

optical properties, which allowed us to use a specialized microscope tuned to the near-infrared to pinpoint their locations within the cells."

Weisman, Paul Cherukuri of the Texas Heart Institute, and their colleagues reported their research in the December 8, 2004, issue of the *Journal of the American Chemical Society* (p. 15638; doi: 10.1021/ja0466311). The researchers cultured mouse macrophage cells in solutions containing between 0 ppm and 7 ppm single-walled carbon nanotubes (SWNTs) for periods of up to 96 h. They found that the amount of SWNTs taken up by the cells increased smoothly as the concentration or the time of exposure increased. In addition, some cells cultured at cooler temperatures showed a slower rate of uptake, a finding that suggested that the nanotubes were being ingested through normal phagocytosis.

The samples were studied using a spectrofluorometer and a fluorescence microscope that was modified for near-infrared imaging by the addition of a digital camera containing InGaAs detector elements.

Not only did the nanotubes retain their optical signatures after entering the white blood cells, but the introduction of nanotubes caused no measurable change in cell properties like shape, rate of growth, or the ability to adhere to surfaces.

The new findings demonstrate that SWNTs might be valuable biological imaging agents, in part because SWNTs fluoresce in the near-infrared portion of the spectrum, at wavelengths not normally emitted by biological tissues. This may allow light from even a handful of nanotubes to be selectively detected from within the body. This option may prove particularly beneficial in cases where the bleaching, toxicity, and degradation of more traditional markers are problematic.

Copper Oxide Nanotube Arrays Produced by MOCVD Process with Template

Because of the tremendous improvement in chemical properties resulting from the incorporation of nanostructured materials, inorganic nanostructures have been extensively studied for applications such as electrical contacts, catalytic gas-sensing devices, and solar cells. Various techniques, including metalorganic chemical vapor deposition (MOCVD), have been attempted for synthesizing inorganic (metal, oxide, halide, and chalcogenide) nanotubes or nanowires. Researchers are now trying to achieve the synthesis of CuO nanotubes by a simple and reproducible method using a so-called "template" to help create well-aligned nanostructures, which may have applica-

tions in devices containing copper oxide thin films or as cathode materials in lithium copper oxide electrochemical cells. In the December 28, 2004, issue of *Chemistry of Materials* (p. 5559; doi: 10.1021/cm048685f), researchers from Università di Catania in Italy announced that they have grown homogeneous CuO nanotube arrays on a template by MOCVD.

G. Malandrino of Università di Catania and colleagues used anodic aluminum oxide membranes as a template. The 60- μm -thick template consists of a precise, non-deformable structure, with pores 200 nm in diameter arranged in a

hexagonal array. The membrane was positioned vertically in a hot-wall reactor and maintained at 400°C. Oxygen and argon were used as the reaction gas and carrier gas, respectively. The Cu(tmhd)₂ (Htmhd = 2,6,6,6-tetramethyl-3,5-heptandione) source was sublimed at 100°C. The deposition was carried out for 3 h at a total pressure of 2 Torr.

Scanning electron micrographs show that the outer diameters of the CuO nanotubes are ~250 nm and the wall thicknesses are ~40 nm. The nanotubes are ~1 μm long. The researchers said that the characteristic pore dimensions of the template membrane influence the diameters of the nanotubes, whereas the length of the nanotubes depends on the process conditions. Furthermore, according to the researchers, the template can be completely removed by dissolving it in a NaOH solution, resulting in freestanding CuO nanotube arrays (see Figure 1).

"To our knowledge, this is the first example of a regularly packed CuO nanotube array made through a rather straightforward process," said the researchers. The "transfer" of a well-assessed MOCVD procedure for the deposition of CuO films to analogue nanotubes, they assert, could open viable routes to the fabrication of nanotube arrays of various oxides.

SHIMING WU

Silicalite-1 Self-Supported Micromembrane Separates Propane/Nitrogen Gas Mixture

Zeolite membranes are used industrially as an aid during the pervaporation process for the dehydration of solvents. They are currently under development for applications such as the separation of certain gas/hydrocarbon mixtures, membrane reactors, and sensors, and heading toward applications in silicon-based microdevices. Among several constraints to take into consideration are the loss of separation selectivity at high temperatures and the high cost of the membranes, at more than \$2600 per m². Efforts are concentrated on developing small-scale membranes, which could potentially be single crystals with improved stability during fabrication and thermal cycling. Following this direction, E. Mateo and colleagues from the University of Zaragoza, Spain, have created arrays of micromembranes of silicalite-1 on a stainless steel sheet, which they reported in the November 30, 2004, issue of *Chemistry of Materials* (p. 4847; doi: 10.1021/cm048504+).

The investigators fabricated the silicalite-1 powders for seeding, starting from a solution of tetrapropylammonium hydroxide (TPAOH), tetraethyl orthosili-

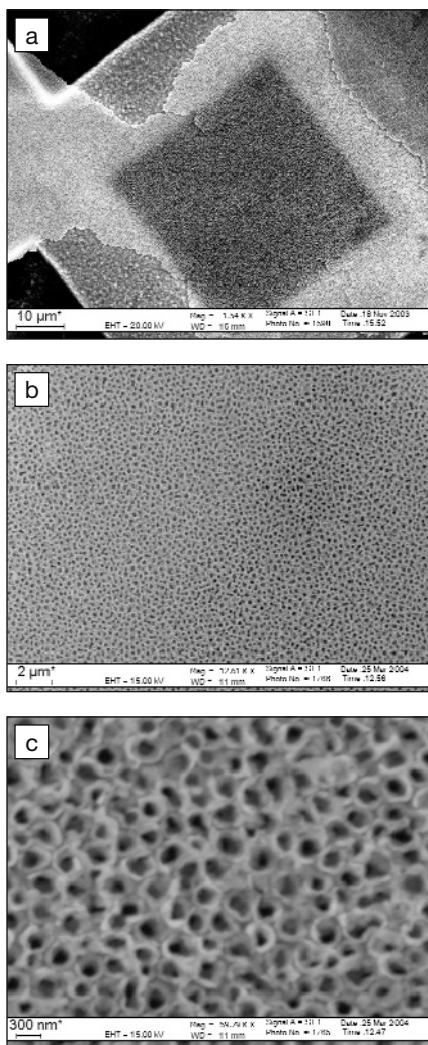


Figure 1. Freestanding CuO nanotube arrays: (a), (b) low-magnification plan-view scanning electron microscopy images of the CuO nanotube sheet; and (c) high-magnification plan view of the nanotube sheet. Reprinted with permission from *Chemistry of Materials* **16** (26) (2004) p. 5559. © 2004 American Chemical Society.