



Toxics Use Reduction Institute

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
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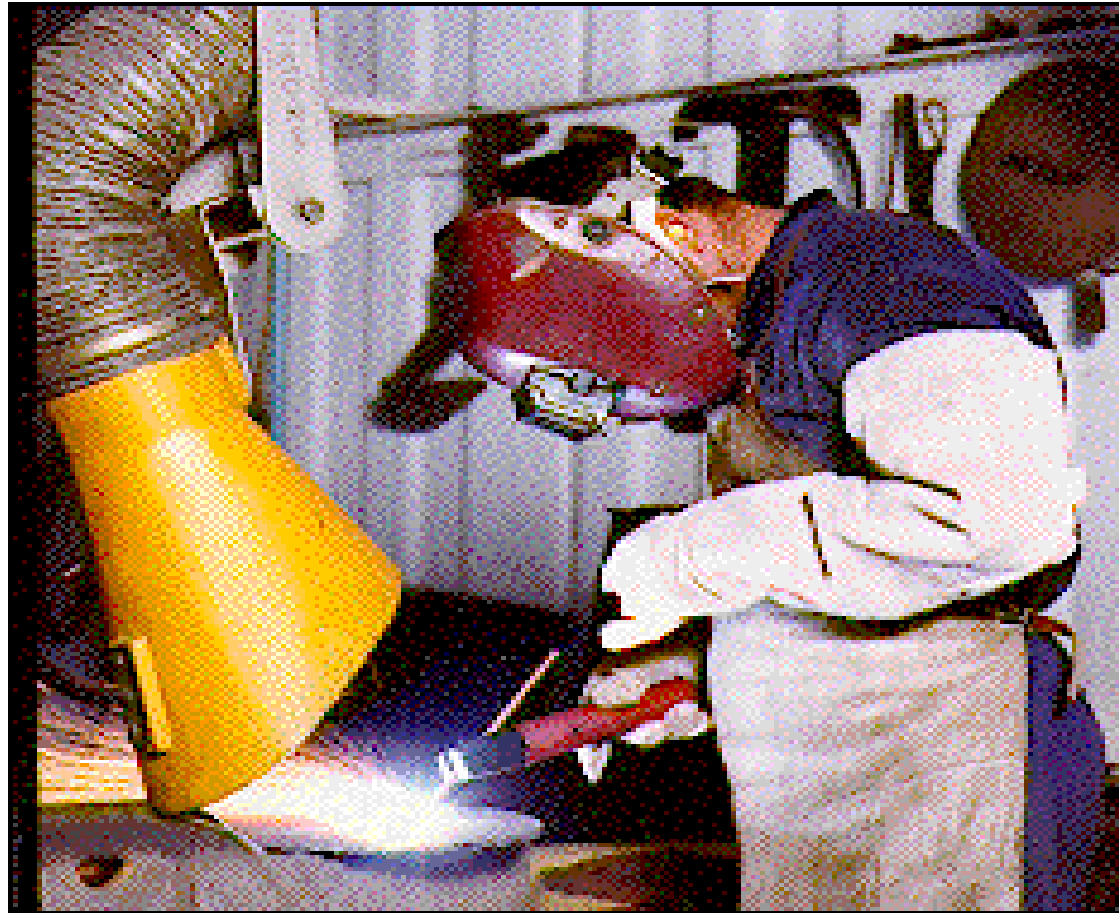


Heirarchy of Control

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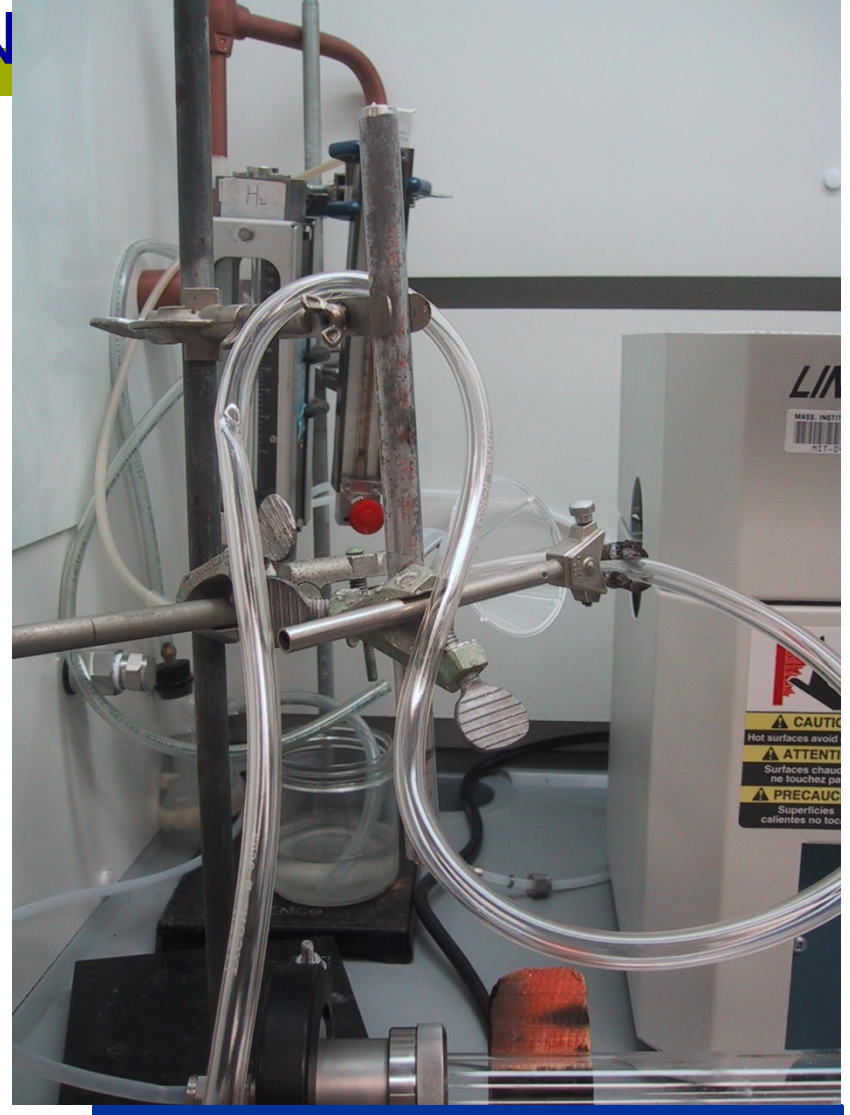
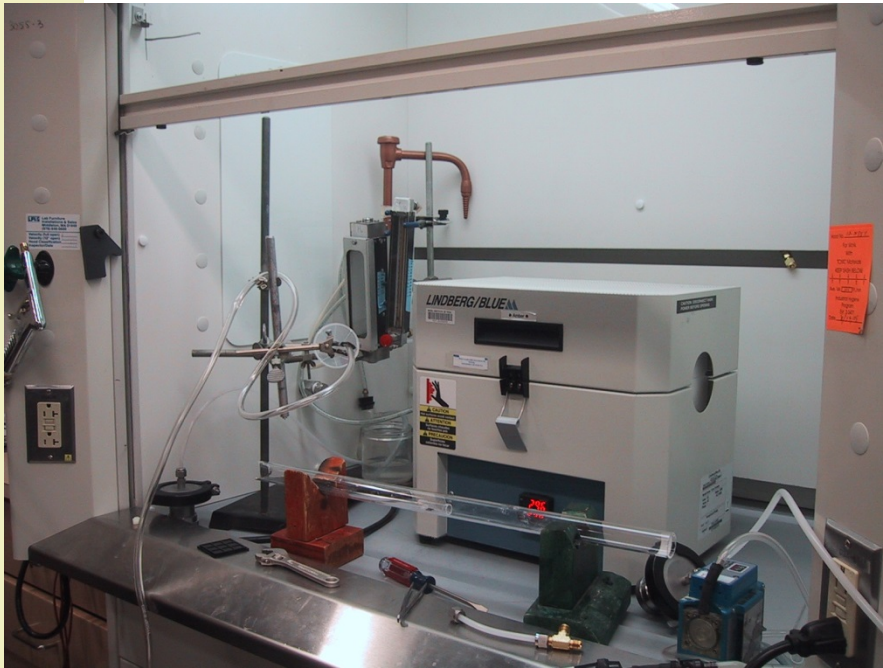
Local Exhaust Ventilation





Results: Aerosol Monitoring- Processing

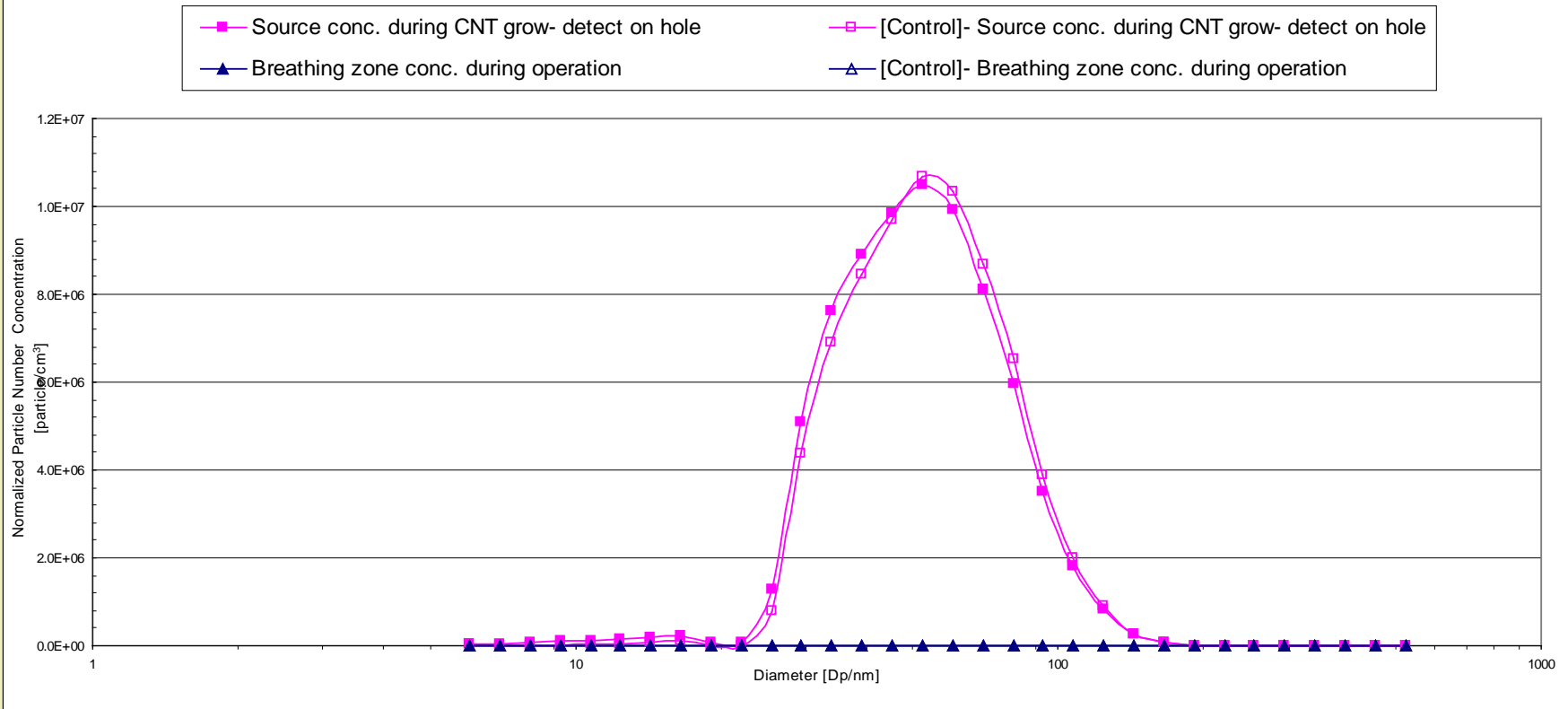
(5) CN





Results: Aerosol Monitoring- Processing (5) CNT Furnace

CNT Furnace Operation - Experimental and Control Data Comparison





Methods of Control, Cont.

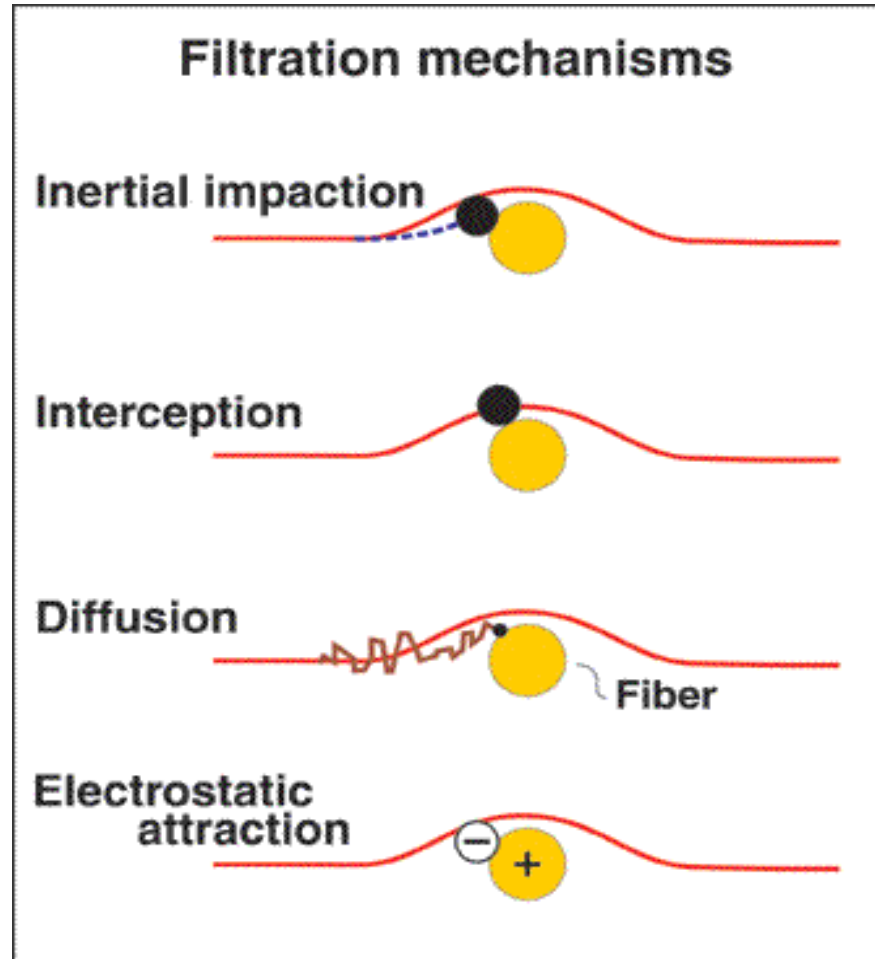
- Personal protective equipment
 - Respirators
 - Protective clothing
 - Gloves
 - Aprons
 - Goggles
 - Etc.
-



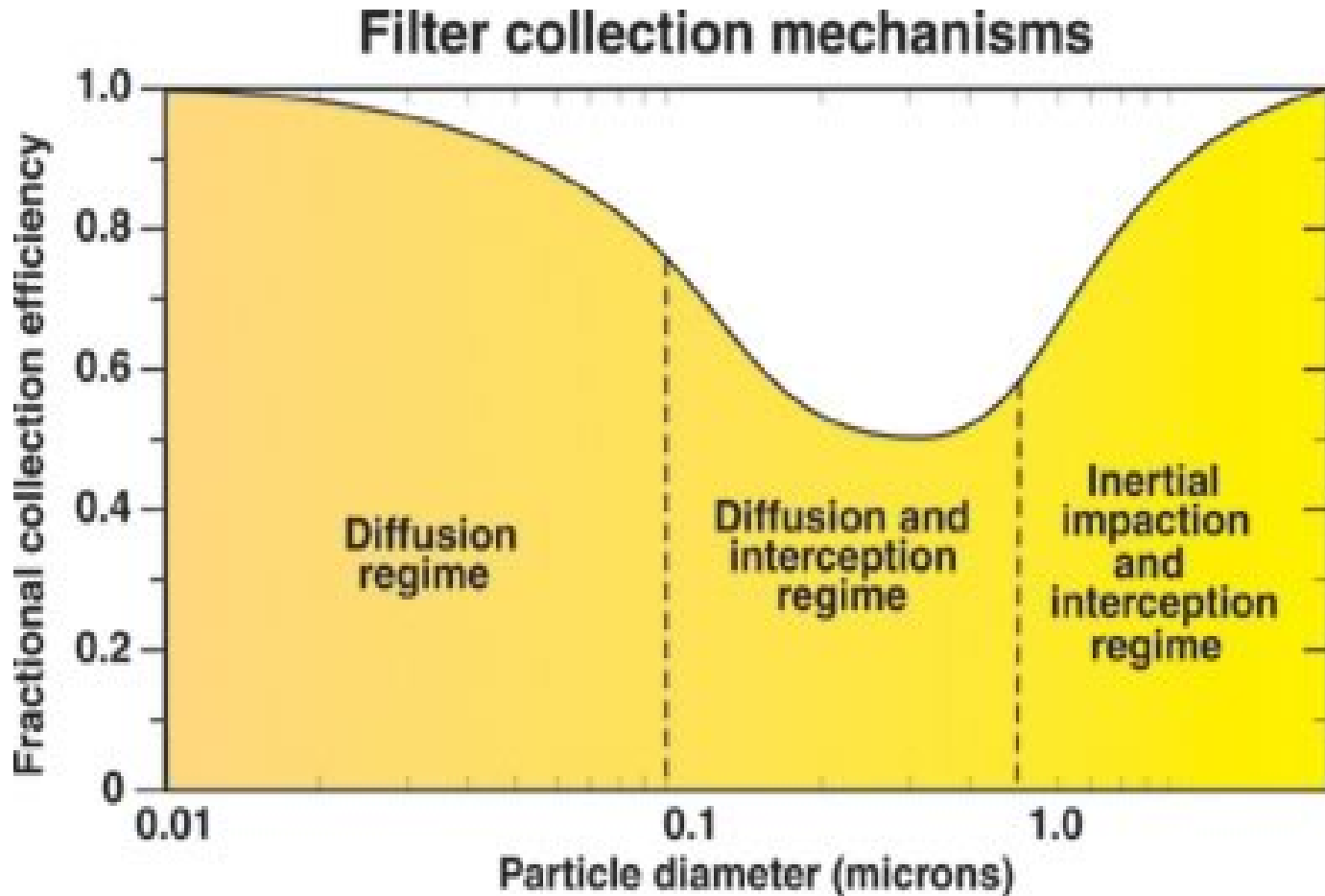
Filtration

- 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
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Filtration Mechanisms



Filter Collection Efficiency

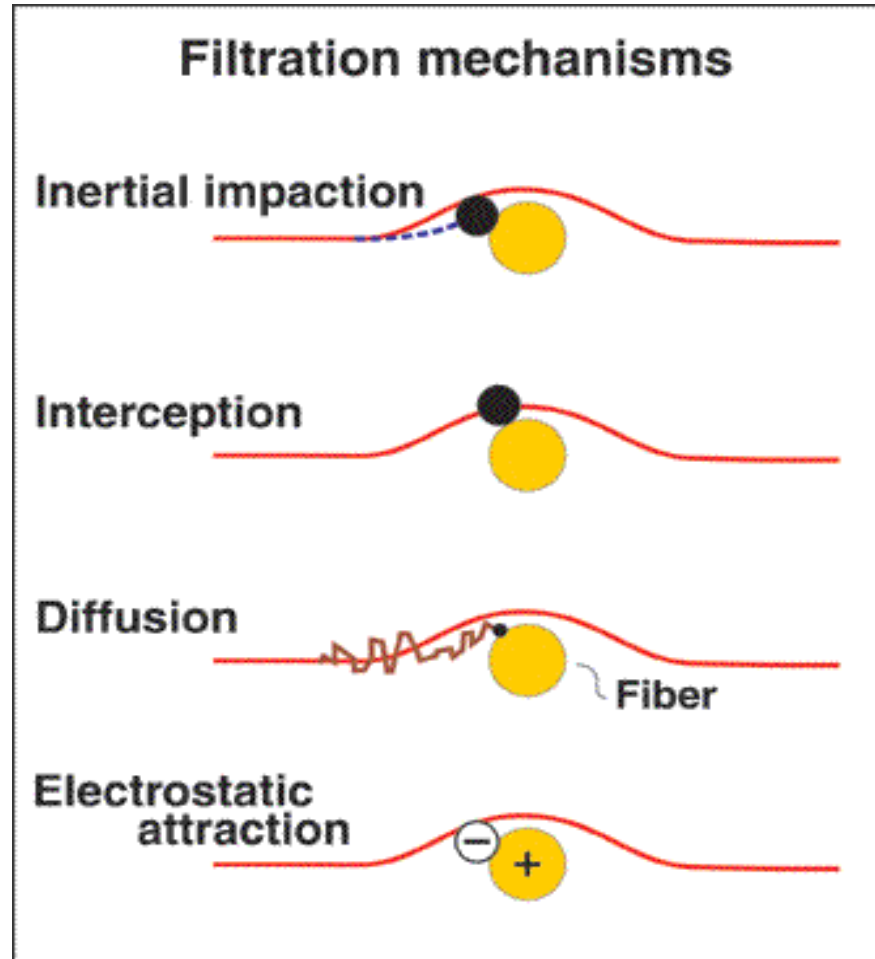




Respirator Performance

- Recent research suggests that the **proper** respirator may be highly effective against nanoparticles
 - N100 cartridges – 100% efficient for nanoparticles, as predicted
 - N95 cartridges – $P_t > 5\%$ for 40 nm particles at high breathing rates

Filtration Mechanisms





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





AIChE November Meeting

- Abstract:

Collection Efficiency of Nanosize Particles in an Electrostatic Precipitator

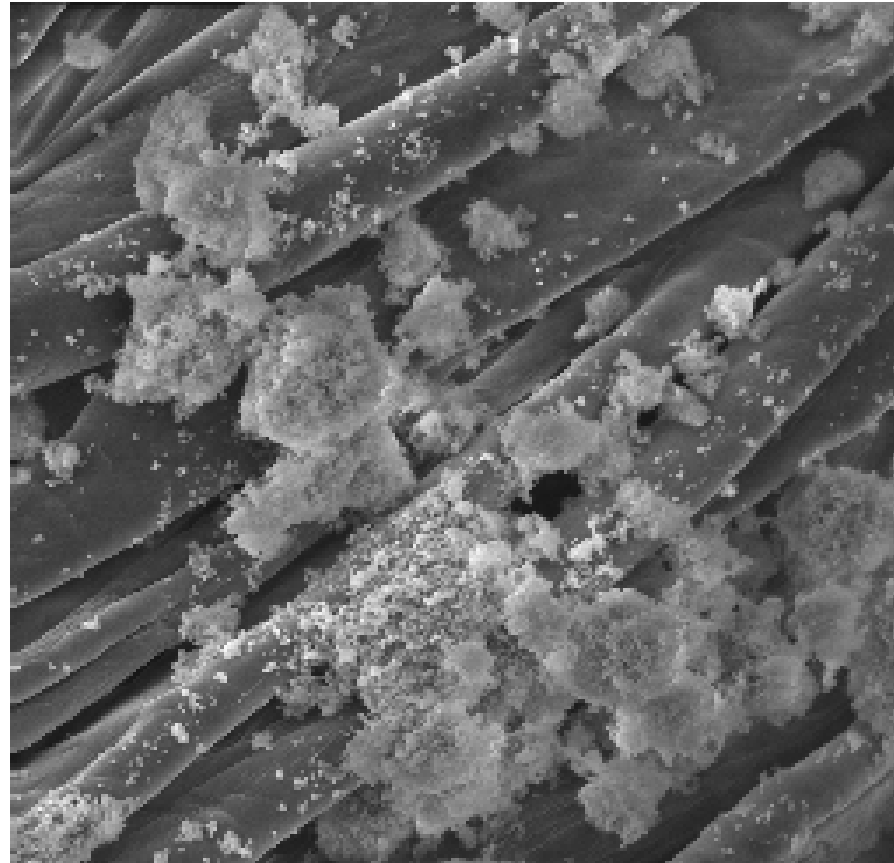
“In this work, the collection efficiency of particles in the nanosize range (5 - 100 nm) in a two stage parallel plate electrostatic precipitator is studied by numerical simulation...”



AIChE, Cont.

“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



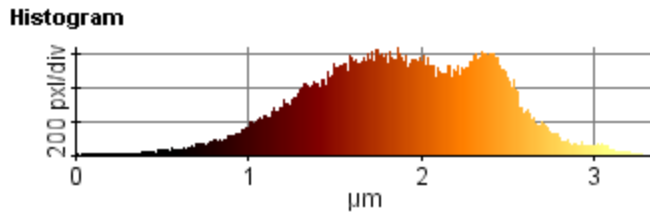
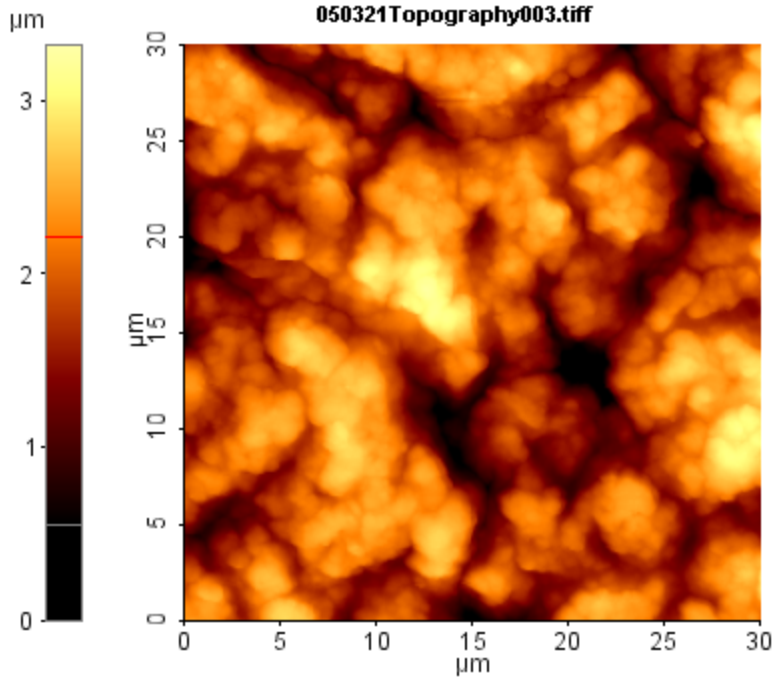
5 μ m

10KeV

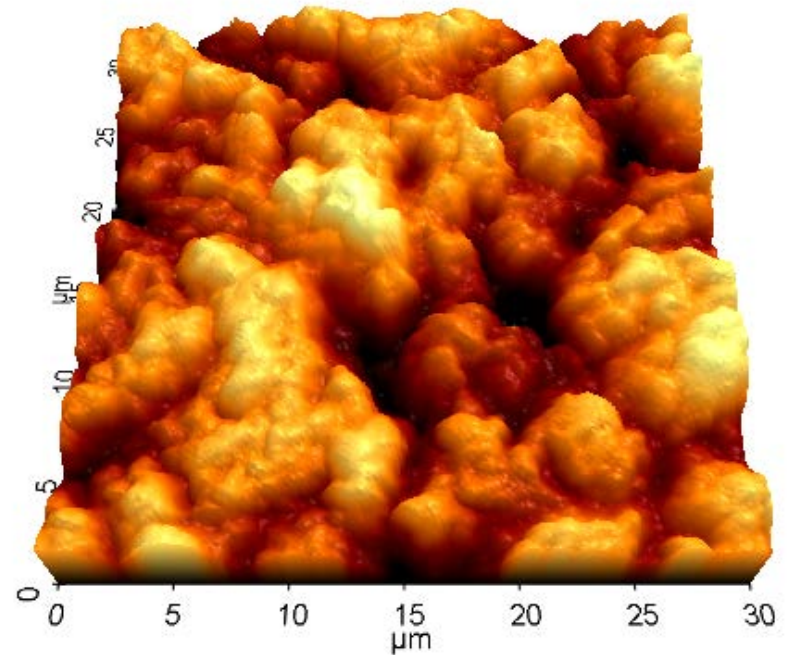
X2000



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



Height information



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
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