News

Research Highlights

Experts state safety concerns regarding carbon nanotubes have been allayed by chemistry

Apprehension regarding the safety of carbon nanotubes – due to the similarity of their structure to asbestos – has been allayed through research showing that toxic properties are removed when the length of the nanotube is reduced.

> *"What we show for the first time is that in order to design risk-free carbon nanotubes both chemical treatment and shortening are needed."*

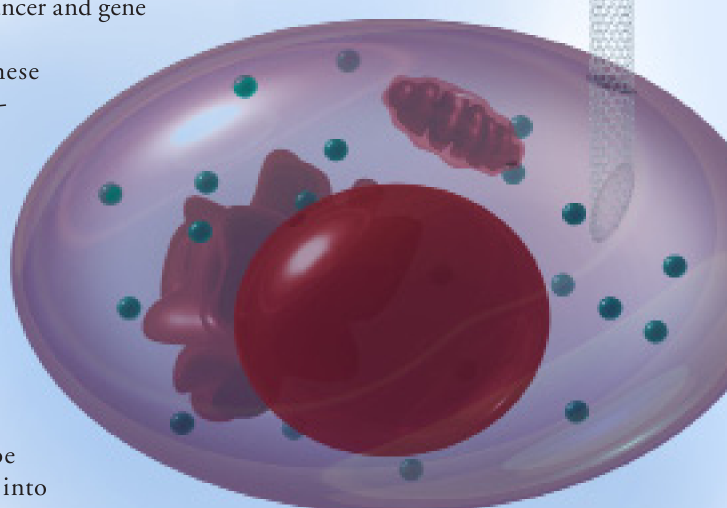
Carbon nanotubes, first described atomically in the 1990s, consist of sheets of carbon atoms that are rolled into hollow tubes measuring several nanometers in diameter. Engineered carbon nanotubes can be modified chemically through the addition of nucleic acids, chemotherapeutic drugs or fluorescent tags. Carbon nanotubes have possible applications in the fields of cancer and gene therapies.

In addition to these applications, chemically modified carbon nanotubes are able to pierce cell mem-branes. This property allows them to behave like a nanoneedle; giving rise to the notion that diagnostic and therapeutic agents can be delivered efficiently into the cytoplasm of cells.

However, there have been concerns regarding the safety profile of nanotubes. A serious concern surrounded the carcinogenic risk from the exposure of the fibers in the body was highlighted in 2008. Several studies have been carried out that appear to demonstrate that when untreated, long nanotubes are injected into the ab-dominal cavity of mice, the responses stimulated are similar to those associated with exposure to particular asbestos fibers.

A new study published in *Angewandte Chemie* demonstrates that long, pristine nanotubes that possess similar reactivity and pathogenicity properties to asbestos had these characteristics completely removed when the nanotube surface was modified and the length reduced. This was achieved through chemical treatment.

Kostas Kostarelos, Senior Editor of *Nanomedicine* (University College London, School of Pharmacy, London, UK), led the research. His



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collaborators included Alberto Bianco (Le Centre National de la Recherche Scientific, Strasbourg, France) and Maurizio Prato (University of Trieste, Trieste, Italy). The authors demonstrate in their paper, two reactions that question if any type of chemical modification will lead to the nanotubes becoming nontoxic. The paper concludes that only those reactions that leave the nanotubes stable in biological fluids without aggregating and shorter in length will result in risk-free material.

Kostarelos commented on why the findings had such importance, "The apparent structural similarity between carbon nanotubes and asbestos fibers has generated serious concerns about their safety profile and has resulted in many unreasonable proposals of a halt in the use of these materials, even in well-controlled and strictly regulated applications, such as biomedical ones. What we show for the first time is that in order to design risk-free carbon nanotubes both chemical treatment and shortening are needed."

– Written by Priti Nagda

Sources: Ali-Boucetta A, Nunes A, Sainz R et al. *Asbestos-like pathogenicity of long carbon nanotubes alleviated by chemical functionalization.* Angew. Chem. Int. Ed. *Engl. 52(8), 2274–2278 (2013); University College London News. Chemistry resolves toxic concerns about carbon nanotubes: www.ucl.ac.uk/news/news-articles/0113/130115-chemistry-resolves-toxic-concerns-about-carbon-nanotubes*

New nanoscale engineering may allow improved drug delivery techniques

A research team from North Carolina (NC) State University (NC, USA) has recently described their work looking into embedding carbon nanofiber needle-like structures into an elastic membrane. The researchers hope that their work, published in the journal *ACS Applied Materials & Interfaces*, can provide a new direction for drug delivery technology research. The development of nanostructures has allowed exciting new developments in drug delivery, with carbon nanotubes being able to function as tiny needles to deliver therapeutic agents in a highly targeted and localized manner.

The NC State University team has been able to embed nanofiber needles into their elastic membrane, generating a flexible 'bed of nails.' One application of this technology would be to create tiny balloons covered in nanoneedles that are coated in a relevant drug. The balloon could be moved to the target area and then inflated, embedding the needles in the surrounding tissue and delivering the drug. The balloon could then be deflated and withdrawn. However, the process of constructing a flexible surface that the needles could be attached to has proved challenging. In order to attach the nanofiber needles to the flexible polymer, the needles were initially grown on aluminum; the needles and aluminum were then spin-coated with the polymer in a liquid form, coating the needles and the base plate. The polymer was solidified into the final elastic membrane. In order to remove the completed structure, the aluminum was dissolved, leaving the flexible needle array.

"The development of nanostructures has allowed exciting new developments in drug delivery, with carbon nanotubes being able to function as tiny needles to deliver therapeutic agents in a highly targeted and localized manner."

The NC state team was able to observe the complete structure using a scanning electron microscope, energy-dispersive x-ray imaging and fluorescence microscopy. To ensure that their new structure was suitable for its intended function, the team succeeded in impalefecting human brain microcapillary endothelial cells using the technique.

Commenting on their success and on the potential future applicability of the technique, one of the manuscript's authors, Anatoli Melechko, an associate professor of materials science and engineering at NC State University, said, "This technique is relatively easy and inexpensive … so we are hoping this development will facilitate new research on targeted drug delivery methods."

– Written by Sean Fitzpatrick

Sources: Pearce RC, Railsback JG, Anderson BD et al. *Transfer of vertically aligned carbon nanofibers to polydimethylsiloxane (PDMS) while maintaining their alignment and impalefection functionality.* ACS Appl. Mater. Interfaces *5(3), 878–882 (2013); North Carolina State University news. Researchers create flexible, nanoscale 'bed of nails' for possible drug delivery: http://news.ncsu.edu/releases/wms-melechko-impale/*