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Development of Low Temperature Syntheses of Nuclear Waste Forms

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Our interest in finding suitable waste forms for the effective immobilization of actinides and other radionuclides, such as Cs, has led to our investigation of low temperature synthesis routes that result in the formation of stable waste forms. Phosphates, including monazite-based ($LnPO_4$) materials are considered to be excellent nuclear waste form candidates and fulfill most of the selection criteria for waste forms. However, the synthesis of the stable anhydrous, monoclinic monazite typically involves the high temperature (~1,000°C) conversion of rhabdophane ($LnPO_4$-nH_2O) to monazite, which creates difficulties for processing large quantities of nuclear waste, especially with respect to the potential volatilization of radionuclides. To address this issue, we developed a new low temperature synthesis route for the preparation of polycrystalline monazite phases, $LnPO_4$, and succeeded in the molten salt crystal growth of monazite, such as $AmPO_4$, and monazite related phases, such as $Ca_{0.5}Th_{0.5}PO_4$, $Ca_{0.5}Th_{0.5}PO_4$, and $Sr_{0.5}U_{0.5}PO_4$.

The sequestration of cesium, a fission product that will be created in molten salt reactors, represents a special challenge as the waste from MSR will be a radionuclide containing mixture of salts, including CsF or CsC, both of which are quite water soluble. We have developed a solid state synthesis, starting with CsF or CsCl, to prepare $CsNb_2O_5F$, a defect pyrochlore that is extremely stable.

The synthetic routes for these phases and their characterizations will be presented.

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