Ramping up lithium-sulfur batteries

Chemists at the Nanosystems Initiative Munich Cluster at Ludwig Maximilian University of Munich (LMU) and at the University of Waterloo, Ontario, synthesized a new material that could lead the way to state-of-the-art lithium-sulfur batteries. They produced a novel type of nanofiber featuring a highly ordered and porous structure that gives it an extraordinarily high surface-to-volume ratio.

“The high surface-to-volume ratio and high pore volume are important because they allow sulfur to bind to the electrode in a finely divided manner, with relatively high loading. This enhances the efficiency of the electrochemical processes that occur in the course of charge-discharge cycles. And the rates of the key reactions at the sulfur electrode-electrolyte interface, which involve both electrons and ions, are highly dependent on the total surface area available,” explains chemistry professor Thomas Bein.

To synthesize the carbon fibers, chemists prepared a porous, tubular silica template, starting from commercially available, but nonporous fibers. This template is then filled with a special mixture of carbon, silicon dioxide, and surfactants, which is heated at 900°C. Finally, the template and the SiO2 are removed by etching. During this process, the carbon nanotubes—and pore size—shrink more than they would without the confining template, and the fibers themselves become more stable.

www.en.uni-muenchen.de

Novel nanofibers hold promise for advanced lithium-sulfur batteries. Courtesy of LMU.

Shooting nanoribbons

The Rice University lab of materials scientist Pulickel Ajayan, Houston, discovered that nanotubes that hit a target end-first generally turn into ragged clumps of atoms. But nanotubes that happen to broadside the target unzip into handy ribbons, which can be used in composite materials for strength as well as in applications that take advantage of their desirable electrical properties.

Researchers fired pellets of randomly oriented, multiwalled carbon nanotubes from a light gas gun built by the lab of materials scientist Enrique Barrera with funding from NASA. Pellets impacted an aluminum target in a vacuum chamber at about 15,000 mph. When the resulting carbon rubble was inspected, nanotubes that smashed into the target end-first or at a sharp angle simply deformed into crumpled tubes. But ones that hit length-wise actually split into ribbons with ragged edges.

According to Ajayan, the process eliminates the need to clean chemical residues from nanoribbons produced through current techniques. “One-step, chemical-free, clean, and high-quality graphene nanoribbons can be produced using our method. They are potential candidates for next-generation electronic materials,” he says. For more information: Pulickel Ajayan, 713.348.5904, ajayan@rice.edu, rice.edu.

Molecular simulations and electron microscope images show what happens to a carbon nanotube when the end of it strikes a target directly at about 15,000 mph—they split into useful nanoribbons. Courtesy of Ajayan Group/Rice University.