

Microprobe-XANES Studies with Uranium after Uptake by a Silica Supported Mat

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Introduction: Natural attenuation of environmental metal contamination has demonstrated the ability of living ecosystems to remediate heavy-metal contaminated in surface and groundwater, including highly soluble radioactive metals such as uranium (U). This project explores the capacity of natural constituent groups of the microbial mat to remove dissolved U, a common contaminant at U.S.D.O.E. sites. When supported on silica gel, the natural advantages offered by the mat facilitate engineering applications by providing a robust housing for the mat community. The process involves mat cells that have been isolated from a healthy Florida wetland. The mat is then immobilized with required nutrients on silica gel producing semi-solid silica particles covered with mat. The resultant silica mat particles (SMP) were tested for their ability to remove U(VI) from synthetic and natural ground water in batch and flow-through systems. To determine whether the removal mechanism of U(VI) involves reduction to the less soluble U(IV) species, the oxidation state speciation of the U associated with the SMP after treatment with the U-containing waters was determined using microprobe U L_{3} -edge X-ray absorption near-edge structure (XANES) spectroscopic techniques.

Methods and Materials: Mat microbes were isolated from a natural Florida wetland and mixed with silica gel as SMP. Uranium(VI)-containing solutions and natural carbonate-rich ground waters were equilibrated with the silica-supported mats in batch and flow-through studies. After reaction, the amount of U lost from solution was determined by inductively-coupled argon-plasma mass spectrometry and the oxidation state speciation of U in the mat microbes was determined with microprobe XANES spectroscopy using a 15 by 15 micron sized beam.

Results: Laboratory studies (at CAU) show that over 80% of the dissolved U(VI), present as mostly U(VI)-carbonate (Superfund) or U(VI)-hydrolysis species (synthetic), was removed by the SMP within 15 minutes of treatment. Within several hours of batch exposure to dissolved U(VI), a black precipitate formed on the bottom of the treatment vessel. Microprobe-XANES studies at NSLS showed the U(VI) that was sequestered by the SMP was reduced to U(IV) with time under reducing conditions. Upon exposure to several hours in light and air, the U(IV) in the air-exposed U-rich SMP was oxidized to U(VI), indicating that the reduced U(IV) is not stable to oxidation. The oxidation state speciation of U in the U-rich black, fine particle size precipitate that formed was found to be U(IV)—indicating that the microbes can reduce U(VI) to U(IV). Upon exposure to light and air, the U(IV) in the precipitate became oxidized to U(VI).

Conclusions: This is an *environmentally friendly* method that has great potential for the remediation of metal-contaminated waters. Effective sequential batch treatments and maintenance of a low redox environment by nutrient additions demonstrated the potential for long-term durability and the capacity of using this system continuously. Drying the SMP produced a hard compact U-rich product (1% of original weight). The capacity for on-site generation of SMP, relative low-cost of required materials, simplicity of management and formation of a compact, light weight disposal product indicate this system has great potential for use in the field remediation of U-contaminated waters.

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