Longer is Better for Nanotube Optical Properties

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If you want to exploit the ability of single-walled carbon nanotubes (SWCNTs) to absorb, fluoresce and scatter light, take the advice of a sandlot quarterback and “go long.”

In the Aug. 29, 2007, issue of the *Journal of the American Chemical Society*, researchers at the National Institute of Standards and Technology (NIST) show that length has a significant impact on enhancing the optical properties (absorption, near-infrared fluorescence and resonant Raman scattering) of these tiny cylinders made up of single-sheet rolls of carbon atoms.

Normally, material properties like refractive index are constants, but, say the NIST researchers, at the nanoscale sometimes size matters in unusual ways. The ability to manipulate these optical properties may one day lead to the development of SWCNTs as microscopic optical sensors, biological probes and highly-specific drug-delivery systems.

To make the optical measurements possible, the researchers used size-exclusion chromatography to separate DNA-wrapped nanotubes based on their length (the DNA enables the SWCNTs to dissolve in water and facilitates their separation by chromatography). Borrowing tools from biology, the scientists consolidated many separation runs to generate different fractions—ranging in size from less than 50 nanometers to greater than 500 nanometers—in concentrations higher than previously reported for length-sorted SWCNTs. This allows SWCNTs of various lengths to be studied individually with higher accuracy and by more techniques.

The optical response of SWCNTs proved to be dependent on nanotube length for all three characteristics examined. The strength of the absorption changes in direct proportion to length for nanotubes approaching a micrometer in length. This relationship, in turn, affects other important optical properties of the nanotubes including near-infrared fluorescence and resonant Raman scattering. The researchers suggest that the length dependence may be a consequence of quantum mechanical phenomena, raising the possibility that at these length scales the usual notion of a constant material property may need to be rethought.

Although the longest nanotubes studied in the NIST experiment had the most intense optical responses, the researchers suggest that length dependence is not without bounds. Defects, kinks, impurities and tube deformations are all potential limiting factors.

Citation: J.A. Fagan, J.R. Simpson, B.J. Bauer, S.H. De Paoli Lacerda, M.L. Becker, J. Chun, K.B. Migler, A.R. Hight Walker and E.K. Hobbie. Length-dependent optical effects in single-wall carbon nanotubes. *Journal of the American Chemical Society* 29 (34), pp. 10607 -10612, 2007.

Source: NIST

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