Comparison of the spectroscopic characteristics of uranium status when U(III) in a LiCl-KCl eutectic melt is leached out with water and ionic liquid

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Molten salt is a high-temperature stable (in some cases, stable up to a temperature of 950 °C), corrosive, nonvolatile, and viscous medium. The most interesting application of this technology in the nuclear energy industry is a molten salt based pyrochemical processing technique, which is regarded as one of the promising options for a future spent nuclear fuel management concept. As a type of spent nuclear fuel treatment, the pyrochemical process is well known for its non-proliferation of nuclear fuel cycles (final product is a mixture of transuranic, and there is no signal of separated pure Plutonium obtained in the pyrochemical processing), separation of long-term radioactive nuclides during processing, the recovery of uranium for re-use as a nuclear fuel, and a significant volume-reduction of high level wastes. Through an electrorefining step of the pyrochemical processing, uranium ions (existing as 3+) dissolved in the LiCl-KCl eutectic melt at 450 °C are recovered as pure uranium metal at a cathode by an electrochemical method, and remaining U(III) in the LiCl-KCl eutectic melt goes to salt waste after an electrowinning step of the pyrochemical process. After the complete pyrochemical processing is finished, a remaining small amount of the salt waste, apart from the salt for recycling will be stored for the long term and is composed of some actinides and lanthanide species (mainly existing as 3+ ions) dissolved in molten salt.

In this study, we investigate the behavior of U(III) dissolved in LiCl-KCl eutectic melt, especially when U(III) is leached out with water compared to ionic liquid, to obtain better understandable information for long term waste salt storage. Actually, U(III) compounds are not stable at common condition and are difficult to be synthesized in normal process except using radiation technique or to be existed as transition state compound. Therefore, the studies of U(III) are very limited, and the results of these are little known. However, it is known that U(III) in molten salt is stable, and the absorption studies of U(III) in the LiCl-KCl eutectic melt was reported before. Nevertheless, to our knowledge, the spectroscopic studies of U(III) in molten salt contacted with water or ionic liquid has not been reported yet. An ionic liquid system, which is similar to the environment of a slushy micelle system in a ground water migration, was considered as a medium for a convenient bench-scale experiment.

U(III) in a LiCl-KCl eutectic melt was dissolved into an appropriate ionic liquid and water, and identification and determination of the uranium (U) in the LiCl-KCl eutectic melt were performed using spectroscopic methods. The ionic liquid of 1-hexyl-3-methyl-imidazolium chloride used in this research did not cause any oxidation or reduction of U(III). The U(III) in LiCl-KCl eutectic melt showed the tendency of stable status in ionic liquid and unstable status in water. Based on the experimental data, a predictive theory of the factors involved in the process is discussed.

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