Best Practices for Control of Nanoparticle Exposures

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Control of Airborne Exposures

- Airborne nanoparticles behave very much like gas molecules
- Therefore, standard engineering control methods developed for gases should work well to protect workers from exposure to nanoparticles
Heirarchy of Control

• **Engineering controls**
  – Substitution
  – Isolation
  – Ventilation
    • General exhaust ventilation
    • Local exhaust ventilation

• **Administrative controls**
  – Worker training
  – Medical monitoring
  – Scheduling
Local Exhaust Ventilation
Results: Aerosol Monitoring-Processing
(5) CN
Results: Aerosol Monitoring-Processing

(5) CNT Furnace

CNT Furnace Operation - Experimental and Control Data Comparison

- Source conc. during CNT grow- detect on hole
- [Control] - Source conc. during CNT grow- detect on hole
- Breathing zone conc. during operation
- [Control] - Breathing zone conc. during operation
Methods of Control, Cont.

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

• The performance of filters used in respirators and air pollution control devices is less certain

• Assumption that, if particles strike a filter element, they will adhere due to van Der Waals attraction

• Concern that, as nanoparticles approach molecular dimensions, thermal rebound may occur
Filtration Mechanisms

- Inertial Impaction
- Interception
- Diffusion
- Electrostatic attraction
Filter Collection Efficiency

Filter collection mechanisms

Fractional collection efficiency vs. Particle diameter (microns)

- Diffusion regime
- Diffusion and interception regime
- Inertial impaction and interception regime
Respirator Performance

• Recent research suggests that the proper respirator may be highly effective against nanoparticles
  – N100 cartridges – 100% efficient for nanoparticles, as predicted
  – N95 cartridges – Pt > 5% for 40 nm particles at high breathing rates
Filtration Mechanisms

- Inertial impaction
- Interception
- Diffusion
- Electrostatic attraction
Boltzman Equilibrium Charge Distribution

- Aerosol particles are charged by random interaction with air ions

- 1 μm particle – 90% charged at any instant

- 40 nm particle – 20% charged at any instant
Air Pollution Control Equipment

- HEPA filters likely to be effective
- Cyclones will not work
- Unanswered questions on the efficacy of fabric filters, electrostatic precipitators, and Venturi scrubbers
Abstract:

Collection Efficiency of Nanosize Particles in an Electrostatic Precipitator

“In this work, the collection efficiency of particles in the nanosize range (5 - 100 nm) in a two stage parallel plate electrostatic precipitator is studied by numerical simulation…”
“Calculation results indicate that particles in the nanosize range are not uniformly charged. Ultrafine particles with diameter less than 20 nm seldom acquire more than one unit of elementary charge. Larger particles (20 - 100 nm) may carry several units of charge, depending on the product of ion concentration and charging time. The simulation results also indicate that there is a local maximum in the collection efficiency in the nanosize range...”
Nanoalumina on Cotton Glove
Surface porosity of a yellow latex glove by a non-contact AFM

by Dr. Jun Lee
Precautionary Principle

• When there is uncertainty, err on the side of precaution
• For nanoparticles, this means we need to reduce exposure to the lowest possible level
• We are working with the various CHN laboratories to identify control strategies to accomplish this