

Performance of the Reaction of Rare Earth and UCl_3 in the LiCl-KCl Salt

Seungwoo Paek*, Dal-Sung Yoon, Gha-Young Kim, Junhyuk Jang, and Sung-Jai Lee

Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea

*swpaek@kaeri.re.kr

1. Introduction

KAERI (Korea Atomic Energy Research Institute) has developed pyroprocessing technology to resolve a limited storage capacity of the accumulated used nuclear fuel (UNF) in Korea [1]. Uranium and transuranic (TRU) elements from UNF can be recovered by electrochemical method in the molten salt. TRU products recovered from pyroprocessing can be supplied to sodium-fast reactor (SFR) as a metal fuel, and may affect the burning of nuclear fuel and the integrity of the fuel claddings if the rare earth (RE) content is high [2]. Therefore, it is necessary to keep the RE content of TRU product for use as SFR fuel as low as possible. In this study, we investigated the performance of the reaction of RE elements and UCl_3 in the LiCl-KCl molten salt.

2. Experimental

U/RE metal alloy containing U, Nd, and Ce was prepared by heating the metals up to 1474 K using an induction furnace. The prepared U/RE ingot was cut to a certain size for the experiments of the reaction between U/RE and UCl_3 . All experiments were conducted in a glove box filled with purified argon and the concentration of oxygen and water were maintained to be below 5 ppm. The concentrations of each element in the salt were determined by ICP-OES. The cyclic voltammetry (CV) measurements were also performed to monitor the concentration of uranium and RE chlorides in the salt. The surface of metal specimen was investigated by XRD and SEM-EDX.

3. Results and Discussion

3.1 Gibbs Free Energy for the Reaction of RE Metals with UCl_3

The reaction between RE elements and UCl_3 proceeds as shown in the following equation.



This reaction is based on the difference in Gibbs free energy of chloride formation between uranium and RE elements. Using this reaction, the uranium remains in a metal form and the RE elements are converted into a chloride form and dissolved into a molten salt.

3.2 Preparation of U/RE Ingot

Fig. 1 shows schematic diagram of a furnace for the U/RE ingot production and the prepared U/RE specimen for the reaction. The prepared U/RE specimen was visually identified as being separated into two areas and is assumed to be due to the difference of the specific gravity between the U and RE elements.

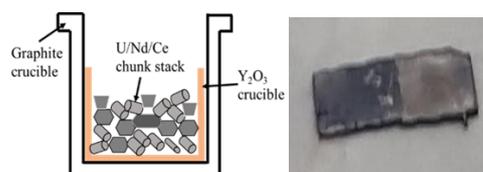


Fig. 1. Preparation of U/RE ingot.

3.3 RE Removal Reaction

Fig. 2 shows the concentration changes of the UCl_3 , $CeCl_3$, and $NdCl_3$ in the salt by the reaction of U/RE ingot with UCl_3 . Uranium concentration decreased to a near zero about an hour after reaction. On the other hand, the concentration of Ce and Nd increased rapidly to about an hour after reaction, and then to a very small amount, maintaining a nearly constant concentration.

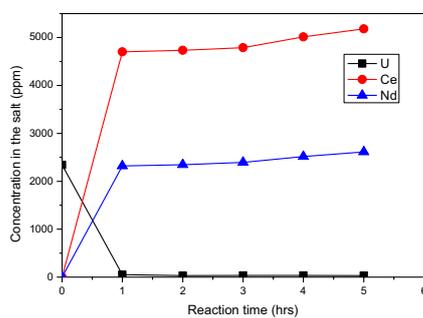


Fig. 2. Concentration change of the reaction salt.

Fig. 3 shows the U/RE specimen after the reaction experiment and results of SEM-EDX analysis. These results shows that RE part of U/RE specimen has been completely removed and only U part remains.

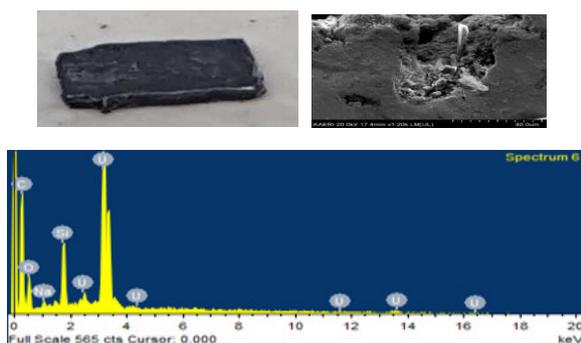


Fig. 3. SEM-EDX results of the surfaces of the U/RE specimen after the reaction.

4. Conclusions

The performance test of the reaction between U/RE ingot and UCl_3 was investigated and it was

shown that the RE elements from U/RE ingot was effectively removed using UCl_3 as an oxidant.

ACKNOWLEDGEMENT

This work was supported by a National Research Foundation (NRF) grant funded by the Korean government (MSIP) (No.2017M2A8A5015079).

REFERENCES

- [1] K. C. Song, et al., "Status of Pyroprocessing Development in Korea", *Nuclear Engineering and Technology*, 42, 131-144 (2010).
- [2] Y. I. Kim et al, "SFR Development Strategy for the Re-use of Spent Fuel in Korea", *Nuclear Engineering and Technology*, 40(6), 517-526 (2008).