Scientists discovering new uses for tiny carbon nanotubes

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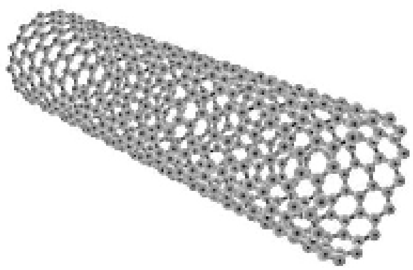

Nanotubes are stronger than steel and smaller than any element of silicon-based electronics. They can potentially process information faster while using less energy. The challenge has been figuring out how to incorporate these properties into useful electronic devices. Now scientists at the University of California, Riverside have discovered that by adding ionic liquid—a kind of liquid salt—they can modify the optical transparency of single-walled carbon nanotube films in a controlled pattern.

The atom-sized world of carbon nanotubes holds great promise for a future demanding smaller and faster electronic components. Nanotubes are stronger than steel and smaller than any element of silicon-based electronics—the ubiquitous component of today's electrical devices

—and have better conductivity, which means they can potentially process information faster while using less energy.

The challenge has been figuring out how to incorporate all those great properties into useful electronic devices. A new discovery by four scientists at the University of California, Riverside has brought us closer to the goal. They discovered that by adding ionic liquid—a kind of liquid salt—they can modify the optical transparency of single-walled carbon nanotube films in a controlled pattern.

"It was a discovery, not something we were looking for," said Robert Haddon, director of UC Riverside's Center for Nanoscale Science and Engineering. Scientists Feihu Wang, Mikhail Itkis and Elena Bekyarova were looking at ways to improve the electrical behavior of carbon nanotubes, and as part of their research they also looked at whether they could modulate the transparency of the films. An article about their findings was published online in April in *Nature Photonics*.

The scientists spent some time trying to affect the optical properties of carbon nanotube films with an electric field, with little success, said Itkis, a research scientist at the Center for Nanoscale Science and Engineering. "But when we applied a thin layer of an ionic liquid on top of the nanotube film we noticed that the change of transparency is amplified 100 times and that the change in transparency occurs in the vicinity of one of the electrodes, so we started studying what causes these drastic changes and how to create transparency in controlled patterns."

An ionic liquid contains negative and positive ions which can interact with the nanotubes, dramatically influencing their ability to store an electrical charge. That increases or decreases their transparency, similar to the way that glasses darken in sunlight. By learning how to manipulate the transparency, scientists may be able to start incorporating nanotube films into products that now rely on slower or heavier components, such as metal oxide.

For instance, using nanotube films meshed with a film of ionic liquid, scientists could create more cost effective Smart Windows, that darken when it's hot outside and become lighter when it's cold.

"Smart Windows are a new industry that has been shown to save 50 percent of your energy costs," said Itkis. "On a very hot day you can shade your window just by turning a switch, so you don't have to use as much air conditioning. And on a winter day, you can make a window more transparent to let in more light."

The scientists still need to study the economic viability of using nanotube film, but Bekyarova said one possible advantage would be that carbon nanotubes are ultra thin—about 1,000 times smaller than a single strand of hair—so you would need very little to cover a large area, such as the windows of a large building.

Itkis said nanotube films also hold great promise in building lighter and more compact analytical instruments such as spectrometers, which are used to analyze the properties of light.

In this application, a nanotube film with an array of electrodes can be used as an electrically configurable diffraction grating for an infrared spectrometer, allowing the wavelength of light to be scanned without moving parts.

Furthermore, by using addressable electrodes, the spatial pattern of the induced transparency in the nanotube film can be modified in a controlled way and used as an electrically configurable optical media for storage and transfer of information via patterns of light.

Carbon nanotubes have great potential, but there is still plenty of work to be done to make them useful in electronics and optoelectronics, Haddon said.

"The challenge is to harness their outstanding properties," he said. "They won't be available at Home Depot next week, but there is continuing progress in the field."

Provided by University of California - Riverside