Production cross-sections of ^{61}Cu in α-particle-induced reaction on ^{59}Co

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The ^{61}Cu radioisotope has a half-life of $T_{1/2}$ = 3.339 h and decays via electron capture (39%) and positron emission processes (61%, $\langle E_{\beta+}\rangle = 500$ keV). ^{61}Cu can be used in positron emission tomography (PET) for prolonged imaging of processes with slower kinetics.[1)]

Charged-particle-induced reactions on nickel and cobalt are possible production routes of ^{61}Cu. In this work, we focused on the α-particle-induced reactions on ^{59}Co targets. Twelve previous experimental studies were found in the EXFOR library.[2)] However, their data show large uncertainties and discrepancies. Therefore, we measured the excitation function of the ^{59}Co($\alpha, 2n$)^{61}Cu reaction. The experimental result was compared with the literature data obtained from the EXFOR database and theoretical calculation in the TENDL-2021 library.[3)]

The experiment was conducted at the AVF cyclotron of RIKEN RI Beam Factory. The stacked-foil technique, activation method and high-resolution γ-ray spectrometry were used. The stacked target comprised pure metallic foils of ^{59}Co (15-μm thick, 99.9% purity), ^{nat}Ti (5-μm thick, 99.6% purity), and ^{27}Al (5-μm thick, >99% purity). All foils were purchased from Nilaco Corp., Japan. The ^{nat}Ti foils were used for the ^{nat}Ti(α, x)^{51}Cr monitor reaction. The ^{27}Al foils were inserted to catch reaction products recoiled from the ^{59}Co and ^{nat}Ti foils. The target thicknesses were derived from the measured size and weight of the foils. The derived thicknesses of ^{59}Co, ^{nat}Ti, and ^{27}Al foils were 14.2 ± 0.2, 2.35 ± 0.01, and 1.21 ± 0.01 mg/cm^2, respectively. The original foils were then cut into sizes of 10×10 mm to fit a target holder that served as a Faraday cup. Seventeen sets of Co-Al-Ti-Al foils were stacked in the target holder.

The stacked target was irradiated with a 50.9 ± 0.2 MeV α-particle beam for 30 min. The primary beam energy was measured by the time-of-flight method.[4)] Energy degradation in the stacked target was calculated using stopping powers derived from the SRIM code.[5)] The average beam intensity measured by the Faraday cup was 200 nA.

The γ-ray spectra were measured by a high-resolution HPGe detector (ORTEC GEM-25185-P) and analyzed using dedicated software (SEIKO EG&G Gamma Studio). The spectra of each ^{59}Co foil together with the following ^{27}Al catcher foil were measured four times. To maintain a dead time less than 4%, the distance between the detector and foils was arranged.

To assess the beam parameters and target thicknesses, cross sections of the ^{nat}Ti(α, x)^{51}Cr monitor reaction were derived. The γ line at 320.08 keV (I_γ = 9.910%) from the decay of ^{51}Cr ($T_{1/2}$ = 27.7025 d) was measured for each ^{nat}Ti foil together with the next ^{27}Al catcher foil of recoiled products after a cooling time of 4 days.

The derived cross sections were compared with the IAEA-recommended values.[6,7)] Based on the comparison, the incident beam energy, and average thicknesses of the ^{59}Co, ^{nat}Ti, and ^{27}Al foils were corrected within uncertainties of +0.2 MeV to 51.1 ± 0.2 MeV and -1% to 14.1 ± 0.3, 2.33 ± 0.04, and 1.20 ± 0.02 mg/cm^2, respectively. The corrected thickness and incident beam energy were used to derive production cross sections.

The preliminary results on the cross sections of the ^{59}Co($\alpha, 2n$)^{61}Cu reaction were derived from the measurement of the γ-line at 282.956 keV (I_γ = 12.7%) emitted with the decay of ^{61}Cu ($T_{1/2}$ = 3.339 h). The measurement was performed after a cooling time of 18 hours. The derived cross sections are shown in Fig. 1 in comparison with the previous experimental data and theoretical estimation of the TENDL-2021 library.

The measured excitation function of the ^{59}Co(α, $2n$)^{61}Cu reaction shows a smooth curve, and is consistent with only part of the previously published data. The peak position of the TENDL-2021 values

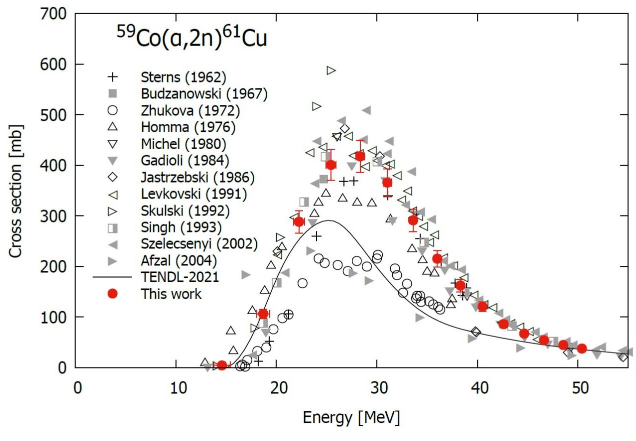

Fig. 1. Excitation function of the ^{59}Co($\alpha, 2n$)^{61}Cu reaction in comparison with the previous studies found in the EXFOR library[2)] and the TENDL-2019 values.[3)]

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is slightly shifted to the lower energy region and underestimates the current cross sections.

The analyses to determine the final cross sections of ^{61}Cu and other co-products are continued. The thick target yields of the products can be calculated using the measured cross sections. The finalized results are expected to contribute to the practical use of radionuclides in nuclear medicine.

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