Development of accelerator production method of ^{139}Ce for domestic supply

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Cerium-139 (^{139}Ce), a radioactive isotope with a half-life of 137.6 days, is an essential nuclide used in calibration of γ-ray detectors and Single Photon Emission Computed Tomography (SPECT) cameras due to its single γ-ray emission of 165.9 keV. Thus far, ^{139}Ce has been imported to Japan from abroad. However, in recent years, its availability has been unstable due to changes in global situations, requiring the domestic production of ^{139}Ce. In this study, we aim to develop a method to produce ^{139}Ce in the ^{nat}La$(d, xn)^{139}$Ce reaction and chemically separate it from the ^{nat}La target.

Three $^{nat}La_2O_3$ pellet targets (purity: 99.999%; thickness: ∼800 mg/cm^2; weight: ∼0.30 g), T1, T2, and T3, were bombarded with 24-MeV deuteron beams from the RIKEN AVF cyclotron. The average beam currents for T1, T2, and T3 were 1.0, 3.0, and 3.0 μA and the irradiation times were 1.0, 0.5, and 6.3 hours, respectively. T1 and T2 were used for the development of chemical separation, while T3 was for the production of a practical quantity of ^{139}Ce.

Referring to previous studies,[1,2] two procedures were investigated for the chemical separation of ^{139}Ce from the target: (a) anion-exchange chromatography with a strongly basic anion-exchange resin and (b) extraction chromatography with a Ln2 resin (Eichrom). In (a), the irradiated $^{nat}La_2O_3$ target was dissolved with concentrated nitric acid (conc. HNO_3). The solution was evaporated to dryness, dissolved with 0.7 M $NaBrO_3$/6 M HNO_3 (2 mL), and loaded onto the anion-exchange column (Muromac 1X8; 100–200 mesh; inner diameter 5 mm × height 23 mm). Then, 0.7 M $NaBrO_3$/6 M HNO_3 (14 mL), 10 M HNO_3 (0.5 mL), and 0.2 M HNO_3 (20 mL) were added to the column, and the eluates were taken in 2-mL fractions to confirm the elution behavior of ^{139}Ce and co-produced ^{140}La. The radioactivities of ^{139}Ce and ^{140}La were measured with a Ge detector. In (b), the target was dissolved with conc. HNO_3. The solution was evaporated to dryness, dissolved with 0.1 M $NaBrO_3$/3 M HNO_3 (2 mL), and loaded onto the extraction column (Eichrom Ln2 resin; 50–100 μm; 5-mm inner diameter × 23-mm height). 0.1 M $NaBrO_3$/3 M HNO_3 (20 mL), 3 M HNO_3 (2 mL), and 0.5 M HCl/0.1 M H_2O_2 (4 mL) were added to the column to confirm the elution behavior of ^{139}Ce and ^{140}La. This extraction chromatography was also applied for T3.

The elution curves for the anion-exchange and extraction chromatography are shown in Figs. 1(a) and 1(b), respectively. The elution time of ^{140}La with the Ln2-resin column was faster than that with the anion-exchange column. The decontamination factors for

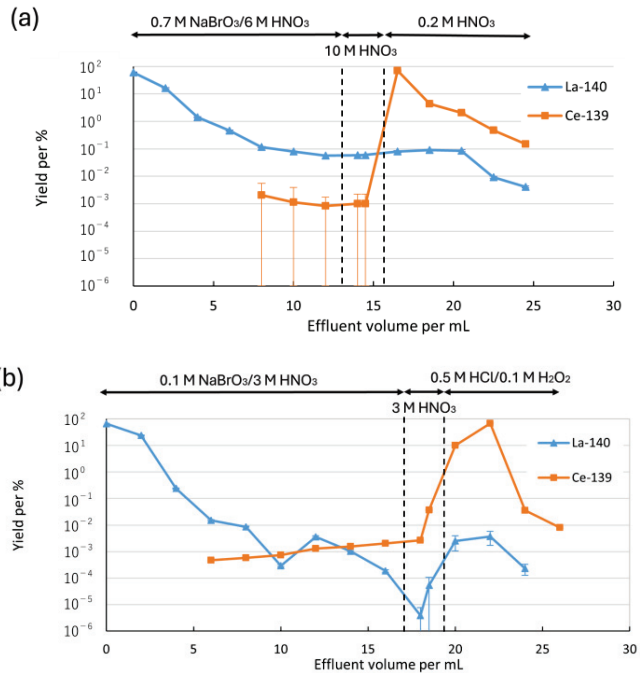

Fig. 1. Elution curves of ^{140}La and ^{139}Ce by (a) anion exchange chromatography and (b) extraction chromatography.

^{140}La in the purified ^{139}Ce were $(4.9 \pm 0.3) \times 10^2$ for the anion-exchange chromatography and $(5.4 \pm 2.0) \times 10^4$ for the extraction chromatography. The chemical yields of ^{139}Ce were 92 ± 4% and 99 ± 4%. For T3, 18.1 ± 0.5 MBq of ^{139}Ce was produced at the end of bombardment with a production yield of 0.96 ± 0.03 MBq/μA · h. The γ-ray spectrum of the purified ^{139}Ce from T3 is shown in Fig. 2. The chemical yield was 104 ± 4%.

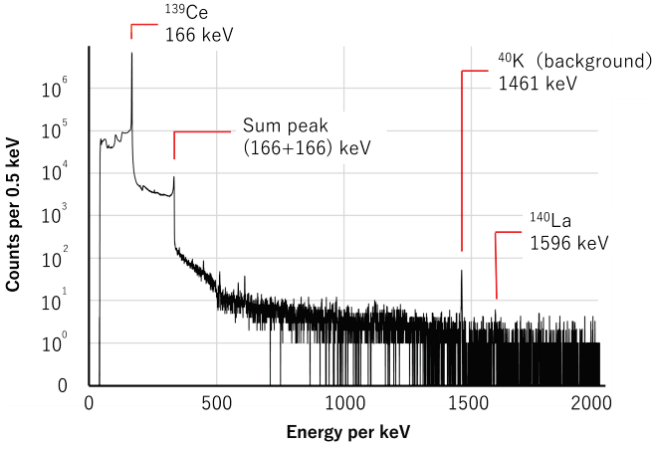

Fig. 2. Gamma-ray spectrum of purified ^{139}Ce by the extraction chromatography with Ln2 resin.

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The radioactivity of radionuclides other than ^{139}Ce was below the detection limits.

References

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