Production cross-sections of holmium-161 radioisotope from alpha-particle-induced reaction on terbium-159 up to 29 MeV

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Terbium and holmium radioisotopes are of interest in medical applications.[1,2] These radioisotopes can be produced by charged-particle-induced reactions on neighbor elements, such as gadolinium and terbium. Among such reactions, we focused on alpha-particle-induced reactions on the monoisotopic element terbium-159 to produce the possible medical radioisotope, holmium-161. In a literature using the EXFOR library, only two relevant experimental studies were found.[3,4] Therefore, we performed an experiment to measure the activation cross-sections of the reaction. In this work, the production cross-sections of ^{160,161}Tb and ^{160g,160m,161,162m}Ho were studied. The results were compared with previous experimental data and TENDL-2019 data based on calculations using the TALYS code.[5]

The experiment was performed the RIKEN AVF cyclotron. In the experiment, we used the stacked foil technique, activation method, and high-resolution γ-ray spectrometry to determine the activation cross-sections.

The stacked target consisted of 8 × 8 mm^2 foils cut from large ^{159}Tb (nominal thickness: 25 μm, size: 50 × 50 mm^2, 99.9% purity, Nilaco Corp., Japan), ^{27}Al (5 μm, 100 × 100 mm^2, 99.9% purity, Nilaco Corp., Japan), and ^{nat}Ti foils (5 μm, 50 × 100 mm^2, 99.6% purity, Nilaco Corp., Japan).

The thickneses of Tb, Al and Ti foils were determined using the measured size and weight; they were found to be 19.1, 1.50, and 2.29 mg/cm^2, respectively. Ti foils were interleaved to check the beam parameters using the ^{nat}Ti$(\alpha,x)^{51}$Cr monitor reaction. The cut foils were stacked in a target holder, which also served as a Faraday cup.

The alpha-particle beam was accelerated to 29.1 MeV by the RIKEN AVF cyclotron. The beam energy was measured by the time-of-flight method.[6] The stacked target was irradiated by the beam for 30 min with an average intensity of 201 nA. The beam intensity was measured by the Faraday cup. Energy degradation in the stacked target was calculated using the SRIM code.[7]

The γ-rays emitted from irradiated foils were measured by a high-resolution high-purity germanium (HPGe) detector. The detector efficiency was calibrated using a multiple γ-ray emitting point source. The γ-ray spectra were analyzed by the software Gamma Studio software (SEIKO EG&G).

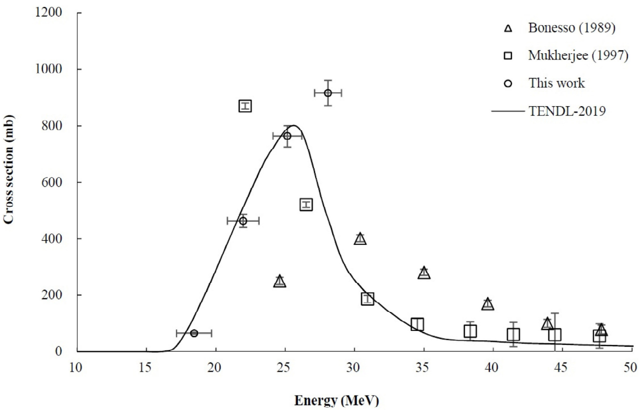

Fig. 1. Excitation function of the ^{159}Tb$(\alpha,2n)^{161}$Ho reaction with previous experimental data[3,4] and TENDL-2019 values.[5]

The cross-sections of the ^{159}Tb$(\alpha,2n)^{161}$Ho reaction were determined using measurements of the γ line at 103.05 keV (I_γ = 3.9%) from ^{161}Ho decay ($T_{1/2}$ = 2.48 h). To reduce γ-ray backgrounds from shorter-lived radionuclides, measurements were executed after cooling for 3.7–8.5 h. The cross-sections of ^{161}Ho production derived from the measured activities are presented with previous experimental data[3,4] and TENDL-2019 data[5] in Fig. 1. Previous experimental data demonstrated different tendencies in comparison to the present result. Our experimental data exhibited peaks above 28 MeV. The peak position and amplitude of TENDL-2019 data were also substantially different.

In summary, we performed an experiment to measure the excitation functions of alpha-particle-induced reactions on ^{159}Tb up to 29.1 MeV in the RIKEN AVF cyclotron. The production cross-sections of ^{160,161}Tb and ^{160g,160m,161,162m}Ho were determined. Subsequently, results were compared with previous experimental data and TENDL data.

References

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