Collection of Uranium Metal From the Salt Mixture Using Yttrium Metal

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1. Introduction

The objective of pyroprocessing technology is to reduce a volume of the high level waste (HLW) by recycling the long lived actinide elements in spent nuclear fuel (SNF) into the sodium fast reactor. KAERI has carried out a study to develop unique drawdown method to recover most of the actinide elements remained in a spent molten salt by introducing the rare earth metal. [1, 2] The previous tests on this drawdown method in the uranium chloride salt have shown promising results from the viewpoint of minimizing actinides concentration. In this study, bench scale tests were conducted using the Yttrium metal to examine the collection behavior of uranium metal into an inner crucible from a simulated LiCl-KCl salt.

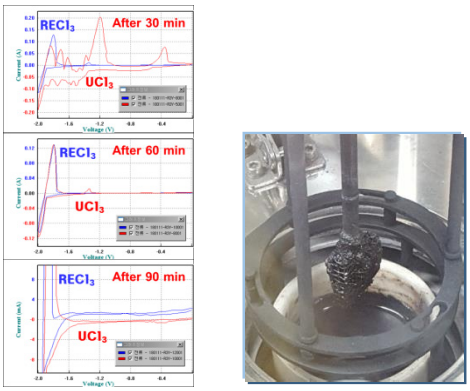
2. Experimental

A simulated LiCl-KCl molten salt mixture containing the uranium and three rare earth metal such as Nd, Ce and La chlorides was prepared in outer crucible, and two Yttrium metal rods basket was introduced into an inner small crucible to collect recovered uranium metal as shown in Fig. 1. A simulated LiCl-KCl salt mixture (400 g) was composed of the U (1.16wt%), Nd (1.43wt%), Ce (0.96wt%) and La (0.57wt%) metal chlorides for the bench scale test. Yttrium metal basket was introduced into an inner crucible to start collection reaction of uranium with stirring the salt at 40 rpm using the Yttrium rods basket. The ICP quantitative chemical analysis of the salt samples and the on-line cyclic voltammetry (CV) monitoring of a salt phase were used to examine the changes of the salt composition.

Fig. 1. Experimental apparatus for collection of uranium using the Yttrium metal in a LiCl-KCl salt mixture.

3. Results and Discussion

The concentration of the uranium ions contained in a simulated salt mixture was reduced from a value more than one weight percent (1.16wt.%) to low value around 0.28wt.% at 60 minutes due to the chemical reduction of uranium ions with the Yttrium metal in a salt mixture. After 90 minutes the concentrations of uranium in two salt samples (at 90 and 180 minutes) decreased to a very low value less than 50 ppm. The on-line cyclic voltammetry (CV) monitoring results of a salt phase are shown in Fig. 2(a).



(a) (b)

Fig. 2. (a) CV monitoring of UCl_3 after 30 min. in a salt mixture and (b) U metal covered on Y metal basket.

The recovery reaction of the uranium with Y metal is as follows.

$$Y(s) + UCl_3 + REsCl_3 \rightarrow U(s) + YCl_3 + REsCl_3 \quad (1)$$

The uranium ions in a salt were converted to U metals which covered on the surface of Yttrium rods basket (Fig. 2,b). These uranium metal particles were easily detached from the basket and collected into the inner crucible by an up-down vibrating force. After removing the inner crucible from the salt $CdCl_2$ oxidant were added into the remaining salt. The ICP analysis result of this remaining salt sample shows that the uranium concentration is a very low value less than 50 ppm.

4. Conclusions

The concentration of uranium ions in a simulated salt mixture can be decreased to a very low value less than 50 ppm by introducing the Yttrium metal into a salt.

The converted uranium metals are covered on the surface of Yttrium rods basket, and these uranium metal particles can be easily detached from the basket by an up-down vibrating force for collecting uranium into the inner crucible.

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