Production cross sections of ^{155}Tb in deuteron-induced reactions on natural gadolinium

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Terbium-155 ($T_{1/2}$ = 5.32 d) can be used for single-photon emission computed tomography (SPECT)[1] and produced through charged-particle-induced reactions. Among the reactions, we focused on the deuteron-induced reaction on natural gadolinium. In a literature survey, three experimental studies on the reaction were found.[2–4] However, some discrepancies could be found among the experimental data. Therefore, we measured the cross sections of the deuteron-induced reaction on natural gadolinium. The result was compared with the previously published experimental data[2–4] and the TENDL-2019 data.[5]

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

The stacked target consisted of 8×8 mm^2 foils cut from a large ^{nat}Gd foil (25 μm, 50×100 mm^2, 99.9% purity, Nilaco Corp., Japan) and a ^{nat}Ti foil (5 μm, 50 × 100 mm^2, 99.6% purity, Nilaco Corp., Japan). The isotopic composition of ^{nat}Gd is ^{152}Gd (0.2%), ^{154}Gd (2.2%), ^{155}Gd (14.8%), ^{156}Gd (20.5%), ^{157}Gd (15.7%), ^{158}Gd (24.8%) and ^{160}Gd (21.8%).

The sizes and weights of the large foils were measured to derive the thicknesses. The thicknesses of the ^{nat}Gd and ^{nat}Ti foils were found to be 25.3 and 2.34 mg/cm^2, respectively. The ^{nat}Ti foils were interleaved for the ^{nat}Ti$(d,x)^{48}$V monitor reaction to assess beam parameters and target thicknesses. The cut foils were stacked into a target holder, which served as a Faraday cup.

The stacked target was irradiated with the beam for 60 min. An average intensity of 98.1 nA was measured by the Faraday cup. The beam energy was measured by the time-of-flight method.[6] Energy degradation in the stacked target was calculated using the Stopping and Range of Ions in Matter (SRIM) code.[7]

The γ-rays emitted from each irradiated foil were measured using a high-resolution high-purity germanium (HPGe) detector and analyzed using the software Gamma Studio software (SEIKO EG&G).

The total uncertainties (~10%) were estimated from the square root of the quadratic summation of each component; statistical uncertainty (0.4–1.5%), target thickness (2%), target purity (1%), beam intensity (5%), detector efficiency (6%) and γ-ray intensity (1.3%).

The cross sections of the ^{nat}Ti$(d,x)^{48}$V monitor reaction were derived using the line at 983.525 keV (I_γ = 99.98%). The derived cross sections were compared with the values recommended by the International Atomic Energy Agency (IAEA).[8] We could obtain good agreements between the results and the recommended values.

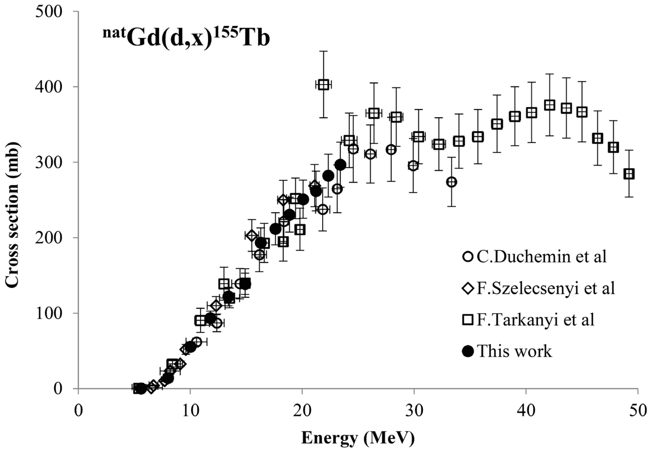

Fig. 1. Excitation function of the ^{nat}Gd$(d,x)^{155}$Tb reaction along with the previously published data[2–4] and TENDL-2019 data.[5]

The γ line at 105.3 keV (I_γ = 25.1%) emitted with the ^{155}Tb decay was measured to derive the cross sections of the ^{nat}Gd$(d,x)^{155}$Tb reaction. The measurements were performed after a cooling time of 3 days. The result is presented in Fig. 1 along with the previously published experimental data[2–4] and TENDL-2019 data.[5] Our result shows good agreement with the previous experimental data within the uncertainty, except for one data point at 22 MeV of Tárkányi *et al.*[4] The TENDL-2019 data substantially overestimate all the experimental data in the lower energy region.

In the summary, we performed an experiment to measure the excitation functions of the ^{nat}Gd$(d,x)^{155}$Tb reaction up to 24.1 MeV at the RIKEN AVF cyclotron. The production cross sections of ^{155}Tb were determined. The result was compared with the experimental data studied published previously and the TENDL data. We good agreement between our result and the previous experimental results.

References

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