Activation cross sections of ^{28}Mg via α-particle-induced reaction on ^{27}Al

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Magnesium-28 ($T_{1/2}$ = 20.9 h) decays with emission of a β^- particle and γ rays. This radionuclide can be used as a radiotracer in several applications.[1)] The promising production reaction of ^{28}Mg is the α-particle-induced reaction on ^{27}Al targets. Ten experimental studies on the cross sections of the ^{27}Al$(\alpha, 3p)^{28}$Mg reaction were found in the EXFOR library.[2)] However, the cross sections of the previous studies are broadly scattered. Therefore, we performed an experiment to obtain reliable cross sections of the ^{27}Al$(\alpha, 3p)^{28}$Mg reaction.

An experiment using a 50.7-MeV α-particle beam was conducted at the RIKEN AVF cyclotron employing the stacked-foil activation technique and high-resolution γ-ray spectrometry.

Pure metallic foils of ^{27}Al (>99% purity, 50 and 5 μm thick) and ^{nat}Ti (99.6% purity, 5 μm thick) were purchased from Nilaco Corp., Japan. The 50- and 5-μm Al foils were used as target and catcher foils, respectively. The Ti foil was used for the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction. The size and weight of all foils were measured for the average thicknesses. The thicknesses of the Al target, Al catcher, and Ti monitor foils were determined as 13.2, 1.22, and 2.37 mg/cm^2, respectively. The foils were cut into a 10 $\times$ 10 mm size and stacked in a target holder that served as a Faraday cup.

The stacked target was irradiated for 30 min with a 50.7-MeV α-particle beam. The initial beam energy was determined using the time-of-flight method.[3)] The average beam intensity measured using the Faraday cup was obtained as 205 nA. The beam energy degradation in the stacked target was calculated using stopping powers obtained from the SRIM code.[4)] γ rays emitted from the irradiated foils were measured using a high-purity germanium detector (ORTEC GEM30P4-70) and dedicated analysis software (SEIKO EG&G Gamma Studio) without chemical separation.

The cross sections of the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction were derived using the γ line at 320 keV (I_γ = 9.91%) from the decay of ^{51}Cr ($T_{1/2}$ = 27.7 d). The derived cross sections were compared with the International Atomic Energy Agency recommended values.[5)] For best agreement between the measured and recommended values, the incident beam energy and thickness of Al target foils were corrected within their uncertainties by +0.2 MeV and −1%, respectively. The other measured parameters were adopted without correction. The corrected cross sections were consistent with the recommended values, indicating proper beam parameters and energy loss determination within the stack, as shown in Fig. 1.

The cross sections of the ^{27}Al$(\alpha, 3p)^{28}$Mg reaction were determined using the γ line at 1342 keV (I_γ = 54%), which was emitted with the decay of ^{28}Mg ($T_{1/2}$ = 20.9 h). Figure 2 shows our preliminary result with the earlier experimental data obtained from the EXFOR library[2)] and the TENDL-2021 theoretical values.[6)] The theoretical values are considerably lower than the experimental data.

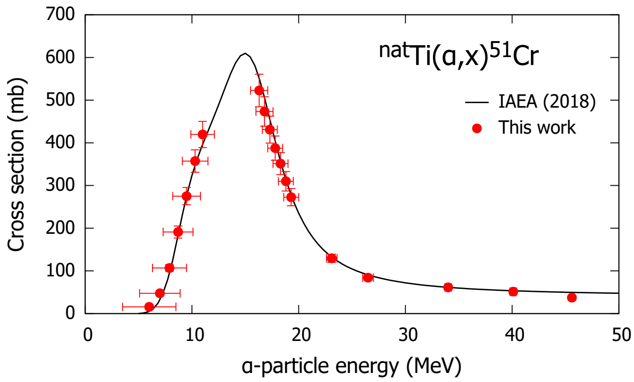

Fig. 1. Cross sections of the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction with the IAEA recommended values.[5)]

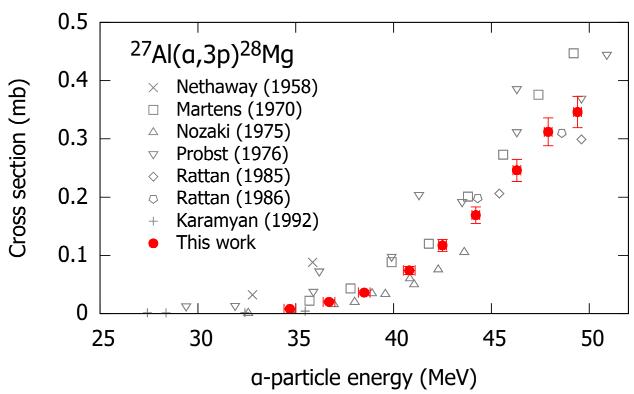

Fig. 2. Measured cross sections of the ^{27}Al$(\alpha, 3p)^{28}$Mg reaction with the literature data and the TENDL-2021 values.[6)]

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