Exposure Assessment and Controls to Reduce Nanoparticle Exposure

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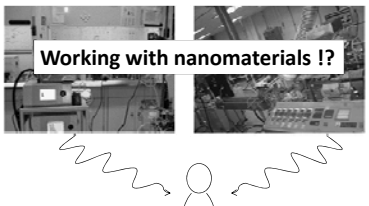
November 9, 2011
TURI CE Workshop

How are we exposed?
How serious the exposure can be?



How do we be exposed?
Airborne or Liquid?

2

How do we measure exposure?

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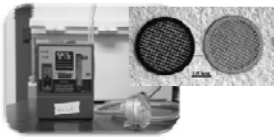
Measure airborne nanoparticle concentration

TSI Aerodynamic Particle Sizer Spectrometer (APS)

TSI Fast Mobility Particle Spectrometer (FMPS)

Collect airborne nanoparticles



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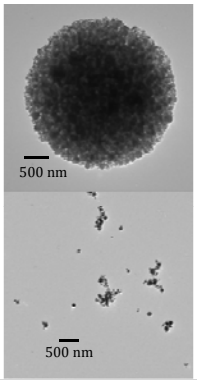
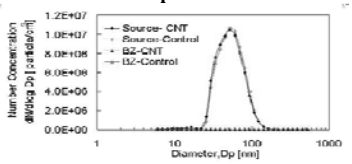


- **Mass concentration**
- **Surface area concentration**
- **Number concentration**
- **Particle size distribution**
- **Total particle number concentration**
- **Morphology**
- **Elemental composition**



Exposure Assessment

1. Identify Potential Exposure and Screening

2. Examine Background Issues

3. Monitoring & Collect Particles

4. Characterize Particles

5. Evaluation & Further action
   - Control Strategies

Instrument

How can we avoid exposure?

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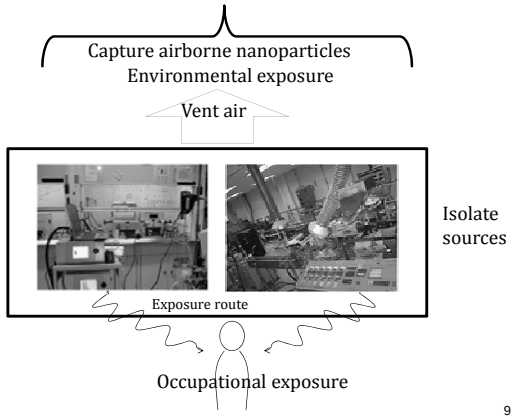

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Hierarchy of Control Methods

Engineering controls
- **Substitution**
- **Isolation**
- **Filtration**
- **Ventilation**
  - **General exhaust ventilation**
  - **Local exhaust ventilation**

Administrative controls
- **Worker training**
- **Medical monitoring**
- **Scheduling**

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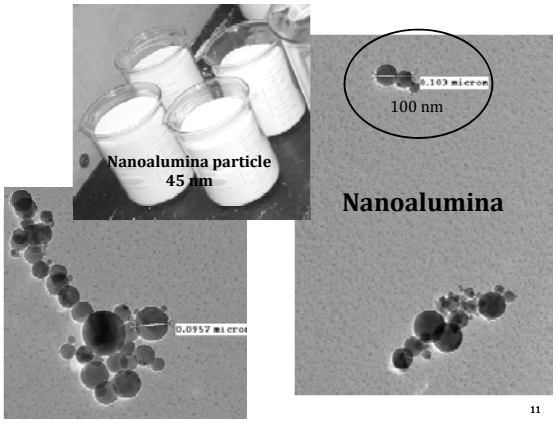

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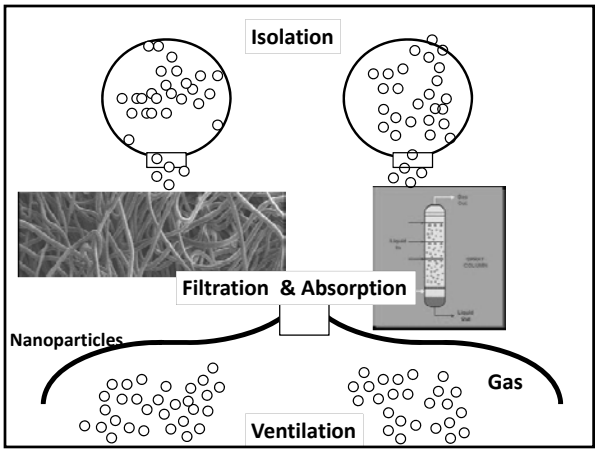

Key Elements to Control Exposure

- Airborne nanoparticles behave very much like gas molecules.
- Ventilation and isolation control methods developed for gases should work well to protect workers from exposure to nanoparticles.
- Air flow pattern plays an important role.
- Agglomerate or not?

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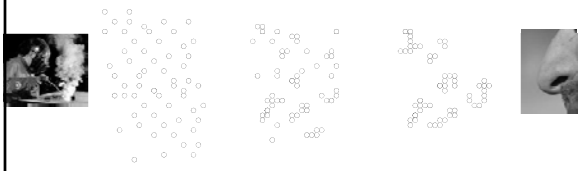
Airborne Nanoparticles

Agglomeration



How does the local exhaust ventilation work?

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Ventilation Systems

Tsai et al. , Journal of Nanoparticle Research, 11 (1): 147-161, 2009.
Tsai, et al., Annals of Occupational Hygiene, 54 (1): 78-87, 2010.

Why Is Important?

- Hoods did not provide "zero" leakage.
- The ASHRAE 110 (ASHRAE/ANSI, 1995) acceptance criterion for hood performance is a breathing zone SF_6 concentration of 0.1 ppm (2×10^9 molecules/cm^3).
- Tested in the close to ideal environment, practical use does not have same conditions.
- Seek the optimal condition/hood for NPs handling.

Examine Airflow Pattern

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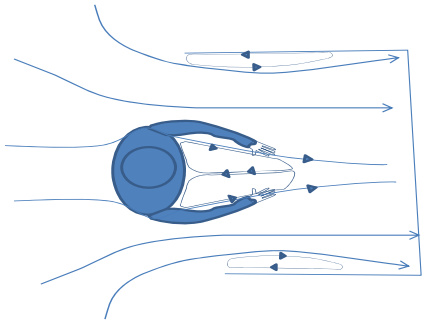

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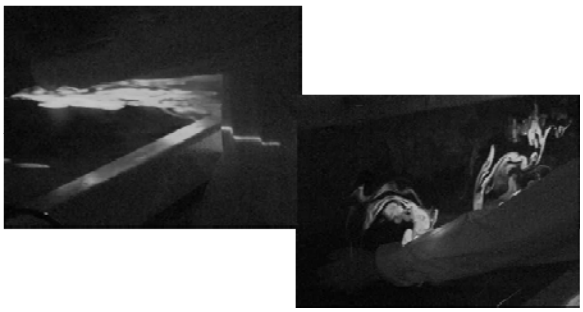
Constant Volume Hood



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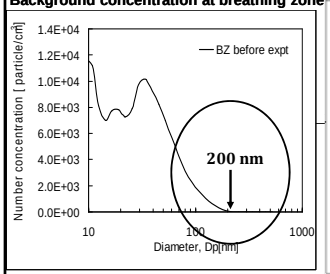
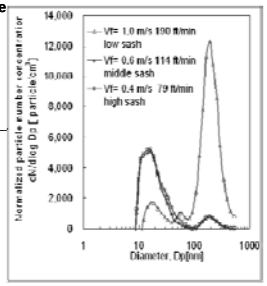
Release from Traditional Hood Conventional Hood

Background concentration at breathing zone





Tsai et al. "Airborne Nanoparticle Exposures Associated with the Manual Handling of Nanoalumina and Nanosilver in Fume Hoods," Journal of Nanoparticle Research, 11 (1): 147-161, 2009.

Biological Safety Cabinet

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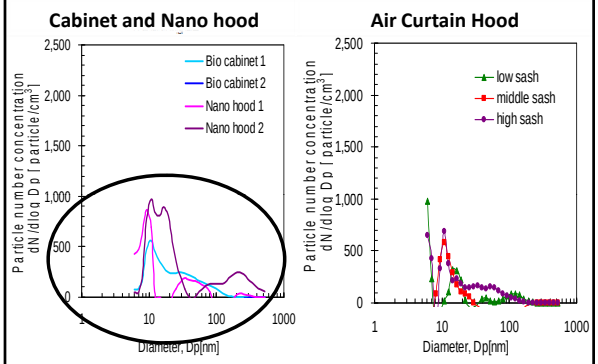

Regular Condition Transferring – BZ data

Nano Hood
Effect of Arms' Motion

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Biological Safety Cabinet
Effect of Arm's Motion

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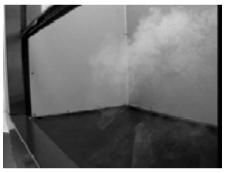
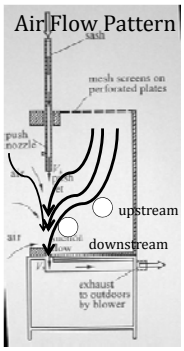
Air Curtain Hood





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Reference: Huang *et al.* Ann Occup. Hyg. pp. 1-18. July 2006

Air Curtain Hood

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Summary

- Newly designed hoods for nanopowders are comparable to biosafety cabinet and air curtain hood.
- Turbulence and wake can be reduced, but not eliminated, for hoods with airflow across the hood opening.
- Optimal face velocity varies by the hood design.
- Must use hoods with high caution and good training concerning **worker's motion**.
- Suction force at the doorsill downward exhaust plays an important role to remove escaping nanoparticles.

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Occupational and laboratory exposure from manufacturing

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Manufacture Nanocomposites

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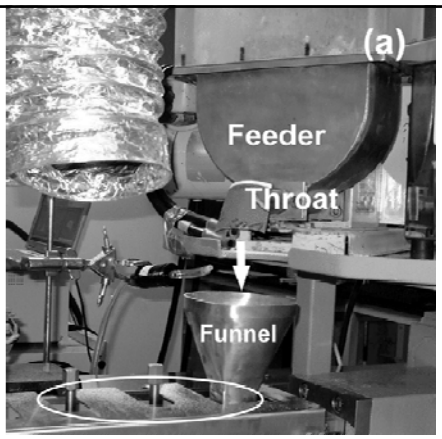
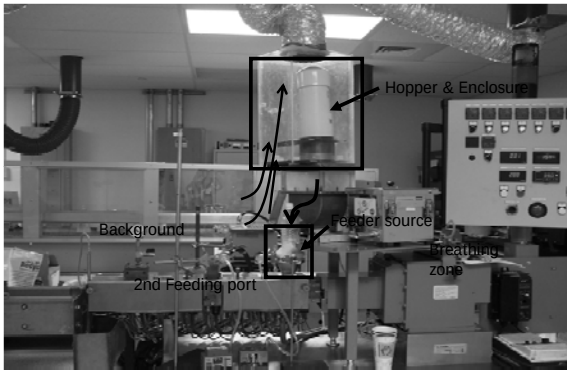
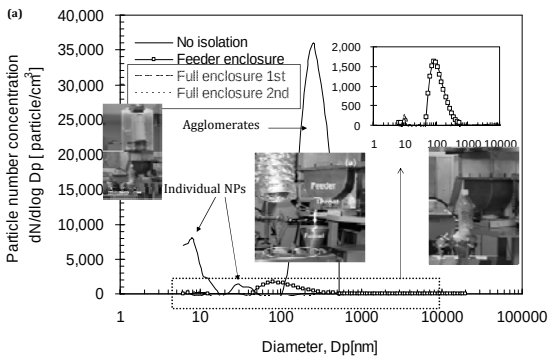


Isolation and Ventilation





Exposure concentration and profile at near-field (source) from nanoalumina compounding affected by engineering controls.

NIOSH

- NIOSH hosted a medical surveillance workshop in 2010, not specific guidance is defined.
  Current approach is to implement engineering controls to reduce and prevent exposure happened to workers while we are developing medical surveillance method, we may get a negative result in the future if our controls are well developed and implemented.
- Special issue published:
  Journal of Occupational and Environmental Medicine, June 2011 - Volume 53 - Supplement 6S
  http://journals.lww.com/joem/toc/2011/06001

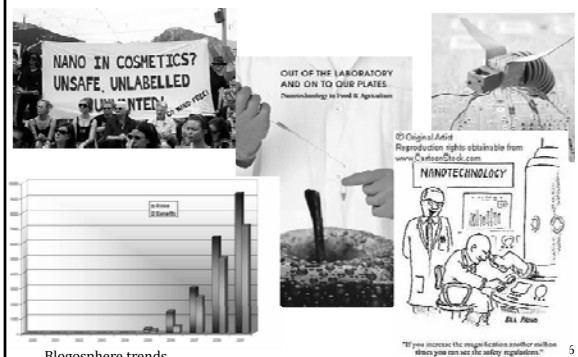
US OSHA

- OSHA current nanotechnology standard:
  Expand the coverage of existing standards to nanomaterials (construction materials)

- Section 5(a)(1) of the Occupational Safety and Health Act of 1970 (29 U.S.C. 654), often referred to as **the General Duty Clause,** requires employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees." Section 5(a)(2) requires employers to "comply with occupational safety and health standards" promulgated under this Act.

  OSHA Nanotechnology standard website
  http://www.osha.gov/dsg/nanotechnology/nanotech_standards.html

Concerns over the Use of ENPs



Blogosphere trends

Recent Regulatory Activity in the United States, CA

Mandatory requirements

- The state of CA require manufacturers to submit information.
  Call-in materials:
  - 2009 CNT
  - 2010 TiO_2, Silver, CeO_2, Nano Zero Valent Iron (NZVI), ZnO, QD
- Require information about analytical result, environment fate and transport, worker safety, etc.

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We proact

not react

to avoid exposure!

THANK YOU !!

Acknowledgement
NSF Nanoscale Science and Engineering Centers Program
(Award no. NSF-0425826)