Activation cross sections of alpha-particle induced nuclear reactions on natural palladium†

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Production cross sections of radioactive isotopes (RI) are fundamental information for medical applications such as therapy and diagnostics. One of the medical RI is ^{103}Pd ($T_{1/2}$ = 16.991 d), which is used for brachytherapy[1] and targeted radionuclide therapy as part of the ^{103}Pd/^{103m}Rh *in vivo* generator.[2] In addition to the direct production of ^{103}Pd, the contribution from the decay of its parent, ^{103g}Ag, is worthy of investigation. There are several charged-particle-induced reactions to produce ^{103}Ag. In a literature survey, only one experimental study of ^{103g}Ag production cross sections of α-induced reactions on ^{nat}Pd was found.[3] The incident energy of the previous study is limited to below 37 MeV and even lower than that at the peak of the cross sections. Therefore, we are motivated to perform an experiment to determine the excitation function of the ^{nat}Pd$(\alpha, x)^{103g}$Ag reaction up to 50 MeV.

The experiment was performed at the RIKEN AVF cyclotron. The stacked-foil activation technique and high-resolution γ-ray spectrometry were used. Thin metallic foils of ^{nat}Pd (99.95% purity, Nilaco Corp., Japan) and ^{nat}Ti (99.9% purity, Goodfellow Co., Ltd., UK) were purchased to fabricate a target. The size and weight of the large foils were measured. The average thicknesses of the Pd and Ti foils were found to be 9.70 and 4.85 mg/cm^2 from the measurement, respectively. The foils were cut into small pieces of 10 × 10 mm^2 to fit a target holder. The stacked target consisted of 12 sets of the group of Pd-Pd-Ti-Ti foils. The target was irradiated for 2 h by a 51.2-MeV α beam with an average intensity of 111.4 nA. The intensity was measured using a Faraday cup. The initial beam energy was determined using the time-of-flight method.[4] The energy degradation of the beam in the target was calculated using the polynomial approximation of stopping-power data.[5] Gamma-ray spectra from each irradiated foil were measured four times to follow the decay of the reaction products with half-lives between 50 min and 460 days. Nuclear-decay data were taken from NuDat 2.7.[6]

The 118.74-keV γ rays (I_γ = 31.2%) emitted with the decay of ^{103g}Ag ($T_{1/2}$ = 65.7 min) were measured after a cooling time of 3.6 h. There are minor contributions to the photo-peak area from co-produced isotopes, ^{100}Pd and ^{111m}Pd, but their total contribution is negligibly small. The measured counts are used to determine the excitation function of the ^{nat}Pd$(\alpha, x)^{103g}$Ag reaction. In addition to the direct production, there are contributions from the decay of its isometric state ($T_{1/2}$ = 5.7 s) and ^{103}Cd ($T_{1/2}$ = 7.3 min). Therefore, cumulative cross sections are derived in this work. The result is shown in Fig. 1 in comparison with the experimental data obtained earlier[3] and the TENDL-2017 data.[7] Our result is slightly higher than the previous experimental data. The TENDL-2017 data provides an excitation function with a consistent tendency.

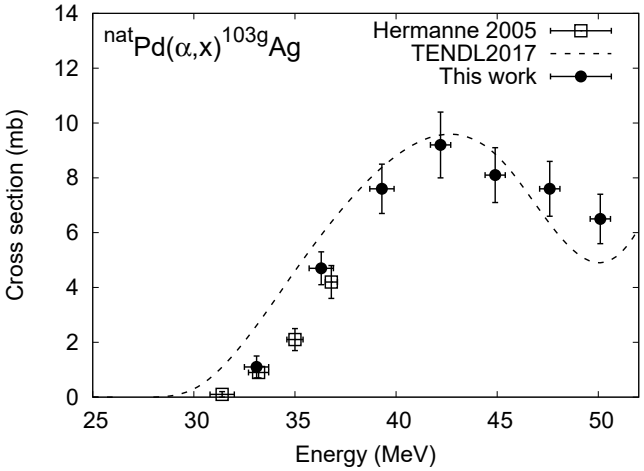

Fig. 1. Cumulative cross sections of the ^{nat}Pd$(\alpha, x)^{103g}$Ag reaction.

Our result extends cross-section data to the higher energy region and covers the peak. It enriches nuclear reaction databases and is available for development of theoretical calculation models.

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