NUCLEAR ENERGY UNIVERSITY PROGRAMS

Ionic Liquid and Supercritical Fluid Hyphenated Techniques for Dissolution and Separation of Lanthanides, Actinides, and Fission Products

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Abstract

This project is investigating techniques involving ionic liquids (IL) and supercritical (SC) fluids for dissolution and separation of lanthanides, actinides, and fission products. The research project consists of the following tasks:

- Study direct dissolution of lanthanide oxides, uranium dioxide and other actinide oxides in [bmin][Tf_2N] with TBP(HNO_3)1.8(H_2O)0.6 and similar types of Lewis acid-Lewis base complexing agents
- Measure distributions of dissolved metal species between the IL and the sc-CO_2 phases under various temperature and pressure conditions
- Investigate the chemistry of the dissolved metal species in both IL and sc-CO_2 phases using spectroscopic and chemical methods
- Evaluate potential applications of the new extraction techniques for nuclear waste management and for other projects.

Supercritical carbon dioxide (sc-CO_2) and ionic liquids are considered 'green' solvents for chemical reactions and separations. Above the critical point, CO_2 has both gas- and liquid-like properties, making it capable of penetrating small pores of solids and dissolving organic compounds in the solid matrix. One application of sc-CO_2 extraction technology is nuclear waste management. Ionic liquids are low-melting salts composed of an organic cation and an anion of various forms, with unique properties making them attractive replacements for the volatile organic solvents traditionally used in liquid-liquid extraction processes. One type of room temperature ionic liquid (RTIL) based on the 1-alkyl-3-methylimidazolium cation [bmin] with bis(trifluoromethylsulfonyl)imide anion [Tf_2N] is of particular interest for extraction of metal ions due to its water stability, relative low viscosity, high conductivity, and good electrochemical and thermal stability.

Recent studies indicate that a coupled IL–sc-CO_2 extraction system can effectively transfer trivalent lanthanide and uranyl ions from nitric acid solutions. Advantages of this technique include operation at ambient temperature and pressure, selective extraction due to tunable sc-CO_2 solvation strength, no IL loss during back-extraction, and no organic solvent introduced into the IL phase.