Production cross-section of ^{109}Cd via alpha-particle-induced reaction on natural silver up to 50 MeV†

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Cadmium-109 has a 462-day half-life and decays to ^{109m}Ag ($T_{1/2}$ = 39.79 s). This decay properties make ^{109}Cd useful for calibrating radiation detectors, and tracking cadmium pollution.[1] Moreover, this radionuclide can be considered as a generator of ^{109m}Ag, which emits 88.03-keV γ rays suitable for single photon emission computed tomography (SPECT).[2] Potential production routes of ^{109}Cd are charged-particle-induced reactions on silver, and palladium targets. Among these production routes, the ^{nat}Ag$(\alpha, x)^{109}$Cd reaction is considered as a promising reaction.[3] However, the experimental data of the ^{nat}Ag$(\alpha, x)^{109}$Cd reaction are largely scattered. Thus, this study aimed to measure the production cross-sections of ^{109}Cd via α-particle bombardment of natural silver to investigate production routes.

Cross-section measurements were performed using the stacked-foil activation technique and γ-ray spectrometry. The stacked target consisted of pure metallic foils of ^{nat}Ag (10.0 mg/cm^2, 99.9% purity) and ^{nat}Ti (2.2 mg/cm^2, 99.5% purity). The target was irradiated for 30 min with a 50.2 MeV α-particle beam from RIKEN AVF cyclotron. The incident beam energy was measured by the time-of-flight method. SRIM code[4] was used to calculate the energy degradation in the stacked target.

Beam intensity of 212 nA was measured directly by using a Faraday cup. We used a high-purity germanium detector for the γ-ray spectrometry. The detector was calibrated using a mixed γ-ray point source. In γ-ray measurements, the dead time was maintained as less than 5%. Furthermore, γ-ray measurements were performed after long cooling times of approximately 50 days. In the measurements, only detectable γ line at 88.0336 keV (I_γ = 3.644%) emitted in decay of ^{109}Cd was used to derive the cumulative cross-sections of ^{nat}Ag$(\alpha, x)^{109}$Cd reaction.[5]

Figure 1 shows the measured cross-sections in comparison with previous experimental data[3,5–7] and TENDL-2021 values.[8] Our data are in agreement with the previous data reported by Porges *et al.* (1956)[7] and Ditroi *et al.* (2018).[5] Furthermore, data reported by Tarkanyi *et al.* (2018)[3] are scattered and exhibit high uncertainty. Data of Peng *et al.* (1996)[6] are much lower than other experimental datasets. The data in TENDL-2021 underestimate the amplitude at the first peak. The physical yield of ^{109}Cd formation was deduced based on the measured excitation function. The result is shown in Fig. 2 when compared with the previous experimental data.[9]

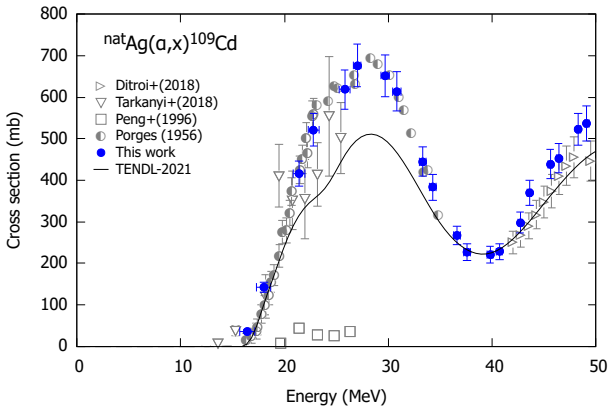

Fig. 1. Excitation function of the ^{nat}Ag$(\alpha, x)^{109}$Cd reaction in comparison with the previous experimental data.[3,5–7]

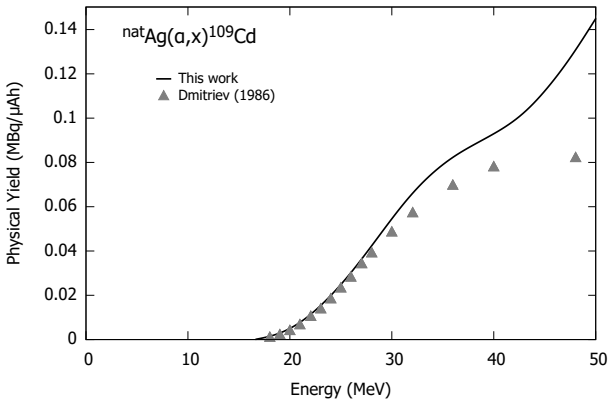

Fig. 2. Physical yield of ^{109}Cd deduced from our measured cross-sections when compared with the only literature data.[9]

Our deduced yield data are in agreement with the literature values below 30 MeV although the literature data are lower for values above 30 MeV. In addition to the activation cross-sections of ^{109}Cd, those of ^{104g,105,106m,110m}Ag, ^{107,111m}Cd and ^{107g,108g,108m,109,110g,110m,111}In were determined in

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References

1) K. Aardaneh *et al.*, J. Radioanal. Nucl. Chem **276**, 831 (2008).
2) M. Faßbender *et al.*, Radiochim. Acta **92**, 237 (2004).
3) F. Tárkányi *et al.*, J. Radioanal. Nucl. Chem. **318**, 1949 (2018).
4) J. F. Ziegler *et al.*, Nucl. Instrum. Methods Phys. Res. B **268**, 1818 (2010).
5) F. Ditrói *et al.*, Nucl. Instrum. Methods Phys. Res. B **436**, 119 (2018).
6) X. Peng *et al.*, Appl. Radiat. Isot. **47**, 309 (1996).
7) K. G. Porges *et al.*, Phys. Rev. **101**, 225 (1956).
8) A. J. Koning *et al.*, Nucl. Data Sheets **155**, 1 (2019).
9) P. P. Dmitriev *et al.*, Report INDC(CCP) 263 (1986) IAEA.