Production cross sections of ^{157}Dy in alpha-particle-induced reactions on natural gadolinium

D. Ichinkhorloo,[*1,*2,*3] M. Aikawa,[*1,*4,*3] Ts. Zolbadral,[*4,*2,*3] T. Murata,[*4,*3] M. Sakaguchi,[*4,*3] Y. Komori,[*3] T. Yokokita,[*3] and H. Haba[*3]

The radioisotope dysprosium-157 ($T_{1/2}$ = 8.14 h) can be used for bone scanning (skeletal imaging).[1)] This radionuclide can be produced through charged-particle-induced reactions on natural gadolinium. In this work, the production cross sections of ^{157}Dy in the alpha-particle-induced reactions on natural gadolinium were studied. No previous experimental data were found in a literature survey. The results were compared with TENDL-2017 data.[2)]

The experiment was performed at the RIKEN AVF cyclotron. In the experiment, we used the stacked foil technique, the 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 a larger Gd foil (25 μm, 50 × 50 mm^2, 99.9% purity, Nilaco Corp., Japan) and Ti foils (5 μm, 50 × 100 mm^2, 99.6% purity, Nilaco Corp., Japan). The isotopic composition of the natural Gd target 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 larger foils were measured to derive the average thickness. The thickness of the Gd and Ti foils were found to be 25.4 and 2.29 mg/cm^2, respectively. The Ti foils were used to assess beam parameters and target thicknesses 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 51.1 MeV by the RIKEN AVF cyclotron. The beam energy was measured using the time-of-flight method.[3)] The stacked target was irradiated for 60 min with an average beam intensity of 257.6 nA. The beam intensity was measured using the Faraday cup. Energy degradation in the stacked target was calculated using SRIM code.[4)]

The γ-rays emitted from the irradiated foils were measured using a high-resolution high-purity germanium (HPGe) detector. The γ-ray spectra were analyzed using the software Gamma Studio (SEIKO EG&G). The γ-rays at 326.3 keV ($I_\gamma = 93\%$) emitted after the decay of ^{157}Dy ($T_{1/2} = 8.14$ h) was measured to derive the cross sections of the ^{nat}Gd$(\alpha, x)^{157}$Dy reaction. The measurements were performed after a cooling time of 15 h.

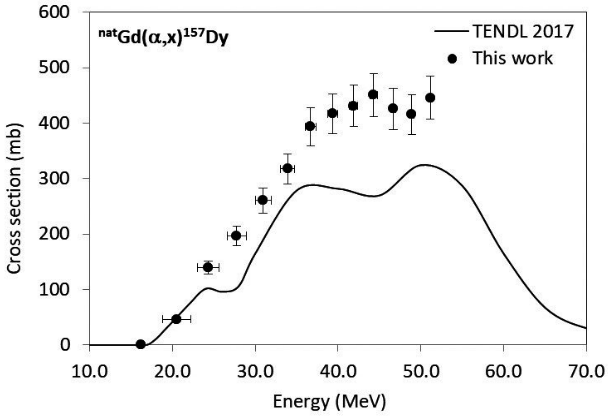

Fig. 1. Excitation function of the ^{nat}Gd$(\alpha, x)^{157}$Dy reaction.

The total uncertainties (8.8%) were estimated from the square root of the quadratic summation of each component: statistical uncertainty (1.5%), target thickness (2%), target purity (1%), beam intensity (5%), detector efficiency (6%), and γ -ray intensity (3.2%).

The cross sections derived from the activity of ^{157}Dy are presented in comparison with TENDL-2017 data[2)] in Fig. 1. The TENDL-2017 data underestimate our experimental cross sections.

In summary, we have performed an experiment to measure the activation cross sections of alpha-particle-induced reactions on ^{nat}Gd up to 51 MeV at the RIKEN AVF cyclotron. In this work, the production cross sections of ^{157}Dy were determined, and the results were compared with the prediction of TALYS-based model calculation, for which data were taken from the TENDL-2017 online database.

This work was supported by JSPS KAKENHI Grant Number 17K07004.

References

1) G. Subramanian *et al.*, J. Nucl. Med. **12**, 558 (1971).
2) A. J. Koning *et al.*, Nucl. Data Sheets **155**, 1 (2019).
3) T. Watanabe *et al.*, Proc. 5th Int. Part. Accel. Conf. (IPAC 2014), 3566 (2014).
4) J. F. Ziegler *et al.*, SRIM: the Stopping and Range of Ions in Matter, `http://www.srim.org`.

*1 Faculty of Science, Hokkaido University
*2 Nuclear Research Center, National University of Mongolia
*3 Nishina Center for Accelerator-Based Science, RIKEN
*4 Graduate School of Biomedical Science and Engineering, Hokkaido University
*5 School of Science, Hokkaido University