Production cross sections of ^{45}Ti via deuteron-induced reaction on ^{45}Sc[†]

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^{45}Ti ($T_{1/2} = 184.8$ min) is an appropriate positron emitter isotope ($E_{\beta+} = 439$ keV, $I_{\beta+} = 84.8\%$) for positron emission tomography (PET). This radioisotope can be produced in the deuteron-induced reaction on a scandium-45 target at cyclotrons. However, the quality of experimental data on the cross sections of the ^{45}Sc$(d,2n)^{45}$Ti reaction is not satisfactory. Therefore, we aim to measure the cross sections of the ^{45}Sc$(d,2n)^{45}$Ti reaction and to investigate a route for ^{45}Ti production.

The stacked-foil activation technique and γ-ray spectrometry were adopted to determine the cross sections. The stacked target included metallic foils of ^{45}Sc (thicknesses of 25.8 and 250 μm with a purity of 99.0%), ^{27}Al (18.5 μm, 99.6%), and $^{\mathrm{nat}}$Ti (20.2 μm, 99.6%). The target was irradiated for 30 min with a 24-MeV deuteron beam from the RIKEN AVF cyclotron. The incident beam energy was measured using the time-of-flight method. The energy degradation in the stacked target was calculated using the SRIM code.[1)] The beam intensity was measured using a Faraday cup and double-checked with the $^{\mathrm{nat}}$Ti$(d,x)^{48}$V monitor reaction.[2)] By comparing the monitor reaction, the measured intensity (180 ± 9 nA) was corrected by decreasing it by 2% to 176 ± 9 nA. The γ-ray spectra of the irradiated foils were measured using a high-resolution and a high-purity germanium (HPGe) detector. The detector was calibrated using a mixed γ-ray point source. In the measurements, the dead time was kept below 7%.

Subsequently, the activation cross sections of ^{44,45}Ti and ^{44g,44m,46}Sc were determined. The measurements of the 719.6-keV γ-ray ($I_\gamma = 0.154\%$) from the ^{45}Ti decay were used to derive the cross sections of the ^{45}Sc$(d,2n)^{45}$Ti reaction. Figure 1 shows our measured excitation function of the ^{45}Sc$(d,2n)^{45}$Ti reaction in comparison with previous experimental data[3)] and the theoretical estimation retrieved from TENDL-2019.[4)] The derived excitation function is consistent with the data reported by Hermanne *et al.*;[3)] however, it is less scattered. The peak position of the TENDL-2019 data is slightly shifted to a lower energy.

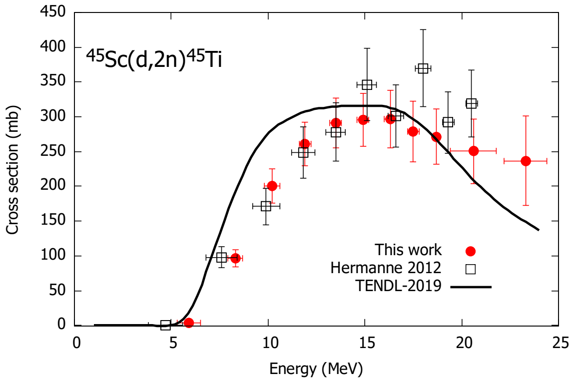

Fig. 1. Excitation function of the ^{45}Sc$(d,2n)^{45}$Ti reaction.

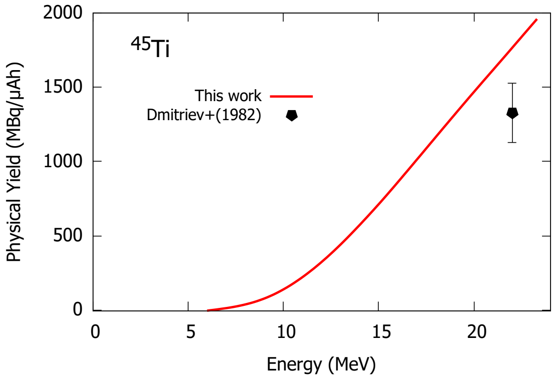

Fig. 2. Physical yield of ^{45}Ti.

The physical yield of ^{45}Ti was deduced from the measured excitation function and is shown in Fig. 2. The present yield curve of ^{45}Ti is slightly higher than the experimental data obtained by Dmitriev *et al.*[5)] at 22 MeV. ^{44}Ti is the only one co-produced radioactive isotope of titanium in our experiment and can be formed by $(d,3n)$ reaction on ^{45}Sc above 15 MeV. Therefore, isotopically pure ^{45}Ti production is possible in $(d,2n)$ reaction on ^{45}Sc in an energy range of 8–15 MeV.

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