Researchers create two-segment nanotubes with distinct semiconducting domains

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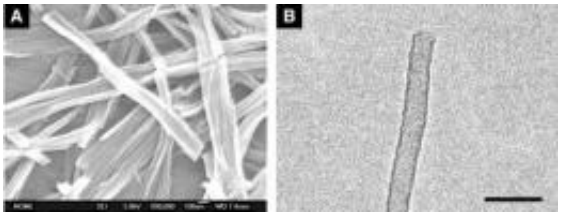

SEM and TEM micrographs of a research sample. Image: *Science*, DOI:10.1126/science.1210369

(PhysOrg.com) -- A group of researchers working in Japan has devised a means of creating dual segmented nanotubes where each segment has separate and distinct semiconducting properties. The team describes how they were able to create the unique nanotubes which are joined by means of a heterojunction, in their paper published in *Science*.

The team, led by Takanori Fukushima and Takuzo Aida and working out of the RIKEN Advanced Science Institute in Saitama, Japan, created the new nanotubes by growing first one segment from an HBC derivative, then adding bipyridine side-chains to help with metal binding. They then coated the outside of the segment with copper ions to stabilize them and to prevent them from clumping.

Once they had the first segment, the next task was to grow another segment of a different type from one of the ends of the first segment.

They did this by treating a second HBC derivative with just four fluorine atoms, which helped the two segments stick to one another while the second segment grew.

The end result was a single nanotube with segments that had distinctly different electronic properties. In this case, one side was made of type p semiconducting material (which has relatively few electrons) while the other side was made of type n semiconducting material (which has a lot of electrons).

Such nanotubes could be used to more efficiently move the hole in an electron-hole pair that strikes a solar cell, shunting it off to the p type semiconductor side of the nanotube and the electron to the type n material side. By making the heterojunction more efficient, i.e. maximizing the electron-hole separation without dissipation, the new technology could conceivably wind up replacing conventional methods used in solar energy and other technologies. Such nanotubes should also extend the life of many such charge carriers and could be grown in virtually any shape, making them usable in a wide variety of applications.

The next challenge for the group will be to figure out a way to grow the nanotubes standing up so that the whole process can be standardized and then of course industrialized. Once that's accomplished, the new nanotubes could be used in all manner of new devices, ranging from lasers to solar collectors to more efficient transistors.

More information: Supramolecular Linear Heterojunction Composed of Graphite-Like Semiconducting Nanotubular Segments, *Science*, 21 October 2011: Vol. 334 no. 6054 pp. 340-343 DOI: 10.1126/science.1210369

ABSTRACT

One-dimensionally connected organic nanostructures with dissimilar semiconducting properties are expected to provide a reliable platform in understanding the behaviors of photocarriers, which are important for the development of efficient photon-to-electrical energy conversion systems. Although bottom-up supramolecular approaches are considered promising for the realization of such nanoscale heterojunctions, the dynamic nature of molecular assembly is problematic. We report a semiconducting nanoscale organic heterojunction, demonstrated by stepwise nanotubular coassembly of two strategically designed molecular graphenes. The dissimilar nanotubular segments, thus connected noncovalently, were electronically communicable with one another over the heterojunction interface and displayed characteristic excitation energy transfer and charge transport properties not present in a mixture of the corresponding homotropically assembled nanotubes.