Recovery of ^{248}Cm material from mixed Cm/Gd target

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In the chemical experiments on superheavy elements (SHEs), the lighter homologue elements in the periodic table are simultaneously produced, and their chemical behaviors are compared to those of SHEs under identical experimental conditions. For this purpose, a mixed ^{248}Cm/Gd target deposited on a thin metallic backing foil has been often used.[1,2] The target as well as the backing material are gradually damaged by the irradiation with the intense heavy-ion beams. Since the available amount of ^{248}Cm is limited, its recovery, which involves purification from the used target, is essential to produce a new target.

Bis(2-ethylhexyl)phosphoric acid (HDEHP) is one of the widely used extractants for separating lanthanide ions.[3] Separation of lanthanide and actinide through extraction chromatography using an HDEHP-laden resin has been studied.[4,5] Using the HDEHP resin, one can perform stepwise separation of lanthanide and actinide elements by simply changing the concentration of the HNO_3 eluents. The distribution coefficients (K_d) of these elements strongly depend on the HNO_3 concentration: The K_d values for +3 ions are inverse third power dependent on the mean activity of the hydrogen ion.[4] Therefore, in this work, we investigated several schemes to effectively separate Cm and Gd with the HDEHP resin using a multitracer of lanthanide elements. Further, we separated the ^{248}Cm material from ^{nat}Gd with the optimized scheme.

The commercially available Ln Resin (Eichrom), the HDEHP-laden hydrophobic resin with the particle size of 100–150 μm, was packed into a polyethylene column (5 mm i.d. × 50 mm height; column volume: ≈1 mL). The multitracer was produced by bombarding a ^{nat}Hf target with a 135-MeV/nucleon ^{14}N beam from the RIKEN Ring Cyclotron. After the irradiation, the rare earth elements were separated from the target material by an establised procedure, detailed in Ref. 6. The multitracer including ^{133}Ba, ^{139}Ce, ^{143}Pm, ^{145}Sm, and ^{153}Gd in 0.1 M HNO_3 was stocked in a polypropylene (PP) tube. The K_d values are reported to be in the order Ba ≪ Ce < Cm < Pm < Sm < Gd in the Ln Resin–HNO_3 system.[5] After the conditioning of the column with 3.0 mL of 0.1 M HNO_3 solution, 1 mL of the stock solution was loaded onto the column. 4 mL of 0.1 M HNO_3 was then fed onto the column as a first eluent. According to the reported K_d values, [5] most of the +1 and +2 metal ions such as ^{133}Ba elute in this fraction. As a second eluent, 0.2–0.5 M HNO_3 solutions were fed until ^{143}Pm was completely eluted from the column. Finally, 6 mL of 1.0 M HNO_3 was fed to elute ^{153}Gd completely. The flow rate was 230–240 μL/min at room temperature. Each 1 mL of the effluent was collected in a separate PP tube and subjected to γ-ray spectrometry at fixed geometry.

Figures 1(a)–(d) show the elution curves of the multitracer with 0.2, 0.3, 0.4, and 0.5 M HNO_3 as the second eluent. ^{133}Ba was eluted with 5 mL of 0.1 M HNO_3 with a recovery of 100.3 ± 2.5%. 30 mL of 0.2 M HNO_3 (Fig. 1(a)) was used to elute ^{139}Ce and then ^{143}Pm, as expected from the difference in the K_d values.[5] ^{145}Sm and ^{153}Gd were not eluted in these fractions. Owing to the increase in the concentration of the second eluent, the peaks of the elution curves of ^{139}Ce and ^{143}Pm get shifted to lower volumes and approach to each other. In the case of 0.5 M HNO_3, 6.2 ± 0.6% of ^{153}Gd was eluted until ^{139}Ce was completely eluted. Since Cm is expected to be found between Ce and Pm from the order of the K_d values,[5] Cm and Gd can be separated with the schemes shown in Fig. 1(a)–(c). However, the scheme shown in Fig. 1(a) takes a large amount of eluent, and in the case of 0.4 M HNO_3, the condition for separation is stricter than that in the case of 0.2 M and 0.3 M HNO_3, owing to the close peaks of the elution curves. Therefore, we selected the scheme in Fig. 1(b) for the separation of ^{248}Cm and ^{nat}Gd.

By applying the scheme of Fig. 1(b) to the purification of 830-μg ^{248}Cm target material containing ^{nat}Gd (about 10 wt%), 99.3 ± 4.1% of ^{248}Cm was collected in the fraction of the 12-mL 0.3 M HNO_3 solution.

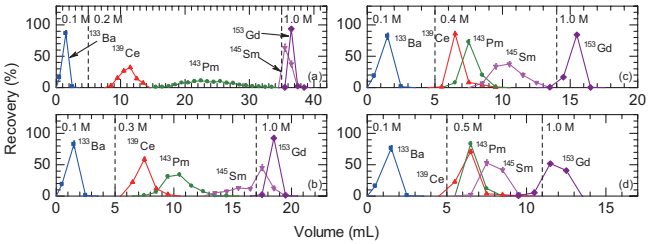

Fig. 1. Elution curves of ^{133}Ba, ^{139}Ce, ^{143}Pm, ^{145}Sm, and ^{153}Gd. The concentrations of the second eluents are (a) 0.2 M, (b) 0.3 M, (c) 0.4 M, and (d) 0.5 M.

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