Nano parfait a treat for scientists

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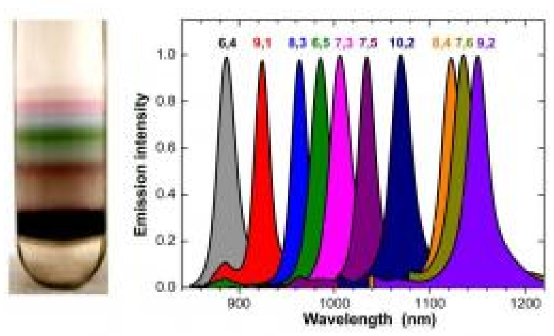

In two new papers, Rice University researchers report using ultracentrifugation (UCF) to create highly purified samples of carbon nanotube species.

One team, led by Rice Professor Junichiro Kono and graduate students Erik Haroz and William Rice, has made a small but significant step toward the dream of an efficient nationwide electrical grid that depends on highly conductive quantum nanowire.

The other, led by Rice Professor Bruce Weisman and graduate student Saunab Ghosh, employed UCF to prepare structurally sorted batches of semiconducting nanotubes that could find critical uses in medicine and electronics.

UCF is what it sounds like: a super-fast version of the centrifuge process medical lab technicians use to separate blood cells from plasma.

The process involves suspending mixtures of single-walled carbon nanotubes in combinations of liquids of different densities. When spun by a centrifuge at up to 250,000 g - that's 250,000 times the force of gravity - the nanotubes migrate to the liquids that match their own particular densities. After several hours in the centrifuge, the test tube becomes a colorful parfait with layers of purified nanotubes. Each species has its own electronic and optical characteristics, all of which are useful in various ways.

Weisman's lab reported its results in today's online edition of *Nature Nanotechnology*. Weisman is a professor of chemistry at Rice.

Kono's lab reported its results recently in the online edition of *ACS Nano*. Kono is a professor in electrical and computer engineering and professor of physics and astronomy.

The lack of pure batches of nanotubes species "has been a real hindrance in the field for nearly 20 years," Weisman said. While the UCF technique is not new, Ghosh found careful fine-tuning of the gradient structure let him sort at least 10 of the numerous species of nanotubes contained in a single sample produced by the Rice-created HiPco process.

Basic research is a big early winner, "because when you can get pure samples of nanotubes, you can learn so much more about them," Weisman said. "Secondly, some electronic applications become much simpler because the tube type determines the nanotube's band gap, a crucial electronic property." Biomedical applications may benefit by exploiting the optical properties of specific types of nanotubes.

In the Kono lab, metallic nanotubes rose to the top of the spinning vial while nearly all of the semiconducting nanotubes sank to the bottom. What surprised lead researchers Haroz and Rice was that nearly all of the metallic tubes were armchair SWNTs, the most desirable species for the manufacture of quantum nanowire. Zigzag and near-zigzag species, also considered metallic, would also sink out.

Armchair nanotubes are so-called because of their "U"-shaped end segments. Theoretically, armchairs are the most conductive nanotubes, letting electrons charge down the middle with nothing to slow them.

The composition of the gradient solution made a difference in the quality of the samples, Haroz said. "One of the surfactants we're using, sodium cholate, has a molecular structure that's similar to a nanotube -- basically hexagons put together," he said. "We think there's a match between the sodium cholate and the structure of nanotubes, and it binds just a little bit better to an armchair than it does to zigzags."

Hurdles remain in the path to quantum armchair nanowires that nanotechnology pioneer and Nobel laureate Richard Smalley, Haroz' first mentor at Rice who died in 2005, felt would be a panacea for many of the world's problems. Fix the distribution of energy and solutions to other challenges - clean water, food, environmental woes - will fall into place, he believed.

"Step 1 of the armchair quantum nanowire project is, 'Can we get armchairs?' We've done that," said Haroz. "Now let's make macroscopic structures -- not necessarily long cables, but small structures -- to test their conductivity."

More information:
Read the Kono abstract at: pubs.acs.org/doi/abs/10.1021/n … 08n?prevSearch=haroz%2Bkono&searchHistoryKey=

Read the Weisman abstract at: www.nature.com/nnano/journal/v … s/nnano.2010.68.html

Provided by Rice University