Study on Cs^+ Separation by Using Ionic Liquid-Solid Extraction System

Seung-Yeon Cho*, Jung-Weon Choi, Hyo-Jeong Lee, Won-Zin Oh, and Sang-June Choi
Kyungpook National University, 80, Daehak-ro, Buk-gu, Daegu, Republic of Korea
*tmddus2049@knu.ac.kr

1. Introduction

In our previous study, we reported that Cs^+ solid-liquid separation was observed when a small quantity of the ionic liquid(IL) was used for Cs^+ extraction from liquid radioactive waste. The Cs^+ selective separation performance of the IL extraction system in the study was evaluated by comparing with that of the conventional Cs^+ selective adsorbents such as MWCNTs-EDA-CuFC (adsorbent-1) and mag@silica-CuFC (adsorbent-2) prepared by Lee et al. [2,3].

2. Experimental

2.1 Materials and reagents

Cesium nitrate ($CsNO_3$, 99%) and the crown ether extractant dicyclohexano-18-crown-6 (DCH18C6, 98%) were purchased from Sigma-Aldrich Chemical Co. (Germany). The ionic liquid 1-ethyl-3-methylimidazolium bis(trifluoro-methylsulfonyl)imide (C_2mimTf_2N) was purchased from C-TRI Co. Ltd. (Korea).

2.2 Experimental method

$CsNO_3$ solutions of concentrations 0.1, 1, 5, 10, 15 and 20 mM were prepared. DCH186 is dissolved to C_2mimTf_2N in the conical tube. The mixture was shaken with 40 mL of $CsNO_3$ solution for Cs^+ extraction. After extraction, the Cs^+ concentration of aqueous phase was analyzed using ICP-OES (Optima 2100 DV, PerkinElmer).

3. Results and discussion

3.1 Cs^+ separation performance

To compare the quantity of waste with adsorption system, the ratio of removed Cs^+ to the weight of precipitate assumed as the sorption capacity. In the Cs^+ extraction using ILs, the precipitate was produced in almost the same molar quantity as the Cs^+ removed by the cation exchange mechanism. These ratios have similar value regardless of Cs^+ concentration. It means that solid-liquid extraction system is especially more efficient at lower concentration of Cs^+ than adsorption process.

Table 1. Comparison of Cs^+ separation performance between the IL solid extraction and the conventional adsorbents of adsorbent-1, 2

C_0_Cs^+ [mmol/L]	q_e [mmol_Cs^+ removed/g_waste]		
	ionic liquid Solid Extraction	adsorbent-1	adsorbent-2
0.1	1.2405	0.0423	0.0350
1	1.2685	0.4746	0.3084
5	1.2715	0.9121	0.4863
10	1.2747	1.1253	0.7585
15	1.2732	1.1770	0.6919

3.2 Industrial applicability

The conventional column adsorption process needs pretreatment and considering many factors to design column as shown in table 2. Whereas, the IL solid extraction system only needs injection of ILs and filtration after extraction. Therefore the IL solid extraction system can be considered as much simpler process and easier for industrial application.

Table 2. Comparison of the IL solid extraction system and the conventional column adsorption process

	Column adsorption	IL solid extraction system
Pretreatment	SS/Oil/Turbidity	-
Design factor	1) Particle size of adsorbent 2) Channeling 3) Throughput	1) Amount of ILs and extractant

4. Conclusion

The following conclusions are obtained by comparison of the Cs^+ selective separation performance between the IL solid extraction system and the conventional adsorbents from the liquid radioactive waste treatment point of view:

1) Cs^+ is extracted 1:1 molar ratio of extractant regardless of the Cs^+ concentration in the IL solid extraction system. Therefore, q_e value is constant unrelated to the Cs^+ concentration.
2) In adsorption system, Cs^+ was removed in equilibrium with Cs^+ concentration in the aqueous solution. Therefore, the lower the Cs^+ concentration, the lower the sorption capacity q_e value of adsorbents compared to that of the IL solid extraction system.
3) IL solid extraction system is much easier for industrial applications without the pretreatment of suspended solid particles and oil contamination than the conventional adsorption system.

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