U.S. Department of Energy

Phosphate Mineral and Glass Waste Forms for Advanced Immobilization of Chloride- and Fluoride-based Waste Streams

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Program: FC-1.5: Advance Salt Waste Form

ABSTRACT:

This project is intended to develop waste form options for immobilizing the fluoride- and chloride-salt waste streams in highly durable and easily processable phosphate minerals and glasses. The main objective is to evaluate three options including: i) phosphate ceramic waste forms by focusing on apatite phases with the general formula $M_{10}(PO_4)_6(Cl/F)_2$, ii) phosphate glass waste forms (particular *Sn-P-O-F/Cl* glass) with low melting temperature, iii) phosphate glass-ceramic waste forms by targeting crystalline apatite and monazite phases. Salt waste streams are mainly generated during molten salt reactor (MSR) operations and electrochemical reprocessing. The options have the ability to fully incorporate full salt waste streams (unseparated salts) and separated salt streams where certain species are removed or recycled. Additionally, an indirect immobilization method using a SAP (SiO_2-Al_2O_3-P_2O_5) composite via dechlorination of the salt waste will be explored as a comparison with our proposed phosphate glass waste forms. The major processing approach for these three options will be melt processing in air, similar to that developed for borosilicate nuclear waste glasses. Spark plasma sintering (SPS) will also be used to fabricate phosphate ceramics at lower temperatures and shorter times to compare with melt-processed ceramic samples. The production of multiple, 20-gram monolithic waste form test samples that would be provided to the DOE National Laboratories for testing beginning no later than 12 months into the effort and continuing to the conclusion of the proposed effort. The result can be used to influence waste form design as well as separations processes of interest to DOE.

This project uses the complementary skills from three diverse groups of researchers at one University and one National Laboratory. Each group brings critical expertise to the project to understand the fabrication of phosphate-based apatite, glass-ceramic, and glass waste forms with various compositions, modifier additions and waste loadings; the characterization of the structure and properties, and the performance of chemical durability testing. Further effort is to evaluate these waste form options for immobilization of Chloride- and Fluoride-based waste streams. Ming Tang at the Clemson University is responsible for overall scientific, technical, and managerial aspects of the project, specifically the development of the phosphate-based ceramic, glass, and glass-ceramic waste forms, microstructural analysis by advanced electron microscopy and diffraction techniques. Kyle Brinkman at the Clemson University is responsible for the characterization of thermophysical and thermodynamic properties of waste form samples and spectroscopy analysis. Brian Riley at the Pacific Northwest National Laboratory will be responsible for providing project support available through the DOE complex to help guide the successful completion of this project, specifically on waste form formulation design and chemical durability testing.