Production cross sections of (d, x) reactions on natural erbium†

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Nowadays, radionuclides find wide applications in various field such as medicine, industry, agriculture etc. The production of such radionuclides is performed via a number of processes, mostly via the use of particle accelerators and nuclear reactors. Although the use of particle accelerators show some advantages over the nuclear reactors, however the production of radionuclides via former process is still not well practiced. The nuclear reaction cross-sections play a key role in optimization of production parameters for radionuclide of interest via the use of particle accelerators. Present study concerns the measurement of production cross-sections of residual radionuclides via deuteron irradiation on natural erbium target in the energy range of 4.59–23.06 MeV. This rare earth metal can also be used as a potential material for the production of some medically important thulium and erbium radionuclides. As an example, the production of the ^{167}Tm finds applications as a tracer for tumor and bone studies by using both the Anger/gamma camera and the rectilinear scanner.[1)] Furthermore, it's relatively long half-life ($T_{1/2} = 9.25$ d) and emission of γ-ray ($E_\gamma = 207.801$ keV, $I_\gamma = 42\%$) and Auger electrons (Auger $L = 5.5$ keV, 114%) made it suitable for applications in radionuclide therapy.[2)] Note that considering the common drawbacks of (n, γ) production route (carrier added and low specific activity production), several authors[3)] studied the production possibility of thulium radionuclides via light-charged particles-induced reactions on several targets. However, since a search of literature shows that the status of deuteron-induced reaction cross-sections on erbium is not satisfactory, further study on such processes may find great significance in various respect.

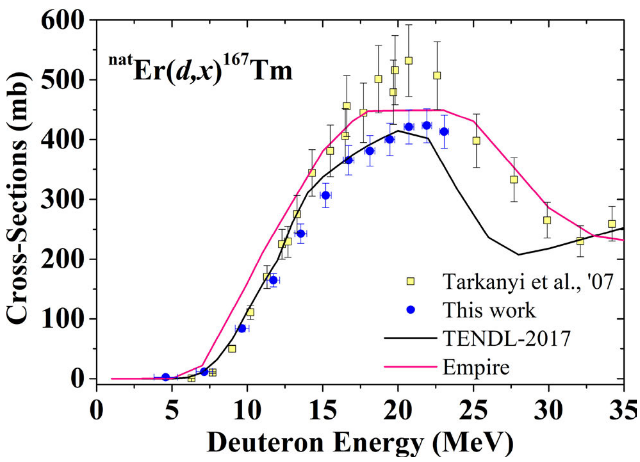

Fig. 1. Excitation function of the $^{\mathrm{nat}}$Er$(d, x)^{167}$Tm reaction.

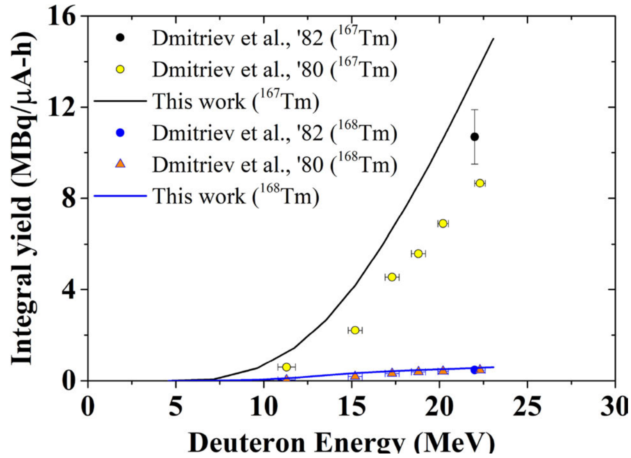

Fig. 2. Thick target integral yields (physical) for $^{167, 168}$Tm radionuclides.

In these circumstances, this study forms an interest to measure the production cross-sections of $^{\mathrm{nat}}$Er$(d, x)^{163, 165, 166, 167, 168}$Tm and $^{\mathrm{nat}}$Er$(d, x)^{171}$Er nuclear processes from their respective thresholds up to 23.06 MeV by using the AVF cyclotron of the RIKEN RI Beam Factory, Wako, Japan. Details on the irradiation technique, radioactivity determination, and data evaluation procedures are available in Ref. 4) Owing to the space limitation of this report, we present only the $^{\mathrm{nat}}$Er$(d, x)^{167}$Tm cross sections and the deduced yield in Figs. 1 and 2, respectively. Measured cross sections with an overall uncertainty of better than 33% are listed in Ref. 4). The cross-sections were normalized by using the $^{\mathrm{nat}}$Ti$(d, x)^{48}$V monitor cross sections recommended by IAEA. Measured data were critically compared with the available literature data, and an overall good agreement was found. However, only partial agreements were obtained with the data extracted from the TENDL-2017 library and Empire-3.2.2 code.

The deduced thick-target yields indicate that a low amount of no-carrier-added radioactivity of ^{167}Tm (4.2 MBq/μA-h) could be obtained by irradiating an enriched ^{167}Er target with 15-MeV deuteron energy from a cyclotron.

References

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