Production of non-carrier added ^{7}Be via the ^{nat}Li$(d, x)^{7}$Be reaction

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Although lithium is considered a preferred dopant for n-type diamond semiconductors, an effective method for lithium injection is yet to be established.[1] Recently, ^{7}Be ($T_{1/2}$ = 53 d, I_{EC} = 100%), which decays to ^{7}Li by electron capture, was suggested for the lithium source by thermal diffusion after its implantation to the diamond.[1] This radioisotope is often produced by the ^{nat}Li$(p, xn)^{7}$Be reaction with accelerators and separated from the target material by cation exchange chromatography.[2,3] However, this separation method requires a large column even for a lithium target of only several milligrams. We found that an extraction chromatography resin impregnated bis(2-ethyl-1-hexyl) phosphoric acid was suitable for purifying beryllium based on the reported capacity factors.[4] In this research, we developed a novel chemical separation method for ^{7}Be using an LN resin (Eichrom Technologies, LLC).

A Li_2CO_3 pellet target (276 mg; chemical purity 99%; KISHIDA CHEMICAL Co., Ltd.; ϕ10 mm; thickness: 351 mg/cm^2) was covered with a 10-μm aluminum foil on a target holder and irradiated for 30 min with a 24.40 MeV d beam (1 particle μA) extracted from the RIKEN AVF cyclotron. The beam energy on the surface of the target was calculated as 24.25 MeV using the SRIM code.[5] The target was subjected to γ-ray spectrometry with a germanium detector to evaluate the production yield of ^{7}Be. Subsequently, the target was placed in 5 mL of pure water in a beaker, and ~1 mL of concentrated hydrochloric acid was added to dissolve the target. The solution was heated and evaporated to dryness on a hot plate, and the residue was dissolved with 1 mL of 0.01 M nitric acid. This drying and dissolving step was repeated once again. 5% of the target solution was mixed with unirradiated target material to reach the same amount of ^{nat}Li as the irradiated one because sufficient radioactivity of ^{7}Be was produced for the development of the chemical separation procedure. Chemical separation was performed according to the procedure presented in Fig. 1. The solution was loaded into the Eichrom LN resin column (*i.d.* 5 mm × height 50 mm) to adsorb ^{7}Be on the column, while ^{nat}Li was eluted out from the column. Then, 1 mL of 0.01 M nitric acid was added into the column ten times to elute ^{nat}Li. Finally, 5 mL of 8 M nitric acid was added to the column to elute ^{7}Be. The flow rate of each solution through the column was ~0.2 mL min^{-1}. The purified ^{7}Be was subjected to γ-ray spectrometry and chemical element analysis with ICP-MS (Agilent7900) to evaluate its radioactivity, radionuclidic purity, and chemical purity.

The γ-ray spectrum of ^{7}Be after separation is shown in Fig. 2. The radioactivity of ^{7}Be at the end of irradiation was 0.50 ± 0.02 MBq which provides a production yield of 0.98 ± 0.03 MBq μA^{-1} h^{-1}. The chemical yield of ^{7}Be was 91 ± 4%. The amounts of impure ^{nat}Li and ^{9}Be were estimated to be 38.9 μg and <2.0 ng, respectively, using ICP-MS. The specific radioactivity of >2.5×10^5 MBq/mg can be achieved for ^{7}Be with our procedure. The decontamination factor of ^{7}Be to ^{nat}Li was 6.5×10^3, which is comparable to $(6.9 \pm 1.0) \times 10^3$ obtained using the previous method.[3]

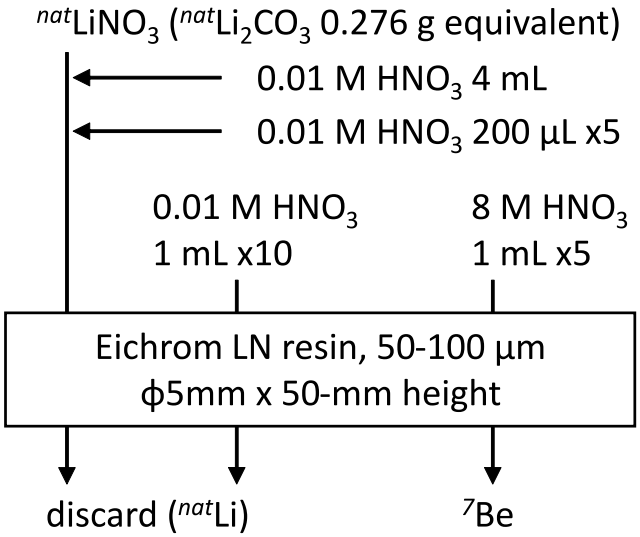

Fig. 1. Chemical separation procedure of ^{7}Be from ^{nat}Li.

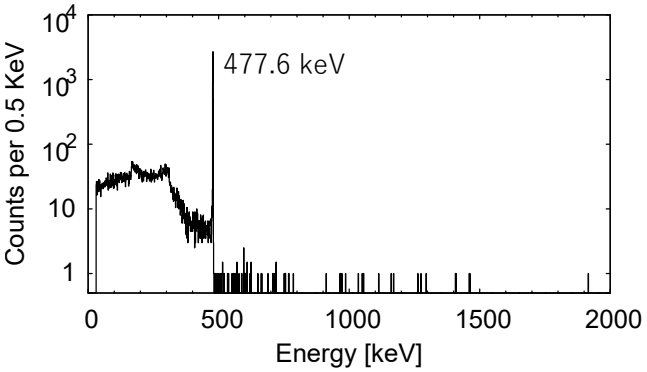

Fig. 2. γ-ray spectrum of the purified ^{7}Be.

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