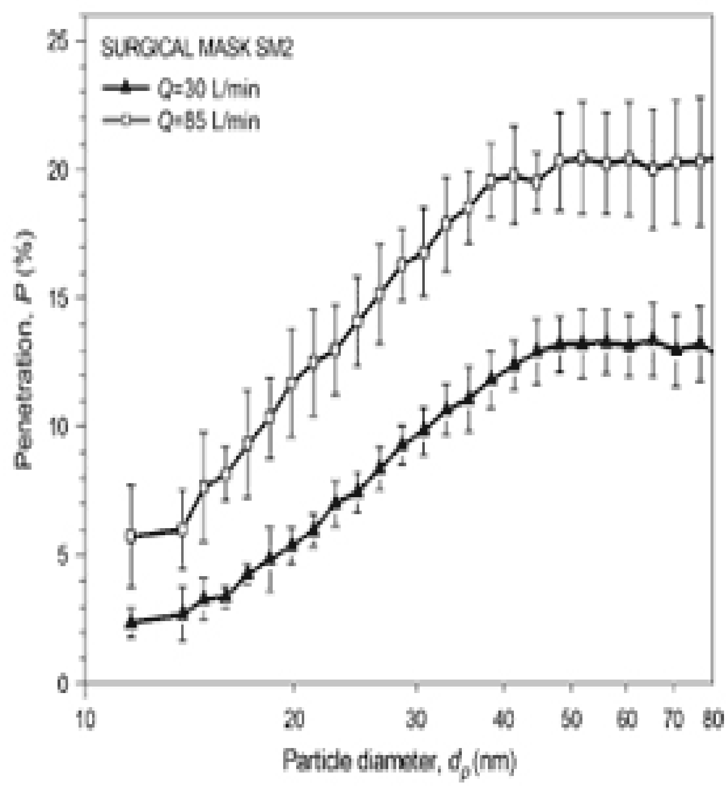
Administrative Controls

Clothing and PPE, Cont.

- Personnel not required to wear a respirator may do so at their discretion.
- In this case, disposable respirators (also called dust masks) are acceptable.
  - surgical masks should be avoided

Surgical Mask Performance





5. Management of Nanomaterials

- Engineered nanomaterials must be managed as a hazardous material.
- All containers containing engineered nanomaterials must be properly labeled.

Waste Streams

The following waste management guidance applies to engineered nanomaterial-bearing waste streams consisting of or containing

- Pure nanomaterials (e.g., carbon nanotubes)
- Items contaminated with nanomaterials (e.g., wipes/PPE)
- Liquid matrices containing nanomaterials (e.g., hydrochloric acid containing carbon nanotubes)

Waste Streams, Cont.

- Solid matrices with nanomaterials that are friable 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 reasonably foreseeable mechanical forces.

The guidance does not apply to nanomaterials embedded in a solid matrix that can not reasonably be expected to break free or leach out when they contact air or water.

Management of Nanomaterial-containing Waste Streams

Required Label (DOE)

CAUTION

Nanomaterials Sample

Consisting of <u>(Technical Description Here)</u>

Contact: <u>(POC)</u>

at <u>(Contact number)</u>

in Case of Container Breakage.

6. Management of Nanomaterial Spills

– **Access Control**

- Determine the extent of the area reasonably expected to have been affected, and demarcate it with barricade tape.
- Assess the extent of the spill. Significant spills are defined as those of more than a few grams of nanoparticles.
- To clean up significant spills, contact the EH&S office.
- Smaller spills can be cleaned up by trained personnel from the lab using the following cleanup procedures.

Dry Materials

- Position a walk-off mat (e.g., Tacki-Mat®) where clean-up personnel will exit the access- controlled area.

HEPA Vacuum Cleaner

- High Efficiency Particulate Air Filter
- Collection efficiency > 99.97% for 0.2 μm diameter particles

Conclusions - CHN

- Significant nanoparticle exposures have been measured in various CHN labs
- Poorly designed/operated engineering controls were documented
- Administrative procedures needed improvement
- In response, a Best Practices document has been developed & distributed

Conclusions - General

- What is needed is **consensus** Best Practices for research laboratories
- Our new document for NIOSH is a step in that direction
- ASTM WK8985 – “Guide for Handling Unbound Engineered Nanoparticles in Occupational Settings” is under development

Acknowledgement

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THANK YOU and QUESTIONS!

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