Drs. Viridiana Perez and Irene Andreu, who lead the team's research in nano-safety in the workplace, discuss their latest results with Prof. Byron Gates.

Cleaning up nanomaterials

By Gail Johnson

How do you clean what you can't see? New research, supported by a WorkSafeBC Innovation at Work grant, looks into the science of cleaning up nanomaterial spills that could potentially be invisible to the naked eye.

Nanotechnology is one of the fastest evolving fields of scientific discovery. Nanomaterials, sometimes referred to as nanoparticles (a subcategory defined by shape and dimensions), are materials and structures with dimensions between 1 nanometre (one billionth of a metre) and 100 nanometres in size.

The minuscule materials are found in everything from electronics to medicine and cosmetics. And they pose a vexing challenge in the workplace. Workers may come into contact with them regularly, and there are potential hazards associated with handling them. Not only that, but questions abound surrounding exposure limits and effective workplace processes and procedures.

That's where Dr. Byron Gates' research comes in. An associate professor of chemistry at Simon Fraser University, Gates specializes in all things nano.

A quick introduction to nanomaterials

To get a sense of just how minuscule they are, picture this: a single human hair is about 80,000 nanometres wide.

Nanomaterials are all around us in nature and have existed since the beginning of time: They can be found in a variety of things, from ocean spray, to volcanic ash, to fine sand, to dust.

Engineered nanomaterials are relative newcomers, and their uses cover everything from enhanced antimicrobial activity to efficient energy conversion. They're used in hospitals worldwide to enhance the contrast of MRI scans and exist in everyday products, such as some sunscreens and new televisions.

It's these engineered nanomaterials that have so many unknowns.

"Many nanoparticles of earth-abundant materials are readily present in our environment, but when you go into a laboratory and start synthesizing a form that is not natural, you're potentially exposing someone to relatively concentrated amounts and reactive forms of nanomaterials that could have biological implications," Gates says. "Workers might also be dealing with relatively large quantities of the material, and that translates into a higher probability for exposure.

"Nanomaterials can accumulate in our environment and in our bodies, and can adversely affect ecological and biological systems," he adds. "Why would you want that risk? That's the foundation of our work: We're ultimately trying to put in place science that helps to determine the potential for exposure to engineered nanomaterials in the workplace environment, and to create methods that minimize this exposure."

Nano safety in the workplace

With support from Research Services at WorkSafeBC, Gates's ongoing research aims to assess the potential for workers to be exposed to engineered nanomaterials in the workplace. He and his research team have so far identified several sectors where engineered nanomaterials exist, including construction, transportation, and utilities; manufacturing of, for example, some forms of antibacterial clothing, bathing suits, and wetsuits; wholesale and retail trade; health care; arts, food, and entertainment; agriculture and mining; and information technology, to name just a few.

The primary means of exposure are inhalation (via aerosols), penetration through the skin, and ingestion.

Nanomaterials can pass into the bloodstream and affect the body's organs and systems. They have the potential to lead to liver damage; autoimmune, neurological, and heart diseases; and other health problems.

"While precise toxicity levels are still being studied, there is evidence that these particles can cause worse health effects than those associated with the parent materials because of their size," says Geoffrey Clark, WorkSafeBC senior occupational hygienist.

"For example, exposure to silver can cause a variety of toxic effects," Clark says. "WorkSafeBC has an occupational exposure limit for silver and silver compounds, but the toxic effects of nano-silver may be even more severe, and the existing limits may not be good enough.

"These things are also going places in the body that the parent materials don't typically go," Clark adds, pointing to an animal study in which inhaled nano-titanium went into the lungs, as expected, but also travelled up nerve cells in the nose straight to the brain.

Another animal study found that certain types of fibrous carbon nanotubes can affect the lungs in a similar way to asbestos, leading to fibrosis, scarring, lung cancer, and the possibility of mesothelioma. "With these materials, we have to be even more careful," adds Clark.

Mark Teo, a WorkSafeBC occupational hygiene officer with a Ph.D. in chemistry and a sub-specialization in nanotechnology, agrees with Clark. In 2014, the International Agency for Research on Cancer classified a specific type of multi-walled carbon nanotube — MWCNT-7 — as possibly carcinogenic to humans.

With many nanotubes still unclassifiable with regard to carginogenity, Teo notes that "research on carbon nanotube toxicities is still ongoing, and much more research needs to be done."

Simple strategies for the safe use of nanomaterials

What makes handling and controlling nano-scale materials especially difficult is that in a number of situations, these materials aren't visible to the naked eye.

Gates's research focuses on the kinds you cannot see, which pose a significant issue when it comes to cleaning them up.

"If you walk into a laboratory to assess its cleanliness, you might be able to notice the presence of dirt or dust on the floor, but if you're talking about non-agglomerated or non-aggregated forms of nanomaterials, it is likely that you will not readily see them," Gates says. "So how do you know you're not exposed to these materials? Furthermore, how do you know how to effectively clean them up?"

Gates's research is applying science to those questions. Although further studies are needed regarding safe exposure limits to engineered nanomaterials, his team has devised ways of detecting engineered nanomaterials and methods to effectively clean them up.

Worker exposure can be controlled using many of the existing occupational hygiene risk assessment and exposure-control methods. For instance, local exhaust ventilation, HEPA filters, and fume hoods may be able to recapture certain types of nanomaterials.

The use of personal protective equipment is also vital. Gloves, safety goggles, respirators with HEPA filters, and full body coveralls may be needed, depending on the risk level of the activity.

A safe practice involves placing absorbent liners underneath work areas, replacing them regularly, and disposing of them in sealed waste containers.

"We're developing techniques that are aimed at being translatable to the broader community," Gates says. "We believe this research is applicable to workplaces around the world. Different employers will be able to implement a very simple set of procedures to test the workplace so workers can be confident it's clean and safe."

Teo, also a member of Gates's research steering committee, sees this research as having a significant impact on nanomaterial health and safety in the workplace.

"Professor Gates's research team is working hard in developing analytical methods that will help users to detect specific types of engineered nanomaterials on work surfaces. Whether you're an employer, a worker, a researcher, or a regulatory officer, Dr. Gates's work will interest you," says Teo.

Raising awareness

Gates's research laboratory at SFU and WorkSafeBC are both collaborating on soon-to-be-released guidelines for employers related to engineered nanomaterial safety.

Raising awareness of engineered nanomaterials, meanwhile, is essential.

"Education is one of the key things we're focused on," Gates says. "There are people using engineered nanomaterials who do not regard the chemical composition and reactivity of these materials, so they don't wear gloves or other necessary protective equipment when handling these materials. Workers still need to protect themselves when working with any form or composition of these materials."

With engineered nanomaterials only becoming more commonplace in our everyday lives, this kind of research will be increasingly necessary.

"Nanotechnology might sound futuristic, but it has already found its way into so many of the products we commonly use," says WorkSafeBC director of Policy, Regulation and Research, Lori Guiton. "Prevention of occupational injury and disease is a central part of our mandate, and the kind of work Dr. Gates is doing at SFU is so important, showing us how we can detect and mediate spills and ultimately safeguard the workplace."