Feasibility of Precipitation Method for Uranium Separation in Molten Salt

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It is well-known that a pyrochemical process can separate uranium as well as useful truansuranic (TRU) elements from a spent nuclear fuel. Metallic uranium and plutonium produced from the pryochemical process can be used as a fuel of a next generation nuclear power plant, Sodium Fast Reactor. In other way, they can be directly sent to a nuclear waste depository. However, the metal forms of uranium, TRU, lanthanide elements can be easily oxidized in an ambient environment so that they need to be converted to their stable phases such as oxide for the safety of the depository. We have sought a method to partition uranium oxide from a high-temperature molten salt where spent nuclear fuel is dissolved. Here, we report a precipitation strategy to remove trivalent uranium from the molten salt as uranium oxide.

All the experiments were carried out in a glove box under Ar where O_2 and H_2O level were maintained to be less than 1 ppm. Lithium chloride (LiCl)/potassium chloride (KCl) eutectic salts (anhydrous beads), and silver chloride (AgCl) were obtained from Sigma Aldrich. Cerium chloride ($CeCl_3$), lanthanum chloride ($LaCl_3$), and lithium oxide (Li_2O) were purchased from Alfa Aesar (purity $\geq$ 99.99%). UCl_3 was made from chemical dissolution of U metal by $CdCl_2$ in LiCl-KCl.

We added Li_2O into a LiCl-KCl melt containing uranium trivalent or lanthanide trivalent cations such as Nd, La, and Ce, and precipitated insoluble solids. We investigated the precipitates with XRD and Raman spectroscopy and confirmed that the products were uranium dioxide and lanthanide oxychlorides. In case of uranium dioxide, the precipitates were directly dropped down to bottom of the melt whereas the lanthanide oxychlorides were suspended in the melt as a colloid then slowly sank. In addition, we added Li_2O into LiCl-KCl containing multi-component such as U, Ce, La, and Nd. We found that uranium dioxide and then lanthanide oxychloride were successively precipitated, which means that the uranium dioxide can be separated from the LiCl-KCl with various metal elements.