New cross section data for production of zirconium-89 by alpha-induced reaction on yttrium target

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Zirconium-89 is considered a good candidate for immuno-PET investigations owing to its decay properties.[1)] Even though it is possible to produce ^{89}Zr with a low incident beam energy (approximately 12 MeV) and high specific activities by using proton beams (470–1195 mCi/mmol),[1)] it is worthwhile to consider its production using heavier particles. Co-production of ^{90}Nb, another expectable radionuclide for medicine,[2)] is possible in the same irradiation with alpha particles.

The alpha-induced reaction on natural yttrium is one of the ways to produce ^{89}Zr and ^{90}Nb. There are, however, only two earlier studies on the ^{89}Y(α, x)^{89}Zr reaction and no data for the high energy region is available, where higher cross sections seem to be achieved. In this work, a new experiment to measure the cross sections for the ^{89}Y(α, x)^{89}Zr reaction was performed to investigate the optional route for ^{89}Zr production.

The well known stacked-foil technique and activation method were used to measure the cross sections for the alpha-induced reactions on natural yttrium. The stacked-foil target consisted of yttrium (25 μm, Nilaco), titanium (5 μm, Nilaco), and aluminum (5 μm, Nilaco) foils. The thicknesses were verified within 0.6% by measuring the sizes and weights of the foils. The stacked-foil target was attached to a target holder, which also served as a Faraday-cup, and was irradiated with a 50-MeV alpha beam with an intensity of 200 pnA for 1 h using the AVF cyclotron at the RIKEN beam factory. The energy of the alpha beam in each foil was calculated using stopping powers that were obtained from the SRIM software.[3)] The intensity was assumed to be constant in the target. The correctness of the beam parameters and foil thicknesses was checked by monitoring the reactions on aluminum and titanium foils by comparing their cross sections with the IAEA recommended values.

After the irradiation, a cooling time of over 40 min was taken to reduce the background radiation, which is an obstacle for the measurement. A high purity germanium detector was used to collect the gamma-ray spectra from the foils. To derive the cross sections of the monitored reactions, the 1274.5 keV ($I_\gamma = 99.94\%$) and 320.08 keV ($I_\gamma = 9.91\%$) gamma-lines were used for ^{nat}Al(α, x)^{22}Na and ^{nat}Ti(α, x)^{51}Cr reactions, respectively. The data obtained from the monitored reactions was significantly consistent with the IAEA recommended values.

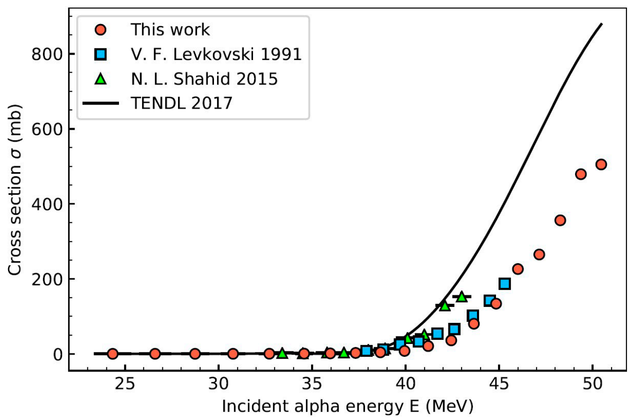

Fig. 1. Experimental cross sections of ^{89}Y(α, x)^{89}Zr reaction with earlier experimental data and TENDL data.

A specific gamma-line of 909.15 keV ($I_\gamma = 99.04\%$) from ^{89}Zr was used to derive the cross sections of the ^{89}Y(α, x)^{89}Zr reaction. Owing to the short half-life of ^{89}Nb ($T_{1/2}$ = 2.03 h) as compared to ^{89}Zr ($T_{1/2}$ = 78.41 h), the derived cross sections were cumulative. The cross sections of ^{89}Zr are shown in Fig. 1 in comparison with earlier two experiments[4,5)] and TENDL data.[6)] Our result is consistent with Levkovski's result and indicates that the TENDL values are overestimated at higher energy.

In this work, the peak position of the cross sections of ^{89}Y(α, x)^{89}Zr reaction could not be obtained. To find the most efficient energy for ^{89}Zr production by alpha particles, another experiment using a higher energy alpha beam is needed. In addition to the peak position of the excitation function, the evaluation of specific activity and yields of other co-produced nuclei is needed for the practical application of ^{89}Y(α, x)^{89}Zr reaction.

References

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