# Reaction of Rare Earth Elements With $UCl_3$ in the LiCl-KCl Salt

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## 1. Introduction

The pyroprocessing technology has been developed for the treatment of light-water reactor spent fuel, to recycle that fuel into sodium-cooled fast reactor in Korea Atomic Energy Research Institute [1]. TRU products supplied to SFR through pyroprocessing treatment may affect the combustion of nuclear fuel and the integrity of the fuel claddings if the rare earth content is high [2]. Accordingly, it is necessary to keep the rare earth content of TRU product as low as possible for SFR fuel to be used. In this study, we attempted to test the removal of rare earth elements from metal alloy of uranium, cerium, and neodymium using uranium tri-chloride as an oxidant.

## 2. Experimental

The metal alloy containing U, Nd, and Ce, was prepared by melting of metals in an induction melting furnace. The ratio of U/RE in the alloy was about 2.5 and the ratio of Ce/Nd was about 3. A STS crucible and mesh basket were used as reactor vessel and metal alloy holder, respectively.

All experiments were conducted in a glove box 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 measured by ICP-OES. The surface of metal ingot was investigated by XRD and SEM-EDS. red, and in Times New Roman 13-point, boldface type. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs. Leave one blank line after the title.

## 3. Results and Discussion

### *3.1 Reaction of RE metals with $UCl_3$*

The RE elements in the U alloy can be removed by the reaction with $UCl_3$ according to the following equation.

$$RE(Nd/Ce) + UCl_3 = RE(Nd/Ce)Cl_3 + U \quad (1)$$

This reaction is based on the difference in Gibbs free energy of chloride formation, and the order of magnitude is Ce>Nd>U. Metals of Nd and Ce are then oxidized to $NdCl_3$ and $CeCl_3$ and $UCl_3$ is reduced to U metal. It is therefore possible to remove RE metals (Nd/Ce) from U alloy.

### *3.2 RE removal reaction*

Fig. 1 shows the CV (Cyclic Voltammetry) curves before and after the reaction was terminated within one hour. In response to the reaction with the RE metals of U/RE ingot, $UCl_3$ peak was disappeared and RE chlorides peak was created.

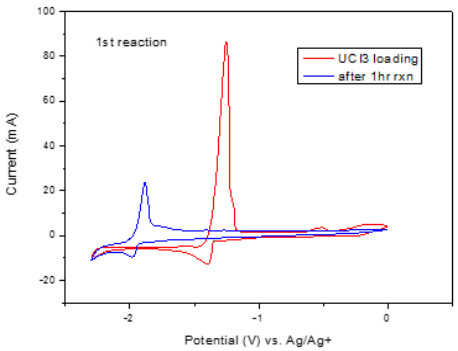


Fig. 1. CV curves of the reaction.

The changes in concentration of U, Nd, and Ce in the salt over the reaction time are shown in Table 1. Only $UCl_3$ existed in the salt before the reaction (S0), but after one hour (S1), $UCl_3$ was completely consumed and RE elements (Nd/Ce) were created. The concentration measured two hours after the reaction (S2) showed a concentration similar to that of S1 sample, indicating that the reaction was terminated within one hour. The concentration ratio of Ce/Nd in the salt after the reaction was approximately 3, which was equivalent to the ratio used in the preparation of the U/RE ingot. In order to review the mass balance of the experimental results, a comparison of the amount of $UCl_3$ used for the reaction with $RECl_3$ produced resulted in $UCl_3$ consumption was approximately 85 % of the $RECl_3$. This is considered to be reasonable value considering the experimental and analysis errors.

Table 1. Concentration of U, Nd, Ce in the salt by ICP analysis

| (ppm) | U | Nd | Ce |
|---|---|---|---|
| S0 | 4956 | ND | ND |
| S1 | ND | 746 | 2099 |
| S2 | ND | 739 | 2013 |

## 4. Conclusions

In this study, as part of the study to remove the RE elements from the TRU product, which is a product of pyroprocessing, it was shown that experiment using $UCl_3$ as an oxidant allowed the RE elements to be effectively eliminated from an (U/RE) alloy.

## ACKNOWLEDGEMENT

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## REFERENCES

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[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).