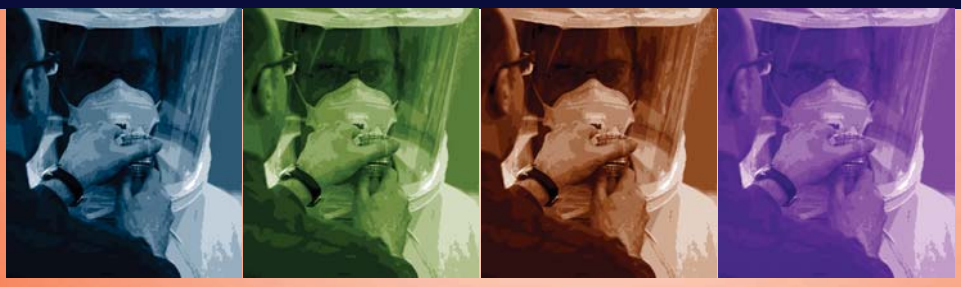
Essential

Trends and Emerging Issues in OEHS

AIHA Essentials Series



By Abby Roberts

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AIHA Essentials Series

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The following chapter on nanomaterial safety comes from "Essential Trends and Emerging Issues in OEHS" and is based on a presentation by Gavin West, director of health research at CPWR. The table of contents lists the other chapters in this ebook, which can be ordered from the AIHA Bookstore: https://online-ams.aiha.org/amsssa/ecssashop.show_product_detail?p_product_serno=3198.

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Introduction

What Are Emerging Trends and Issues in OEHS?

No one could have predicted, in early December 2019, that the occupational and environmental health and safety (OEHS) profession was about to witness global changes affecting workplace health and safety that would linger for years to come. This installment of the *Essentials* series does not cover COVID-19—for that, refer to *The Essentials of Pandemic Response*, published in January 2022. However, the pandemic illustrates how quickly and unpredictably the workplace can change when a new hazard appears or an established one becomes much more prevalent.

This ebook summarizes presentations given at AIHce EXP in May 2023, selected for their coverage of emerging trends and issues in OEHS. Some of the hazards discussed are novel or, at least, not widely understood within the profession. Violence has traditionally been thought of as a community health issue, but statistics show that rates of violence towards workers and within workplaces are increasing (Chapter 3). In Canada and the U.S., the OEHS profession is familiar with many hazards associated with mining operations but not those specific to the emerging rare earth element mining industry (Chapter 4). Nanomaterials have been in the public eye for a few decades, but new applications may put workers at risk for hazards that are not yet fully understood (Chapter 5). Likewise, antineoplastic drugs, used predominately for cancer treatments, are not recent technological developments—but strategies for assessing workplace exposures to these hazardous drugs are still limited (Chapter 6).

Other, more familiar issues are expected to become significantly more serious and widespread in the foreseeable future. Chapters 1 and 2 address workplace hazards associated with climate change. As global average temperatures increase due to buildup of carbon dioxide in the atmosphere, OEHS professionals will be called on to protect workers and communities from surging heat illness, indoor air quality problems, severe weather effects, and a range of other hazards.

CHAPTER 5

5

Hazard Communication for Nanomaterials in Construction

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Hazard Communication for Nanomaterials in Construction

This chapter is based on a presentation given by Gavin West at AIHce EXP 2023.

Nanomaterials are particles so small that they must be measured in billionths of a millimeter. As defined by NIOSH, nanomaterials have at least one dimension between 1 and 100 nanometers in length. "At this size, materials begin to exhibit unique properties that affect physical, chemical, and biological behavior," NIOSH states.

The National Institute for Environmental Health Sciences (NIEHS) explains that nano-sized particles exist in nature, but engineered nanomaterials are synthesized from substances such as carbon and silver. Ongoing research continues to improve our understanding of the effects of nanomaterials on human health and the environment. Even well-understood materials such as silver may pose new hazards at nano scale.

Engineered nanomaterials have been in the public eye since at least the 2000s, but within the last decade, new applications have become commercially available. Gavin West, MPH, the director of nanomaterials research for the Center for Construction Research and Training (CPWR), presented some of the center's work at AIHce EXP 2023. His session, "The Latest in Exposure Science and Hazard Communication for Engineered Nanomaterials in Construction" outlined hazard assessment for nanomaterial applications in the construction industry.

Engineered Nanomaterials in Construction

At present, engineered nanomaterials in construction are most likely to be found as components in paints, coatings, cement, and insulation, although CPWR hasn't identified every application on the market. "We do our best to track what's out there," said West, "but nobody has a really clear idea of the extent to which nanomaterials are used right now."

CPWR maintains ELCOSH-NANO, a publicly accessible online inventory of nanomaterial applications used in the construction industry. As of May 2023, ELCOSH-NANO had documented 875 products that manufacturers claimed included nanomaterials, with paints and coatings accounting for 54 percent of the inventory. According to the manufacturers, nanomaterials enhance their paints and coatings with anti-graffiti, anti-corrosive, anti-microbial, anti-pollution, densifying, self-cleaning, self-healing, ultraviolet radiation protective, and water repellent properties. But West cautioned that CPWR is not able to verify nanotechnology-related claims for the majority of products in the inventory. "You can go to the peer-reviewed literature, and you can see corresponding studies," he said, "but on a case-by-case basis, we're just taking these at face value."

Products related to cement made up roughly 25 percent of the ELCOSH-NANO inventory. Cement densifiers and sealers overlap with the paint and coating category,

but CWPR has also found nanomaterial claims for cement mixes, precast cement, additives, and patching compounds. Carbon nanotubes can reinforce cement at 100 times the tensile strength of steel at a fraction of the weight and are now being used in products. In 2015, concrete road surface enriched with carbon nanotubes was tested on a portion of Interstate 20 in Georgia and approved by the state's department of transportation.

The ELCOSH-NANO inventory has also found nanomaterials used as additives to enhance raw materials before being sold to producers, as well as in lubricants, solar panels, surface prep adhesives, and HVAC system parts.

Aerogels—nano-structured materials comprised mostly of air—are a highly effective form of insulation that is becoming more commonly used. For some time, researchers have known that aerogels have the potential to release some nanoscale debris, but a study published in 2022 confirmed that two commercial aerogel products contained nanoscale heavy metals and metal oxides not listed in their safety data sheets (SDSs).

Sampling Strategies and Control Measures

OEHS professionals must make use of new research to develop and deploy sampling and control measures for engineered nanomaterials in work environments. In 2022, NIOSH published a guidance document outlining goals for nanomaterial exposure monitoring programs. These included maintaining exposures below NIOSH's RELs, but since the agency has developed RELs only for engineered nanomaterials composed of carbon nanotubes and nanofibers, silver, and titanium dioxide (TiO_2), this document also advises minimizing workers' exposures to engineered nanomaterials without RELs. In addition, the document provides guidance on measuring, monitoring, and sampling, including an exposure assessment technique for nanomaterials lacking RELs.

CPWR found NIOSH's sampling approaches feasible for evaluating nanomaterial exposures during various construction tasks. West and his colleagues assessed spraying and sanding tasks using silver and TiO_2 nanomaterials, as well as a sealant containing zinc oxide nanoparticles. Working in an environmentally controlled chamber, they followed NIOSH-recommended methods for collecting gravimetric samples, using direct-reading instruments, and characterizing the sizes and morphologies of nanoparticles through electron microscopy. The studies also examined conventional alternatives without nanomaterials and demonstrated the effectiveness of engineering controls to reduce nanoparticle emissions at the source.

CPWR uses a task-based exposure assessment model because tasks and skills provide continuity in dynamic construction environments. In the construction environment, employers, projects, and work sites may change quickly. The center's model emphasizes the identification, implementation, and evaluation of engineering controls and work practices.

CPWR also makes a point of "including construction workers who are specially trained to have extensive health and safety expertise and involving them in the exposure process," West said. "They understand the work much better than we do, and

we want what we do to be relevant and to involve our stakeholders early on in the process."

This sense of inclusivity led the center to partner with the International Masonry Institute (IMI) for a study of graphene in cement. First, the researchers used transmission electron microscopy to confirm the presence of graphene, a carbonaceous nanomaterial, in the liquid concrete admixture. The manufacturer of the product also supplied information on the graphene nanoparticles. The SDS listed graphite—the material milled down to create graphene—as between 2 and 20 percent by weight, but the manufacturer withheld the exact percentage as a trade secret. Concrete and mortar cure times can affect the release of nanoparticles, so CPWR cured the material for 30 days and followed the manufacturer's technical specifications for high-strength concrete applications.

This study was performed at IMI's International Training Center in Bowie, Maryland. IMI members performed cutting, grinding, and tuckpointing tasks, with and without local exhaust ventilation, and with and without the graphene admixture. CPWR researchers collected air samples to measure respirable elemental carbon in the workers' personal breathing zones as a proxy for graphene.

Under an electron microscope, some of the graphene in samples taken during tuckpointing had an altered or fractured physical appearance. CPWR's microscopist also found free graphene particles that were not embedded in the cement matrix more often than the research team had expected, based on prior studies.

Use of controls reduced respirable elemental carbon to below detectable levels, or 0.045 mg/m^3, but one minute of tuckpointing without controls generated 3 mg/m^3 of elemental carbon in workers' breathing zones. "Nanoparticles have very little mass, so that's a pretty substantial number," West said. "That was more than we were expecting there." Tuckpointing also generated a large amount of respirable dust, so researchers staggered sampling times to avoid overloading the sampling filters.

West encouraged OEHS professionals to look out for new studies investigating nanoparticles released from workers' clothing. Nanoparticles can easily become airborne when displaced from clothing, potentially causing take-home exposures similar to those for lead and asbestos.

Communicating Risk to Workers and Employers

The historic cases of lead and asbestos offer cautionary tales for nanomaterial applications. "Asbestos was a revolutionary material," West said. "It didn't have very many acute health effects but ended up having quite severe chronic health effects after a long latency period." A 2017 study estimated that $24 million spent on anticipatory research into lead and asbestos could have saved between $272 and $369 billion in sustainability costs, including remediation, litigation, and adverse health effects.

Compared to larger particles of similar composition, nanoparticles may be more toxic on an equivalent mass basis, can cross cell membranes and penetrate intact healthy skin, and may translocate to other organs following inhalation and deposition deep within the respiratory tract. Nanoscale powders are fire and explosion hazards, given

that minimum ignition energy decreases as particle size decreases. In animal studies, exposure to carbon nanotubes has been associated with pulmonary inflammation and rapidly developing, persistent fibrosis. In existing human health studies, occupational exposure to carbon nanotubes is associated with biomarkers for fibrosis, inflammation, oxidative stress, and cardiovascular effects. Rats that inhaled silver nanoparticles showed decreased lung function, inflamed lung tissue, and liver and kidney effects, while rats that inhaled titanium dioxide experienced pulmonary inflammation, oxidative stress, and lung cancer.

However, "there are many engineered nanomaterials out there, and they all differ by their toxicity," West said.

He referred to a paper published in 2019 with Paul Schulte, PhD, as the lead author. Schulte was then the codirector of the NIOSH Nanotechnology Research Center. "In this state of uncertainty, precautionary controls for each engineered nanomaterial are warranted while further study of potential health effects continues," Schulte and his coauthors concluded.

CPWR's studies on nanomaterial exposures and controls demonstrate the wisdom of this guidance. Earlier engineered nanomaterial research had focused on environments in laboratories and manufacturing plants, as well as on "pristine" materials that had not been incorporated into products. "So, how relevant are these to construction workers?" West asked. "What forms of engineered nanomaterials are released once you put them into cement, for example? And what are their health effects?"

Most of these previous studies had indicated that engineered nanomaterials remained embedded in their matrices, which CPWR's study on nanomaterials in paint spray found to be true. But the center's study on graphene-enhanced concrete admixture measured relatively high levels of free nanomaterials released during construction tasks. "There are a lot of factors that can influence the exposure, like the duration and the types of ventilation being used," West explained. "Multiple factors, such as weathering or the amount of physical energy applied through, for example, tuckpointing, can affect the release of engineered nanomaterials from composites." Despite their more durable, weather-resistant qualities, nanomaterial-enhanced products aren't immune to the effects of time.

CPWR is communicating the risks of engineered nanomaterials through its toolbox talk series, which is available for free from its website. The center has also developed a nanomaterial hazard alert card that provides important information about identifying nanomaterials, situations in which workers are likely to be exposed, and controlling the hazard. In the "Train the Trainer" approach, the center shares information about exposure risk, health risk, and controls with trainers. So far, the center has worked with unions representing finishing trade workers, operating engineers, and insulators, as well as with the Community College Consortium for Health and Safety Training, to disseminate its findings on nanomaterials and controls.

Existing and Proposed Standards for Nanomaterial Hazard Communication

In the U.S., there are currently no requirements to identify nanomaterials in SDSs. "So that's a barrier when we're trying to inform our risk assessment strategies and prioritize what materials we're going to be looking at when we go to our inventory," West said. "In about half of the cases, we don't even know what's in there." Sometimes, CPWR has found claims in marketing or promotional materials that refer to nanomaterials, but SDSs for the same products don't provide further information. "The state of hazard communication right now is not great in terms of being transparent that there are risks," he continued.

In 2010, Safe Work Australia published their evaluation of 50 SDSs, finding that less than one in five provided information that could reliably inform occupational risk assessment for nanomaterials. A NIOSH study published in 2019 also found that most of the nanomaterial SDSs evaluated needed "significant improvement."

OSHA's proposed revision of the hazard communication standard (29 Code of Federal Regulations 1910.1200) would require manufacturers to report particle size and, if appropriate, other attributes related to toxicity on SDSs for nanomaterial products. According to West, if this revision is enacted, it would help OEHS professionals identify and assess risks posed by nanomaterials on construction sites. "That'll make our work easier, to be able to have a better starting point to do our risk assessments," West said.

A revision of ISO/TR 13329: 2012, *Nanomaterials—Preparation of material safety data sheets (MSDS)*, is in progress. Finally, CPWR launched its Nano Safety Data Sheet Improvement Tool, which uses questionnaire responses to provide recommendations on strengthening SDSs.

Resources

CPWR: The Center for Construction Research and Training, cpwr.com.

CPWR: "Data Dashboards – Nanomaterials in Construction," bit.ly/nanodatacenter.

ELCOSH-NANO: Construction Nanomaterial Inventory, nano.elcosh.org.

Federal Register: "Hazard Communication Standard," bit.ly/comm-standard (February 2021).

International Organization for Standardization: ISO/TR 13329:2012, *Nanomaterials—Preparation of material safety data sheets (MSDS)*, bit.ly/iso13329-2012 (2019).

Journal of Chemical Health and Safety: "An Evaluation of Engineered Nanomaterial Safety Data Sheets for Safety and Health Information Post Implementation of the Revised Hazard Communication Standard," bit.ly/hodson0319 (March 2019).

Journal of Environmental Management: "People, Planet, and Profit: Unintended Consequences of Legacy Building Materials," bit.ly/zimmer1217 (December 2017).

The Journal of Hazardous Materials: "Release of Particulate Matter from Nano-Enabled Building Materials (NEBMs) Across Their Lifecycle: Potential Occupational Health and Safety Implications," bit.ly/singh0122 (January 2022).

Journal of Occupational and Environmental Hygiene: "Exposure to Airborne Nano-Titanium Dioxide During Airless Spray Painting and Sanding," bit.ly/west021219 (February 2019).

Journal of Occupational and Environmental Hygiene: "Inhalation Exposure During Spray Application and Subsequent Sanding of a Wood Sealant Containing Zinc Oxide Nanoparticles," bit.ly/cooper062817 (June 2017).

Journal of Occupational and Environmental Hygiene: "Occupational Exposure Risk During Spraying of Biocidal Paint Containing Silver Nanoparticles," bit.ly/west051421 (May 2021).

Nano Safety Data Sheet Improvement Tool, nanosds.elcosh.org.

National Institute of Environmental Health Sciences: "Nanomaterials," bit.ly/niehs-nano.

NIOSH: "Current Intelligence Bulletin 63: Occupational Exposure to Titanium Dioxide," bit.ly/niosh0411 (April 2011).

NIOSH: "Current Intelligence Bulletin 65: Occupational Exposure to Carbon Nanotubes and Nanofibers," bit.ly/niosh0413 (April 2013).

NIOSH: "Health Effects of Occupational Exposure to Silver Nanomaterials," bit.ly/niosh0521 (May 2021).

NIOSH: "Nanotechnology," bit.ly/niosh-nano.

NIOSH: "Technical Report: Occupational Exposure Sampling for Engineered Nanomaterials," bit.ly/samplingnanos (July 2022).

Safe Work Australia: *An Evaluation of MSDS and Labels Associated With the Use of Engineered Nanomaterials*, bit.ly/safeworknano (PDF, June 2010).

Scandinavian Journal of Work, Environment, and Health: "Current State of Knowledge on the Health Effects of Engineered Nanomaterials in Workers: A Systematic Review of Human Studies and Epidemiological Investigations," bit.ly/schulte0519 (May 2019).

West, Gavin: "The Latest in Exposure Science and Hazard Communication for Engineered Nanomaterials in Construction," AIHce EXP (May 2023).

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Occupational and environmental health and safety (OEHS) professionals (also known as industrial hygienists) practice the science of anticipating, recognizing, evaluating, controlling, and confirming workplace conditions that may cause workers' injury or illness. Through a continuous improvement cycle of planning, doing, checking, and acting, OEHS professionals make sure workplaces are healthy and safe.

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