Calculations of excitation function of ^{100}Mo(p,2n)^{99m}Tc from threshold to 60 MeV.

R.Ghosh[1*], S.Badwar[1], B.Jyrwa[1], H.Naik[2]

[1] *North Eastern Hill University, Shillong-793022, Meghalaya, India*

[2] *Radiochemistry Division, BARC, Mumbai*

[*] *email: reetuparna.ghosh@gmail.com*

Introduction

The radionuclide ^{99m}Tc ($T_{1/2}$ =6hrs) is widely used as a [1] radiotracer in nuclear medicine, and at present it is applied in more than 70% of all nuclear medical diagnosis. The status of nuclear data [2] of these proton induced reactions on ^{100}Mo targets was not very satisfactory. Therefore, highly accurate nuclear data for Mo are vital due their importance as a structural material in nuclear reactors. Hence improved nuclear data for proton on the isotopes of Mo are necessary for applications on the incident proton energy as stated earlier. The available experimental data [3] was retrieved from the EXFOR data base, and fitted with the code TALYS 1.6 [4], then the theoretical studies were done accordingly.

Nuclear models

We had used TALYS 1.6 nuclear reaction code to calculate the excitation function of the (p,2n) reaction of ^{100}Mo , and thereafter we had plotted the graph. The justification for using Talys 1.6 was because it is a computer code which includes various nuclear reactions such as direct, compound, pre-equilibrium and fission reactions. Moreover, there is a flexibility of adjusting several parameters as long as they remain within physically acceptable limits.

Parameters adjusted in this work

The calculation of cross-sections is the main task in the field of low and medium nuclear reactions. Different models are used for describing these reactions. Pre-equilibrium process covers a major part of the reaction cross-section for incident energies above 10 MeV.

Basically, we had applied the exciton model [5], whereby, the incident particle on entering the nucleus collides with one of the nucleus of the Fermi Sea (E_F). The formed state with n=3 (2p/h), is the first to be subjected to particle emission. In this way we can have the 3p2h picture. Thus, the probability that a particle is emitted exists. Such a phase is known as the pre-equilibrium phase and it manifests itself as forward peaked angular distribution and high energy tails from experimental results. Thus, using the exciton model one can complete the emission cross sections in a unified way.

One of the most important factors is the level density, since it allows one to explore the mechanism of nuclear excitations, and obtain the information about the structure of the excited nuclei. The dependence of the level density parameter λ with energy is given by

$$\lambda = \tilde{\lambda}[1 + \frac{\delta\epsilon_0}{U'-E_{co}}(U'-E_{co})] \quad \text{-----(1)}$$

where $\tilde{\lambda}$ is the asymptotic value of λ at high $\delta\epsilon_o$ is the shell correction of the nuclear energy. Damping factor γ is incorporated through the following equation

$$f(U) = \frac{(1-\exp(-\gamma U)}{U}$$

where U is the time excitation energy.

If ρ (U) is the total level density for the nuclear state, and σ is the spin cut-off parameter defined by

$$\sigma^2 = 0.0139A^{5/3}\sqrt{(\lambda U)} \quad \text{--- (1.2)}$$

and

$$\rho(U,J) = \frac{1}{\sqrt{2\pi\sigma}}\frac{\sqrt{\pi}}{12}\frac{\exp[2\sqrt{\lambda U}]}{\tilde{\lambda}} \quad \text{------(1.3)}$$

Hence by introducing the level density parameter λ and adjusting the above parameters, we find that the calculated cross-sections were in good agreement with the experimental data.

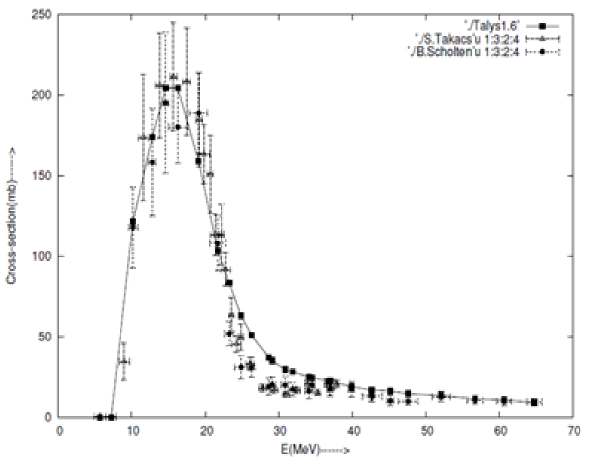
Table 1: Values of parameters used in the calculation

Parameters	Values
Kph	6
γ_0	2
Pair constant	30
Energy dependent Matrix element	3
A	2
$\tilde{a}$	y
σ^2	2
A	0.19

Conclusion

Studies carried out using Talys 1.6 [4] shows that the emission of neutrons for MeV is due to pre-equilibrium contribution of the system in a time much shorter that the time for evaporation for a compound nucleus. Initially the number of interactions is small, so the energy available to each degree of freedom is large. Hence the nucleons emitted at these stages will carry more energy than those emitted from compound nucleus. The latter's contribution is dominated by a lower energy region of emitted neutrons.

Fig. 1 Excitation Function of $^{100}Mo(p,2n)^{99m}Tc$



References

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