Indian scholar offers global perspective on fiber nanotoxicology

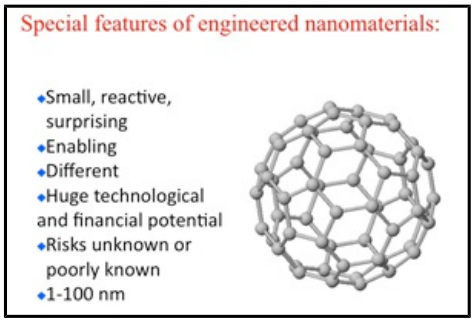
By Aleksandra Adomas

Qamar Rahman, Ph.D., dean of Research Science and Technology at Amity University in India, visited NIEHS July 19 to deliver an eye-opening talk on nanotoxicology, exploring the question, "Are carbon nanotubes really following the footprints of asbestos fibers?" Hosted by NIEHS and NTP Director Linda Birnbaum, Ph.D., Rahman's presentation outlined her concerns about the public health impact of the dramatic growth in the production and use of carbon nanofibers in a wide range of consumer products, as well as the absence of effective regulatory oversight.

For almost 40 years, Rahman has been actively engaged in chemical and biological research on the health effects of occupational and environmental exposure to asbestos and asbestos-like fibers. In September 2009, she became the first Indian scientist ever awarded an honorary doctorate from University of Rostock in Germany. (Photo courtesy of John Maruca)

As the title of her talk suggests, Rahman and other researchers are increasingly worried that the morphological and adsorptive characteristics of carbon nanofibers, which are strikingly similar to asbestos, may mean they could pose a similar threat to human health. Even though the adverse effects of asbestos exposure are known, the mineral is still widely used in India, where regulation is minimal and the incidence of asbestos-related disease is on the rise.

Rahman is a strong advocate for the development of a systematic approach to nanotoxicology, and has made it her aim to unify physical, biological, and toxicological approaches with computational modeling, to better understand the impact of nanoparticles on human health.



CNTs differ in length, shape, dimension, physical characteristics, surface modifications, purity, and formation of agglomerates and aggregates. Single-walled CNTs consist of a single rolled graphene sheet and have a typical diameter of approximately 1-5 nanometers, while the length may be up to tens of micrometers. Multiwalled CNTs consist of many single-walled tubes, stacked one inside the other, with diameters in the range of 5-100 nanometers and length reaching several micrometers. They all offer huge technological potential because of their exceptional strength, but carry a poorly understood risk to human health. (Photo courtesy of Qamar Rahman)

Fiber toxicology

Carbon nanotubes (CNTs) are nanoscale cylinders made from rolled layers of graphene. Due to their exceptional mechanical, electrical, chemical, thermal, and optical properties, CNTs are used in a variety of applications. These range from structural mechanics, electronics, and clothing, to medical uses, such as the creation of artificial muscles and scaffolding for improved healing of broken bones, even in the spine. However, as Rahman pointed out, despite its benefit in terms of new and improved products, the new technology might pose a risk to human health.

According to Rahman, because CNTs are thin, long, and biopersistent, they might behave like asbestos fibers. Asbestos becomes a health concern when fibers are inhaled over a long time, leading to asbestosis, a progressive lung fibrosis, or malignant mesothelioma, a rare form of cancer, which normally takes decades to fully develop. Rahman said she is alarmed by the way asbestos exposure can act synergistically with other exposures, such as indoor air pollution, to trigger disease much more quickly.

"In unorganized sectors [in India], women using unprocessed cooking fuel develop asbestosis within five years," Rahman said. She explained that this accelerated disease progression seems to be due to the ability of asbestos to adsorb other

harmful chemicals and facilitate their delivery deep into the respiratory system.

Technology comes first

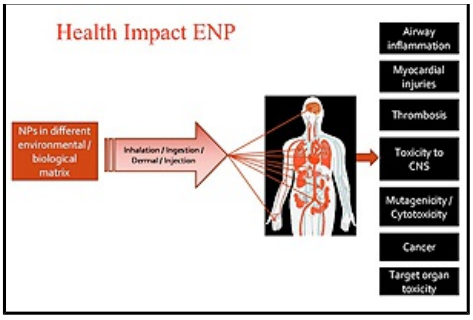
Not much is known about the potentially adverse effects of occupational exposure to CNTs. "There are no effects reported in exposed workers [so far]," Rahman said. Animal studies have found pulmonary effects, inflammatory response, oxidative stress, and granuloma development among potential consequences of CNT exposure. But Rahman emphasized that it is not clear if fiber uptake is necessary, or if interaction with cell surface is sufficient.

Long CNT fibers have been shown to cause an asbestos-like inflammatory reaction in the pleural cavity of exposed animals, while other studies of animals exposed to short CNT fibers have found no carcinogenic response to exposure. Rahman said both carbon and asbestos fibers can lead to DNA damage, cytotoxicity, and inflammation, and they appear to regulate expression of similar genes.

Nanotoxicology development is hampered by an absence of well-defined modes of action. Proposed possible mechanisms include chromosome tangling through DNA damage, oxidative stress activating signaling cascades, chronic inflammation, and adsorption of other carcinogens on CNT fibers, but nanomaterials are difficult to characterize due to differences in manufacturing and composition. "No [two] nanoparticles are the same," Rahman explained. "They have different dimensions and can be chemically modified in different ways."

Because of limited data and lack of biomarkers for CNT exposure, it is difficult to reach regulatory decisions. For example, there are no safety programs in India, even though nanomaterials are used and produced. As Rahman described the regulatory situation there, "Technology is first - toxicology comes later."

(Aleksandra Adomas, Ph.D., is a research fellow in the NIEHS Laboratory of Molecular Carcinogenesis.)



As Rahman explained, engineered nanoparticles can enter the human body through different entry points - skin, blood, respiratory, and digestive track pathways - and may result in a range of adverse biological effects. (Photo courtesy of Qamar Rahman)

Birnbaum, right, joined Rahman during the question and answer session. Like her host, Rahman is concerned about the introduction of untested chemicals and materials that might trigger diseases, such as asbestosis, that take years or even decades to manifest. (Photo courtesy of John Maruca)

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