Study of alpha induced reaction cross-section on ^{nat}Mo

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Introduction

Nowadays, there are various radioactive materials with unique properties, playing an important role in medicine [1]. The radioisotope ^{97}Ru ($T_{1/2}$ = 2.79 $days$) is useful for diagnostic imaging. The radioisotope ^{103m}Rh is useful for augur electron therapy due to it's very low photon/electron ratio. Since ^{103m}Rh has a short half-life of 56.11 min, ^{103}Ru as a parent to ^{103m}Rh provides a good option due to its relatively longer half-life of 39.26 days . Also molybdenum [2] plays an important role as a target material for the above-mentioned radioisotope production.

Excitation functions were measured for $^{92}Mo(\alpha,n)^{95}Ru$, $^{100}Mo(\alpha,n)^{103}Ru$, $^{nat}Mo(\alpha,x)^{95}Tc$, $^{nat}Mo(\alpha,x)^{97}Ru$ nuclear reactions in the energy range 11 to 32 MeV. We used the stacked foil activation technique to measure the excitation functions. The excitation functions were compared with available experimental data from EXFOR. The main goal of this investigation was to extend the activation cross-section data for $^{nat}Mo(\alpha,x)$ reactions with respect to the production of medicines related to ^{97}Ru, ^{103}Ru.

Experimental Details

The experiment was performed at the (K-130) Variable Energy Cyclotron Center (VECC), Kolkata, India. We have used the stacked foil activation technique followed by the offline gamma ray spectroscopy using HPGe detector. Thin metallic foils of ^{nat}Mo (99.9%), ^{nat}Al (99.9%) and ^{nat}Ti (99.9%) were used. The thickness of Mo, Al and Ti foils were 12.85 mg/cm^2 , 13.5 mg/cm^2 and 1.80 mg/cm^2 respectively. The stacked target was made with 6 sets of Mo-Al foils (10x10 mm^2). The Ti foil (10x10 mm^2) was placed in front of the stack as a monitor to confirm the intensity and energy of the incident beam.

Aluminum foils have been used as catcher foils to capture the product nuclides (recoils) extracted from molybdenum foils. The Mo and Al foils were measured simultaneously to capture the recoil products and to calculate the nuclear reaction cross sections of the products formed in the Mo foils. The stacked target was irradiated for 2 hours by a 32 MeV alpha beam with the average intensity of 170 nA.

Result and Discussion

In the present work, efficiency [3] calibration of the HPGe detector for different gamma ray energies has been calculated using a standard ^{152}Eu point source. The geometry dependent efficiency ϵ_p of the point source for source-detector distance 17.85 cm was estimated using the following equation;

$$\epsilon_{\rm p} = \frac{\rm CK_c}{\rm A_o I_\gamma \Delta t e^{-\lambda t}}$$

In the above equation [4, 5], A_o is the known activity of ^{152}Eu (A_o = 39080 Bq as on 17 May 1982) point source, C is the number of counts taken in 10000 second for a γ-ray energy with absolute intensity (I_γ) and t is the lapse time between the date of manufacturing to the start of counting.

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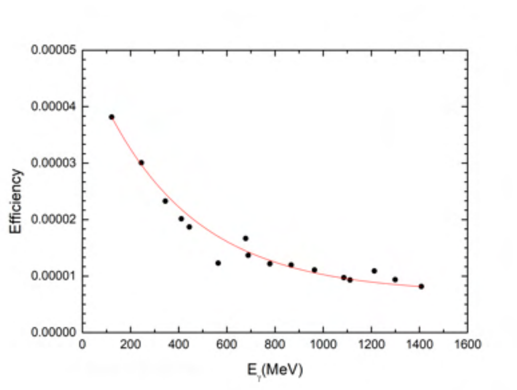

FIG. 1: The geometry- dependent efficiency as a function of γ-ray energies.

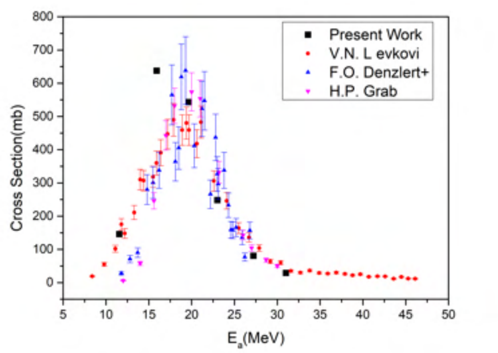

FIG. 2: Experimental data of $^{92}Mo(\alpha, n)^{95}Ru$ reaction.

^{95}Ru production

The measurement of the 336.40 keV γ-ray with intensity ($I_\gamma = 69.9\%$) from the ^{95}Ru decay ($T_{1/2}$ = 1.64 hours) was done after cooling time of 8.4 hours. The cross sections of ^{95}Ru from the reaction $^{92}Mo(\alpha, n)$ are shown in Fig. 2 with respect to the available experimental data from the EXFOR. The nuclear reaction cross sections were calculated using the following standard activation formula;

$$\sigma = \frac{\mathrm{C}_\gamma \lambda}{\epsilon_\mathrm{p} \mathrm{I}_\gamma \mathrm{D}_\mathrm{t} \phi \mathrm{N}_\mathrm{t} \mathrm{e}^{-\lambda \mathrm{t}_\mathrm{c}} (1 - \mathrm{e}^{-\lambda \mathrm{t}_\mathrm{irr}})(1 - \mathrm{e}^{-\lambda \mathrm{t}_\mathrm{m}})}$$

In the above formula, C_γ is the net counts of the peak area of a particular γ-ray with it's abundance (I_γ), ϵ_p is the detector efficiency with dead time D_t, λ is the decay constant (s^-1), N_t is the surface density of the target (cm^-2), ϕ is the number of bombarding particles per unit time(s^-1), t_c(s) is the cooling time of the target, t_m(s) is the counting time, and t_{irr}(s) is the irradiation time.

More details about the data analysis of cross sections and uncertainty quantification [6] will be presented during the conference.

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