

Electrochemical Formation of RE-Mg Alloy in LiCl-KCl-RECl₃ Molten Salt

Gha-Young Kim* and Sung-Jai Lee

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

*gkim@kaeri.re.kr

1. Introduction

Pyroprocessing is considered as a potential option for an innovative nuclear fuel cycle to attain the sustainable use of nuclear energy [1]. The spent oxide nuclear fuel is reduced through electrolytic reduction process and then the fuel components (U and TRU) are recovered from the reduced fuel at electrorefining process. After the recovery of U and TRU, there are abundant amounts of rare earth elements (RE) in the salt. The molten salt needs to be recycled to minimize the secondary generation of radioactive waste and the amount of radioactive waste and, for this purpose, the RE remained in the salt should be removed.

The molten salt electrolysis method is an efficient method to produce and/or recover rare earth metals. In this work, we observed the electrochemical formation of RE-Mg alloy in a LiCl-KCl-RECl₃ molten salt at 773 K by potentiostatic electrolysis.

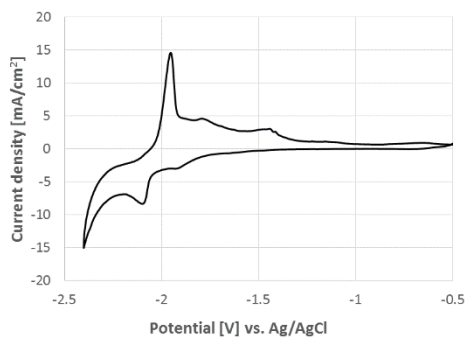
2. Experimental

All the experiments were performed in a glove box with an Ar(g) atmosphere ($H_2O < 1$ ppm; $O_2 < 3$ ppm). A mixture of LiCl-KCl eutectic salt (99.99%purity, Sigma-Aldrich) and RECl₃ (RE: Dy and Gd, 99.99%purity, Alfa-Aesar) was prepared in an alumina crucible. The CV measurements were conducted with Mo wire (1 mm diameter) and Mg plate (2 mm×5 mm) as a working electrode and a

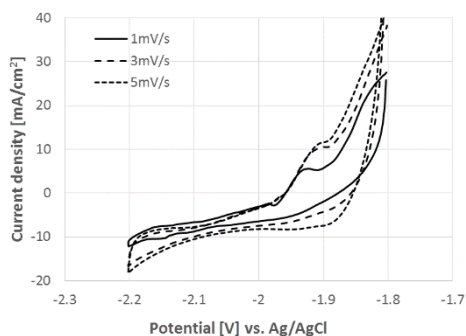
glassy carbon rod (3 mm diameter, Alfa-Aesar) as a counter electrode, and a Ag/1 mol%AgCl as a reference electrode. Electrochemical experiments were carried out by Bio Logic SP-300 potentiostat/galvanostat. The cross-sectional morphology of the RE-deposited Mg was observed with scanning electron microscopy (SEM) (Hitachi, S-8010).

3. Result and discussion

Fig. 1 shows the CV results using Mo wire and Mg electrode in LiCl-KCl-DyCl₃-GdCl₃ at 773 K. At Mo electrode, the reduction peaks of Dy³⁺ to Dy and Gd³⁺ to Gd were observed at -1.90 V and -2.06 V vs. Ag/AgCl, respectively (Fig. 1a). However, these reduction peaks were not clearly found at Mg electrode and it was due to the formation of RE-Mg alloy. The formation potentials of Dy-Mg and Gd-Mg alloy were assumed about -1.88 V and -1.94 V vs. Ag/AgCl, respectively. According to the phase diagram, one Dy-Mg alloy (DyMg) and four Gd-Mg alloys (GdMg_n, where n = 1, 2, 3, 5) can be obtained at 773 K [2], but only one peak of Gd-Mg alloy formation was found in Fig. 1b.



(a)



(b)

Fig. 1. Cyclic voltammety measurement of (a) Mo and (b) Mg electrode in LiCl-KCl-DyCl₃-GdCl₃ at 773 K (scan rate: (a) 100 mV/s, (b) 1, 3, 5 mV/s).

To confirm the electrochemical formation of RE on Mg electrode, potentiostatic electrolysis was conducted in LiCl-KCl-DyCl₃(0.15wt%)-GdCl₃(0.59wt%) at -1.9 V for 12 h at 773 K. The RE deposit on Mg electrode was visually examined and the deposited RE layer was confirmed by the analysis of cross-sectional area of the RE-positied Mg electrode.

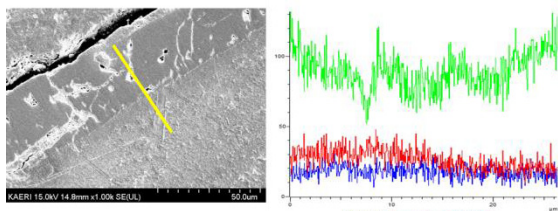


Fig. 2. The cross-sectional image and elemental analysis of RE-deposited Mg electrode.

4. Conclusions

In this study, we reported the electrochemical formation of RE-Mg alloy in LiCl-KCl-RECl₃. CV result showed formation of RE-Mg alloys and the electrodeposition of RE on Mg electrode was confirmed by employing potentiostatic electrolysis.

ACKNOWLEDGEMENT

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