Cross-section measurement of α-induced reactions on ^{nat}Er for ^{169}Yb production

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Radioisotopes (RIs) are widely used in the medical fields such as therapy and diagnosis. To develop such medical treatments, the candidates of medical RIs need to be studied further. Ytterbium-169 (^{169}Yb) is a type of RI that has a half-life of 32.018 days and emits Auger electrons, X and γ rays. The Auger electrons and X rays can be used in brachytherapy as an alternative RI to ^{125}I and ^{192}Ir.[1)] The γ rays at 177.21 keV (I_γ = 22.28%) and 197.96 keV (I_γ = 35.93%) provide the opportunity for diagnosis.[2)] Therefore, owing to these characteristics, ^{169}Yb can be used in theranostics.

Various reactions can be used to produce ^{169}Yb such as the neutron-capture reaction on ^{168}Yb and charged-particle induced reactions on ^{169}Tm and ^{nat}Er. Among these, the best production route has not been determined yet. Therefore, we performed systematic studies on the charged-particle induced reactions to produce ^{169}Yb such as deuteron- and alpha-induced reactions on ^{169}Tm and alpha-induced reactions on ^{nat}Er. In this report, we focus on the α-induced reaction on ^{nat}Er. The cross-sections for these reactions have already been experimentaly measured and reported.[3–6)] However, these cross-sections are different. Therefore, we again measured them to ensure a higher accuracy.

The experiment was performed at the AVF cyclotron of the RIKEN RI Beam Factory using the activation-stacked-foil method. Metallic foils of ^{nat}Er (purity: 99%, Goodfellow Co., Ltd., UK) and ^{nat}Ti (purity: 99.6%, Nilaco Corp., Japan) were stacked as the target. The Ti foils were inserted for the ^{nat}Ti(α, x)^{51}Cr monitor reaction to assess the target thicknesses and beam parameters. Their average thicknesses were 20.26 and 2.24 mg/cm^2, which were derived from their measured weights and areas. The stacked target was irradiated for 1 h by a 50-MeV α beam with an intensity of 100.1 pnA measured with a Faraday cup. The initial beam energy was determined by the time of flight measurement.[8)] The energy degradation in the stacked target was calculated by the SRIM code.[9)] The irradiated foils were separated and subjected to the γ-ray spectrometry using a HPGe detector. The nuclear decay data were taken from the NuDat 2.7 database.[10)]

The cross-sections of ^{nat}Ti(α, x)^{51}Cr monitor reaction were derived from the measurement of γ line at 320.08 keV (I_γ = 9.910%). The result was compared with the recommended values of IAEA and we confirmed the accuracy of the foil thicknesses and beam parameters within the uncertainties.

The γ line at 177.21 keV (I_γ = 22.28%) was used to derive the cross-sections of ^{169}Yb. The comparison between our preliminary result, former experimental data, and the TENDL-2017 data is shown in Fig. 1. The peak position of our result is consistent with the data obtained by B. Király *et al.* (2008).[3)] However, the amplitude of their data is larger than our result. Other experimental data[4–6)] are very different from our result. The TENDL-2017 data show a peak at the same energy as ours, although the ampulitude of the peak is lower.

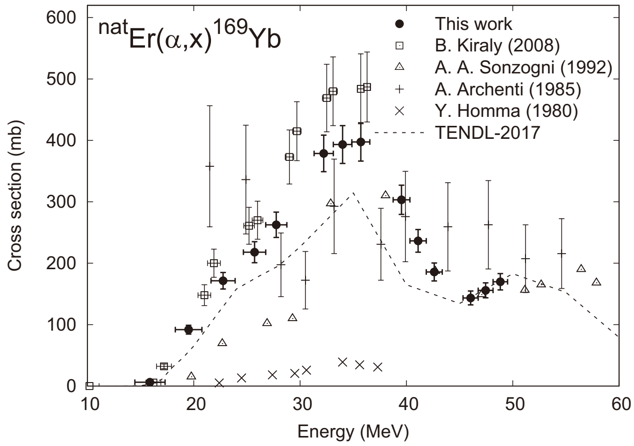

Fig. 1. Preliminary result of ^{nat}Er(α, x)^{169}Yb compared with previous data[3–6)] and TENDL-2017.[7)]

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References

1) Neil S. Patel *et al.*, Cardiovasc. Radiat. Med. **2**, 173 (2001).
2) F. H. DeLand *et al.*, J. Nucl. Med. **12**, 683 (1971).
3) B. Király *et al.*, Nucl. Instrum. Methods Phys. Res. B **266**, 549 (2008).
4) A. A. Sonzogni *et al.*, J. Radioanal. Nucl. Chem., Lett. **165**, 295 (1992).
5) A. Aechenti *et al.*, Radiochemica Acta **38**, 65 (1985).
6) Y. Homma *et al.*, Int. J. Appl. Radiat. Isot. **31**, 505 (1980).
7) A. J. Koning *et al.*, Nucl. Data Sheets **113**, 2841 (2012).
8) T. Watanabe *et al.*, Proc. 5th Int. Part. Accel. Conf. (IPAC2014), 3566 (2014).
9) J. F. Ziegler *et al.*, SRIM: the Stopping and Range of Ions in Matter, `http://www.srim.org/`.
10) National Nuclear Data Center, The NuDat 2 database, `http://www.nndc.bnl.gov/nudat2/`.