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FULL PAPER

Lithium isotope enrichment by electrochemical pumping using solid lithium electrolytes

Shunsuke HONDA[1], Kiyoto SHIN-MURA[1] and Kazuya SASAKI[1,†]

[1]Graduate School of Science and Engineering, Hirosaki University, 3 Bunkyo-cho, Hirosaki, Aomori 036–8561, Japan

Concentrating ^{6}Li isotopes, which exist only approximately 7.6% in nature, to 40 to 90%, is necessary for development of thermal fusion reactors, which are promising as next-generation base-load energy systems. We investigated the possibility of ^{6}Li enrichment by electrochemical pumping using $La_{0.57}Li_{0.29}TiO_3$ solid lithium electrolytes. We also clarified the influence of potential application profiles on separation efficiency. Giving a potential difference to electrodes prepared on both sides of the electrolyte made the electrode on the lithium solution side positive and concentrated ^{6}Li. The efficiency of lithium isotope enrichment was affected by the potential application profile. An intermittent potential application concentrates ^{6}Li with high efficiency. In an intermittent potential application in which the electrode on the lithium solution side was positive, an ^{6}Li concentration with higher efficiency was achieved when a small negative potential was applied to the lithium solution side electrode while suspending application of the positive potential.

Key-words : Isotope enrichment, Lithium, Electrochemical pumping, Alternative potential application, Intermittent potential application

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1. Introduction

The nuclear fusion reactor is a promising next-generation base-load energy system, because of its abundant fuel and excellent safety. Reaction between deuterium (D) and tritium (T) is selected for the nuclear fusion reactor because the temperature and pressure required are low. Deuterium is abundant in sea water and can be recovered easily at low cost. Since tritium scarcely exists in nature, on the other hand, it must be produced in the fusion reactor.[1)] In the thermonuclear fusion reactors, now under development, lithium compounds called "tritium breeders" are entered into the neutron irradiation area of the furnace, and T is produced by a nuclear reaction between lithium and neutrons. To produce more T in the limited furnace space than that consumed in the nuclear fusion reaction, a reaction with ^{6}Li [Eq. (1)] rather than with ^{7}Li [Eq. (2)] should be used, because the neutron reaction cross-section of ^{6}Li is three orders of magnitude larger than that of ^{7}Li.[2)] Reactions with ^{6}Li are also accompanied by great heat generation, which can contribute to power generation. To supply a large enough amount of T to maintain a nuclear fusion reaction in the furnace, it is necessary to concentrate the ^{6}Li isotope, only approximately 7.6% of which is present in nature, to 40 to 90%:[3)]

$$^6\mathrm{Li} + \mathrm{n} \rightarrow \mathrm{T} + \mathrm{He} + 4.8\,\mathrm{MeV} \quad (1)$$

$$^7\mathrm{Li} + \mathrm{n} \rightarrow \mathrm{T} + \mathrm{He} + \mathrm{n}' - 2.5\,\mathrm{MeV} \quad (2)$$

The mercury amalgam method, which seems to be the only practical application available in the world today, imposes a large environmental burden.[4),5)] Thus, several new ^{6}Li enrichment methods have been studied. Taylor and Urey investigated a chemical exchange method using zeolites and reported a large fractionation factor for the lithium isotopes of 1.022.[6)] Glueckauf et al. studied isotope enrichment by the ion-exchange method.[7)] The most studied isotope separation techniques are the solvent extraction and chromatography methods using crown ethers or polymerized crown ethers as lithium isotope receptors.[8)–12)] Yan et al. reported a maximum value of 1.039, however, while the fractionation factor for single-stage separation in most studies was small. Thus, to realize a sufficiently large separation factor, it is necessary to repeat a long and complicated batch-type process. Due to its poor cation selectivity, this requires solution of high-purity lithium as a starting material. There are also concerns about the environmental burden due to the use of large amounts of organic solvent. In recent years, Hoshino reported that it is possible to condense ^{6}Li by electrochemical pumping using an electrolyte membrane impregnated

† Corresponding author: K. Sasaki; E-mail: k_sasaki@hirosaki-u.ac.jp

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