

## Removal of Uranium by Exchanger Resins from Soil Washing Solution

Seung Soo Kim\*, G. S. Han, G. N. Kim, D. S. Koo, J. W. Jeong, J. K. Moon  
Decontamination and Decommissioning Research Div., Korea Atomic Energy Research Institute  
1045 Daedeok-daero, Yusong-gu, Daejeon, 305-353  
\*Corresponding author: nsskim@kaeri.re.kr

### 1. Introduction

Great amounts of radioactive soil waste had been generated from the decommissioning of a uranium conversion plant at KAERI. A volume reduction of the concrete waste by appropriate treatment technologies will decrease the amount of waste to be disposed of and result in a reduction of the disposal cost and an enhancement of the efficiency of the disposal site.

Our group has developed a decontamination process with washing and electrokinetic methods for uranium-contaminated (U-contaminated) soil. However, this process generates a large amount of waste solution containing various metal ions. If the uranium selectively removed from the waste solution, a very small amount of the 2<sup>nd</sup> waste would be generated. Thus, selective sorption of uranium by ion exchange resins was examined in this study.

### 2. Experiment and Results

#### 2.1 Sorption of uranium by an ampholyte resin

The sorption of uranium from the washing solutions by an ampholyte resin (hereafter it is called AM-resin) was tested. Two washing solutions, Solution 1 and Solution 2, were sampled after the 1<sup>st</sup> washing and from the electrokinetic decontamination eluent, respectively. The dominant ions dissolved in two solutions are shown in Table 1. Uranium sorbed on the AM-resin was desorbed by two methods; dynamic and batch-type methods. The detailed procedure for the sorption and desorption of uranium by AM-resin is as follows.

##### 1<sup>st</sup> experiment

- ① The washing solution was filtered with a Whatman 4 filter paper.
- ② 10 g of AM-resin was added into 100 mL of filtrate.
- ③ The solution was stirred for 2 hours at 100 rpm, and then left for more than 12 hours.
- ④ The solution was filtered with a Whatman 4 filter paper.
- ⑤ A new sheet of Whatman 4 filter paper was folded into a funnel-shape, and put onto a funnel.
- ⑥ 5 g of AM-resin from ④ was added to the funnel-shaped filter paper.

- ⑦ AM-resin was washed 10 times to desorb ions at 5 mL/time of 0.5 M Na<sub>2</sub>CO<sub>3</sub>, preheated to 60°C, in dynamic mode at an elution rate of about 10 mL/min.
- ⑧ The solution and resin were sampled before and after sorption, and after the desorption experiment, respectively.
- ⑨ 3 mL of concentrated sulfuric acid was added to 0.5 g of AM-resin sampled in ⑧, and heated at about 250°C on a hotplate to dissolve the resin.
- ⑩ 15-20 mL of concentrated nitric acid was added and heated until the solution was clear.
- ⑪ The final volume of the solution was adjusted to 50 mL with 1% nitric acid.
- ⑫ The solutions from ⑧ and solutions dissolved resin from ⑪ were analyzed using ICP-AES.

##### 2<sup>nd</sup> experiment

- ① The sorption of uranium from the electrokinetic decontamination eluent by the AM-resin was performed as the same procedure of ①-④ in above 1<sup>st</sup> experiment.
- ② The resin was dried for 24 hours at room temperature.
- ③ After mixing, 4 g of the resin was added into a 500 mL of Teflon bottle.
- ④ 50 mL of 0.5 M and 1.0 M Na<sub>2</sub>CO<sub>3</sub> solutions were added into the bottles, respectively.
- ⑤ The bottles were shaken for 5 hours at 60 rpm in the shaker adjusted to 60°C.
- ⑥ The solution was filtered with a Whatman 4 filter paper.
- ⑦ The filtrate was analyzed using ICP-AES.

From the sorption experiment of uranium by AM-resin in the 1<sup>st</sup> washing solution and the electrokinetic decontamination eluent, Table 1 was obtained. This table shows that the relative sorption efficiency for uranium is greater than those of other dominant ions in both waste solutions, and trivalent ions (Fe and Al) relatively adsorbed greater than divalent ions (Ca and Mg) in the 1<sup>st</sup> washing solution (pH 1.50). However, iron sorption was significantly decreased in the

electrokinetic decontamination eluent (pH 2.66). From a comparison between the two solutions, uranium might be removed more effectively at pH 2.66 than at pH 1.50. In the 2<sup>nd</sup> experiment of section 2.4.1, 97% of uranium was sorbed on AM-resin, and 90% of uranium was desorbed from the resin by a batch-type washing with 0.5 M Na<sub>2</sub>CO<sub>3</sub> solution at 60 °C [14], though desorption rate by washing with 1.0 M Na<sub>2</sub>CO<sub>3</sub> solution was a little decreased unexpectedly. However, uranium sorbed on AM-resin was hardly desorbed by a dynamic washing with a 60 °C heated 0.5 M Na<sub>2</sub>CO<sub>3</sub> solution at the fast flow rate of about 10 mL/minutes.

### 2.2 Sorption of uranium by an anion exchanger resin

Rahmati et al. [1] reported that uranyl sulfate anion complexes such as UO<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub><sup>2-</sup> and UO<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub><sup>4-</sup> are formed in 0.02–9.0 M of the sulfuric acid solution, and 70–80 % of these complexes were adsorbed by IRA 910, a strong anion exchanger. Thus, the soil was washed with 1.0 M sulfuric acid solution instead of nitric acid, and the solution was filtered. Then, a sorption test by IRA 910 was performed with the filtered solution as follows.

- ① IRA 910 resin was activated in the dilute NaOH solution and washed with demineralized water.
- ② 1.0 g of activated IRA 910 resin was put into 50 mL of soil washing sulfuric acid solution.
- ③ After 2 hours of shaking, the supernatant was collected.
- ④ The activity of the solution was measured.

Unlike in the literature, the concentration of uranium in a soil washing solution by 1.0 M sulfuric acid was not significantly changed after the sorption by IRA 910. The little sorption of uranium onto the strong anion exchange resins in 0.1–2.0 M sulfuric acid may be due to the low formation of UO<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub><sup>2-</sup>(aq) and UO<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub><sup>4-</sup> (aq) [2] and/or the hindrance of sulfate ions [3].

### 3. Conclusions

Uranyl ions in the acidic waste solution were sorbed on AM-resin resin with a high sorption efficiency, and desorbed from the resin by a batch-type washing with a 60 °C heated 0.5 M Na<sub>2</sub>CO<sub>3</sub> solution. However, the uranium dissolved in the sulfuric acid solution was not sorbed onto the strong anion exchanger resins.

### REFERENCES

- [1] A. Rahmati, A. Ghaemi and M. Samadfam, Kinetic and Thermodynamic Studies of Uranium(VI) Adsorption Using Amberlite IRA-910 Resin, Ann. Nucl. Energy, Vol.39, p.42, 2012.
- [2] A. Burneau, M. Tazi and G. Bouzat, Raman Spectroscopic Determination of Equilibrium Constants of Uranyl Sulphate Complexes in Aqueous Solutions, Talanta, Vol.39, p.747, 1992.
- [3] A. C. Q. Ladeira and C. R. Goncalves, Influence of Anionic Species on Uranium Separation from Acid Mine Water Using Strong Base Resins, J. Hazard Mater., Vol.148, p.499, 2007.

Table 1 The concentration of ions in solution before and after sorption, and after desorption by AM-resin

			Concentration (g/L)				
			Fe	Al	Ca	Mg	U
1 <sup>st</sup> experiment <sup>a</sup>	Solution 1 <sup>b</sup>	Before sorption	0.89	10.6	16.6	2.23	0.64
		After sorption	0.22	8.39	15.5	2.09	0.087
	Solution 2 <sup>b</sup>	Before sorption	0.31	9.78	11.7	2.01	0.32
		After sorption	0.29	7.51	11.5	1.95	1.0E-2
2 <sup>nd</sup> experiment <sup>a</sup>	Solution 2 <sup>b</sup>	Before sorption					0.31
		After sorption					9.4E-3
	Desorption solution <sup>b</sup>	0.5 M Na <sub>2</sub> CO <sub>3</sub>					0.22
1.0 M Na <sub>2</sub> CO <sub>3</sub>						0.18	

<sup>a</sup>Desorption of uranium from the AM-resin in 1<sup>st</sup> experiment and 2<sup>nd</sup> experiment was performed dynamic and batch-type methods, respectively.

<sup>b</sup>Solution 1 and Solution 2 were sampled after the 1<sup>st</sup> washing (pH 1.50) and from the electrokinetic decontamination eluent (pH 2.66), respectively.