

# Electrolytic Behaviors in Large-scale LCC Electrowinning System

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## 1. Introduction

Electrowinning is a process to recover uranium and transuranic elements using liquid cadmium cathode (LCC) [1,2]. Major components such as electrodes should be remotely handled and relatively easily replaceable to operate the large-scale electrowinning system. In this paper, the performance of electrodes and LCC crucible was evaluated through cyclic voltammetry (CV) and electrodeposition experiments.

## 2. Experimental

Fig. 1 shows the photographs of graphite anode, reference, monitoring electrode and LCC assembly. Monitoring electrode is composed of glassy carbon anode and tungsten (W) electrode. In order to obtain cyclic voltammogram (CV), monitoring electrode and reference electrode are used. Graphite anode, reference and LCC assembly are used to conduct electrodeposition experiment, where LCC crucible containing LCC is loaded in the LCC assembly. Main frames of electrodes and LCC assembly are usually made of stainless steel (SUS). During the electrolysis experiment, current should flow between anode and cathode in electrolytic salt. So, insulated material is respectively inserted to the electrodes and LCC assembly to block electric current to flow to surrounding SUS parts such as lid and vessel through the salt. The insulated material is  $\text{Al}_2\text{O}_3$  and shown in Fig. 1(a) ~ (c). LCC crucibles used at this study are  $\text{Al}_2\text{O}_3$  and BeO. The used salt is the mixture of  $\text{LiCl-KCl}$ ,  $\text{UCl}_3$ ,  $\text{NdCl}_3$ ,  $\text{CeCl}_3$  and  $\text{LaCl}_3$ .

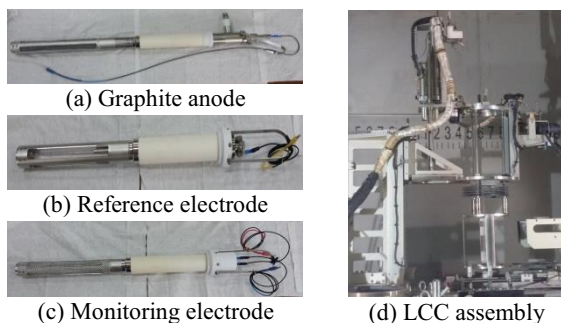
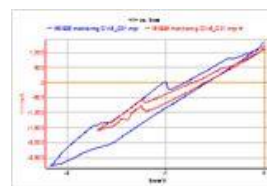


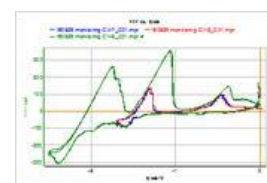
Fig. 1. Electrodes and LCC assembly used in LCC electrowinning system.

## 3. Results and Discussion

After the LCC assembly is loaded into the salt, CVs are acquired using the W cathode. Fig. 2 shows the current values of CVs depending on the connection/disconnection of ground cable of power source. When the ground cable is connected to the potentiostat, the value of reduction current is about -2.500 mA (Fig. 2(a)). On the contrary, when the cable is disconnected, the value is approximately -200 mA. The current values of Fig. 2(b) are more reasonable when compared with the area of the W cathode dipped into the salt. So, the following electrodeposition experiments were conducted using ungrounded potentiostat.



(a) grounded potentiostat



(b) ungrounded potentiostat

Fig. 2. Cyclic voltammograms at standard mode depending on the loading LCC assembly into the salt contained in the SUS electrolytic vessel.

Fig. 3(a) shows the potential change of anode and cathode at constant current density ( $50 \text{ mA/cm}^2$ ) for 20 hours aiming recovering  $7\text{wt}\% \text{M/Cd}$  ( $\text{M}=\text{U}$ , RE metals). Anode potential is nearly constant around 3V during the electrodeposition and cathode potential changed from -5V at initial time to -3.5V at ending time. The change of the cathode potential is thought to be related to the U/RE deposits reducing into the LCC. Fig. 3(b) shows the  $\text{Al}_2\text{O}_3$  crucible containing salt/Cd and U/RE deposit after electrodeposition.

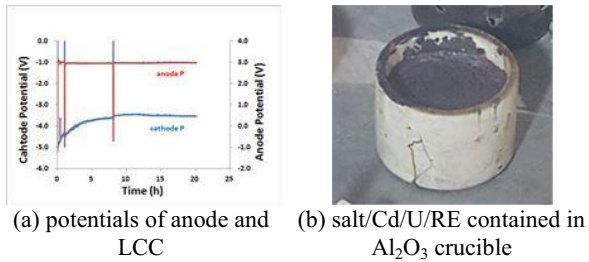


Fig. 3. Electrodeposition result carried out using LCC at  $50 \text{ mA/cm}^2$  at  $500^\circ\text{C}$ .

Fig. 4(a) shows the potential change of anode and cathode at constant current density ( $70 \text{ mA/cm}^2$ ) for 14.5 hours to recover  $7\text{wt}\%\text{M/Cd}$ . Both anode potential and cathode potential are moving upward showing similar vibration behavior. That is, the anode potential moved from  $3.8\text{V}$  at initial time to  $5.8\text{V}$  at ending time and the cathode potential from  $-4.7\text{V}$  to  $-3.2\text{V}$ . Fig. 3(b) shows the BeO crucible containing salt/Cd and U/RE deposit. Some deposits are seen to climb on the edge of the crucible.

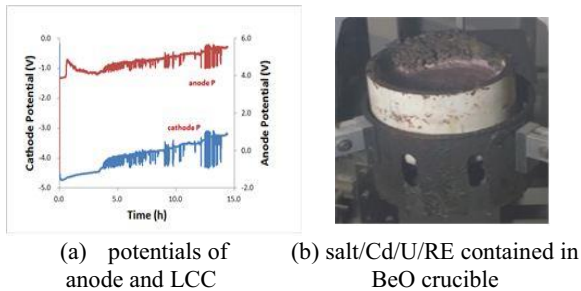


Fig. 4. Electrodeposition result carried out using LCC at  $70 \text{ mA/cm}^2$  at  $500^\circ\text{C}$ .

#### 4. Summary

In this paper, electrolytic behavior of large-scale LCC electrowinning system was studied. Reasonable CV behavior was obtained using ungrounded power source after dipping of LCC assembly into the electrolytic salt. Electrodeposition experiments were successfully conducted at the current densities of  $50$  and  $70 \text{ mA/cm}^2$ .

#### REFERENCES

- [1] Vaden, D.; Li, S.X.; Westphal, B.R.; Davies, K.B. (2008) Engineering-scale liquid cadmium cathode experiments. Nucl. Tech. 162:124-128.
- [2] Kato, T.; Inoue, T.; Iwai, T.; Arai, Y. (2006) Separation behaviors of actinides from rare-earths in molten salt electrorefining using saturated liquid cadmium cathode. J. Nucl. Mater. 357:105-114.