Study on the Common Ion Effect on Cs^+ Extraction by Using Ionic Liquid

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1. Introduction

The radioactive substance, cesium (Cs^+), is the main fission product. It is long half-life and water-soluble.

As a method for removing cesium, there is a method of cation exchange of cation and cesium ions of an Ionic liquid to extract cesium as organic solvent.

In this study, we applied a new extraction method "common ion effect" which extracts cesium ions by combining the common ion and the Cs^+ comparing with conventional extraction method.

2. Experimental details

2.1 Material

1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide ($[C_2mim][Tf_2N]$) was used as an Ionic liquid and Lithium Bis(trifluoromethanesulfonyl)imide ($[Li][Tf_2N]$) was used as the common ion that is same as ionic liquid's anion. Dicyclohexano-18-crown-6 (DCH18C6, 98%, Sigma-Aldrich, Germany) was used as extractant. Cesium nitrate ($CsNO_3$, 99%, Sigma-Aldrich Chemical Co. Korea) was used as a simulated waste solution.

2.2 Method

$CsNO_3$ simulated waste solution was prepared at 0.3, 0.6, and 1.2 mmol concentration. And then 0.6 mmol of $LiTf_2N$ were dissolved to simulated solution, $CsNO_3$. The 0.6 mmol DCH18C6 was dissolved in 2 mmol C_2mimTf_2N. These mixtures of aqueous phase and organic phase was mixed for 2 hours (25 °C, 250 rpm). After extraction, the mixture was centrifuged at 3000 rpm for 10 minutes and filtered aqueous phase using 0.2 μm nylon filter.

An inductively coupled plasma spectrometer (ICP-OES, Optima 2100 DV, Perkin Elmer, USA) was used to measure the residual Cs^+ concentration.

The conventional extraction method is the same process except for common ion ($LiTf_2N$).

3. Results

As you can see, Table 1 shows the distribution coefficient and removal according to Cs^+ concentrations when using the common ion effect method.

Distribution coefficient Cs^+ (D_{Cs}) of generally larger than 10 (D_{Cs} >10) is efficient extraction system. In the common ion effect system, D_{Cs} is much larger than 10, so this is an efficient extraction system.

Table 1. Distribution coefficient and removal of Cs^+ extraction efficiency using common ion effect method.

Cs^+ [mmol]	D_{Cs}	R_{Cs} (%)
0.3	9428.78	99.21
0.6	8957.43	99.14
1.2	84.25	52.02

Following Table 2 shows the distribution coefficient and removal efficiency according to Cs^+ concentrations when using the conventional extraction method.

D_{Cs} is higher than 10 at all concentrations, so it shows high efficient extraction system. However, at 0.6 mmol of Cs^+ concentration, it is slightly lower than the common ion effect method.

Table 2. Distribution coefficient and removal of Cs^+ extraction efficiency using conventional extraction method.

Cs^+ [mmol]	D_{Cs}	R_{Cs} (%)
0.3	20928	99.63
0.6	1453.43	94.91
1.2	82.55	51.51

4. Conclusions

The following conclusions were obtained through this study

1) Conventional cation exchange mechanisms cannot regenerate ionic liquids because cation exchange of ionic liquid and Cs^+ occurs. However, using the common ion effect method of this study, ionic liquid can be regenerated because there is no ionic change of ionic liquid during extraction.
2) Since the selectivity of cesium is higher than that of lithium, the common ion effect method can be effectively separated by the use of a selective extractant for Cs^+.

We will study about "common ion effect" further, using various ionic liquids and extractants to show higher efficiency and commercialize.

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