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Engineered Nanomaterials in the Workplace

Fact Sheet

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General Overview

Advanced materials science and advanced manufacturing techniques often take advantage of enhanced performance or unique properties that emerge when particle size is in the "nanoscale." Although not a fine line dictated by nature or health effects, the nanoscale is usually denoted by at least one particle dimension less than 100 nanometers or 0.1 micrometer. As particle size gets smaller, the surface area of a unit mass of particulate matter increases exponentially, sometimes leading to effects such as greater thermal conductivity, magnetic susceptibility, optical and electrical performance and enhanced chemical activity. Associated hazards may sometimes also differ from the properties of the same material in non- nanoscale form. Industrial hygienists, engineers and safety professionals face the challenge of assessing and managing potential risks to worker and public health, safety or the environment posed by such advanced materials. This fact sheet is concerned primarily with intentionally produced "engineered nanomaterials (ENM), sometimes also referred to as "manufactured nanomaterials (MNM)." The particulate matter form of intentionally produced nanoscale materials are sometime referred to as "engineered nanoparticles (ENP)." The term "ultrafine particulate matter" is often used to refer to naturally occurring or incidentally created nanoscale particulate aerosols such as welding fume or diesel particulate matter. Consider that airborne particles present in your workplace at any one time may come from a variety of sources and pose a mixed exposure to workers.

Do You Have ENMs At Your Site?

Commercialized engineered nanomaterials may be found in textiles, composite building materials used in aerospace applications, cosmetics, electrical and electronic equipment, sporting goods, concrete and other building materials, and in additives for diesel fuels, higher strength alloys, explosives, inks, coatings, paints, drilling and machining fluids. An important first step is to determine whether workers handle ENMs in your operations. Be aware that labels and Safety Data Sheets (SDSs) often do not accurately reflect nanomaterial content or hazard. It is common to find that SDSs for mixtures don't indicate which ingredient is present at the nanoscale. If a nanoscale ingredient is indicated or the involved process uses or generates a nanoscale contaminant, the hazard information and/or occupational exposure limit provided may be for the non-nanoscale substance with no indication there may be uncertainty regarding its level of protection for the nanoscale substance. It's a good idea to be proactive and ask about the nano-scale nature of chemicals being brought to your site using Occupational Health and Safety Management System tools (e.g., hazard reviews for new materials). Ask your suppliers to provide information on ENMs in their materials , e.g. ask the question *"Does this material contain any nanomaterials with a primary particle size from 1- 100 nm?"* Enlist your product developers to alert you when there is ENM content in new product formulations or potential processes. Don't wait for an SDS to tell you about the presence of engineered nanomaterials in your workplace.

Nanomaterial Characterization

In the AIHA Exposure Assessment Strategy for workplace handling of chemicals, Basic Characterization includes determining what is being handled, where and by whom, and what the hazards are. This can be complicated for ENMs, but accurate material characterization is very important. There are many ENM types with a large variety of characteristics which may contribute to a wide range of hazard potential. Hazard information for the non-nanoscale material of the same chemical composition may provide a starting point for hazard evaluation, but the most important characteristics related to health hazard may vary from one ENM to another, and remain largely unknown. Useful physical-chemical characterization information for ENMs in the workplace, in addition to chemical composition, may include: size distribution, shape, surface area, surface modifications, solubility, crystallinity, charge, particle density, degree of agglomeration or aggregation, at least a qualitative indication of potential dustiness, and nature and residual amount of catalyst or impurities from synthesis process. Reach out to the materials scientists and engineers who design and manufacture these advanced materials for their assistance to obtain and interpret this type of physical – chemical information.

Hazard Evaluation

Case-by-case hazard assessment research on ENMs continues, but as mentioned above, there are so many different types of ENMs that alternate solutions are also being sought for understanding and managing the type and severity of potential hazards. There is much interest in the possibility of grouping 'like' nanomaterials into categories for the purpose of describing the hazard, but there is not yet agreement among experts on appropriate grouping strategies. Regarding health-based occupational exposure limits (OELs), as of February 2015, there are no enforceable regulatory occupational exposure limits in the United States specific to nanoparticles or nanomaterials, but OELs for a few ENMs have been adopted by non-regulatory agencies (e.g., NIOSH) or suggested by manufacturers. In lieu of having nano-specific OELs available, several hazard banding approaches have been developed and described in industrial hygiene science literature as a way to support appropriate risk management of nanomaterials in the workplace. Until authoritative OELs are developed, it is prudent to control exposures to "as low as reasonably practicable." Safety hazards (e.g., explosivity) must also be considered for some nanomaterials if process conditions result in high dust concentrations.

Exposure Assessment

Research into appropriate exposure assessment approaches and practical field methods for ENM or nanoscale particle concentration measurement continues. The focus is on inhalation exposures, but dermal exposure must also be prevented.

Qualitative exposure banding approaches have been developed and described in the literature. These closely reflect similar approaches for handling of non-nanoscale materials, and typically consider such indicators of potential ENM exposure as: possible routes of worker exposure, physical form (e.g., in solid matrix vs. in liquid vs. dry powder), potential for aerosol generation, quantity handled, handling task frequency and duration, etc.

Next considering quantitative approaches, the 'gold standard' for workplace exposure assessment requires 1) a health risk-based occupational exposure limit appropriate to the nanoscale particle, 2) validated (and practical) sampling and analytical methods, and 3) standardized approaches for data analysis and interpretation. These have not been defined for most nanomaterials. Questions also remain about the appropriate measurement metric (i.e., particle concentration in mass vs. surface area vs. count). With all the uncertainties, when air monitoring is conducted, a multi-metric, tiered approach is typically recommended. One must understand the nanomaterial physical-chemical characteristics, the sampling environment (e.g., other particles present), and the capabilities and limitations of instruments and methods selected when developing a sampling plan. Even without being able to meet the 'gold standard', carefully designed air monitoring projects for ENMs may contribute to understanding the potential for exposure (e.g., when or where particle releases may occur in a process) and confirm performance of exposure controls.

There are no recommendations to implement ENM-specific Medical Surveillance Programs for workers at this time. Until more research reveals a specific medical surveillance protocol, NIOSH has issued Current Intelligence Bulletin (CIB) 60, "Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles (2009-116)." In CIB 60, NIOSH recommends taking prudent measures to control exposures to engineered nanoparticles, conducting hazard surveillance as a basis for implementing controls, and continuing the use of established medical surveillance procedures.

Remember that if a regulatory OEL exists for a material being handled at the nanoscale, the regulation still applies for workplace compliance purposes. Unless there is supporting toxicity data, one should not assume that an OEL will be protective at the nanoscale if it was developed for non-nanoscale material.

Exposure Control

As with exposure control for handling of non-nanoscale substances of high or uncertain hazard, the Industrial Hygiene Hierarchy of Controls should be followed, and a precautionary approach to worker protection is recommended (i.e., control exposures to "as low as reasonably practicable"). If possible, the ENP should be substituted or modified to present less hazard (e.g., via surface modification), or less potential for exposure (e.g., handled in liquid slurry vs. as dry powder). Traditional powder/dust controls (e.g., enclosure, local exhaust ventilation) can be effective.

They must be well designed, and properly installed, used, and maintained. NIOSH has issued "Current Strategies for Engineering Controls in Nanomaterial Manufacturing and Downstream Handling Processes (2014-102)," which offers specific recommendations for common tasks. Administrative controls should include hazard communication training specific to the nanomaterials in the workplace, and include information on how the worker is protected from exposure. Personal protective equipment should not be used as primary protection, but can be effective to further reduce exposures.

Additional Information Resources

- AIHA Nanotechnology Working Group - https://www.aiha.org/get-involved/Volunteer-Groups
- GoodNanoGuide- https://nanohub.org/groups/gng/personal_protection_measures
- NIOSH CIB 60 Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles - http://www.cdc.gov/niosh/docs/2009-116/pdfs/2009-116.pdf
- NIOSH Current Strategies for Engineering Controls in Nanomaterial Manufacturing and Downstream Handling Processes - http://www.cdc.gov/niosh/docs/2014-102/
- NIOSH Nanotechnology Overview - http://www.cdc.gov/niosh/topics/nanotech/
- NIOSH Nanotechnology Guidance and Publications - Search NIOSH TIC-2 for PPE research articles http://www.cdc.gov/niosh/topics/nanotech/pubs.html
- UK HSE- Using Nanomaterials at Work - http://www.hse.gov.uk/pubns/books/hsg272.htm
- US OSHA Safety and Health Topics: Nanotechnology - https://www.osha.gov/dsg/nanotechnology/nanotechnology.html