Media Contact: Angeline French
(803) 725-2854
angeline.french@srnl.doe.gov

FOR IMMEDIATE RELEASE

Reducing ion exchange particles to nano-size shows big potential

AIKEN, S.C. (January 30, 2012) – Sometimes bigger isn't better.

Researchers at the U.S. Department of Energy's Savannah River National Laboratory have successfully shown that they can replace useful little particles of monosodium titanate (MST) with even tinier nano-sized particles, making them even more useful for a variety of applications.

MST is an ion exchange material used to decontaminate radioactive and industrial wastewater solutions, and has been shown to be an effective way to deliver metals into living cells for some types of medical treatment. Typically, MST, and a modified form known as mMST developed by SRNL and Sandia National Laboratories, are in the form of fine powders, spherically-shaped particles about 1 to 10 microns in diameter (a micron is one-millionth of a meter).

"By making each particle smaller," says Dr. David Hobbs of SRNL, lead of the research project, "you increase the amount of surface area, compared to the overall volume of the particle. Since the particle surface is where reactions take place, you've increased the MST's working area." For example, a 10-nanometer particle has a surface area-to-volume ratio that is 1000 times that of a 10-micron particle. Thus, this project sought to synthesize titanate materials that feature nano-scale particle sizes (1 – 200 nm). After successfully synthesizing nanosize titanates, the team investigated and found that the smaller particles do indeed exhibit good ion exchange characteristics. They also serve as photocatalysts for the decomposition of organic contaminants and are effective platforms for the delivery of therapeutic metals.

Dr. Hobbs and his partners in the project examined three methods of producing nano-sized particles, resulting in three different shapes. One is a sol-gel method, similar to the process used to produce "normal" micron-sized MST particles, but using surfactants and dilute concentrations of reactive chemicals to control particle size. This method resulted in spherical particles about 100 – 150 nm in diameter.

A second method started with typical micron-sized particles, then delaminated and "unzipped" them to produce fibrous particles about 10 nm in diameter and 100 – 150 nm long. The third method, which had been previously reported in the scientific literature, was a hydrothermal technique that produced nanotubes with a diameter of about 10 nm and lengths of about 100 -500 nm.

(more)

The team had considerable expertise in working with MST, having previously modified it with peroxide to form mMST, which exhibits enhanced performance in removing certain contaminants from radioactive waste and delivering metals for medical treatment. Nanosize MST produced by all three methods was successfully converted to the peroxide-modified form. As with micron-sized titanates, the peroxide-modified nanosize titanates exhibit a yellow color. The intensity of the yellow color appeared less intense with the hydrothermally produced nanotubes, suggesting the chemically resistant surface of the nanotubes may limit conversion to mMST.

Testing confirmed that the materials function as effective ion exchangers. For example, the spherical nanoMST and nanotube samples and their respective peroxide-modified forms remove strontium and actinides from alkaline high-level waste radioactive waste. Under weakly acidic conditions, the nanosize titanates and peroxotitanates removed more than 90% of 17 different metal ions.

The “unzipped” titanates and their peroxide-modified forms proved to be particularly good photocatalysts for the decomposition of organic contaminants.

Screening in-vitro tests showed that both nano-size and micron-size metal-exchanged titanates inhibit the growth of a number of oral cancer and bacterial cell lines. The mechanism of inhibition is not known, but preliminary scanning electron microscopy results suggest that the titanates may be interacting directly with the wall of the nucleus to deliver sufficient metal ion concentration to the cell nucleus to inhibit cell replication.

In addition to Dr. Hobbs, the team included M. C. Elvington, M. H. Tosten, K. M. L. Taylor-Pashow of SRNL; J. Wataha of the University of Washington; and M. D. Nyman of Sandia National Laboratories.

This work was funded under SRNL’s Laboratory Directed Research & Development program, which supports highly innovative and exploratory research aligned with the Laboratory's priorities.

SRNL is DOE’s applied research and development national laboratory at the Savannah River Site. SRNL puts science to work to support DOE and the nation in the areas of environmental stewardship, national security, and clean energy. The management and operating contractor for SRS and SRNL is Savannah River Nuclear Solutions, LLC.