Method sorts out double-walled carbon nanotube problem

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It's hard to study something with any rigor if the subject can't be produced uniformly and efficiently. Researchers who study double-walled carbon nanotubes -- nanomaterials with promising technological applications -- find themselves in just this predicament.

The problem is that current techniques for synthesizing double-walled carbon nanotubes also produce unwanted single- and multi-walled nanotubes. These two forms each have interesting properties, but an intriguing blend of those properties is found in double-walled nanotubes, attracting the attention of an increasing number of researchers. (A double-walled nanotube is made up of two concentric single-walled nanotubes.)

Perhaps most significantly, double-walled nanotubes provide distinct advantages when used in transparent conductors, materials that are important components of solar cells and flat-panel displays because they are optically transparent and electrically conductive. As the demand for energy-efficient devices and alternative energy sources rises worldwide so does the demand for transparent conductive films.

Two Northwestern University researchers now offer a clever solution to the double-walled nanotube production problem. They used a technique developed at Northwestern called density gradient ultracentrifugation to cleanly and easily separate the double-walled nanotubes (DWNTs) from the single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs).

The sorting method works by exploiting subtle differences in the buoyant densities of the nanotubes as a function of their size and electronic behavior. The results will be published online Sunday, Dec. 14, by the journal *Nature Nanotechnology*. The paper also will appear as the cover story in the January 2009 issue of the journal.

"Nanomaterials possess the unique attribute that their properties depend on physical dimensions such as diameter," said Mark C. Hersam, professor of materials science and engineering in Northwestern's McCormick School of Engineering and Applied Science, professor of chemistry in the Weinberg College of Arts and Sciences and the paper's senior author.

"This size dependence implies, however, that the physical dimensions must be exquisitely controlled in order to realize uniform and reproducible performance in devices. Our study directly addresses this issue for double-walled carbon nanotubes, an emerging nanomaterial with applications in information technology, biotechnology and alternative energy," said Hersam.

He collaborated with Alexander A. Green, a graduate student in materials science and engineering at Northwestern and lead author of the paper, titled "Processing and Properties of Highly Enriched Double-Walled Carbon Nanotubes."

Using the Northwestern method, carbon nanotubes first are encapsulated in water by soap-like molecules called surfactants. The surfactant-coated nanotubes then are sorted in density gradients that are spun at tens of thousands of rotations per minute in an ultracentrifuge. Each nanotube's diameter and electronic structure help determine the nanotube's buoyant density, which enables the method to separate DWNTs from the SWNTs and MWNTs.

The double-walled nanotubes, the researchers discovered, were approximately 44 percent longer than the single-walled nanotubes. This longer length of the DWNTs results in a factor of 2.4 improvement in the electrical conductivity of transparent conductors.

Double-walled nanotubes also enable improved spatial resolution and longer scanning lifetimes as tips for atomic force microscopes and are useful in field-effect transistors, biosensing and drug delivery.

Source: Northwestern University

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