Measurement and study of reaction mechanism of ^{100}Mo(n,2n)^{99}Mo reaction cross-sections .

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Introduction

Molybdenum is an excellent structural material, it has a wide potential for applications such as an accelerator-driven system or a controlled nuclear fusion device.^{99m}Tc, the daughter nuclide of ^{99}Mo with a half-life of 65.976h, has been widely used in nuclear medicine for diagnostics because of its many advantages. The short half-life $T_{1/2}$ of 6.0 h of ^{99m}Tc allows one to use large quantities of ^{99m}Tc with a low radiation dose to the patient [1].In the present work ^{100}Mo(n,2n)^{99}Mo reaction cross section at 11.9 MeV is reported for first time.The present work concerns additional systematic measurements for neutron-induced reaction on Mo target nuclei from energy threshold of Molybdenum to 21 MeV.

Experimental Description

Average neutron energy of 11.90 MeV was produced by the ^{7}Li(p,n) reaction at proton energy of 14 MeV, using the 14 UD BARC-TIFR Pelletron facility at Mumbai, India. Mo metal foil of known weight of 0.2916g was placed for irradiation. Similarly, a known weight of gold foil of 0.0324g was also placed for irradiation, The ^{197}Au(n,2n) ^{196}Au reaction cross-section was used as the neutron flux monitor. The Mo–Au stack was mounted behind the Ta–Li–Ta stack. The samples were irradiated for 7 hours. The γ-ray counting of the samples were done by using pre-calibrated 80 cm^3 HPGe detector .

Analysis and Calculations

Neutrons are generated by the ^{7}Li(p,n) reaction. The threshold value of the ^{7}Li(p, n) reaction to the ground state of ^{7}Be is 1.881 MeV [2-3]. The first excited state of ^{7}Be is having a threshold of 2.38 MeV. Thus for the proton energy of 14 MeV, the corresponding first group (n_0) of neutron energies is 12.12 MeV and second group of neutrons (n_1) is 11.62 MeV. The neutron spectrum has continuous tailing besides n_0 and n_1 group of neutrons. On removing the tailing distribution, the average neutron energy under the main peak region ,is 11.90 MeV. The number of detected γ-rays and (Aobs) of the reaction products are related by the equation

$$\sigma_R = \frac{Aobs(CL/\mathrm{LT})\lambda}{N\varphi I\gamma\varepsilon(1-e^{-\lambda t})e^{-\lambda T}(1-e^{-\lambda CL})}$$

where N is the number of target atoms and φ is the flux from ^{197}Au(n,2n)^{196}Au reaction, λ is the decay constant of the reaction product with half-life, $T_{1/2}$. I_γ is the branching ratio of ^{99}Mo and ε is its detection efficiency. t, T, CL and LT are the irradiation, cooling, clock and live time, respectively. The nuclear spectroscopic data of ^{99}Mo were taken from refs. [4] .^{100}Mo(n,2n)^{99}Mo reaction cross section has been corrected by removing the contribution from tail region .The contribution of the cross-section from the tail region to ^{100}Mo(n,2n)^{99}Mo reaction has been estimated by folding the cross-sections from TALYS 1.8 [5] with neutron flux distributions of Refs[3] and Ref[6].

Nuclear Model Calculations

The nuclear reaction model calculations for ^{100}Mo(n,2n)^{99}Mo have been performed with the recently developed TALYS 1.8 code from energy threshold of Molybdenum to 21 MeV. In the present work the pre-equilibrium reactions was used which includes up to date particle-hole level densities related to the level density parameter, a. The theoretical cross section value at 11.9 MeV is presented in Table1.

Table 1. ^{100}Mo(n,2n) ^{99}Mo reaction cross-sections (σ_R) at neutron energy of 11.9 MeV. The bold numbers are the data obtained from the present work.

E_n (MeV)	*FLUX n $cm^{-2}s^{-1}$*	^{100}Mo(n,2n)^{99}Mo *Cross-section(σ_R) (mb)*	
		TALYS 1.8	***Experimental***
11.90	**7.58x10^5**	***1304.86***	***1305.29***
11.77± 0.11		**1277.44**	1299±60 [8]
12.09± 0.11		**1335.92**	1344±60 [8]

Results and Discussion

The experimental results of the present work are presented in Table 1. ^{100}Mo(n,2n)^{99}Mo reaction cross-section using TALYS 1.8 are plotted in Figure 1 along with available experimental data of ^{100}Mo(n,2n)^{99}Mo from literature[7].It can be seen from Figure 1 that the theoretically obtained cross section data using TALYS code is in excellent agreement with the experimental data of the present work. On comparing with the existing experimental data the TALYS obtained cross section is in good agreement with data of V.Semkova et al[8] . The experimental and theoretical data are also compared with evaluated data of ENDF/B-VII.1, CENDL-3.1 and JEFF-3.2.

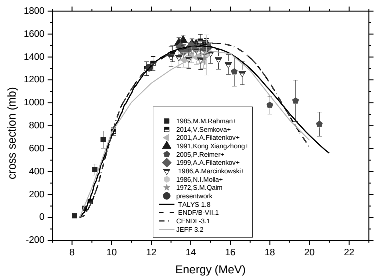

Figure1: Plot of the experimental and theoretical data with ENDF/BVII.1, CENDL -3.1 and JEFF 3.2**.**

References

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