Laboratory Workplace Safety Practices and Sampling and Analysis Considerations

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About RJ Lee Group

• Commercial Laboratory and Consulting Services
• AIHA Accredited Laboratory
• 80,000 + square ft. facility
• Optical and Electron Microscopy Capabilities
• Located in Monroeville, PA
Nanotechnology Hype

• Why all of the Hype?
  – Nanotechnology is a “How”
  – Infrastructure and Technology Advances
  – Broad Range of Industries and Use

• Engineering materials at the molecular level
Nanomaterials Safety:
The Industrial Hygiene Approach

- Recognition
- Evaluation
- Control
Nanotechnology Questions

• Uncertainties
  – Short/Long Term Health Effects
• Historical Analogies
• Analytical Issues
  – Sampling
  – Analysis Protocols
  – Reference Values
Similar Experience – Ultrafines “Nanosized” Particles
RJLG Nanotechnology Safety Issues

• Variety of Different Materials
  – MWCNTs
  – Silver and Gold precipitates

• Potential Laboratory Worker Exposure??
  – Inhalation, Ingestion, Dermal Absorption, or Injection
  – Engineering Controls
  – Work Practices
  – Personal Protective Equipment

• Social Responsibly
  – Air Emissions
  – Disposal
Nano-particle Laboratory Safety

• Provide Safety Awareness Training

• Laboratory Worker Guidelines
  – Handle Limited Bulk Sample Amts. (e.g., only enough for testing)
  – Request Bulk Material be Submitted in Suspension
  – Properly Label and Containerize Samples
  – Immediately Clean-up “Spills”
    • Wet Methods
    • HEPA Filtered Vacuum
Nano-particle Laboratory Safety

• Laboratory Worker Guidelines (cont.)
  – Maintain Clean Facility (ref. “Tack Mats”)
  – Use disposable lab supplies when possible
  – Use Engineering Controls (appropriate ventilation)
  – Wear Lab Coats and Gloves when Handling
  – On-going Monitoring (when applicable)
  – Do not discharge into environment (i.e., air or water)
Laboratory Hoods / Glove Boxes

• Positive Pressure Hood
  – e.g., “Clean Bench”
  – Typically protects samples only

• Negative Pressure Hoods
  – a.k.a. “Fume Hood”
  – Typically protects worker
  – Exhaust may or may not be filtered

• Laminar Flow Filtered Hood
  – Protects Worker and Sample
Laboratory Equipment Modification

Filtration on Vacuum Pump Systems
Sample Disposal Considerations

• Containerize in Leak Tight Containers

• Wet material prior disposing

• Consider asbestos as a model for disposal for insoluble particles

• For large amounts of waste – return to customer for disposal
Sample Collection

• Direct Read Instruments
• Air
  – Size Selective Samplers and Filters
  – Passive Samplers
• Bulk Samples
• Surfaces
  – Wipes
  – Adhesive Samplers
Sampling – Direct Read Instruments

- Size Selective Particle Counts or Surface Area Concentrations
- Instantaneous Feedback
- Good Application in Clean Environments
- Limitations
  - “Portability” sometimes difficult
  - Counts particles “not of interest”
  - High “Background” Levels interfere
  - Nanoparticulate can be associated with larger particles
Analytical Techniques

• Trace Analysis (gravimetry, ICP-MS, etc.)
• Scanning Electron Microscopy (SEM)
• Transmission Electron Microscopy (TEM)
• Atomic Force Microscopy (AFM)
• BET Gas Desorption (surface area – bulk samples)
Cascade Impactors

Figure 1. Sioutas Impactor, exploded view
Cascade Impactors
MICRO-ORIFICE UNIFORM DEPOSIT IMPACTORS (MOUDI™)

Non-Rotating MOUDI™
MOUDI™ with Rotator
Nano-MOUDI™
Integrated Air Filter Considerations
Sample Analysis – TEM or SEM

• Simplified Approach
• Evaluate Material for Unique Characteristics
  – Particle Size
  – Morphology
  – Nano-chemistry
  – Crystalline Properties

• Determine analysis protocol based on bulk analysis results
Material Identification - Morphology

SEM Micrograph Displaying Different Morphologies of Two Similar Sized Particles

Crystalline Morphology Obtained by SEM
Air Samples by TEM or SEM

• Complements Direct Read Data
• Determine “Background” Levels
• Collect Samples on Polycarbonate Filters
• Speciate and Count Particles
• Establish Reference Values
  – Background
  – Control Banding
  – Surface Area Adjusted PELs
Nanoparticle Characterization

- Fullerene Nanotube Technology

Catalyst Carryover

Multiple Nanotubes Form Rope
Nanoparticle Characterization

- MWCNT Agglomerate
Nanoparticle Characterization

- MWCNT Aggregate
Anodized Aluminum Film

- Nano Thin Layers
- Nano Sized Features

Raw Material Used in Honeycomb for Aircraft Wings