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Nanotubes glow, even within biological cells

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Scientists use fluorescence to track ultrafine particles taken up by white blood cells

In some of the first work documenting the uptake of carbon nanotubes by living cells, a team of chemists and life scientists from Rice University, the University of Texas Health Science Center at Houston and the Texas Heart Institute have selectively detected low concentrations of nanotubes in laboratory cell cultures.

The research appears in the Dec. 8 issue of the Journal of the American Chemical Society. It suggests that the white blood cells, which were incubated in dilute solutions of nanotubes, treated the nanotubes as they would other extracellular particles – actively ingesting them and sealing them off inside chambers known as phagosomes.

"Our goal in doing the experiment was both to learn how the biological function of the cells was affected by the nanotubes and to see if the fluorescent properties of the nanotubes would change inside a living cell," said lead researcher Bruce Weisman, professor of chemistry at Rice. "On the first point, we found no adverse effects on the cells, and on the second, we found that the nanotubes retained their unique optical properties, which allowed us to use a specialized microscope tuned to the near-infrared to pinpoint their locations within the cells."

The research builds upon Weisman's groundbreaking 2002 discovery that each of the dozens of varieties of semiconducting, single-walled carbon nanotubes (SWNTs) emits its own unique fluorescent signature.

The new findings suggest that SWNTs might be valuable biological imaging agents, in part because SWNTs fluoresce in the near-infrared portion of the spectrum, at wavelengths not normally emitted by biological tissues. This may allow light from even a handful of nanotubes to be selectively detected from within the body.

Carbon nanotubes are cylinders of carbon atoms that measure about one nanometer, or one-billionth of a meter, in diameter. They are larger than a molecule of water, but are about 10,000 times smaller than a white blood cell.

The latest tests bode well on two counts. Not only did the nanotubes retain their optical signatures after entering the white blood cells, but the introduction of nanotubes caused no measurable change in cell properties like shape, rate of growth or the ability to adhere to surfaces.

In conducting the tests, Weisman was joined by colleagues Paul Cherukuri and Silvio Litovsky, both of the University of Texas Health Science Center at Houston and the Texas Heart Institute, and Sergei Bachilo of Rice. The researchers cultured mouse macrophage cells in solutions containing between zero and 7 parts-per-million carbon nanotubes for periods of up to 96 hours. They found that the amount of carbon nanotubes taken up by the cells increased smoothly as the concentration or the time of exposure increased. In addition, some cultures were run at cooler temperatures and showed a slower rate of uptake, a finding that suggested that the nanotubes were being ingested through normal phagocytosis.

The samples were studied using a spectrofluorometer and a fluorescence microscope that was modified for near-IR imaging through the addition of a digital camera containing indium gallium arsenide detector elements.

Although long term studies on toxicity and biodistributions must be completed before nanotubes can be used in medical tests, the new findings indicate nanotubes could soon be useful as imaging markers in laboratory in vitro studies, particularly in cases where the bleaching, toxicity and degradation of more traditional markers are problematic.

Source: Rice University