Radioisotopes (RI) are used for diagnosis and therapy in nuclear medicine. $^{186}$Re is a $eta$ emitter with a half-life of 3.72 days, a maximum $\beta$ energy of 1.07 MeV, average penetration ranges of 1.1 mm in soft tissue and 0.5 mm in bone, and a 9.47% $\gamma$-ray emission at 137 keV. $^{188}$Re is a $\beta$ emitter with a half-life of 17 hours, maximum $\beta$ energy of 2.12 MeV, and 15.61% $\gamma$-ray emission at 155 keV. Both isotopes can be used for theranostics (therapy and diagnosis).

We focused on a process to produce $^{186,188}$Re through alpha-induced reactions of natural tungsten because we could find data for only one 43 MeV. Therefore, we measured the excitation function of the $^{nat}W(\alpha,x)^{186,188}$Re reactions up to 51 MeV.

The excitation functions of the $^{nat}W(\alpha,x)^{186,188}$Re reaction were measured by the stacked-foil method, activation method and high-resolution $\gamma$-ray spectroscopy. $^{nat}$W foils (purity: 99%, Goodfellow Co., Ltd., UK) were stacked with $^{nat}$Ti foils (purity: 99%, Goodfellow Co., Ltd., UK) for monitoring the beam parameters and degrading the beam energy. The thicknesses of the W and Ti foils were 15.03 and 2.23 mg/cm$^2$, respectively.

The irradiation was performed at the RIKEN AVF cyclotron. A 51 MeV alpha beam with an average intensity of 209.7 pmA was irradiated on the target for 2 h. The incident beam energy was measured by the time-of-flight method using plastic scintillator monitors. The $\gamma$-ray spectra of the activated foils were measured by an HPGe detector. Nuclear decay data were taken from the online NuDat 2.7 database.

From the net peak areas of the 137.16- and 155.04-keV $\gamma$-rays, the activation cross sections for the $^{nat}W(\alpha,x)^{186,188}$Re reaction were deduced using the standard activation formula

$$\sigma = \frac{T_{\gamma} \lambda}{\varepsilon_{d}\varepsilon_{\gamma} \varepsilon_{t} N_{t} N_{b} (1 - e^{-\lambda t_{b}}) e^{-\lambda t_{c}} (1 - e^{-\lambda t_{m}})}$$

where $N_{t}$ denotes the surface density of target atoms; $N_{b}$ the number of bombarding particles per unit time; $T_{\gamma}$ the number of counts in the photo-peak; $\varepsilon_{d}$ the detector efficiency; $\varepsilon_{\gamma}$ the $\gamma$-ray abundances; $\varepsilon_{t}$ the measurement dead time, which is the ratio of live time to real time; $\lambda$ the decay constant; $t_{b}$ the bombarding time; $t_{c}$ the cooling time; and $t_{m}$ the acquisition time.

We found that our $^{nat}W(\alpha,x)^{186,188}$Re result is in good agreement with previous data obtained by NE. Scott et al. and the theoretical calculation (TENDL-2015). On the other hand, the $^{nat}W(\alpha,x)^{188}$Re result shows disagreements with the other data. TENDL-2015 underestimated the cross section at all energies.

References
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