# Nano World: Making safer carbon nanotubes

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Carbon nanotubes can get modified to help them pass apparently safely through bloodstreams, potentially easing past concerns about nanotube toxicity, experts told UPI's Nano World.

"Our studies indicate that provided those structures are properly modified to be made biocompatible, toxicity levels should be tolerable. This automatically opens up the door for the development of carbon nanostructure-based pharmaceuticals," said researcher Kostas Kostarelos, a pharmaceutical nanotechnology expert at the University of London's School of Pharmacy.

While carbon nanotubes have attracted much attention for their potential applications in electronics and advanced high-strength composite materials, scientists are also developing carbon nanotubes for use in medical therapies. For instance, Kostarelos and his colleagues in France and Italy discovered carbon nanotubes could transfer DNA into cells. They also have modified nanotubes "with anticancer drugs like methotrexate," Kostarelos said.

However, prior experiments raised fears that carbon nanotubes could be toxic. For example, when inhaled nanotubes can accumulate in the lungs, causing inflammation. Kostarelos and his colleagues noted all these studies involved pristine nanotubes, which "are not water soluble, therefore not compatible with any type of biological fluid or tissue," he said. Instead, the researchers developed carbon nanotubes with chemically modified surfaces that make them soluble in water.

In addition, the researchers noted that no past experiments studied what effects carbon nanotubes had when intravenously administered, which could prove useful if these nanotubes are to find use as implantable or injectable diagnostics and therapeutics. They injected mice with their coated nanotubes, which they also tagged with the radioactive isotope indium-111 to help track nanotubes as they circulated in the blood throughout the body.

Radioactivity tracing revealed that while the modified single-walled nanotubes were detected in organs soon after injection, virtually all were eliminated and excreted in the urine within three hours. Experiments with similarly altered multi-walled carbon nanotubes found they got excreted in the urine as well. Kostarelos and his colleagues reported their findings online Tuesday in the Proceedings of the National Academy of Sciences.

"For the first time the authors have shown that if the nanotubes are properly chemically functionalized, they are not retained by the body but are easily removed via the circulatory system," said materials scientist Pulickel Ajayan of Rensselaer Polytechnic Institute in Troy, N.Y. "People who have been looking at medical applications of nanotube constructs, for example drug delivery, can have a first sigh of relief.

"Of course more work needs to be done to prove specific interactions of nanotubes with cells, but the recent contention that nanotubes may be lodged in organs to cause harm, is dispensed with the present study," Ajayan said.

Future research could investigate the bodily mechanism through which nanotubes were cleared from the blood, results of which could help "prolong the blood circulation of carbon nanotubes in order to give them enough time before excretion to get to a target tissue," Kostarelos said.

Competing delivery systems for molecules into the body do exist, such as polymer nanoparticles or capsules known as liposomes, which are essentially made of artificial cell membranes. One advantage carbon nanotubes have over these competitors "is one can really engineer carbon nanotubes and nanoparticles very precisely, almost atom by atom, all essentially identical, which is much more difficult with liposomes or polymer systems. If it turns out the size of these nanoparticles is very important for delivery to the active site or clearance from the body or safety, this ability to engineer them very precisely would be pretty important," said Mark Saltzman, chair of Yale University's biomedical engineering department.

Saltzman cautioned polymer nanoparticle and liposome toxicity remain far better understood than carbon nanotube toxicity. "To use carbon-based systems in clinical applications, we still need a lot to learn about their toxicology," he said. They could "require more tests than the conventional toxicology tests used now, and that may take some time to figure out."