§9. Displacement Chromatography Using Criptand Resin for Lithium Isotope Separation

Sugiyama, T., Yamamoto, I., Sugiura, K.
(Nagoya Univ.),
Tanaka, M.

Natural isotope abundance ratio of lithium-6 is 7.6 %. A technology to enrich lithium-6 over 90 % in the isotope abundance ratio is necessary to establish the breeding of tritium by a blanket in a fusion power plant. Displacement chromatography using cation-exchange resin is one of the suitable methods for a large-scale production of the enriched lithium-6, because a scale-up of a process seems easy and energy consumption is relatively small. The disadvantages of the process are small equilibrium separation factor and generation of a volume of saline waste liquid during regeneration process of the resin. A cryptand resin is a promising candidate because of its large equilibrium separation factor and availability of water in the regeneration process. The purpose of the present study is to evaluate the separative performance of the cryptand resin by experiments and numerical simulation.

i) Experiments

In order to study transport phenomena and separative performance of the displacement chromatography using a cryptand resin, we obtained experimentally chromatograms with various kind of lithium solution and eluent, flow rate and concentration of lithium.

The chromatographic column was 0.8 cm in inner diameter and 1 m long. Cryptand (2_B, 2, 1) resin (350 μm in average diameter, Merck) was packed in the column. Lithium solution or eluent was fed into the column at a certain flow rate. The effluent was collected into a number of samples using a fraction collector. The concentrations and isotopic ratios of lithium in the samples were measured with an atomic absorption spectrometer (Z-6100, Hitachi) and an inductive coupling plasma high resolution mass spectrometer (ELEMENT, Finnigan MAT), respectively. An example of chromatogram around the front and rear boundaries is shown in Fig. 1.

It was found that CH_3COOLi and CH_3COOK were available for the displacement chromatography as a combination of lithium solution and eluent. A enrichment factor and HETP (Height Equivalent to a Theoretical Plate) were obtained experimentally as 0.04±0.005 and 3±0.5 cm, respectively. The value of HETP obtained for the cryptand resin was about 10 or 100 times larger than that of cation-exchange resin. In practical use, it is necessary to reduce the value of HETP.

ii) Numerical analyses

It is important to optimize operational conditions by predicting a profile of lithium isotope concentration. To predict the concentration profile, it is effective to solve a set of fundamental equations which give a description of transport phenomena in the column. We have already developed a simulation model for lithium isotope separation by displacement chromatography using cation-exchange resin. The model was given by one-dimensional, convection-diffusion equation and by isotope exchange terms. Figure 2 shows a comparison between experiment and calculation at the front boundary. The profiles of isotopic ratio as well as lithium concentration obtained from the results of the experiments and the numerical analyses showed good agreement.

iii) Conclusion

Separative performances of lithium isotope using displacement chromatographic column packed with cryptand resin were evaluated by experiments and numerical simulation. It was found that CH_3COOLi and CH_3COOK were available as a combination of lithium solution and eluent. A enrichment factor and HETP were obtained as 0.04±0.005 and 3±0.5 cm, respectively. The validity of the simulation code was assured by the fact that the profiles of isotopic ratio and lithium concentration obtained by the calculation showed good agreement with those of experiments.

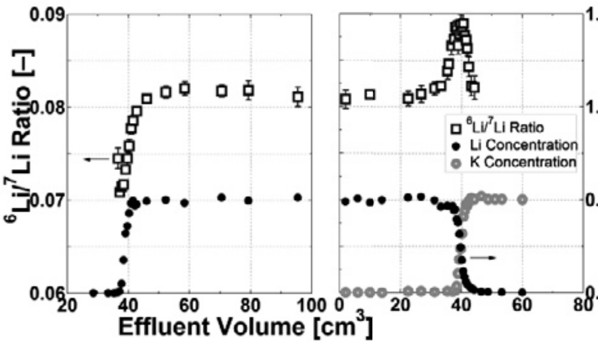

Fig. 1 A part of chromatogram in the front and rear edge of the lithium band

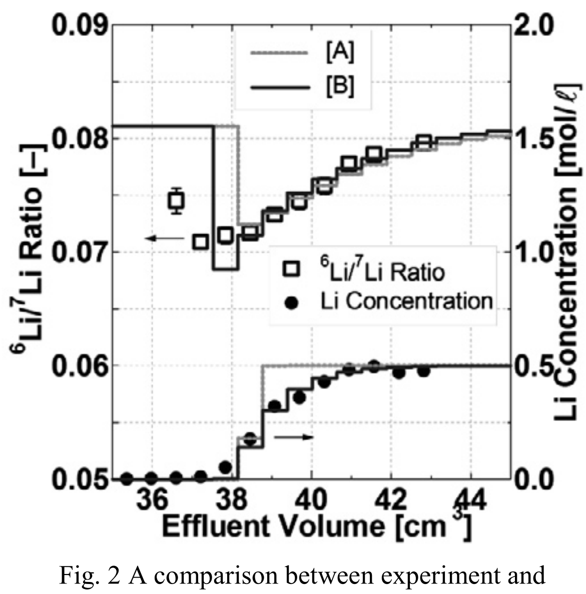

Fig. 2 A comparison between experiment and calculation at the front edge