2017 CFA 12757: Elucidation of Electrochemical Behavior of Technetium, Tellurium, and Iodine in Molten Salt Solutions

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ABSTRACT:

Several radioactive iodine isotopes are formed as fission products in used nuclear fuel and ^{129}I is one of particular concern. Iodine is retained within the fuel matrix and by the containment provided by the fuel cladding. During dissolution of spent fuel in the molten salt, a significant fraction of the iodine will be retained in the molten salt as iodide. Fission of ^{235}U produces four short lived tellurium isotopes, and additional isotopes are produced due to β-decay during cooling of the spent fuel. The used nuclear fuel contains about 0.092 wt% Te in the form of Cs_2Te and noble metal tellurides. The fission yield of ^{99}Tc is about 6.1%. Presence of iodide and telluride in the molten salt could interfere with the electrolytic separation of actinides. Technetium could potentially form volatile species and only very little information is available on its electrochemical behavior in molten salts. The electrochemistry of iodide in high temperature molten salts such as LiCl-KCl eutectic or LiCl-Li_2O is not documented in detail. Technetium exhibits unusual properties in aqueous extraction process such as formation of anionic species such as $[TcO_4]^-$. Not much work has been reported on the electrochemistry and chemical speciation behavior of Tc in molten salts. The proposed research aims at addressing these issues.

The objectives of this proposed research are to:

- Evaluate the electrochemical speciation behavior of iodide, and telluride in LiCl-KCl eutectic, LiCl, and LiCl + Li_2O electrolytes at temperatures relevant to reprocessing conditions;
- Use rhenium as surrogate for technetium, and investigate the electrochemical, and chemical speciation properties of rhenium ions in chloride molten salts along with addition of other fission products such as Mo and Ru that are relevant to pyro-processing of spent nuclear fuels;
- Determine the redox potentials, reaction intermediates, activity coefficients, and diffusivities of iodide, telluride, and rhenate species as a function of concentration and temperature.

Understanding the electrochemistry of fission products such as iodide and telluride will help enhance the spent fuel reprocessing efficiency, improve the scalability, and result in commercial viability. This project will educate and train several graduate and undergraduate students in nuclear materials engineering.