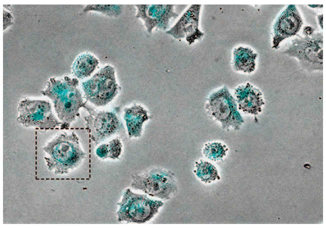
Nanoparticles 'Glow Crazy' for Bioapplications

Difluoroboron-based dyes have many optical properties that make them useful as imaging agents, photosensitizers, and sensors. These dyes can be used in biological contexts when embedded in



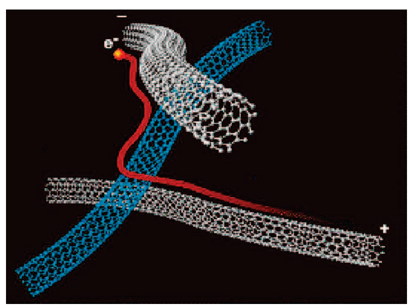
polymer matrices that act as protective shells, increasing their stability and improving their delivery. Recently, Pfister *et al.* combined one such dye, boron difluoride dibenzoyl-methane (BFD_2dbm), with the biocompatible polymer poly-(lactic acid) (PLA). In addition to finding that this treatment had little effect on the intense blue fluorescence of the dye, the researchers also discovered that new properties emerge, such as temperature-sensitive delayed fluorescence and green oxygen-sensitive room-temperature phosphorescence.

In a new study (p 1252), the researchers examined whether these characteristics remained when this material was converted into nanoparticles, a form that expands its possible biological applications. The team found that the resulting nanoparticles, measuring less than 100 nm, are relatively homogeneous and are not damaged when passed through syringe filters commonly used in biological contexts. When placed in an aqueous suspension, the particles retained the strong blue fluorescence seen in previously made films. They also showed high sensitivity to oxygen quenching and exhibited long-lived phosphorescence at room temperature and at body temperature, an important prerequisite for biological use. The particles displayed high shelf stability, still fluorescing and phosphorescing in aqueous solution even after 8 months. When taken up by cells, the particles kept their properties and had low toxicity. With these promising results, the researchers plan to continue developing these nanoparticles for biological use.

In Conducting Business, Semiconducting Nanotubes Beat Metallic Ones

Transparent and conductive thin films made of single-walled carbon nanotubes (SWNTs) have many potential applications, including use in solution-processed solar cells, field-effect transistors, and touch-screens. However, the complex makeup of carbon nanotubes has thus far limited understanding of how to optimize these films for such applications. SWNTs are naturally composed of about two-thirds semiconducting and one-third metallic nanotubes. The general properties of semiconductors and metals suggest that films made mostly with metallic nanotubes might be better conductors and those made mostly with semiconducting nanotubes might have better transparency. Yet, researchers had not tested this idea to formulate an ideal composition that simultaneously optimizes both characteristics.

To explore this issue, Blackburn *et al.* (p 1266) examined the optical and elec-

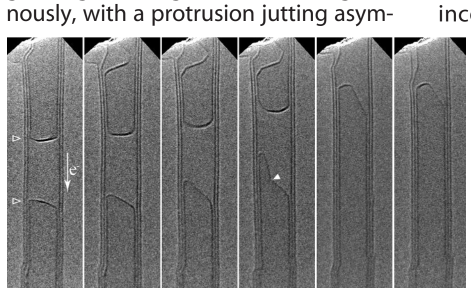


trical properties of films crafted with precisely tuned ratios of semiconducting and metallic SWNTs. These ratios ranged from films made almost solely with semiconducting nanotubes to those made almost exclusively from metallic ones. Surprisingly, the researchers found that films made with higher ratios of semiconducting nanotubes were more conductive than those made with higher ratios of metallic ones; as the concentration of semiconducting tubes increases in the films, resistivity consistently drops. This effect is increased dramatically by soaking the films in redox dopants, such as HNO_3 and $SOCl_2$, which increases conductivity on a much larger scale in semiconducting films than in metallic-tube-enriched ones. Further tests indicate that the main source of resistance in the films is that associated with tube−tube junctions. The researchers suggest that future work could further optimize these junctions, bringing them closer to applications.

How Do Nanotubes Grow? No Cockleshells Necessary

Understanding how single-walled carbon nanotubes form is essential to tuning qualities specific to a variety of structural and electrical applications. Though some previous microscopy studies have gathered information on nanotube growth, these studies typically focused on nanotube formation through catalysis. Consequently, little was known about how noncatalyzed nanotube growth occurs.

To investigate, Jin *et al.* (p 1275) used high-resolution transmission electron microscopy (HR-TEM) to follow the growth of single-walled within double-walled carbon nanotubes. The team focused on discontinuous inner walls of the double-walled tubes and applied voltage to heat the tubes, using carbon in the tubes for feedstock. In multiple experiments, each lasting several seconds, the researchers saw one-half of each discontinuous tube grow while the other shrank. The team reports that the growing half lengthened inhomogeneously, with a protrusion jutting asymmetrically from the tube end. In contrast, the end of the shrinking half maintained a symmetrical, rounded shape. Surprisingly, the ends of both the growing and shrinking tubes remained closed. The researchers suggest that the growing end acquires free carbon radicals in either C_2 or other carbon cluster forms from the shrinking end but may not be able to incorporate these radicals into a



stable geometry, hence leading to the protrusion seen bulging from the growing nanotube end. The researchers report that their findings may eventually help to grow nanotubes specific to applications, as well as to repair defects of the inner tubes in multiwalled nanotubes.

Published online June 24, 2008.
10.1021/nn8003185 CCC: $40.75