Engineers develop rapid, uniform dispersion method for carbon nanotubes in solutions and solids

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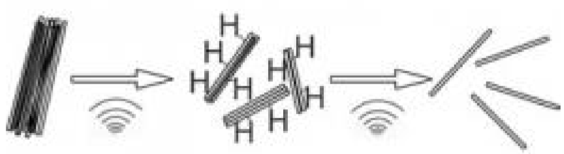

(PhysOrg.com) -- Harnessing the power of carbon nanotubes could get considerably easier, thanks to an advance by engineers from the University of South Carolina and the University of Georgia.

A team led by Xiaodong Li, a professor in the College of Engineering and Computing at USC, reported a breakthrough in the handling of nanotubes in the Feb. 14 issue of Advanced Materials. They combined two methods, hydrogen passivation and ultrasonication, to generate remarkably uniform dispersions of multi-walled carbon nanotubes.

"In applications such as lightweight and energy-efficient composites, electronic and optoelectronic devices, energy harvesting, energy conversion, and energy storage systems, carbon nanotubes have demonstrated superior performance," said Li, "but unfortunately dispersing them was always a major barrier in applications. This new technique is low cost, easy to use, and environmentally friendly--it should be quickly adapted in a wide range of areas."

Carbon nanotubes have many desirable properties, ranging from outstanding mechanical strength to unusual electrical behavior. By incorporating them into materials, even in small 'doses,' researchers can dramatically improve a material's utility.

But working with carbon nanotubes, which are strongly hydrophobic, can be difficult. In many solvents and polymers, their insolubility and tendency to clump together is a major obstacle to getting uniform coatings on surfaces or distributions within solids or gels.

Ultrasonication has long been used to try to disperse carbon nanotubes in solvents, but its success is slow, middling, and all too often reversed when the sonication stops.

Li's team combined ultrasonication with a simultaneous flow of hydrogen gas, producing fully dispersed multi-walled carbon nanotubes in ethanol in just 2 hours. The uniform dispersion, which is evident even to the naked eye, was characterized by scanning and transmission electron microscopy.

They then fabricated a nanotube-epoxy composite with the method and examined its mechanical properties. The elastic modulus of the nanocomposite (with 1% nanotube by weight) prepared with hydrogen passivation increased nearly 100% compared to that of the pure epoxy, whereas in the absence of hydrogen passivation an increase of less than 40% was earlier reported.

The engineers reason that energy from ultrasonication drives the breaking of C-C bonds in the nanotubes, which then react with the hydrogen to create C-H bonds. X-ray photoelectron spectroscopy confirms the addition of C-H bonds.

This kind of modification is particularly useful, added Li, because the absorbed hydrogen is readily removed from the multi-walled carbon nanotubes by heating. "The conventional techniques--fluorine, alkane, or ionic modification, for example--introduce impurities into matrix materials," he said.

More information: onlinelibrary.wiley.com/doi/10 … a.201104337/abstract

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