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INTRODUCTION

Pyrochemical processing is a promising technology for closing the nuclear fuel cycle for next generation nuclear reactors. At Idaho National Laboratory (INL), such a pyrochemical process has been implemented for the treatment of spent fuel from the Experimental Breeder Reactor (EBR-II). A successful demonstration of the technology was performed from 1996 to 1999 for the Department of Energy (DOE) [1]. Since 2002, processing of the spent fuel and associated research and development activities have been carried out under DOE's Advanced Fuel Cycle Initiative (AFCI) program. Electrorefining is considered to be the signature or central technology for pyrochemical processing. This paper summarizes recent experience and results in electrorefining, specifically focusing on electrochemical dissolution of spent EBR-II driver fuel in the Mark-IV (Mk-IV) electrorefiner (ER).

EXPERIMENTS, RESULTS, AND SUMMARY

The results reported here were obtained from the Mark-IV electrorefiner, located in the Fuel Conditioning Facility (FCF) at INL. Descriptions of the major components of the ER and the process in general have been provided elsewhere [2].

During the EBR-II spent fuel treatment demonstration project (1996 -1999), the goal for the electrorefining of spent driver fuel was to achieve total noble metal retention in the cladding hulls. Achieving a high extent of U dissolution was also considered desirable, but noble metal retention was not sacrificed for the sake of improving U dissolution. The uranium dissolution was reported to be 96 wt% when greater than 85 wt% of noble metal was retained [2]. Under the guidance of the AFCI program, more of an emphasis has been placed on achieving complete uranium dissolution. Mk-IV ER operating parameters have, thus, been adjusted to meet this goal. During the demonstration, an anode cut-off voltage (the voltage difference in between the anode and a reference electrode) of 0.4V was used to achieve 96 wt% of uranium dissolution and greater than 85 wt% noble metal retention [2] [3]. An analysis of the experimental data indicated that the anode resistance would be a better operational parameter to meet the AFCI goals. Therefore, an anode cut-off resistance of 30 m-ohm has been used as the endpoint to achieve a near complete uranium dissolution from the cladding materials.

Table 1 lists dissolution results of spent driver fuel from recent electrorefining runs under the modified operating conditions. The data shown in the table are the weight percentages of elements dissolved from the anode baskets after the electrorefining process. The percentages of the elements dissolved were determined by the ratio of the elements or isotope left in the cladding hulls in relation to their original quantities in the feed. The quantity of an element left in the cladding hulls was determined through specific sampling and analytical techniques.

The data in Table 1 indicate that an average 99.7 wt% uranium dissolution has been achieved when using the anode resistance as the processing endpoint. As expected, approximately 88 wt% of zirconium was removed from the cladding hulls under such operating conditions. Nevertheless, on average, approximately 77% of technetium, 73% of molybdenum, and 74% of ruthenium were retained in the cladding hulls when this much zirconium was dissolved. The results given in Table I demonstrate that the electrorefining process can dissolve nearly all the uranium from the spent driver fuel while retaining approximately three quarters of noble metal fission products within the cladding hulls. Most of the removed zirconium accumulated in the cadmium pool at the bottom of the ER vessel and can be electrochemically recovered subsequently from the ER. The zirconium recovery experiments and results are summarized in a separate report [4].

Table 1. Uranium and Noble Metal Dissolution from Spent EBR-II Driver Fuel (wt %)

Batch ID	U	La	Ce	Nd	Zr	Tc	Mo	Ru
ERBF005	99.82	100.00	100.00	100.00	87.37	47.18	49.87	52.66
ERBF006	99.50	100.00	100.00	100.00	83.77	10.98	17.82	13.36
ERBF007	99.73	100.00	100.00	100.00	88.69	0.34	17.80	10.64
ERBF008	99.94	99.12	99.86	99.79	97.54	40.23	43.52	49.11
ERBF009	99.82	98.42	99.84	99.93	94.86	44.59	38.54	43.93
ERBF010	99.89	99.34	99.82	99.75	93.01	18.11	23.50	25.42
ERBF011	99.81	100.00	100.00	100.00	74.10	13.48	22.44	17.81
ERBF012	99.68	100.00	100.00	100.00	87.47	13.52	13.01	9.19
ERBF013	99.61	100.00	100.00	100.00	82.88	34.02	34.83	34.91
ERBF014	99.84	100.00	96.52	100.00	94.13	38.12	45.14	43.53
ERBF015	99.53	100.00	100.00	100.00	82.23	10.28	12.44	5.13
ERBF016	99.45	100.00	100.00	100.00	88.15	10.14	8.93	6.36
Average	**99.72**	**99.74**	**99.67**	**99.96**	**87.85**	**23.42**	**27.32**	**26.02**
STDV	**0.16**	**0.51**	**0.99**	**0.09**	**6.55**	**16.20**	**14.32**	**17.92**

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REFERENCES:

1. “Electrometallurgical Techniques for DOE Spent Fuel Treatment: Final Report,” National Research Council, National Academy Press, Washington, DC (2000).

2. S. X. Li and M. F. Simpson, “Anodic Process of Electrorefining Spent Driver Fuel in Molten LiCl-KCl-UCl_3/Cd System,” *Journal of Mineral and Metallurgical Processing,* Nov. 2005.

3. S. X. Li and et al., “Initial Results for the Electrochemical Dissolution of Spent EBR-II Fuel, *“Proceedings of the DOE Spent Nuclear Fuel and Fissile Materials Management*, American Nuclear Society, Charleston, SC, September 8-11, 1998.

4. S. X. Li and et al, “Electrochemical Co-Collection of Uranium and Zirconium in Mk-IV Electrorefiner for Treating Spent EBR-II Driver Fuel,” *Trans. American Nucl. Soc., ANS,* 93, pp. 741, 2005.