LiCl-KCl-UCl_3 Salt production and Transfer for the Uranium Electrorefining

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1. INTRODUCTION

A pyrometallurgical partitioning technology to recover uranium from an uranium-TRU mixture which is the product material of electroreduction system is being developed at KAERI since 1997. In the process, the reactor of an electrorefiner consists of the electrodes and the molten chloride salt which is LiCl-KCl-UCl_3. The role of uranium chloride salt (UCl_3) is to stabilize the initial cell voltage between electrodes in the electrorefining reactor. The process to produce a uranium chloride salt includes two steps: a reaction process of gaseous chlorine with liquid cadmium to form the $CdCl_2$ occurring in a Cd layer, followed by a process to produce UCl_3 by the reaction of U in the LiCl-KCl eutectic salt and $CdCl_2$.[1] The apparatus for producing UCl_3 consists of a chlorine gas generator, a chlorinator, and a off-gas wet scrubber. The temperature of the reactants are maintained at about 600℃. After the reaction is completed, the product salt is transferred from the vessel to the electrorefiner by a transfer system.

2. EXPERIMENTAL

The UCl_3 chlorinator equipment for making the uranium chloride salt used in this work is shown in Fig.1. It consists of a muffle furnace, a reactor, a chlorine and argon gas supplying system, an effluent gas collecting system, a personal computer and recorder system. Molten salt in the stainless steel(SUS) reactor vessel was mixed by SUS blades attached to the uranium basket.

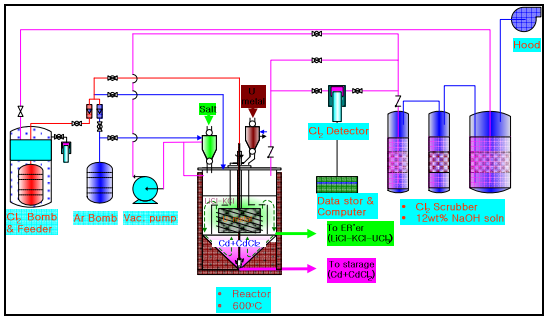

Fig.1.Conceptual diagram of UCl_3 production equipment.

Argon gas was supplied into the reactor in order to control argon atmosphere in the reactor as well as some time, to control the flow velocity of chlorine gas. A eutectic salt, LiCl-KCl (59-41 mol %) of 716g per batch was prepared at 600℃. At the same time, an uranium metal of 1,013g/batch and a Cd metal of 789g per batch were prepared in order to making UCl_3. Chlorination experiments with chlorine gas in the molten salt was carried out for 6 hrs at 600℃. A chlorine gas supply nozzle in the UCl_3 chlorinator was a 1/4" stainless steel 316 tube at the initial stage of the experiment and as the experiments goes on, the nozzle was switched to a quartz tube of 6mm in diameter due to corrosion resulting in blocking off the stainless steel nozzle. In order to

obtain the optimum velocity of chlorine gas flow to avoid this blockage occurring at the nozzle tip, the gas supply rate was varied in the range of 30~450ml/min. Sampling time interval from the reactor was 6hrs. The chemical analyses of the samples were done by using an XRD.

3. RESULTS AND DISCUSSION

The product of the chlorination reaction after for 6 hrs at 600 ℃ was a pure eutectic LiCl-KCl-UCl3 salt. An XRD analysis result of the salt product after chlorination reaction showed the product to be a salt, as shown in Fig.2.

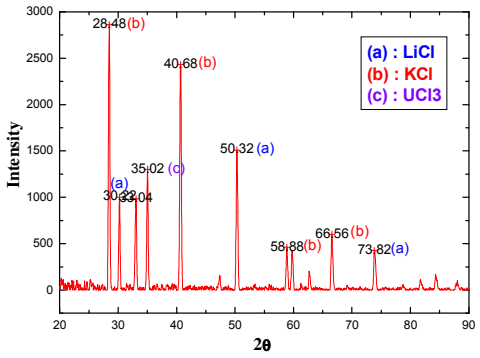

Fig.2.Result of XRD analysis after UCl_3 making experimental.

In this experiment, the cause of the nozzle blockage was found to be a residual oxygen impurity in the chlorine gas, so this problem was solved by controlling the gas linear velocity at the nozzle tip to be higher than 12.7m/min. Then, the LiCl-KCl-UCl_3 salt product was transferred from the chlorinator to a pelletizer through a pressurized transfer system in order to make the pellets of LiCl-KCl-UCl_3 salt. The temperature of the tubing lines of the pressurized transfer system has to be maintained at about 400℃. Added pressure in the transfer system was kept to be 3 bar/cm^2 using argon gas. The pellet type salt was made from the transferred salt at 90℃, as shown in Fig.3.

Fig.3.Photograph of a LiCl-KCl molten salt pellet in the mold

4. CONCLUSION

A pure LiCl-KCl-UCl_3 eutectic salt was prepared using the chlorinator made in this study and its purity was confirmed from the XRD analysis. Finally the pellet type salt was made at 90℃ by the pelletizer from the pure LiCl-KCl-UCl_3 salt made in this study which was transferred by the pressurized transfer system maintained at about 400℃. In addition, a quartz tube as the chlorine gas supply nozzle in the UCl_3 chlorinator was found to be better than a stainless steel tube in this study.

REFERENCES

[1] Miller et al , “Method for Making a Uranium Chloride Salt Product”, Patent No.: US 6,800,262B1, Date of Patent: Oct.5,2004.