

**Using Spectroscopic Techniques to Study the  
Biotransformation of Organic Ligands  
Complexed with Radionuclides Under  
Anaerobic Conditions**

Charlotte Eng,<sup>1</sup> Gary Halada,<sup>1</sup> Arokiasamy  
J. Francis,<sup>2</sup> Cleveland Dodge<sup>2</sup> and Jeffrey B. Gillow<sup>2</sup>

<sup>1</sup>State University of New York at Stony Brook  
Department of Materials Science and Engineering  
Stony Brook, NY 11794  
USA

<sup>2</sup>Brookhaven National Laboratory  
Department of Applied Sciences  
Upton, NY 11793  
USA

Shutdown of nuclear weapons production reactors after the end of the cold war threat has caused the DOE to shift its emphasis to remediation, decommissioning and decontamination of the large amounts of contaminated water, sediments and structures. At DOE's nuclear facilities, chelating agents such as carboxylic acids (such as citric, hydroxy-acetic, oxalic, and tartaric acids) and amino-carboxylic acids (such as EDTA, DTPA, NTA, and HEDTA) have been disposed of in subsurface environments.

The disposal of these chelating agents where complexing agents are present from microbial production may cause the biotransformed radionuclides to i) precipitate out; ii) bind to inorganic ligands or iii) associate more closely with immobile inorganic and organic phases; all of which would hinder nuclide migration. The biotransformation of uranium and some toxic metals with citric acid was studied by Francis et al. (1992), which showed that biodegradation of the metal citrate complexes depended on the association of the metal with the citric acid. Under anaerobic conditions, it was shown by Ganesh et al. (1997) that complexed uranium with oxalate or citrate is accessible for iron- and sulfate-reducing bacteria as an electron acceptor, despite the inability of the bacteria to metabolize the organic ligand complexed to the uranium. However, more research is needed towards a better understanding of the biotransformation of naturally organic ligand complexed with radionuclides, as well as their fate under anaerobic conditions.

In this study, we will try to elucidate the mechanisms of biotransformation under anaerobic conditions and other factors that affect the stability and mobility of uranium in the subsurface. U-citrate and U-malate will be emphasized in this study. Some questions that this research will address include: 1) How is the uranium complexed onto the organic ligands? 2) What is the fate of U-organic complexes when in the presence of bacterial cultures? 3) What happens to the complexes after being exposed to zero-valence iron? We will approach these questions by using various analytical techniques. X-ray Photoelectron Spectroscopy (XPS) is a powerful tool in determining chemical states of species found on the surface, which will help us form a chemical model of the association of uranium with the organic ligand. Synchrotron infrared microspectroscopy (SIRMS) is used because the bright intensity infrared light emitted from the synchrotron will allow for small spot chemical analysis to characterize the in-

teraction of uranyl groups with the organic ligands. Samples are also analyzed using UV vis spectrophotometry and lab-based infrared microspectroscopy.

The information gathered from these techniques can provide a fundamental understanding of the radionuclide association with natural organic ligands and will be extremely valuable in helping to understand and optimize novel remediation processes. Also, the feasibility of using XPS, SIRMS, FTIR, and UV vis to study the interaction between uranium and organic ligands is determined.

This research is supported by the DOE, Office of Biological and Environmental Research, through the Natural and Accelerated Bioremediation Research Program (NABIR), subcontract number through Brookhaven National Lab pending.