Measurement and Characterization

Government Resources

- DOE
  - DOE N456.1, The Safe Handling of Unbound Engineered Nanoparticles, 1/5/09
  - DOE Nanoscale Science Research Centers, Approach to Nanomaterial ES&H, Revision 3a – May 08
- EPA
  - Nanoparticle Air Monitoring Workshop, 2-3 March 2009
- NIOSH
  - Approaches to Safe Nanotechnology – Managing the Health and Safety Concerns Associated with Engineered Nanomaterials, 2009
- NNI
  - Human & Environmental Exposure Assessment of Nanomaterials Workshop, 24-25 February 2009
  - NanoEHS Environment & Instrumentation Workshop: Nanomaterials and the Environment & Instrumentation, Metrology and Analytical Methods, 6-7 October 2009
  - NanoEHS Health & Instrumentation Workshop: Nanomaterials and Human Health & Instrumentation, Metrology, and Analytical Methods, 17-19 November 2009
- NIST
  - Characterization, Nanometrology, and Nanoscale Measurements Portal
  - "How to Measure" Book Series
    1. Measurement Issues in Single Wall Carbon Nanotubes

2. Porosity and Specific Surface Area Measurements for Solid Materials

3. Particle Size Characterization

- Material Standards for Environmental Health & Safety for Engineered Nanoscale Materials, a Report Based on a NIST Workshop held September 12-17, 2007

- The Second Tri-National Workshop on Standards for Nanotechnology, 2008

- Standard Reference Materials and Reference Materials

1. NIST Reference Materials

1. Nanoparticle Metrology and Standards for Biomedical Applications and Health

2. Material Standards for Environmental Health & Safety for Engineered Nanoscale Materials, a Report Based on a NIST Workshop held September 12-17, 2007

External Resources

- ASTM E56 Nanotechnologies (Published)

1. E2490-09 Standard Guide for Measurement of Particle Size Distribution of Nanomaterials in Suspension by Photon Correlation Spectroscopy (PCS)

2. E2578-07 Standard Guide for Calculation of Mean Sizes/Diameters and Standard Deviations of Particle Size Distribution

3. ASTM, E2535-07 Standard Guide for Handling Unbound Engineered Nanoscale Particles in Occupational Settings, November 2007

- ASTM E56 Nanotechnologies (Draft Stage)

1. WK21915 Zeta potential measurement by electrophoretic mobility

2. WK26321 Measurement of particle size distribution of nanomaterials in suspension by nanoparticle tracking analysis (NTA)

3. WK29480 - New Practice for Size Measurement of Nanoparticles Using Atomic Force Microscopy (AFM)

- IRSST

  - Best Practices Guide to Synthetic Nanoparticle Risk Management, January 2009

  - Engineered Nanoparticles, Current Knowledge about OHS Risks and Prevention Measures, 2nd Edition, July 2010

- ISO TC 146 Workplace Atmospheres: Ultrafine, nanoparticle and nano-structured aerosols - Exposure characterization and assessment. Geneva: Switzerland: International Standards Organization. Document no. ISO/TR 27628, 2007

- ISO TC 229 Nanotechnologies (published standards)

  1. ISO TC 229 Nanotechnologies: Health and safety practices in occupational settings relevant to nanotechnologies. Document no. ISO/TR 12885, 2008

  2. ISO/TS 10867:2010 Nanotechnologies - Characterization of single-wall carbon nanotubes using near infrared photoluminescence spectroscopy, 2010

  - ISO TC 229 Nanotechnologies (projects under development)

    – ISO/WD TS 10797 Nanotubes -- Use of transmission electron microscopy (TEM) in single-walled carbon nanotubes (SWCNTs)

    – ISO/CD TS 10798 Nanotubes -- Scanning electron microscopy (SEM) and energy dispersive X-ray analysis (EDXA) in the characterization of SWCNTs

    – ISO/AWI TS 10812 Nanotechnologies -- Use of Raman spectroscopy in the characterization of SWCNTs

    – ISO/CD TS 10868 Nanotubes - Use of UV-Vis-NIR absorption spectroscopy in the characterization of SWCNTs

    – ISO/CD TR 10929 Measurement methods for the characterization of multi-walled carbon nanotubes (MWCNTs)

    – ISO/PRF TS 11251 - Nanotechnologies -- Characterization of volatile components in single-wall carbon nanotube samples using evolved gas analysis/gas chromatograph-mass spectrometry

- ISO/CD TS 11308 Nanotechnologies -- Use of thermo gravimetric analysis in the purity evaluation of SWCNT
- ISO/AWI TR 11808 Nanotechnologies – Guidance on nanoparticle measurement methods and their limitations
- ISO/NP TR 11811 Nanotechnologies -- Guidance on methods for nanotribology measurements
- ISO/NP TR 11888 Determination of mesoscopic shape factors of MWCNTs
- ISO/AWI TS 11931-1 Nanotechnologies -- Nano-calcium carbonate -- Part 1: Characteristics and measurement methods
- ISO/AWI TS 11937-1 Nanotechnologies -- Nano-titanium dioxide -- Part 1: Characteristics and measurement methods
- ISO/CD 12025 Nanomaterials -- General framework for determining nanoparticle content in nanomaterials by generation of aerosols
- ISO/AWI TR 13014 - Nanotechnologies - Guidance on physico-chemical characterization of engineered nanoscale materials for toxicologic assessment
- ISO/NP TS 13126 Artificial gratings used in nanotechnology – Description and measurement of dimensional quality parameters
- ISO/NP TS 13278 Carbon nanotubes – Determination of metal impurities in carbon nanotubes (CNTs) using inductively coupled plasma-mass spectroscopy (ICP-MS)
- ISO/NP TS 14101 - Surface characterization of gold nanoparticles for nanomaterial specific toxicity screening: FT-IR method
- ISO/AWI TS 16195 – Nanotechnologies – Generic requirements for reference materials for development of methods for characteristic testing, performance testing and safety testing of nanoparticle and nano-fiber powders

- International Workshop on Documentary Standards for Measurement and Characterization in Nanotechnologies, February 2008

- Literature and Presentations

1. Bello et. al., Particle exposure levels during CVD growth and subsequent handling of vertically-aligned carbon nanotube films, Carbon 266: 974-981, 2008

2. Bello et. al., Exposure to nanoscale particles and fibers during machining of hybrid advanced composites containing carbon nanotubes, J. Nanoparticle Research, 11:231-249, 2009

3. Brouwer et. al., Personal Exposure to Ultrafine Particles in the Workplace: Exploring Sampling Techniques and Strategies, Annals of Occupational Hygiene, Vol. 48, No. 5, March 2004

4. Brouwer, et. al., From workplace air measurement results toward estimates of exposure? Development of a strategy to assess exposure to manufactured nano-objects, J. Nanoparticle Research, 11:1867-1881, October 2009

5. Demou et. al., Exposure to Manufactured Nanostructured Particles in an Industrial Pilot Plant, Ann. Occup. Hyg, No. 8, pp. 695-706, 2008

6. Fujitani, et. al., Measurement of the Physical Properties of Aerosols in a Fullerene Factory for Inhalation Exposure Assessment, Journal of Occupational and Environmental Hygiene, 5:380-389, June 2008

7. Geraci, CL, Exposure Assessment: Current Exposure Data, Conference Presentation at "Nanomaterials and Worker Health: Medical Surveillance, Exposure Registries, and Epidemiologic Research", 21-23 July 2010

8. Han JH, et. al., Monitoring multiwalled carbon nanotube exposure in carbon nanotube research facility, Inhal Toxicol 20:741-749, 2008

9. Johnson et. al., Potential for Occupational Exposure to Engineered Carbon-Based Nanomaterials in Environmental Laboratory Studies, Environmental Health Perspectives, Volume 118, Number 1, January 2010

10. Johnson et. al, Potential for Occupational Exposure to Carbon-Based Nanomaterials in Environmentally-Relevant Matrices, Presentation, 23 November 2009

11. Kuhlbush, et. al., Number Size Distribution, Mass Concentration, and Particle Composition of PM_1, $PM_{2.5}$, and PM_{10} in Bag Filling Areas of Carbon Black Production, Journal of Occupational and Environmental Hygiene, 1:660-671, October 2004

12. Kuhlbush, T.A.J., and Fissan, H., Particle Characteristics in the Reactor and Pelletizing Areas of Carbon Black Production, Journal of Occupational and Environmental Hygiene, 3:558-567, October 2006

13. Lee et. a., Exposure assessment of carbon nanotube manufacturing workplaces, Inhalation Toxicology, Vol. 22(5), pp. 369-81, April 2010

14. Maynard et. al., Exposure to Carbon Nanotube Material: Aerosol Release During the Handling of Unrefined Single-Walled Carbon Nanotube Material, Journal of Toxicology and Environmental Health, Part A, 67:87-107, 2004

15. Maynard, A.D. and Aitken, R.J., Assessing exposure to airborne nanomaterials: Current abilities and future requirements, Nanotoxicology, Volume 11, 26-41, March 2007

16. Methner et. al., Identification and characterization of potential sources of worker exposure to carbon nanofibers during polymer composite laboratory operations, J. Occup Environ Hyg 5:D63-D69, 2007

17. Methner et. al., Nanoparticle Emission Asessment Technique (NEAT) for the Identification and Measurement of Potential Inhalation Exposure to Engineered Nanomaterials – Part A, 16 December 2009

18. Methner et. al., Nanoparticle Emission Assessment Technique (NEAT) for the Identification and Measurement of Potential Inhalation Exposure to Engineered Nanomaterials – Part B: Results from 12 Field Studies, 6 January 2010

19. Old, L. and Methner, M., Engineering Case Reports: Effectiveness of Local Exhaust Ventilation (LEV) in Controlling Engineered Nanomaterial Emissions During Reactor Cleanout Operations, Journal of Occupational and Environmental Hygiene, 5:D63-D69, June 2008

20. Ono-Ogasawara et. al., Distinguishing nanomaterial particles from background airborne particulate matter for quantitative exposure assessment, J. Nanoparticle Research, 11:1651-1659, July 2009

21. Park et. al., Characterization of exposure to silver nanoparticles in a manufacturing facility, 11:1705-1712, August 2009

22. Peters et. al., Airborne Monitoring to Distinguish Engineered Nanomaterials form Incidental Particles for Environmental Health and Safety, Journal of Occupational and Environmental Hygiene, 6:73-81, February 2009

23. Tsai S-J. et. al., Airborne nanoparticle exposures associated with the manual handling of nanoalumina and nanosilver in fume hoods, J. Nanoparticle Res, 2008

24. Tsai S-J. et. al., Airborne nanoparticle release associated with the compounding of nanocomposites using nanoalumina as fillers, Aerosol Air Qual Res 8:160-177, 2008

25. Yeganeh et. al., Characterization of airborne particles during production of carbonaceous nanomaterials, Environ Sci Technol 42:4600-4606, 2008

- OECD

1. No. 8 - ENV/JM/MONO(2009)6, Preliminary Analysis of Exposure Measurement and Exposure Mitigation in Occupational Settings: Manufactured Nanomaterials, 17 April 2009

2. No. 10 - ENV/JM/MONO(2009)15, Identification, Compilation and Analysis of Guidance Information for Exposure Measurement and Exposure Mitigation: Manufactured Nanomaterials, 22 June 2009.

3. No. 11 - ENV/JM/MONO(2009)16, Emmision Assessment for Identification of Sources and Release of Airborne Manufactured Nanomaterials in the Workplace: Compilation of Existing Guidance, 18 June 2009

4. No. 13 - ENV/JM/MONO(2009)18, Report of an OECD Workshop on Exposure Assessment and Exposure Mitigation: Manufactured Nanomaterials, 27 August 2009

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