

§3. Lithium Isotope Fractionation on Ion Exchange Reaction and its Application to Isotope Separation

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Tritium is used as fusion fuel, but natural abundance among hydrogen isotopes is too low. Thus, the tritium must be produced artificially. The ${}^6\text{Li}(n,\alpha)\text{T}$ reaction is a most well-known tritium breeding method. For the effective breeding the tritium, the enrichment of lithium-6 is necessary, since the natural ratio of lithium-6 is about 7.5%. We are proposing the lithium-6 enrichment method by using the ion exchange. In the report of previous fiscal year, we found the relationship of isotope separation coefficient, ϵ , and the degree of cross-linkage of cation exchange resin in the cation exchange reaction; according to this cross-linkage effect, the isotope separation coefficient is proportional to cross-linkage. By the way, the commercial strongly acidic cation-exchange resin with the highest degree of cross-linkage is 24%. Thus, we synthesized the sulfo-type strongly acidic cation exchange resin with 50% degree of cross-linkage, and the lithium isotope separation chromatography experiment using this synthesized resin was carried out.

The sulfo-type strongly acidic cation exchange resin is synthesized in two steps; the base resin synthesis and the adding the sulfo base. The base resin is synthesized using the styrene and the divinyl-benzene, and the degree of cross-linkage can be controlled by these ratio; we adjusted 50%. The suspended copolymerization method was used as the synthesis method. We did not control the resin size and the size distribution. The chloro-sulfonic acid was reacted with styrene-divinylbenzene base resin, as a result, we obtained the sulfo-type strongly acidic cation exchange resin with 50% degree of cross-linkage.

The synthesized cation exchange resin was filled into a column of 1 m length and of 8 mm inner diameter. The cation exchange resin in the column was adjusted with H^+ type by feeding 200 mL of 1 M HCl. After this, the deionized water was fed this column until the eluted water became neutral. After these conditioning treatments, 60 mL of 0.5 M lithium acetate aqueous solution was fed in this column. We exchanged Li^+ and H^+ on cation exchange resin. Li^+ was eluted by ion exchange for K^+ by feeding 0.5 M potassium acetate aqueous solution. This chromatography was carried out in room temperature (25°C) which was controlled by air-conditioner and the flow rate is 0.1 mL/min. Each the concentration and the isotope ratio of lithium in eluted fractions was evaluated by ICP-MS. The obtained chromatogram and the isotope fractionation curve is shown in Fig. 1. From these curves, the separation coefficient (ϵ), height equilibrium to a theoretical plate (HETP), and capacity (q) of lithium were calculated.

Obtained data are ϵ : 6.6×10^{-3} , HETP: 1.2 mm, q : 1.3 mmol/g. The obtained ϵ is plotted with the data obtained in the previous fiscal year (Fig.2). The obtained ϵ is a little smaller than the expected value from the cross-linkage. However this ϵ is highest value among the experimentally obtained data by using cation exchange resin.

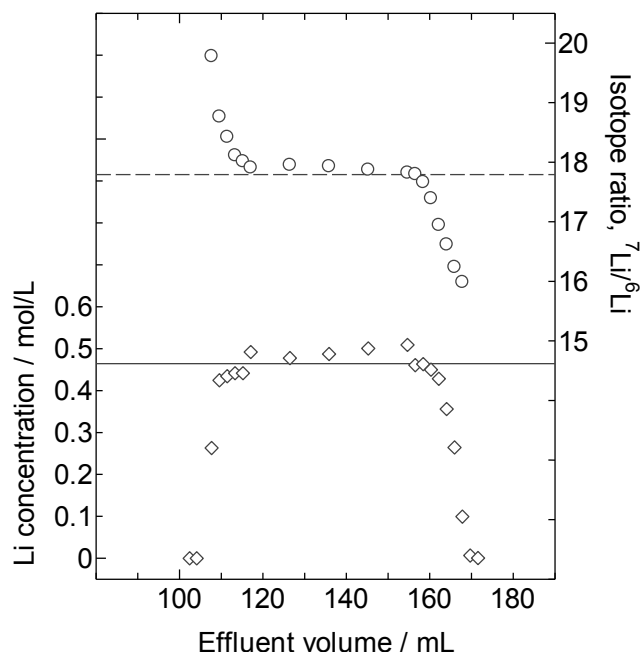


Fig.1. Lithium chromatogram and isotope fractionation curves by using cation exchange resin with 50% of cross-linkage.

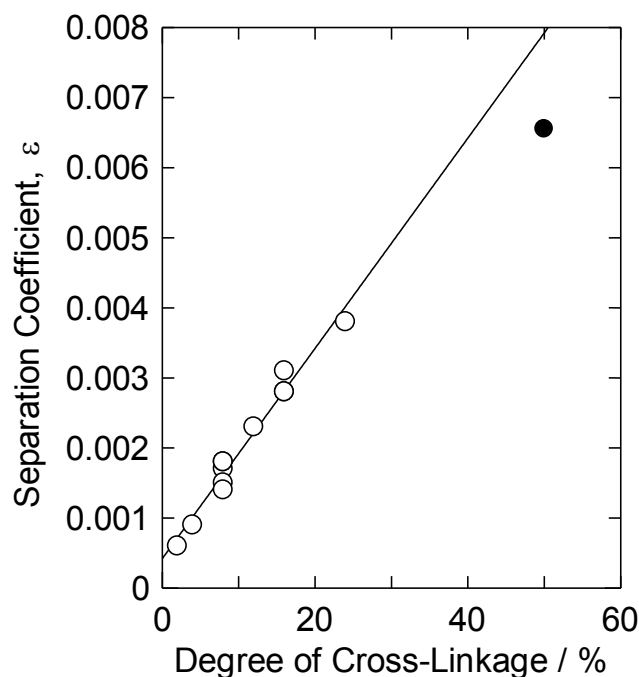


Fig. 2. Cross-linkage effect of cation exchange resin on isotope fractionation. Open circles: obtained data in previous fiscal year, closed circle: this work.