Application of Acid Dissolution and Natural Evaporation to Wet Cake containing Uranium

Kil J. Kim, Il Sik Kang, Jong S. Shon, and Kwon P. Hong
Division of Nuclear Fuel Cycle Examination Facility, Korea Atomic Energy Research Institute

1. Introduction

Chemical wastes containing small amounts of uranium cause environmental problems, if those wastes exceed the concentration of the EPA standard, 20 ㎍㎍ /L, and the concentrated sludge should be additionally dried and packaged into a drum, and categorized as a radioactive waste.

Diphosil resin is developed to specifically remove actinides or multivalent metals. The immobilization technique is adopted to make a bead form of Diphosil by embedding into sodium alginate, and adsorption characteristics for uranium are reported for a simulated waste solution. [1]

In this study, acid dissolution is applied to dissolve uranium from the precipitates of sludge or the dewatered cake in the reduced volume of wastes solution, and removal characteristics of uranium is experimented. From the results, the most effective treatment method for the dissolved solution is suggested.

2. Experimental Methods

2.1 Preparation of Sodium alginate-Diphosil Bead

Sodium alginate is solved into the deionized water with a constant stirring, and the Diphosil powder is introduced into the mixing solution very slowly because of the insolubility in water. Then, the stirring is slowed down to remove the air bubbles within the mixed solution.

The mixture of sodium alginate and Diphosil powder with water is transferred into the injector and dropped into 0.1M $CaCl_2$ solution. The bead produced is washed with the deionized water and stored at room temperature.

3. Results

3.1 Removal Characteristics of Uranium

Removal capacity of uranium from the simulated solution is measured using the sodium alginate-4%Diphosil(AD) bead and Diphosil powder(DPS) itself through adsorption and resorption. AD bead shows unit adsorption capacity of 5.3 mg in the low concentration of uranium and 4.3 mg in the higher range, respectively. Diphosil itself marked a higher adsorption capacity of 11.2 mg and 18.2 mg in the low and higher concentration of uranium, respectively.

But, AD bead shows an good adsorption capacity, considering the Diphosil content in 0.25g of AD bead and 0.15g of pure Diphosil.

Table 1 Characteristics of Adsorption and Resorption of Uranium

Resins	Amount g	U Concent -ration mg/L	Adsorp -tion	Resorp -tion	Adsorp -tion Capacity mg/g
			U Concentration mg/L		
AD	0.25	9.2-9.5	0.6	4.8	5.3
	0.5		0.3	0.5	3.6
	1.0		0.3	0.1	1.8
	1.5	48-49	2.4-4.0	30	4.3
	2.0		1.2-2.7	15	4.0
	2.5		0.9-2.1	8.3	3.5
DPS	0.15	9.2-9.5	1.8	<0.1	11.2
	0.25		2.9	<0.1	6.3
	0.35		3.8	<0.1	4.2
	0.5	48-49	5.6-7.3	0.3	18.2
	0.75		7.3-7.8	0.2	11.9
	1.0		8.1-9.2	0.3	8.9

3.2 *Acid Dissolution of Uranium from Waste Sludge and Wet Cake*

It is reported in the previous study[2] that most of uranium was presented in the precipitates of waste sludge. Acid dissolution was applied to extract uranium from waste sludge reduced from the generated volume. The higher concentration of uranium was obtained from the dissolution by the concentrate HNO_3 than the 1:1 HNO_3, and little differences was found between the heating time of 5 and 10 hours. The concentrations of the dissolved uranium from the different addition of concentrate HNO_3 were almost same and there was little effect between stirring and stirring with heating. Accordingly, waste sludge was dissolved using concentrate HNO_3 with the ratio of one fourth to sludge without heating, showing the maximum uranium concentration with 2.0 mg/L.

On the contrary, in the dissolution of uranium from the dewatered cake of sludge, heating with stirring was more effective to get a higher dissolved concentration of uranium with 11 mg/L.

Table 2 Effect of Increasing Amount of HNO_3 and Heating on the Uranium Dissolution from Wet Cake

Conditions	Wet Cake g	HNO_3 ml	U Concentration mg/L
Stirring	15.008	10	8.9
	15.004	15	6.9
	15.021	20	6.0
Stirring and Heating(66°C)	15.065	10	11
	14.995	15	7.4
	14.999	20	5.8

3.3 *Application of Uranium Adsorption to the Dissolved Solution from the Real Waste*

It was found by analysis that when sludge is dissolved, a large amount of metal ions were simultaneously dissolved with uranium from the precipitates, and the amount of resin needed is equivalent to the dissolved solution. IRN-77 and Diphosil bead were used separately or in a mixed form to effectively remove other metal ions by IRN-77 and then selectively absorb uranium ion by Diphosil bead.

But there were little differences between the concentrations obtained by single or mixed form of each resin.

Table 3 Effect of Mixed and Separate Bed with IRN-77 and AD Bead on the Uranium Adsorption

Methods	Resins		Adsorp-tion Time d	U Concent-ration mg/L	U Residue mg/L
Mixed	IRN-77	5 ml	3	2.2	0.45
	AD	5 g			
Separate	IRN-77	5 ml	2		0.55
	AD	5 g	3		

3.4 *Alternative Treatment Method for the Real Waste Solution*

The Natural Evaporation Facility(NEF) in KAERI could be applicable, if uranium concentration is quite low and the volume to be treated is relatively small. The annual volume of the dissolved solution from dewatered wet cake is estimated to be below 30 m^3 from 16 m^3 of wet cake.

Activity analysis shows that the content of uranium in the dried cake is 115 μg/g, and specific activity is calculated to be 1.12E+01 Bq/g from the isotopes ratio.

Table 4 Isotopes Ratio and Activities of Uranium in the Dried Cake of Waste Sludge

Isotopes	Weight Ratio	Uran-ium μg/g	U Amount μg/g	Specific A Bq/μg	Concentra-tion Bq/g
U-234	0.0368	115	0.0423	2.263E+02	9.57E+00
U-235	2.7215		3.122	7.64E-02	2.39E-01
U-236	0.0086		0.0099	2.318E+00	2.29E-02
U-238	97.2332		111.82	1.233E-02	1.38E+00
Total	1.12E+01 Bq/g				

The concentration of the dissolved solution is 6.97E-01 Bq/ml. It was found that the specific activity of uranium on the waste sheets after evaporation by NEF is estimated to be 3.4 Bq/g, which is about one third of the exemption level of 10 Bq/g for each uranium isotopes.

Table 5 Evaluation of Activity in the Final Waste Sheet after Evaporation

Dry Cake m^3/y	Precipi-tates m^3/y	U Concent-ration Bq/g	Annual Activity MBq	Evaporation Sheets		Activi-ty Bq/g
				Units EA	Weight g/EA	
4.0	2.4	11.2	26.88	1,000	788	3.4

4. Conclusion

These results lead to the conclusion that the natural evaporation is effectively applicable to the dissolved solution from wet cake, and the final evaporation sheets from the facility could be disposed of as exemption wastes.

REFERENCES

[1] Kil. J. Kim, Jong S. Shon, et al., “Removal of Uranium by Sodium alginate–based Diphosil Bead”, Waste Management ‘04 Conference, Feb.29-Mar.4 (2004)

[2] Young H. Lee, Kil. J. Kim, Jong S. Shon, et al., “Alternative method for the Treatment of Waste Sludge containing Uranium”, Proceeding of the Korean Nuclear Society Autumn Meeting, 10.28-29 (2004)

Acknowledgement

The authors are thankful to Mr. Choi, Kwang Soon and Dr. Park, Kyung Kyun for providing the useful advices and chemical analysis.