Adsorption and Separation Behavior of Strontium and Yttrium Using a Silica-based CMPO Adsorbent

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In order to separate Y(III) from Sr(II)-Y(III) mixture, two macroporous silica-based CMPO/SiO_2-P and (CMPO+Dodec)/SiO_2-P adsorbents were synthesized by impregnating CMPO extractant and a molecule modifier 1-Dodecanol into SiO_2-P support, respectively. Furthermore, the adsorption and separation behavior of Sr(II) and Y(III) in HNO_3, HCl or $HClO_4$ medium onto adsorbents were investigated by batch and column methods.

I. INTRODUCTION

In our previous research, Sr(II) could be separated from simulated high level liquid waste (HLLW) using distilled water as elution solution by extraction chromatography [1-2]. For the utilization of large amounts of separated ^{90}Sr from HLLW, ^{90}Y, a daughter nuclide of ^{90}Sr, is expected to be separated from ^{90}Sr-^{90}Y group and used as radioactive material in the medical field [3]. For this purpose, two macroporous silica-based CMPO/SiO_2-P and (CMPO+Dodec)/SiO_2-P adsorbents were synthesized by impregnating CMPO (octy(phenyl)-N,N-diisobutylcarbamoyl-methylphosphine oxide) extractant or with a molecule modifier 1-Dodecanol into macroporous silica/styrene-divinylbenzene copolymer composite support (SiO_2-P), respectively. Adsorption and separation behaviors of Sr(II) and Y(III) in HNO_3, HCl or $HClO_4$ solutions onto the adsorbents were investigated by batch and column methods.

II. EXPERIMENTAL

Adsorption behaviors of Sr(II) and Y(III) ions onto two adsorbents were examined by batch method. 0.2 g weighed quantity of dry adsorbent was mixed into a 13.5 cm^3 glass vial with 4 cm^3 liquid phase solution under 5 hour contact time in a thermostatic shaking bath. This solution contained 5 mM (M = mol dm^{-3}) of Sr(II) and Y(III) ions in different concentrations of HNO_3, HCl or $HClO_4$ medium. After phase separation of the mixture by filtration, concentrations of metal ions in the liquid phase were determined by inductively coupled plasma–atomic emission spectrometer (ICP-AES, Shimadzu ICPE-9000). The distribution coefficients (K_d, cm^3 g^{-1}) and uptake ratios (R, %) of the Sr(II) and Y(III) ions were calculated as follows:

$$K_d = \frac{C_0 - C_e}{C_e} \times \frac{V}{m} \qquad (1)$$

$$R = \frac{C_0 - C_f}{C_0} \times 100 \qquad (2)$$

where C_0, C_f, and C_e are the concentrations of metal ion before adsorption, after adsorption and after reaching equilibrium in the liquid phase, respectively. m, and V are the weight of dry adsorbent in g, and volume of the liquid phase in cm^3, respectively.

III. RESULTS AND DISCUSSION

As shown in figure 1, (CMPO+Dodec)/SiO_2-P showed strong adsorption affinity to Y(III) and weak adsorption for Sr(II) in $HClO_4$ or HNO_3 solution. K_d values of Y(III) increased with the increase of $HClO_4$ or HNO_3 concentration. These indicate that (CMPO+Dodec)/SiO_2-P can selectively separate Y(III) from Sr(II) in $HClO_4$ or HNO_3 solution. Especially, $HClO_4$ was considered to be a dominant medium because large K_d value of Y(III) could be obtained by the addition of small amount of $HClO_4$ to Y(III)-Sr(II) aqueous solution.

In further studies, (CMPO+Dodec)/SiO_2-P adsorbent reflected almost weak adsorption to Sr(II) and Y(III) in HCl solution from 0.001 M to 5 M. In addition, similar results were obtained in experiments using CMPO/SiO_2-P from HNO_3, HCl or $HClO_4$ solutions. The evaluation study for two adsorbents is still in progress.

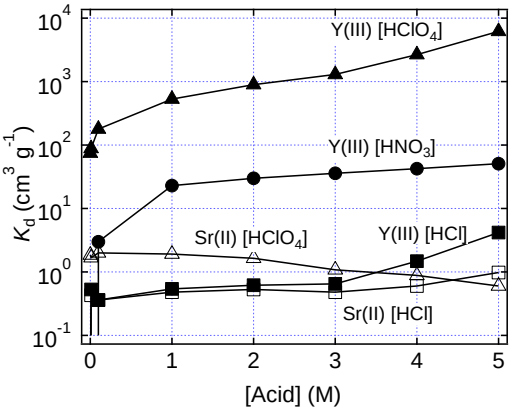

Fig.1. Effect of acid concentration on the adsorption of Y(III) and Sr(II) towards (CMPO+Dodec)/SiO_2-P adsorbent ([HNO_3, HCl or $HClO_4$] : 0.001-5 M; Temp.:298 K; Time:5 h)

II. CONCLUSIONS

Adsorption behavior of Sr(II) and Y(III) onto CMPO/SiO_2-P and (CMPO+Dodec)/SiO_2-P adsorbent were investigated by batch method under various different contact time, HNO_3, HCl or $HClO_4$ concentration and phase ratio at 298 K, and further separation behavior by extraction chromatography was studied by column method. It was found that the adsorbent showed high adsorption affinity to Y(III) and weak adsorption ability to Sr(II) under the experimental conditions. Considering the complex desorption behavior of Y(III) from adsorbed adsorbents in our previous work, the separation of Y(III) and Sr(II) from HNO_3 or $HClO_4$ solutions using CMPO/SiO_2-P and (CMPO+Dodec)/SiO_2-P adsorbents might be possible in the further extraction chromatography experiment.

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