Seeking the Next Kevlar: Researchers Fine Tune Nanotube/Nylon Composite Using Carbon Spacers

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A team of University of Pennsylvania and Rice University researchers have added a significant new step to the creation of materials fortified by single-walled carbon nanotubes, or SWNTs, resulting in a nylon polymer composite with greater strength and toughness and opening the door for researchers to broadly improve the mechanical properties of such composites at the molecular level.

Starting with a method patented by engineers from Penn called interfacial polymerization, which evenly disperses carbon nanotubes throughout nylon, researchers have now fine tuned the composite material on a molecular level by introducing alkyl segments, or "carbon spacers."

The carbon spacers act as linking segments, covalently bonding the nanotubes and nylon chains, improving both the toughness of the material and the strength. Previous attempts to create a carbon nanotube/nylon composite had resulted in a brittle material, a problem solved by the addition of these carbon spacers.

The resulting nanocomposites with the covalent bond exhibit as much as 160 percent higher modulus, 160 percent higher strength and 140 percent higher toughness.

"Nanotechnology is providing new composite materials with tunable mechanical properties," said Karen I. Winey, professor of materials science and engineering and also chemical and biomolecular engineering at Penn. "By adding covalently bonded carbon spacers to the filler-matrix interface in these composite, we have significantly improved their mechanical properties and perhaps demonstrated a broadly applicable approach to nanocomposite design."

The results, which could give scientists a new tool to customize nano-tube-laced materials to meet their particular needs, are reported by Winey and her colleagues online this week in the journal *Nano Letters*.

"Nanocomposites are likely to be more efficient methods for improving the mechanical, thermal and electrical properties of polymer than starting from scratch and synthesizing completely new ones," Winey said.

SWNTs are tubular-shaped molecules of carbon no wider than several nanometers. One nanometer is approximately 10 atoms in width; for comparison a single human hair is nearly 90,000 nanometers in diameter. Yet they are strong, light and show promise for advanced applications due to their mechanical, electrical and thermal properties. Nanotube-based composites have the potential to revolutionize fabrics, structural materials for aerospace, electrical and thermal conductors for energy applications, nano-biotechnology and other disciplines.

The study was conducted by Winey, as well as Mohammad Moniruzzaman of Penn's Department of Materials Science and Engineering and Jayanta Chattopadhyay and W. Edward Billups of the Department of Chemistry at Rice University.

Source: University of Pennsylvania