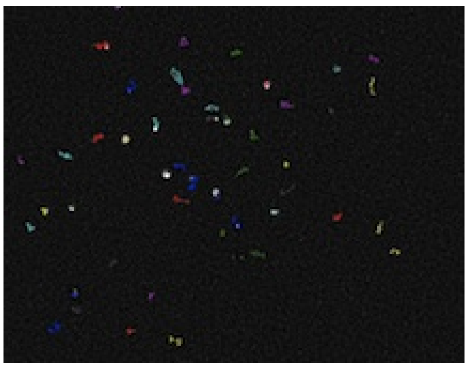
PHYS.ORG

Researchers discover method of measuring nanotubes with greater efficiency

September 19 2012, by Mike Williams



(Phys.org)—A Rice University laboratory has come up with a one-size-fits-almost-all way to measure batches of single-walled nanotubes that promises to help researchers and industry make more efficient use of the wondrous carbon material.

Nanotubes grown in a single batch can range in length from a few nanometers to thousands of nanometers. Until now, the only practical method for measuring them was by imaging with an expensive atomic force microscope (AFM).

But with the new technique from the Rice lab of chemist Bruce Weisman, revealed this month in the American Chemical Society journal ACS Nano, researchers will be able to carry out these analyses more quickly and with less manual labor.

The end product is a histogram that shows the distribution of lengths in a batch of nanotubes that, individually, are 50,000 times thinner than a human hair.

This is just the kind of thing researchers want to know because, even at that scale, the details loom large. When used to deliver strands of DNA or drugs, for example, single-walled carbon nanotubes 200-300 nanometers long seem easiest for cells to absorb. Other applications require longer nanotubes, for example, in high-tech composite materials for aircraft and spacecraft that need the strength and load transfer efficiency offered by longer tubes.

Jason Streit, a graduate student and lead author of the paper, spent two years developing an experimental method and image-processing algorithm able to pick out and track batches of nanotubes floating in solution in a tiny well, about a millimeter across and a little less than two micrometers deep.

The highly automated technique allows him to analyze batches of about 800 nanotubes in two hours.

"The main way to measure lengths until now has been with AFM," he said. "For that, you have to prepare a sample, look at it under a microscope, make sure that contaminants have been removed, record images and then measure the lengths. It can take hours and hours for most workers."

The new process, called length analysis by nanotube diffusion (LAND), is much simpler. Although it only observes semiconducting single-walled nanotubes, which are naturally fluorescent at near-infrared wavelengths, it should help researchers simplify the characterization of nanotube batches.

"Different lengths have different utilities and functions in applications," said Weisman, a professor of chemistry and a pioneer in the science of nanotube fluorescence. "Some applications need a certain short length, while there are others where longer is better. And currently, nanotube length distributions are poorly controlled.

"So one goal is to get more control over the lengths of your nanotubes, and to do that you need to develop separation methods. To develop separation methods, you need good characterization tools."

Co-author Sergei Bachilo, a research scientist at Rice, compared the need for different-size nanotubes to a shoe store, where one size definitely does not fit all. "It wouldn't work very well if the store only had shoes in the average size," he said.

Like dust in a shaft of light, nanotubes in a liquid environment move around due to Brownian motion. It's that inherent movement that reveals their lengths. So Streit takes video. The resulting movies look like a field of stars blinking and wandering in the night sky, but from those frames he is able to extract trajectories that tell him how long each individually tracked nanotube is. The software also automatically compiles the statistical data to make the histogram.

Some special computations are necessary to account for nanotubes that show "fragmented trajectories," when a tube disappears behind another or leaves the field of view for a few frames.

The shorter nanotubes (below a few dozen nanometers in length) are hard to capture on video. "They're dimmer, and they move faster, so sometimes they're just a blur," Weisman said. "One of the tricks Jason uses is to make the liquid in which they're moving more viscous" simply by adding a special sugar. "That slows them down enough to give us a better view.

"We hope that this will be a valuable tool for basic and applied research," Weisman said. "Right in our laboratory, we're already doing basic photophysical studies in which this method plays a crucial part.

"Diagnostics that are slow and cumbersome just don't get used," he said. "That's simply the truth. And when you convert to a method that's fast and easy, people will use it a lot more. It not only speeds things up, it leads scientists into activities they never would have undertaken before.

"This is going to be an important method for a lot of what we do around here, and hopefully for other labs as well," Weisman said.

More information: pubs.acs.org/doi/abs/10.1021/nn3032744

Provided by Rice University