Cross sections of alpha-particle-induced reactions on ^{nat}Sb[†]

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Cross sections of alpha-particle-induced reactions on natural antimony targets were investigated up to 51 MeV. Some produced iodine isotopes are frequently used in nuclear medicine; therefore, their cross sections can be interesting as alternative production routes. For most of these reactions, the available experimental data in the literature are not sufficiently consistent; therefore, additional experimental cross sections of these reactions are required. The experiment was performed at the RIKEN AVF cyclotron. The stacked-foil activation technique and high-resolution γ-ray spectrometry were used. Thin Sb targets were prepared by vacuum evaporation onto Kapton (polyimide) (24.5 ± 0.25 μm, Goodfellow, Co., Ltd., UK). Kapton backings with a diameter of 13 mm were cut, numbered, and measured by weight before the evaporation process. Small grains of Sb (approximately 5 mg) were placed in a resistive heated tantalum boat to evaporate it in vacuum and deposit a thin layer of Sb onto the Kapton backings with a 10 mm in diameter mask placed approximately 15 cm from the source of evaporating Sb. This geometry provided relatively even Sb layers on the Kapton backings. The thickness of the evaporated Sb layer was determined from the measured weight and known surface of the evaporated spot. Each sandwiched Sb target was composed of two Sb layers enclosed between two Kapton backings with an average thickness of $\sim$1 mg/cm^2. Pure ^{nat}Ti foils (99.9% Nilaco Corp., Japan) with an average thickness of 5.3 ± 0.05 μm were inserted into the stack to monitor the irradiation parameters. To address the recoil effect, an additional Kapton catcher foil was used behind every Ti foil. The irradiations lasted for 2 h with an alpha-particle beam of 50.42 ± 0.2 MeV and 50 nA. The incident beam energy was measured using the time-of-flight method.[1)] The energy loss of the alpha particles was calculated using the semi-empirical formula proposed by Andersen and Ziegler.[2)] The average beam intensity measured using a Faraday cup was cross checked with the $^{nat}Ti(\alpha, x)^{51}Cr$ monitor reaction.[3)] After applying a +5% correction of the measured beam intensity, the re-measured cross sections for the $^{nat}Ti(\alpha, x)^{51}Cr$ monitor reaction agreed perfectly with their recommended values[3)] indicating that a proper beam and target parameters were used. Three series of γ-ray spectra were recorded for every irradiated foil by using a high-resolution HPGe detector-based γ-spectrometer without chemical separation with average cooling times of 25, 75, and 180 h to follow the decay of the reaction products. Q-values and decay data were obtained using the Q-value calculator[4)] and NuDat 2.7 database[5)] of National Nuclear Data Center, respectively.

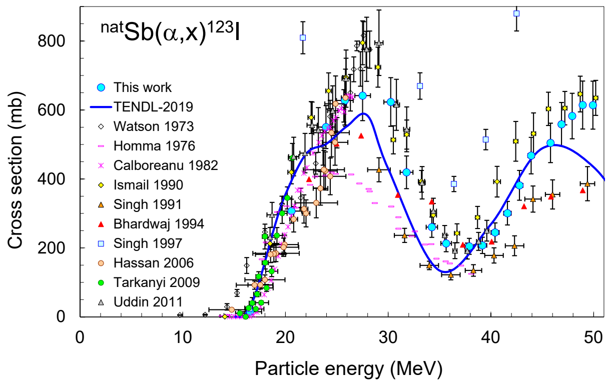

Fig. 1. Excitation function of the $^{nat}Sb(\alpha, x)^{123}I$ reaction in comparison with previously reported experimental data and results of the model calculation from the TENDL-2019 database.[5)]

Direct or cumulative cross sections for the formation of ^{121,123,124,125,126}I, ^{121m,g,123m,125m}Te, and ^{118m,120m,122g}Sb were determined. The obtained experimental data were compared with the experimental data available in the literature and the results of the TALYS theoretical model calculation taken from the TENDL-2019[6)] data library.

A comparison with the theoretical estimation revealed that the TALYS prediction provided an acceptable agreement with the experimental data except for the ^{125m}Te isotope, for which the prediction was far too conservative.

Cross section data were reported for the first time for the $^{nat}Sb(\alpha, x)^{121m}Te$, $^{nat}Sb(\alpha, x)^{123m}Te$, $^{nat}Sb(\alpha, x)^{125m}Te$, $^{nat}Sb(\alpha, x)^{118m}Sb$, and $^{nat}Sb(\alpha, x)^{122g}Sb$ reactions.

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References

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