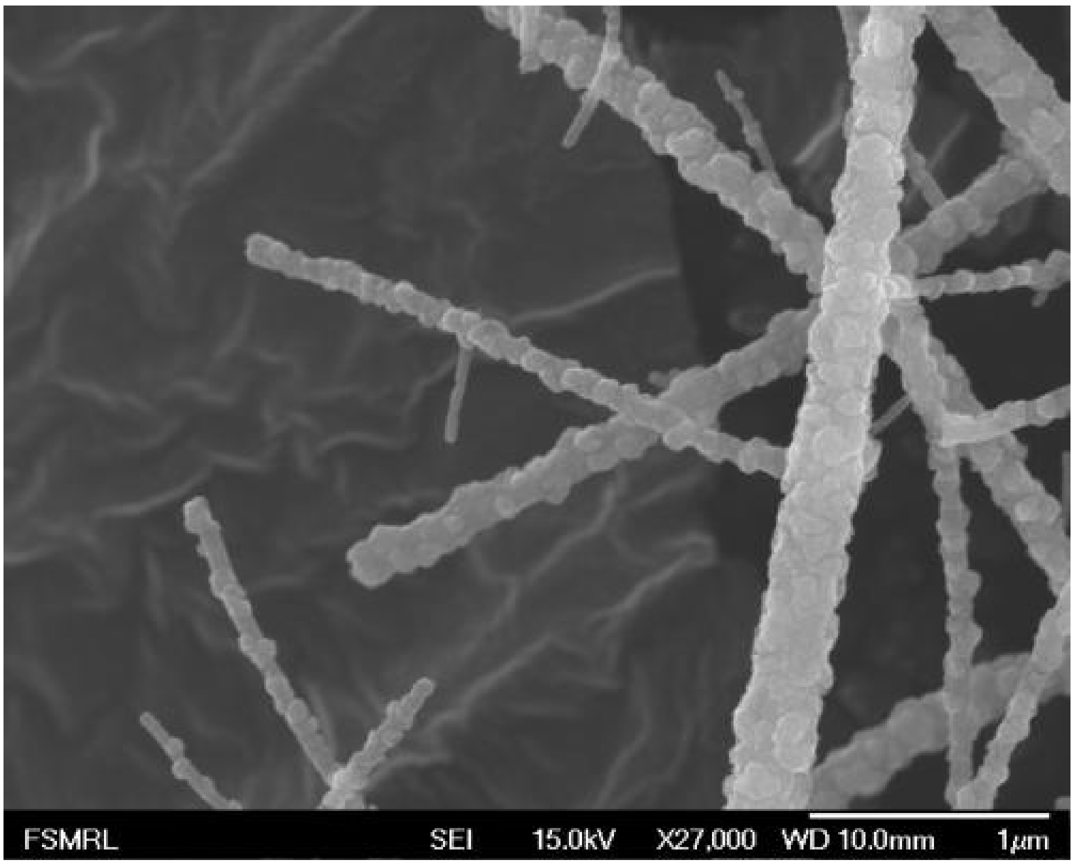
Nanofibers clean sulfur from fuel

December 17 2012, by Liz Ahlberg



Nanofibers of metal oxide provide lots of highly reactive surface area for scrubbing sulfur compounds from fuel. Sulfur has to be removed because it emits toxic gasses and corrodes catalysts. Credit: Prashant Jain

(Phys.org)—Sulfur compounds in petroleum fuels have met their nano-structured match. University of Illinois researchers developed mats of metal oxide nanofibers that scrub sulfur from petroleum-based fuels much more effectively than traditional materials. Such efficiency could lower costs and improve performance for fuel-based catalysis, advanced energy applications and toxic gas removal.

Co-led by Mark Shannon, a professor of mechanical science and engineering at the U. of I. until his death this fall, and chemistry professor Prashant Jain, the researchers demonstrated their material in the journal *Nature Nanotechnology*.

Sulfur compounds in fuels cause problems on two fronts: They release toxic gases during combustion, and they damage metals and catalysts in engines and fuel cells. They usually are removed using a liquid treatment that adsorbs the sulfur from the fuel, but the process is cumbersome and requires that the fuel be cooled and reheated, making the fuel less energy efficient.

To solve these problems, researchers have turned to solid metal oxide adsorbents, but those have their own sets of challenges. While they work at high temperatures, eliminating the need to cool and re-heat the fuel, their performance is limited by stability issues. They lose their activity after only a few cycles of use.

Previous studies found that sulfur adsorption works best at the surface of solid metal oxides, so graduate student Mayank Behl, from Jain's group, and Junghoon Yeom, then a postdoctoral researcher in Shannon's group, set out to create a material with maximum surface area. The solution: tiny grains of zinc titanate spun into nanofibers, uniting high surface area , high reactivity and structural integrity in a high-performance sulfur adsorbent.

The nanofiber material is more reactive than the same material in bulk form, enabling complete sulfur removal with less material, allowing for a smaller reactor. The material stays stable and active after several cycles.

Furthermore, the fibrous structure grants the material immunity from the problem of sintering, or clumping, that plagues other nano-structured catalysts.

"Our nanostructured fibers do not sinter," Jain said. "The fibrous structure accommodates any thermophysical changes without resulting in any degradation of the material. In fact, under operating conditions, nanobranches grow from the parent fibers, enhancing the surface area during operation."

Jain's group will continue to investigate the enhanced properties of nanofiber structures, hoping to gain an atomic-level understanding of what makes the material so effective.

"We are interested in finding out the atomic sites on the surface of the material where the hydrogen sulfide adsorbs," said Jain, who is also affiliated with the Beckman Institute for Advanced Science and Technology at the U. of I. "If we can know the identity of these sites, we could engineer an even more efficient adsorbent material. The atomic or nanoscale insight we gain from this material system could be useful to design other catalysts in renewable energy and toxic gas removal applications."

More information: The paper, "A regenerable oxide-based H2S adsorbent with nanofibrous morphology," is available online.

Provided by University of Illinois at Urbana-Champaign