Excitation functions of ^{nat}Cu(α, x)$^{57,58g+m}$Co nuclear reactions†

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Studies on radionuclides production cross-sections through the (*p,x*) route is relatively more active compared to the other light-charged particles production-routes, though sometimes, the production of the same radionuclides are more effective via the (*d,x*) or (α,x) reaction process. Using copper (Cu) as a target material, several important radionuclides can be produced. Some of such radionuclides are gallium (Ga) and cobalt (Co) radionuclides. In particular, ^{66}Ga was recently tested in in vivo studies as ^{66}Ga-labeled nano-graphene and reported to be a good candidate for imaging (PET) of vascular system[1]. The radionuclide ^{67}Ga ($T_{1/2}$ = 3.2617 d) is useful due to its short half-life and the Auger and Coster-Kronig electron emissions, making ^{67}Ga-labeled radiopharmaceuticals more appropriate to patients (in clinical terms) compared to its prototype ^{125}I ($T_{1/2}$ = 59.4 d) equivalent [2]. Additionally, ^{57}Co is a popular candidate in Mössbauer spectroscopy and also as a calibration standard in γ-ray spectrometry as well as in single photon emission computed tomography (SPECT) [3].

Our extensive literature survey of previous experimental data shows that Cu have been used as target in radionuclides production. However, these studies reported mainly the production of Ga and Zn radionuclides for α beam monitoring purposes. In addition, there are also obvious discrepancies among the studies in the reported data. More so, the reported studies on cobalt (Co) radionuclides through this route is relatively less. Present work therefore reports new α-particle-induced reaction cross-sections on ^{nat}Cu to reduce the observed discrepancies and also to enrich Co production cross-sections database.

The stacked-foil activation method and γ-ray spectrometry were used for the excitation functions measurements. The stack was irradiated for 2.0 hours by a 50.4 MeV α beam in a Faraday cup-like water-cooled target holder using AVF cyclotron of the RIKEN RI Beam Factory, Japan. The intensity of the beam was determined from the measured activities of the front Ti of the stack, the foil directly facing the incident beam. The ^{nat}Ti(*α,x*)^{51}Cr IAEA [4] recommended monitor reaction (σ = 26.4 mb at E_d = 50.0 MeV) was used for the evaluation of the beam intensity. The intensity was considered as a constant in the stack and was used to deduce cross-sections of the ^{51}Cr from each Ti foil of the stack.

The production cross-sections of ^{66,67}Ga, ^{65}Zn, and $^{57,58g+m,60}$Co have been assessed and presented with their relevant total uncertainties in Tables of Ref.[4] while the corresponding excitation factions of these radionuclides have been presented in the Figures of Ref.[4].

The present results were compared with the previous experimental data as well as the extracted theoretical TENDL-2014 data. Due to space constrain, only excitation functions of ^{57}Co and $^{58g+m}$Co are presented in this report. The cross-sections of ^{57}Co ($T_{1/2}$ = 271.74 d) were assessed using its interference-free γ line (E_γ = 122.0607 keV; I_γ = 85.60%). The evaluated TENDL-2014 library data indicate that the ^{57}Co production is due to the ^{63}Cu(α,2n2α)^{57}Co process below 50 MeV. Two earlier studies[5,6] have been reported for the production of ^{57}Co. The TENDL-2014 library reproduced the excitation function of $^{58g+m}$Co more closely as compared to ^{57}Co.

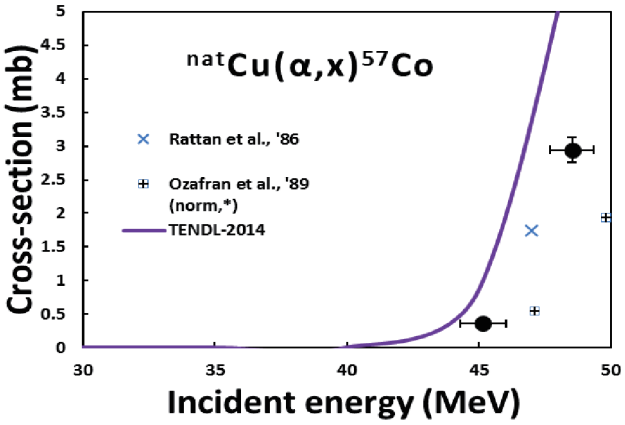

Fig. 1. Excitation function of the ^{nat}Cu(α,x)^{57}Co reaction.

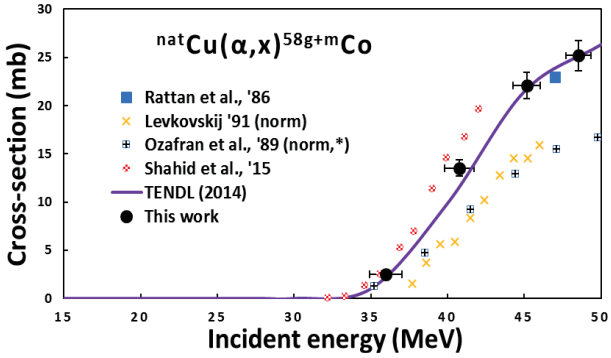

Fig. 2. Excitation function of the ^{nat}Cu(α,x)$^{58g+m}$Co reaction.

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