# Production cross sections of $^{nat}Er(d,x)^{171}Er$ reactions on natural erbium†

M. U. Khandaker[*1,*2] and H. Haba[*2]

The nuclear reaction cross-sections play a key role in optimization of production parameters for radionuclide of interest via the use of particle accelerators. In this study, the production cross-sections of $^{nat}Er(d,x)^{171}Er$ reaction has been measured by using stacked foil activation technique combined with HPGe gamma-ray spectrometry. $^{171}Er$ ($T_{1/2}$ = 7.516 h; $E_\gamma$ = 308.291 keV, $I_\gamma$ = 64%) finds remarkable applications for the development and evaluation of pharmaceutical drug delivery systems via the well-known gamma scintigraphic technique.[1] The measured cross-sections for $^{171}Er$ also find great significance as a short-lived parent for producing medically important long-lived daughter $^{171}Tm$ ($T_{1/2}$ = 1.92 y) via the $^{170}Er(d,p)^{171}Er \rightarrow ^{171}Tm$ process. Note that considering the common drawbacks of $(n,\gamma)$ production route, several authors[2] studied the production possibility of erbium 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.

Under this circumstance, the production cross-sections of $^{nat}Er(d,x)^{171}Er$ nuclear reaction has been measured from threshold 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. 3). Owing to the space limitation of this report, we present only the $^{nat}Er(d,x)^{171}Er$ cross sections and the deduced yield in Figs. 1 and 2, respectively. Measured cross sections with an overall uncertainty are listed in Ref. 3). The cross-sections were normalized by using the $^{nat}Ti(d,x)^{48}V$ 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.

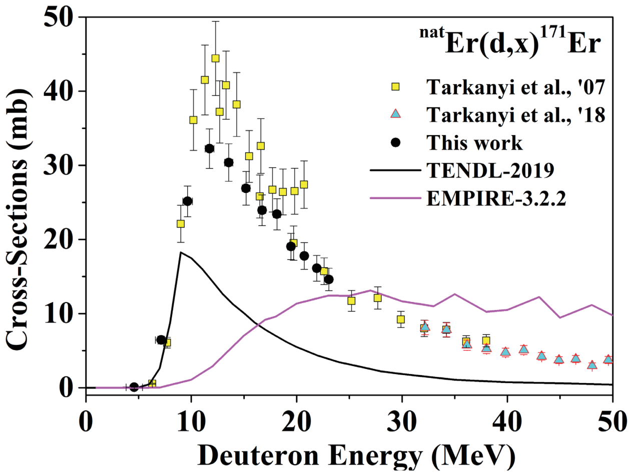


Fig. 1. Excitation function of the $^{nat}Er(d,x)^{171}Er$ reaction.

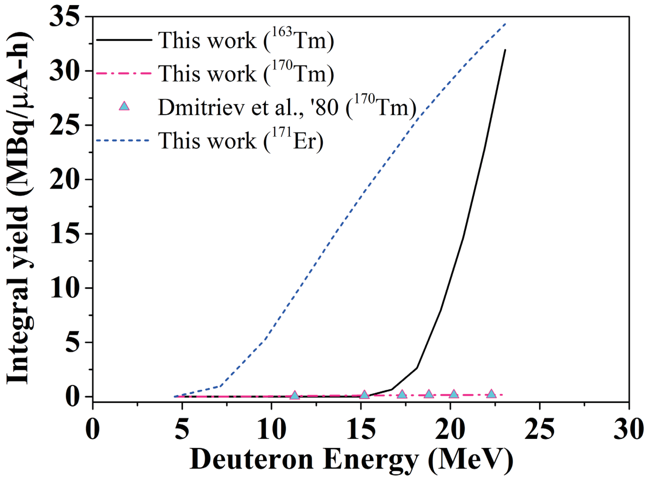


Fig. 2. Thick target integral yields (physical) for $^{163,170}Tm$ and $^{171}Er$ radionuclides.

Realizing the applications of measured radionuclides including $^{nat}Er(d,x)^{171}Er \rightarrow ^{171}Tm$ in medical and other fields, it is hope that the measured data could play an important role in enrichment of the cross section database that are useful for applications in the medical, industrial and accelerator technologies. The large discrepancy for the $^{170}Er(d,p)^{171}Er$ ($E_{thr}$ = 0.0 MeV) reaction between the model code and the measurement is an important clue to modify the model code.

† Condensed from Nucl. Instrum. Methods Phys. Res. B **470**, 1 (2020)

*1 Centre for Biomedical Physics, Sunway University
*2 RIKEN Nishina Center

References
1) A. F. Parr, R. M. Beihn *et al.*, Pharm. Res. **4**, 486 (1987).
2) H. Uusijarvi, P. Bernhardt *et al.*, J. Nucl. Med. **47**, 807 (2006).
3) M. U. Khandaker, H. Haba *et al.*, Nucl. Instrum. Methods Phys. Res. B **470**, 1 (2020).