Measurement of excitation functions for ^{165}Ho(α, xn)$^{165-168}$Tm reactions

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Currently, therapeutic radioisotopes are predominantly produced via the (n, γ) reactions routes. However, charged-particle-induced nuclear reactions serve as good alternatives to produce these radioisotopes with high specific activities. The irradiation of holmium (Ho) with alpha-particle beams leads to the production of several important thulium (Tm) radioisotopes for applications in nuclear medicine. In addition to the use of ^{167}Tm as a skeletal imaging agent, the radioisotope was reported to be useful for studying bone and tumour.[1)] Furthermore, the Auger electrons as well as low-energy γ- and X-rays emitted from the moderately long-lived ^{167}Tm (9.25 days) are suitable for radiotherapy.[2,3)] On the other hand, ^{165}Tm (1.25 days) has been considered as a potential replacement of the popular ^{167}Tm owing to its desirable decay characteristics.

A comprehensive analysis of all previous measurements of alpha-particle-induced reactions on holmium shows large and unacceptable discrepancies. In this work, new measurements have therefore been made with a relatively large number of holmium foils to explore the excitation functions at various energy points.

The overall procedure employed in the present work is similar to that of our previous studies.[4–6)] The stacked target foils were irradiated with a beam of alpha-particles, and the foils were subjected to gamma-ray spectrometry to determine the production cross sections. Thin metallic holmium foils (purity: 99%, thickness: 12.29 μm, supplier: Goodfellow, UK) served as the target. There is only one isotope, ^{165}Ho (100%), in natural holmium. Natural copper foils and natural titanium foils served as degraders of the beam energy and were used for monitoring of beam the intensity. A 50.4 MeV beam extracted from the RIKEN AVF cyclotron was focused on target foils of 9-mm diameter. The stack was irradiated for 2.0 h with a beam intensity of 5.45×10^{11} alphas/s. The beam intensity was determined from the activities of ^{51}Cr produced from the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction, for which the cross section recommended by the IAEA (σ = 26.4 mb at E_α = 50 MeV) was adopted. The measured production cross sections were calculated using the well-known activation equation.[6)]

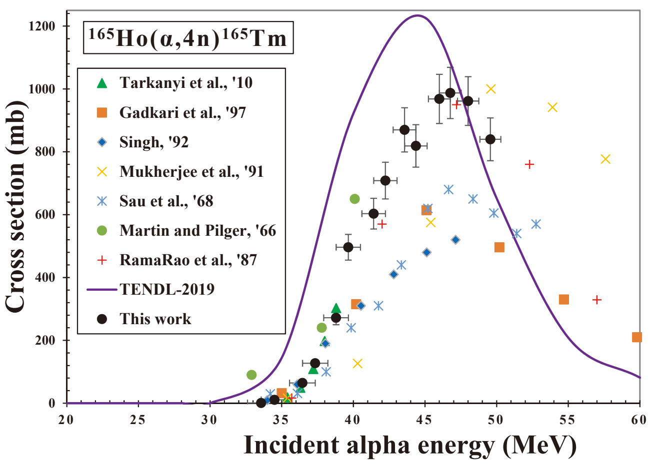

Fig. 1. Excitation function of the ^{165}Ho$(\alpha, 4n)^{165}$Tm reaction.

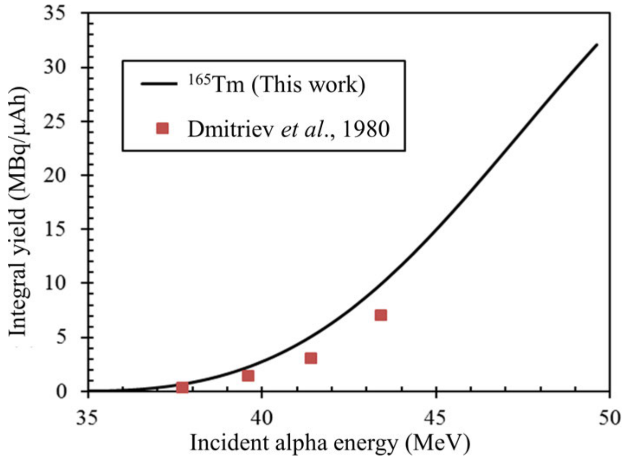

Fig. 2. Integral thick target yield for ^{165}Tm.

Owing to space constraints, only the excitation function of ^{165}Tm and its thick target yield are presented in this report. ^{165}Tm is populated through the ^{165}Ho$(\alpha, 4n)^{165}$Tm reaction. ^{165}Tm (30.06 hours) decays via the EC + β^+ (100%) process to ^{165}Er. The cross sections of this radioisotope were measured via its relatively intense gamma line of E_γ = 242.917 keV (I_γ = 35.5%).

The physical thick target yield has been calculated for the investigated radioisotope using the interpolation of the measured production cross sections by spline fits as well as the stopping power calculated using SRIM code.

In conclusion, new cross sections have been investigated for the ^{165}Ho$(\alpha, 4n)^{165}$Tm, ^{165}Ho$(\alpha, 3n)^{166}$Tm, ^{165}Ho$(\alpha, 2n)^{167}$Tm, and ^{165}Ho$(\alpha, n)^{168}$Tm reactions, but in this short report, only the results for ^{165}Tm have been presented.

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