Production of no-carrier-added ^{169}Yb by the ^{169}Tm$(d, 2n)^{169}$Yb reaction

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^{169}Yb ($T_{1/2} = 32$ d, EC = 100%), which emits Auger electrons, X rays, and γ rays of approximately 100 keV, can substitute for ^{125}I or ^{192}Ir for brachytherapy.[1] As it emits cascade γ rays, ^{169}Yb is also expected to be applied to double photon emission coincidence imaging (DPECI).[2] ^{169}Yb has often been produced via ^{168}Yb$(n, \gamma)^{169}$Yb reaction at nuclear reactors; the natural isotopic abundance of ^{168}Yb is only 0.12%, which results in a low specific radioactivity of ^{169}Yb. Thus, a separate production method of ^{169}Yb with higher specific radioactivities is desirable for radiotherapeutic and radiodiagnosis research. Recently, we measured the production cross sections of ^{169}Yb in several types of reactions with different projectiles and targets, and found that the ^{169}Tm$(d, 2n)^{169}$Yb reaction provided the highest production yield.[3] In this study, we developed a chemical separation method of ^{169}Yb from the ^{169}Tm target, referring to the mutual separation methods of rare earth elements.[4,5]

Four metal plates of ^{169}Tm (chemical purity: 99%; thickness: 104 μm × 4; weight: 48.14 mg × 4) were irradiated for 1 hour with a 24-MeV d beam (5 μA) extracted from the AVF cyclotron. The target was subjected to γ-ray spectrometry with a Ge detector to evaluate the production yield of ^{169}Yb. Four target foils were dissolved with concentrated hydrochloric acid (conc. HCl). Further, ^{169}Yb was purified through a three-step column chromatography according to the procedure presented in Fig. 1. In the first cation-exchange chromatography using a strongly acidic cation-exchange resin (Muromac 50WX8; 200–400 mesh) in the α-hydroxyisobutyric acids (α-HIB) system, 74% of ^{169}Yb was recovered together with 9% of ^{169}Tm (18 mg); the remaining ^{169}Tm was left adsorbed on the column. The recovered ^{169}Yb in the α-HIB solution was co-precipitated with ^{169}Tm using aqueous NH_3 and separated from the solution by centrifugation. In the extraction chromatography using the LN2 resin (Eichrom LN2 resin; 50–100 μm) in the nitric acids system, ^{169}Tm was first eluted until its γ ray was not detected and then pure ^{169}Yb was recovered separately. In the last cation-exchange chromatography using the strongly acidic cation-exchange resin (Muromac 50WX8; 200–400 mesh) in hydrochloric acids system, organic impurities from the LN2 resin were removed. Purified ^{169}Yb was subjected to γ-ray spectrometry and chemical element analysis with ICP-MS to evaluate radioactivity, radionuclidic purity, and chemical impurity of the purified ^{169}Yb.

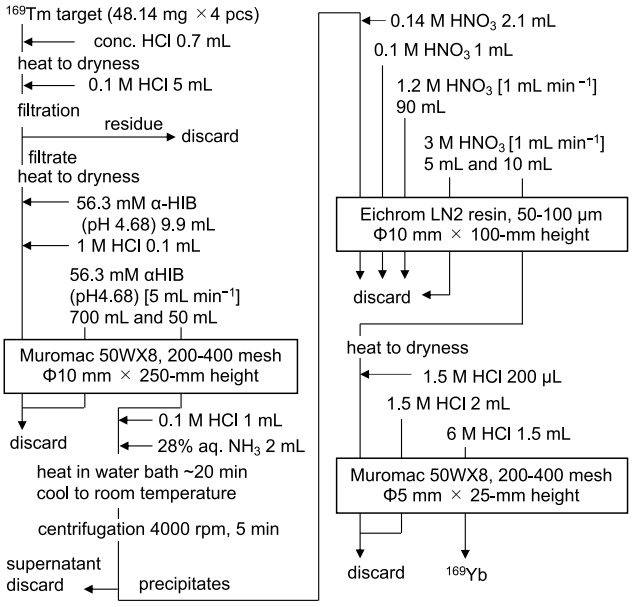

Fig. 1. Chemical separation procedure of ^{169}Yb from ^{169}Tm target.

The radioactivity of ^{169}Yb at the end of irradiation was 7.9 ± 0.3 MBq, providing a production yield of 1.5 MBq μA^{-1} h^{-1}. This yield can be increased to 3.9 MBq μA^{-1} h^{-1} by decreasing the incident energy from 24 to 19 MeV to cover the peak region of the excitation function.[3] The γ-ray spectrum of the purified ^{169}Yb is shown in Fig. 2. The chemical yield of ^{169}Yb was 60 ± 3%. γ rays from radionuclides other than ^{169}Yb were below the detection limit: the ra-

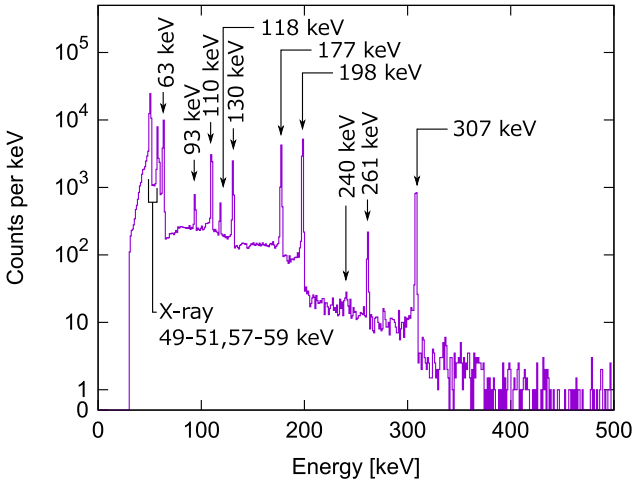

Fig. 2. γ-ray spectrum of the purified ^{169}Yb.

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dionuclidic purity of ^{169}Yb was >99%. The chemical impurities were less than tens of nanograms (ng) for all detectable metal elements other than Sn (550 ng) and Tm (2.3 μg). The decontamination factor of ^{169}Tm from ^{169}Yb was 4.9×10^4. The specific radioactivity of ^{169}Yb was 329 ± 12 MBq μg^{-1}.

References

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