Production cross sections of Mo, Nb and Zr radioisotopes from α-induced reaction on ^{nat}Zr†

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The most important medical radioisotopes at present are ^{99m}Tc ($T_{1/2}$ = 6.0 h) and its generator ^{99}Mo ($T_{1/2}$ = 66.0 h). Nuclear reactions to produce ^{99}Mo using accelerators are energetically investigated worldwide. One of the charged-particle reactions used to create ^{99}Mo is the ^{96}Zr(α, x)^{99}Mo reaction. Three experimental data[1–3] were found in a literature survey. The three datasets, however, show quite different shapes from each other. Therefore, we performed two experiments to measure the cross sections of the ^{96}Zr(α, x)^{99}Mo reaction. In addition, the cross sections for the production of ^{93m}Mo, $^{90g, 92m, 95g, 95m, 96}$Nb, and $^{88, 89g, 95}$Zr isotopes were measured.

Two independent irradiations using different targets and α-beam energies were performed at the RIKEN AVF cyclotron. The stacked-foil technique, activation method, and high-resolution γ-ray spectrometry were used. Two stacked targets consisted of ^{nat}Zr foils of different thicknesses (6.75 and 13.22 mg/cm^2) and ^{nat}Ti foils (2.43 and 2.40 mg/cm^2). The targets were respectively irradiated for 2 h by α beams of two different energies, namely 29 and 50 MeV. The incident beam energies were determined by using the time-of-flight method.[4] The energy degradation in the targets was calculated using the SRIM code.[5] The average intensity measured by a Faraday cup was about 400 nA in both cases. The γ lines from the decay of the radioisotopes for each irradiated foil were measured using an HPGe detector.

The excitation function of the ^{nat}Zr(α, x)^{99}Mo reaction was derived from measurements of the γ line at 739.500 keV (I_γ = 12.20%). The parent nuclei of ^{99}Mo, ^{99g}Nb ($T_{1/2}$ = 15.0 s), and ^{99m}Nb ($T_{1/2}$ = 2.5 min), decayed during cooling times longer than 47 h. The cross sections of ^{96}Zr were deduced by taking into account the isotopic composition of natural zirconium. The results are shown in Fig. 1 and compared with previous experimental data[1–3] and the TENDL-2017 data.[6] Our results are in complete agreement with the recent experimental data,[3] but very different from the others. Based on our measured excitation function, the end of bombardment activity of ^{99}Mo was deduced with the stopping powers obtained using the SRIM code.[5] Our result shown in Fig. 2 is almost consistent with the two datasets,[3,7] but larger than one dataset.[2]

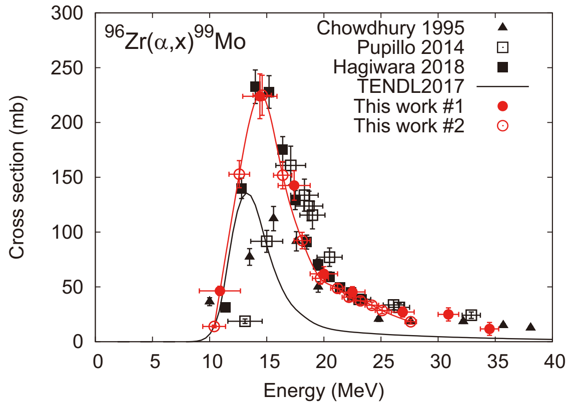

Fig. 1. Excitation function of the ^{96}Zr(α, x)^{99}Mo reaction.

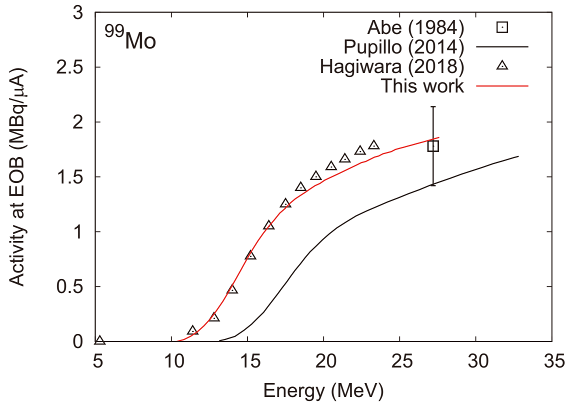

Fig. 2. End of bombardment activity of ^{99}Mo for 1 h irradiation.

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