ENVIRONMENTAL REMEDIATION AND THE ADVANCED PHOTON SOURCE

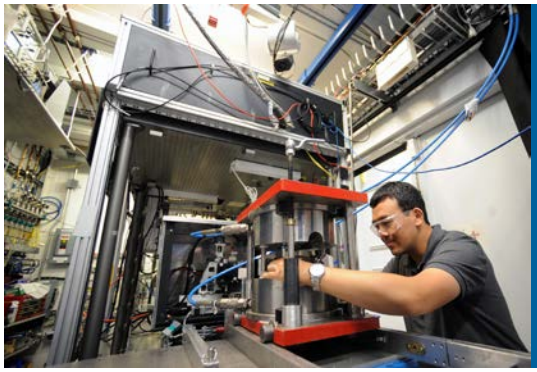
Synchrotron-based experimental techniques used at the U.S. Department of Energy Office of Science's Advanced Photon Source (APS) at Argonne National Laboratory are 10 to 1,000 times more sensitive than traditional methods, making the APS a crucial resource for environmental-remediation research. A principle public concern is the enormous quantity of mixed radioactive and toxic wastes from the nuclear weapons programs, which pose a long-term threat to our soil, our water supply, and the public health. X-ray techniques in use at the APS enable significant gains in overcoming some of the special challenges of the earth and environmental sciences. Detailed information on the chemical forms of toxic elements is crucial to a complete understanding of this problem, and non-synchrotron research methods lack the sensitivity for study of the relatively small amounts of toxic materials present in a typical sample.

Studying Nanocluster Contaminants

For almost half a century, scientists have struggled with plutonium contamination spreading further in groundwater than expected, increasing the risk of sickness in humans and animals. It was known that nanometer-size clusters of plutonium oxide were the culprit, but no one had been able to study their structure nor find a way to separate them from groundwater. Scientists used high-energy x-ray beams from the APS to discover and study the structure of plutonium nanoclusters in order to create better models to account for free-roaming plutonium ions, and nanoclusters.

Reducing Subsurface Migration of Uranium

Uranium has been widely used for over 70 years in a variety of military and commercial roles, but the safe disposal and remediation of this element remains a challenge. One strategy involves introducing substances below ground that retard the formation of highly-soluble uranium compounds. Researchers tracked the chemical changes associated with keeping uranium in a low-solubility mineral form using several techniques, including x-ray spectral measurements performed at the APS. They confirmed that calcium and phosphate slow the transition from less-soluble uranium compounds to more-soluble ones. While the protective effects of the chemical treatment eventually faded under real-world oxidizing conditions, the processes employed and the data gathered will substantially contribute toward the goal of reducing subsurface uranium hazards.



Postdoctoral researcher Feng Shi setting up a sample for an acoustic emission high-pressure and temperature experiment at the APS.

Oxidation of Uranium Dioxide

UO_2 is the main component of the fuel for nuclear reactors and the most economically significant uranium mineral, so understanding how it corrodes in the presence of air and water is important. In addition, some bioremediation efforts to immobilize uranium at contaminated sites rely on microbes that produce uranium dioxide by chemically altering the oxidation state of other forms of uranium. Researchers using the APS investigated how oxygen atoms infiltrate a UO_2 crystal through an exposed surface. Their results provide insight into material failure as well as conditions that help or hinder bioremediation.

Reducing Uranium Mobility

Uranium contamination in earth and water has resulted from power generation, nuclear weapons production and the weathering of uranium-bearing minerals. When bacteria are active in subsurface environments they can reduce uranium to a less-soluble form. Researchers using the APS have gained a new understanding of how uranium reduction occurs so that it may be used to control the spread of uranium contamination, and how a form of reduced uranium could be used as an indicator of how bacteria breathe, providing insight into bacterial physiology.

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