599 North Avenue, Suite 8
Wakefield, MA 01880
Phone: 781-245-1400

NANOTECHNOLOGY & THE WORKPLACE: The Hazards Might Not Be So Small

"But I am not afraid to consider the final question as to whether, ultimately---in the great future---we can arrange the atoms the way we want; the very atoms, all the way down!"
–Richard Feynman, There's Plenty of Room at the Bottom

According to the renowned physicist Richard Feynman in a 1959 lecture, if one were able to manipulate matter on the atomic scale, then all of the information that humanity has accumulated since the beginning of recorded time could be recorded on a pamphlet that could fit in your pocket. [1]

As of 2009, scientists are doing just that.

But they're not writing down humanity's trove of information – they are manipulating individual atoms in order to create structures less than 100 nanometers in length. This science – called nanotechnology – has an enormous range of applications, from medicine to plastics to cosmetics. [2]

A nanometer (nm) is one millionth of a millimeter. To get an idea as to how small this is, consider the following:

- Ant = 5,000,000 nanometers long
- Pin head = 1,500,000 nanometers wide
- Blood cell = 7,500 nanometers in diameter
- DNA = 2.5 nanometers
- Human hair grows at a rate of one nanometer per second

Substances of this size (1-100 nm), called nanomaterials, are being used to create new products, devices, and manufacturing methods at an ever-increasing rate. According to *Approaches to Safe Nanotechnology*, published by the National Institute of Occupational Safety & Health (NIOSH), "new emerging technology applications will affect nearly every type of manufactured product through the middle of the next decade, becoming incorporated into 15% of global manufacturing output, totaling $2.6 trillion in 2014." [3]

Nanomaterials are used in materials science at an ever growing rate because they can make products stronger, lighter, more conductive, or heat-resistant. For instance, the carbon nanotube, a cylindrical structure made of carbon atoms, is about 100 times stronger than steel, while being about one sixth of the weight [4]. The bucky ball, a 60-atom spherical carbon structure, is able to contain other atoms within it, making it a possible solution for drug delivery in the body. Different colors of light can manipulate atoms on a computer chip in order to create circuitry at a scale never before dreamed of. Students at the Massachusetts Institute of Technology (MIT) have shown it is possible to build a battery on a virus framework. Two billion of these batteries could fit on the surface of a nickel.

Working with structures that are much, much smaller than a human blood cell can, as would be expected, present certain occupational risks. Materials that might not be harmful in larger particle form may become harmful at such small sizes. Concerns related to the health and safety ramifications of nanotechnology have prompted NIOSH to develop *Approaches to Safe Nanotechnology*, a publication that seeks to gather and present information from current research, to raise awareness of potential occupational health and safety risks, and to identify gaps in research data.

According to the publication, the main route of nanomaterials exposure is through inhalation. Studies have shown that, because of the size and chemical characteristics of the particles, they can pass from the lung into the bloodstream and translocate to other organs.

It has also been found that the toxicity of nanoparticles can be greater than the toxicity of larger particles with the same chemical makeup. One of the chief reasons for this is the fact that nanoparticles have relatively large surface area in relation to their mass. Other characteristics influencing toxicity are shape, solubility, and surface coatings.

In rats, mass doses of nanoparticles have led to pulmonary inflammation and tumors. In studies involving worker exposure to nanoscale particles, adverse lung effects were experienced, including lung function decrements and fibrotic or obstructive lung disease.

Nanoparticles may pose risks other than those resulting from inhalation. For instance, some particles may be able to be absorbed through the skin, or be ingested through the mouth. Further, the size of the combustible nanoparticles may increase the potential for fire and explosion hazards. Due to their structure and composition, nanoparticles may act as a catalyst in ways that would not necessarily be expected given their chemical makeup.

One of the many interesting things about these particles is that it may be the size, shape, and surface area of the material, and not so much the mass or chemical composition that determine their toxicity. Thus, exposure assessment and characterization is rather difficult and expensive.

NIOSH asserts that, given the fact that insufficient data exist in order to clearly ascertain health risks, it is necessary to take measures to prevent worker exposure. NIOSH recommends the development of a risk management program, which would include the following:

- Hazard evaluation based on available chemical, physical, and toxicological data
- Assessing potential for worker exposure
- Education and training of workers
- Developing standards for the evaluation of control methods
- Determining the need for respirators and other personal protective equipment
- Evaluating exposure according to a systematic plan

Like asbestos, the health effects of these particles may not be immediately experienced, but may develop over time as the particles deposit in the body. This makes it all the more important to be conservative when developing a risk management program for workers dealing with such materials, as the hazard may not be immediately noticeable.

As humans continue to develop ways of manipulating matter on a smaller and smaller scale, more research will need to be performed in order to ascertain the potential health effects of

resultant materials. While encouraging development in fields such as medicine, materials science, computing, and the like, we must make sure that these advances do not come at the cost of health and well-being. This is why Cashins & Associates will always be aware of current and upcoming trends in industrial settings. It is in this way that we may facilitate the implementation and growth of these technologies through the development of plans to protect human health.

References

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