Activation-cross-section measurement of alpha-induced reactions on natural dysprosium

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Holmium-166 can be used for a liver-cancer treatment called radioembolization.1) It is worthwhile to investigate the most efficient method for 166Ho production by comparing possible production reactions. The alpha-induced reaction on dysprosium is one of them. However, there are no available experimental data for this reaction. Thus, we were motivated to perform an experiment for the natDy(α, x)166Ho reaction.

The experiment was performed using the AVF cyclotron at the RIKEN Beam Factory (Wako, Saitama, Japan). The stacked-foil activation technique and high-resolution γ-ray spectrometry were used to measure the cross sections of generated radionuclides. The stacked-foil target consisted of natural dysprosium (99% purity, Goodfellow Co., Ltd., UK) and natural titanium (99.6% purity, Nilaco Corp., Japan). The sizes and weights of both foils were measured, and the derived average thicknesses of the natural dysprosium and natural titanium foils were 23.6 μm and 5.1 μm, respectively. Both foils were cut into pieces of 8 x 8 mm² size and inserted into the target holder, which served as a Faraday cup. The target was irradiated with a 50.6-MeV alpha beam. The measured beam intensity was 103.8 pNA. The beam energy was measured using the time-of-flight (TOF) method.2) The energy degradation in the target was calculated using the stopping powers obtained from SRIM code.3)

After one-hour irradiation, the target was removed from the target holder for off-line γ-ray spectrometry using a high-purity germanium (HPGe) detector. The 320.08-keV γ-line (T1/2 = 27.704 d, Iγ = 9.91%) was used to derive the cross sections of the natTi(α, x)51Cr monitor reaction.

Because the cross sections of the monitor reaction were significantly different from IAEA’s recommended values,4) an elemental analysis of the dysprosium foil was conducted via scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) using JSM-6610LA with JED-2300, JEOL Ltd. at Hokkaido Research Organization. The foil was found to contain 4.27% oxygen by mass. The stopping power of natural dysprosium was modified by considering the oxygen compounds. Consequently, the excitation function of the natTi(α, x)51Cr reaction showed good agreement with the recommended values4) as shown in Fig. 1. The beam intensity was corrected by ~4% from the measured one.

The γ-line of 80.576 keV (T1/2 = 26.824 h, Iγ = 6.56%) was used to derive the excitation function of the natDy(α, x)166Ho reaction. The result is shown in Fig. 2 with the TENDL-2017 data.5) It was found that the TENDL-2017 data5) significantly underestimate the cross sections of this reaction.

The production of the radioactive by-products, such as 167Ho (T1/2 = 3.003 h), is being analyzed. The results will be published in a forthcoming paper.

References

Fig. 1. Comparison of the excitation function of the natTi(α, x)51Cr monitor reaction with IAEA’s recommended values.4)