# Coating carbon nanotubes reduces lung injury risk

*By Ernie Hood*

Experimental evidence from researchers around the world has shown that inhalation exposure to carbon nanotubes, which are one of the most commonly engineered nanomaterials, can cause chronic lung disease in animals that is similar to the fibrotic damage found in asbestos exposure. A series of collaborative experiments by NIEHS grantee James Bonner, Ph.D. *(http://bonnerlab.wordpress.ncsu.edu/)* , and co-lead researcher Gregory Parsons, Ph.D., both of North Carolina State University, and the NIEHS Clinical Research Unit *(http://www.niehs.nih.gov/research/clinical/join/durham/index.cfm)* , has shown that coating multiwalled carbon nanotubes with thin layers of aluminum oxide, via a process called atomic layer deposition, reduces lung injury in both animal and cellular models.

*Bonner, a longtime NIEHS grantee and collaborator, studies potential human health risks of emerging nanotechnologies, to support safe design. (Photo courtesy of Anna Bonner)*

The collaborative study was a transdisciplinary effort that combined expertise in nanotoxicology by Bonner's team, nanoscale engineering by the Parsons Laboratory, and a human translational component provided by the NIEHS Clinical Research Unit.

Multiwalled carbon nanotubes are fiber-like, engineered graphene nanomaterials with a wide range of applications in engineering, electronics, and medicine. Human exposure to the nanotubes is inevitable because of their increasing production and use in a variety of consumer products. Recent studies shed light on potential risks to human health from exposures and support the safe design of materials that contain carbon nanotubes.

## Coating works

In a paper *(http://www.ncbi.nlm.nih.gov/pubmed/25216247)* published Sept. 12 in the journal PLOS ONE, researchers studied aluminum oxide coating via atomic layer deposition to determine whether it would alter the expression of pro-inflammatory and pro-fibrogenic cytokines, and whether the coating would alter the pro-fibrogenic potential in the lungs of mice, in response to exposure. Both *in vitro* and *in vivo* results showed that the coating significantly reduced lung fibrosis both in the cell and animal models, compared to uncoated nanotubes.

*Garantziotis and Bonner have collaborated for several years on research exploring the health and safety risks associated with emerging nanoparticle technology. (Photo courtesy of Steve McCaw)*

Asked whether it was likely that the study's findings would change manufacturing practices, Bonner explained that initial production probably would not be affected, but the results should provide some insight as to how post-manufacturing modifications, referred to as functionalization, change the potential of nanotubes to cause disease.

"The specific type of functionalization will more likely be driven by how well it improves the utility of the carbon nanotube for a specific product," he said. "The challenge for toxicologists will be to test the potential adverse human health effects of an increasing number and variety of functionalized engineered nanomaterials."

## Breaking up helps

The study also showed that nanotube length is likely to be an important determinant of the inflammatory and fibrogenic effects of multiwalled carbon nanotubes in the animal lung. It is difficult for mammalian lungs to clear long fibers, such as asbestos, making them more

persistent and more likely to cause fibrosis. Fortunately, coated nanotubes tend to break up in the lungs, and the resulting shorter fibers are likely to be cleared more rapidly than uncoated or thinly coated particles.

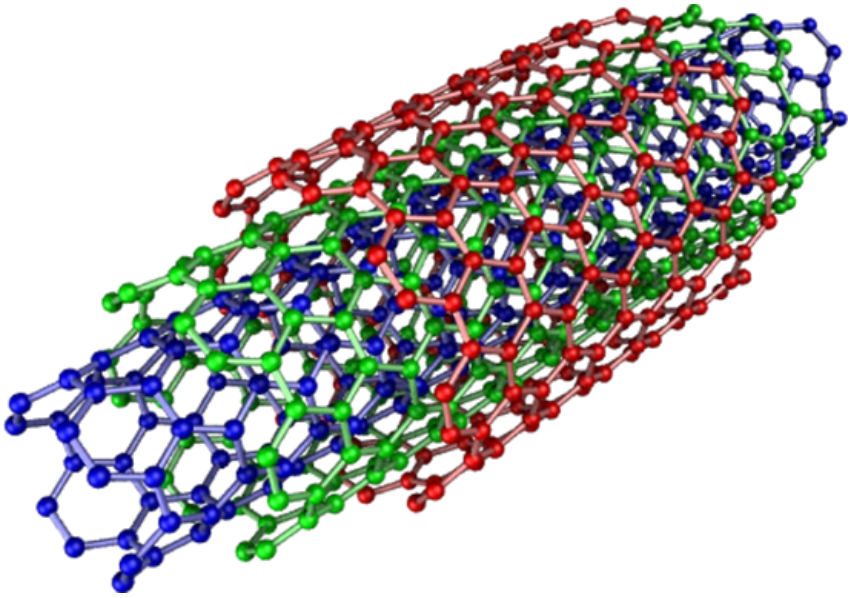
The NIEHS Clinical Research Unit collected the primary human monocytes used in the study from healthy adult volunteers, under a protocol approved by the NIEHS Institutional Review Board. “We were pleased to have an opportunity to collaborate directly with Dr. Bonner’s group in this and the other studies we are jointly conducting,” said Stavros Garantziotis, M.D., medical director of the Clinical Research Unit and acting clinical director.

"Dr. Garantziotis and Dr. Salik Hussain were instrumental in providing an important clinical translational component to the study by establishing that blood monocytes (white blood cells) from normal human donors had very similar responses compared to our immortalized human monocyte cell lines, when exposed to the carbon nanotubes modified by atomic layer deposition," Bonner said.

(Ernie Hood is a contract writer with the NIEHS Office of Communications and Public Liaison.)

*Citation*: Taylor AJ, McClure CD, Shipkowski KA, Thompson EA, Hussain S, Garantziotis S, Parsons GN, Bonner JC.
*(http://www.ncbi.nlm.nih.gov/pubmed/25216247)*
2014. Atomic layer deposition coating of carbon nanotubes with aluminum oxide alters pro-fibrogenic cytokine expression by human mononuclear phagocytes *in vitro* and reduces lung fibrosis in mice *in vivo*. PLoS One 9(9):e106870.


*The Society of Toxicology recently named Salik Hussain, D.V.M., Ph.D., Outstanding Postdoctoral Fellow, Nanotoxicology Specialty Section. He is a visiting fellow with the NIEHS Office of Clinical Research and co-author of the study. (Photo courtesy of Steve McCaw)*



*Multiwalled carbon nanotubes are made of concentric layers of graphene rolled into a tubular shape and are currently used in conductive polymers and sporting goods. They show promise for applications in textiles and fibers, advanced ceramics, and medical implants. (Image by Eric Wieser (Own work) [ CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0) ], via Wikimedia Commons (http://commons.wikimedia.org/wiki/File%3AMulti-walled_Carbon_Nanotube.png) )*

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