Production cross sections of ^{52g}Mn in α-particle-induced reactions on ^{nat}V†

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Manganese-52 has the longer-lived ground state ^{52g}Mn ($T_{1/2} = 5.6$ d, $\varepsilon + \beta^+$: 100%) and the shorter-lived excited state ^{52m}Mn ($T_{1/2} = 21.1$ min, IT: 1.78%, $\varepsilon + \beta^+$: 98.22%). The decay processes of ^{52g}Mn are electron capture (70.6%) and positron emission (29.4%, $\langle E_{\beta+} \rangle = 242$ keV).[1] The positrons emitted from the decay of ^{52g}Mn can be used for Positron Emission Tomography (PET).[2] The direct routes to produce ^{52g}Mn involve charged-particle-induced reactions on chromium and vanadium. Whereas, the indirect route involves the internal transition of ^{52m}Mn co-produced simultaneously in the reactions. This study, we focused on the α-particle-induced reaction on ^{nat}V. Eleven experimental cross section data of the ^{nat}V$(\alpha, x)^{52g}$Mn reactions were found in the EXFOR library.[3] However, their data are largely scattered. Therefore, we measured the excitation function of the ^{nat}V$(\alpha, x)^{52g}$Mn reaction up to 50 MeV. The obtained cross sections were compared with the literature data and theoretical calculation in the TENDL-2019 library.[4]

The stacked-foil activation technique and high-resolution γ-ray spectrometry were used to measure the cross sections. Pure metallic foils of ^{nat}V (25-μm thick, 99% purity), ^{nat}Ti (5-μm thick, 99.6% purity), and ^{27}Al (5-μm thick, >99% purity) were purchased from Nilaco Corp., Japan, and used for the stacked target. The ^{nat}Ti foils were interleaved for the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction. The ^{27}Al foils were used to catch recoiled products from the ^{nat}V and ^{nat}Ti foils. The average target thicknesses were derived from the measured size and weight of the original foils. Derived average thicknesses of ^{nat}V, ^{nat}Ti, and ^{27}Al foils were 20.4, 2.24, and 1.22 mg/cm^2, respectively. The original foils were cut into a size of 8×8 mm. Eleven sets of V-Al-Ti-Ti-Al foils were stacked into a target holder, which served as a Faraday cup.

The stacked target was irradiated with an α-particle beam for 30 min. The primary beam energy was measured by the time-of-flight method.[5] The measured beam energy was 50.6 ± 0.2 MeV. Consequently, the energy degradation in the stacked target was calculated using stopping powers obtained from the SRIM code.[6] The average beam intensity measured using the Faraday cup was 194 nA.

γ rays emitted from each irradiated foil were measured by a high-resolution HPGe detector (ORTEC GEM-25185-P), which was calibrated with a multiple gamma-ray emitting point source. The spectra were analyzed using dedicated software (SEIKO EG&G Gamma Studio). Each ^{nat}V foil with the following ^{27}Al catcher foil was measured several times. The distance between the detector and foils was arranged to ensure a dead time of less than 3%.

The cross sections of the ^{nat}Ti$(\alpha, x)^{51}$Cr monitor reaction were derived and used to assess the beam parameters and target thicknesses. The measurement of the γ line at 320.08 keV ($I_\gamma = 9.91\%$) from the decay of ^{51}Cr ($T_{1/2} = 27.7025$ d) was performed following a cooling time of 3 days. Only the Ti foils at the beam downstream of each Ti-Ti foil pair in the stack were used for cross section deduction because the compensation of recoiled ^{51}Cr was expected. The dead time during the measurements was maintained at less than 1%. Subsequently, the derived cross sections were compared with the IAEA-recommended values[7] and found to be consistent with each other. We adopted the measured beam parameters and target thicknesses without any corrections for data analyses.

The cross sections of the ^{nat}V$(\alpha, x)^{52g}$Mn reaction were derived. The γ line at 935.544 keV ($I_\gamma = 94.5\%$) from the decay of ^{52g}Mn was measured following a cooling time of 17 d. During the cooling time, the excited state ^{52m}Mn completely decayed to the ground state ^{52g}Mn or the stable nuclide ^{52}Cr. The cumulative cross

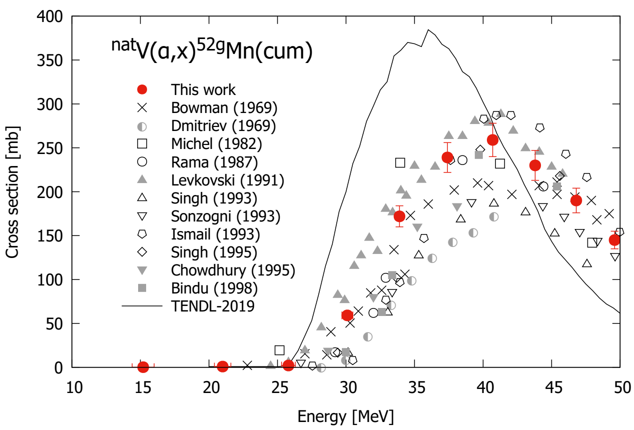

Fig. 1. Excitation functions of the ^{nat}V$(\alpha, x)^{52g}$Mn reaction.

† Condensed from the article in Appl. Radiat. Isot. **184**, 110204 (2022)

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sections could be derived from the measured net counts of the γ line. The excitation functions are shown in Fig. 1 along with the literature data and TENDL-2019 values.[4)] The measured cross sections exhibited a smooth curve and agreement with part of the previous experimental data. However, the shape of the TENDL-2019 values was largely different from the experimental data.

G. Damdinsuren was granted a scholarship by the M-JEED project (Mongolian-Japan Engineering Education Development Program, J11B16).

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