Light touch brightens nanotubes (w/ Video)

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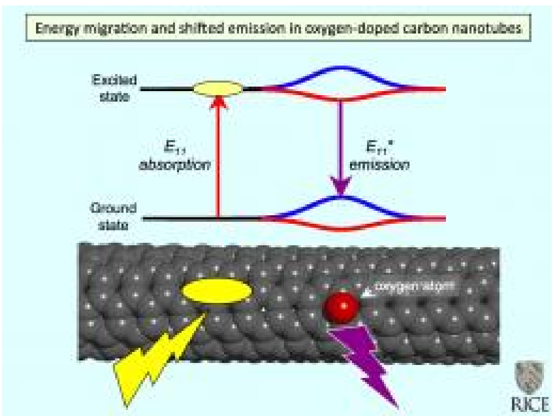

Single-walled carbon nanotubes treated with ozone incorporate oxygen atoms that shift and intensify the nanotubes' near-infrared fluorescence emission. The discovery by Rice University scientists should lead to new uses of nanotubes in biomedicine and materials science. (Credit: Bruce Weisman/Rice University)

(PhysOrg.com) -- Rice University researchers have discovered a simple way to make carbon nanotubes shine brighter.

The Rice lab of researcher Bruce Weisman, a pioneer in nanotube spectroscopy, found that adding tiny amounts of ozone to batches of single-walled carbon nanotubes and exposing them to light decorates all the nanotubes with oxygen atoms and systematically changes their near-infrared fluorescence.

Chemical reactions on nanotube surfaces generally kill their limited natural fluorescence, Weisman said. But the new process actually enhances the intensity and shifts the wavelength.

He expects the breakthrough, reported online in the journal *Science*, to expand opportunities for biological and material uses of nanotubes, from the ability to track them in single cells to novel lasers.

Best of all, the process of making these bright nanotubes is incredibly easy -- "simple enough for a physical chemist to do," said Weisman, a physical chemist himself.

He and primary author Saunab Ghosh, a graduate student in his lab, discovered that a light touch was key. "We're not the first people to study the effects of ozone reacting with nanotubes," Weisman said. "That's been done for a number of years.

"But all the prior researchers used a heavy hand, with a lot of ozone exposure. When you do that, you destroy the favorable optical characteristics of the nanotube. It basically turns off the fluorescence. In our work we only add about one oxygen atom for 2,000-3,000 carbon atoms, a very tiny fraction."

Ghosh and Weisman started with a suspension of nanotubes in water and added small amounts of gaseous or dissolved ozone. Then they exposed the sample to light. Even light from a plain desk lamp would do, they reported.

Most sections of the doped nanotubes remain pristine and absorb infrared light normally, forming excitons, quasiparticles that tend to hop back and forth along the tube -- until they encounter oxygen.

"An exciton can explore tens of thousands of carbon atoms during its lifetime," Weisman said. "The idea is that it can hop around enough to find one of these doping sites, and when it does, it tends to stay there, because it's energetically stable. It becomes trapped and emits light at a longer (red-shifted) wavelength.

"Essentially, most of the nanotube is turning into an antenna that absorbs light energy and funnels it to the doping site. We can make nanotubes in which 80 to 90 percent of the emission comes from doped sites," he said.

Lab tests found the doped nanotubes' fluorescent properties to be stable for months.

Weisman said treated nanotubes could be detected without using visible light. "Why does that matter? In biological detection, any time you excite at visible wavelengths, there's a little bit of background emission from the cells and from the tissues. By exciting instead in the infrared, we get rid of that problem," he said.

The researchers tested their ability to view doped nanotubes in a biological environment by adding them to cultures of human uterine adenocarcinoma cells. Later, images of the cells excited in the near-infrared showed single nanotubes shining brightly, whereas the same sample excited with visible light displayed a background haze that made the tubes much more difficult to spot.

His lab is refining the process of doping nanotubes, and Weisman has no doubt about their research potential. "There are many interesting scientific avenues to pursue," he said. "And if you want to see a single tube inside a cell, this is the best way to do it. The doped tubes can also be used for biodistribution studies.

"The nice thing is, this isn't an expensive or elaborate process," Weisman said. "Some reactions require days of work in the lab and transform only a small fraction of your starting material. But with this process, you can convert an entire nanotube sample very quickly."

More information: www.sciencemag.org/content/ear … nce.1196382.abstract

Provided by Rice University