Exposure Assessments – Update on Strategic Approaches

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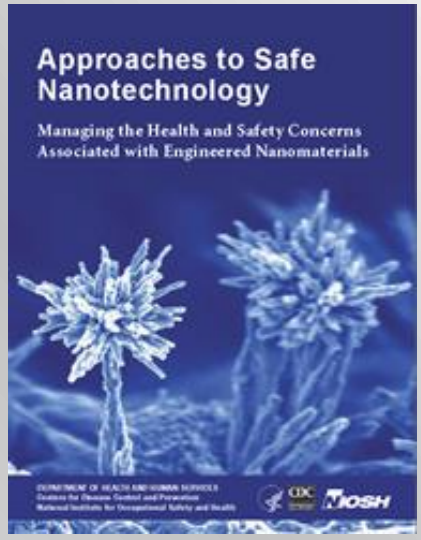
The findings and conclusions in this presentation have not been formally reviewed by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

NTRC Field Studies Team Background

- Formally organized in 2006 as a component of the NIOSH Nanotechnology Research Center
- Conducted 20 site visits in a variety of work places
- Tasked with “learning nanomaterial processes”…
- Attempting to fill an important knowledge gap regarding nanomaterial creation and use:
  - ***Is there a release?***
  - ***To what extent?***
  - ***Is there potential worker exposure?***

Nanotechnology Emissions Assessment Technique (NEAT)

- NEAT was developed as an initial step to semi-quantitatively evaluate exposures in nanomaterial workplaces and consists of a combination of field portable, ***direct reading instrumentation (DRI)*** and ***filter-based air sampling*** with subsequent laboratory analysis
- Assessment steps
  - Develop list of target areas, processes, or tasks for DRI
  - Identify potential emission sources
    - Review process and process flow
    - Examine material inputs and discharges
    - Evaluate worker practices and tasks
    - Review literature



NEAT – 2005 to 2010

Methods

- DRI (CPC and OPC)
  - Characterize background concentrations
    - At process and in adjacent work areas
    - Average pre task and post task concentrations
    - Short sample times (approximately 1 minute)
    - Document background contributing activities
  - At emission source
  - Compare emission source versus background (differential evaluation)
    - ↑ CPC ↑ OPC (300nm – 500nm) ◊ Presence of nanomaterials
    - ↓ CPC ↑ OPC (>1000nm) ◊ Presence of large particles and/or agglomerates

NEAT – Lessons Learned

- Real-Time Instrumentation
  - Background concentrations fluctuate significantly
    - In excess of 10^6 particles/cm^3
    - Variations by
      - Season
      - Day
      - Within day
    - Averaging pre and post task does not adequately address background influences
    - Data logging would better capture and account for background variations
    - Documentation of critical events essential
    - Careful attention to selection of background location
    - Real-Time Instruments alone are insufficient to adequately evaluate a worksite

NFST – 2011 to Present

Goals

- Evaluates the entire material flow of a process and identifies points of potential material emission that can result in worker ***exposure***
- Uses an array of instruments and conventional air sampling methods to characterize exposures
  - Available to the practicing industrial hygienist
- Evaluates ***engineering controls*** and their effectiveness in reducing emissions and exposures
- Evaluates ***work practices*** used during the production or use of nanomaterials
- Evaluates the use of Personal Protective Equipment in use, if any, including respiratory protection

NFST – 2011 to Present

Methods

- Preassessment
  - Occupational exposure limits and health effects
    - Review pertinent literature
      - Toxicology
      - Epidemiology
    - Provides context of interpretation of data
  - Develop sampling strategy
    - Integrated samples
    - Real-time instrumentation (RTI)
    - Wipe sampling

NFST – 2011 to Present

Methods

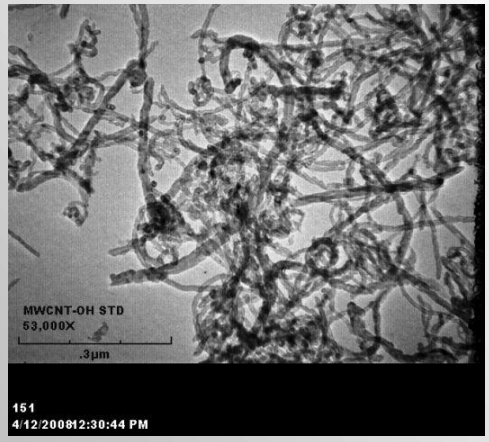
- Sampling Strategy
  - Integrated samples
    - *Core component of exposure assessment*
    - Filter-cassette based
      - Elements
      - Electron Microscopy
    - Area and personal breathing zone
    - Full-shift and task-based

Integrated Sampling

- Elemental mass
  - Sampling and analytical methods not designed for nanomaterials
    - Specificity

      NMAM 5040 (elemental carbon) versus NMAM 7300 (cadmium)
    - Sensitivity

      10 µm particle weighs the same as 10^9 (1 billion) 10 nm particles
- Electron microscopy
  - TEM versus SEM
  - Morphology
  - EDS for chemical composition
  - Particle count
  - No counting convention exists
- Respirable fraction



Inhalable	• 100 µm diameter
Thoracic	• 10 µm diameter
Respirable	• 4 µm diameter

Direct Reading Instruments

- TSI CPC 3007 (TSI Inc., Shoreview, MN)
- ARTI HHPC-6 (Hach Company, Grants Pass, OR)
- TSI DustTrak DRX (TSI Inc., Shoreview, MN)

Appropriate Use of DRIs

- Assess efficacy of engineering controls
- Assess potential for emission of specific processes/tasks
- Identify general increases or decreases in total particle concentration
- Provide supporting evidence for integrated samples

Limitations of DRIs

- ***No*** material identification
- Condensation Particle Counter
  - Engineered to measure 'particle' concentrations – not fibers
  - Upper dynamic range in the order of 10^5 pt/cc
- Small inlet can become clogged with larger particles
- Optical Particle Counter (DustTrak)
  - Unable to accurately assign 'size bin' to fibrous materials
- Optical Particle Counter (ARTI)
  - Unable to accurately assign 'size bin' to fibrous materials
  - Only total count is useful data
    - Only 50% collection efficiency for the smallest size bin (0.3-0.5 µm)
    - Unable to correct accurately due to inaccurate size designations
  - Clean room instrument
    - Inlet easily clogged in dusty environment

Wipe Sampling

- Surface contamination
- No correlation with worker inhalation exposures
- Assess worker hygiene practice
- NMAM 9102
  - Elements
  - Wash ‘n Dry or ASTM equivalent

    Pre-packaged moist disposable towelette
  - Analysis by inductively coupled argon plasma atomic emission spectroscopy

Vacuum Sampling

- Surface contamination
  - Filter sock
    - More mass
    - Less time
    - Use of a template
    - Analysis requires resuspension
  - 37-mm filter cassette
    - Good for hard to reach areas
    - Less mass
    - Labor intensive
    - Amenable to standard sample analysis and EM

NFST – 2010 to present

12 Field Studies

Types of facilities	Number of sites
Primary producer of nanomaterials	9
Secondary user of nanomaterials (manufacturer)	1

- Agents
  - Carbon nanotubes, aluminum oxide, amorphous silica, cerium oxide, quantum dots, silver nanowires, zirconium oxide, hafnium oxide, catalytic nanoparticles (iron, nickel, silver-palladium, and magnesium) and nickel-titanium alloy