Theoretical estimation of cross section of ^{nat}Cd(α,x)^{110}Sn and ^{nat}Cd(α,x)^{115m}In reactions upto 50 MeV using TALYS-1.96

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Introduction

Light charged particles (proton, deuteron, alpha particles etc.) induced nuclear reactions on different target nuclei find extensive application in research, nuclear medicine and industry. Hence, systematic study of light ion induced reactions are being carried out at various accelerator facilities. In comparision to the proton induced reactions, the cross section (CS) measurement data for the α induced reactions are scanty in literature. Accurate knowledge of the production CS of various radioisotopes are often required for optimized production of the medicinally useful radionuclide from natural cadmium target. The present work is aimed at theoretical estimation of CS of various radioisotopes produced via α particle induced reactions on natural cadmium.

Present work

In this work, the theoretical estimation of the CS of the ^{nat}Cd(α,x)^{110}Sn and ^{nat}Cd(α,x)^{115m}In reactions have been carried out using the TALYS code [1] for incident α energies ranging from 10 to 70 MeV. TALYS is a theoretical nuclear model code in which photons, neutrons, protons, deuterons, ^{3}He and ^{4}He can be used as projectiles in the energy range of 1 keV to 200 MeV for target elements with mass of 12 and heavier. In TALYS, the six level density models used for the theoretical calculation of CS using default parameters are as follows:- (i) ldmodel1: Constant temparature model + Fermi Gas model (default) (ii) ldmodel2: Back-Shifted Fermi Gas model (iii) ldmodel3: Generalized Superfluid Model (iv) ldmodel4: Microscopic model of Goriely based on Hartree Fock calculations(v) ldmodel5: Microscopic Combinatorial model of S. Goriely-S. Hilaire (vi) ldmodel6: Microscopic level density based on temparature dependent Hartree-Fock-Bogoliubov calculations using the D1M Gogny force [2]. The cross-section of a nuclear reaction depends on Level Density Models (LDMs), Optical Model Potentials (OMPs) and γ strength functions (γSFs) [3–5].

In the present work, the theoretically estimated CS values using the various level

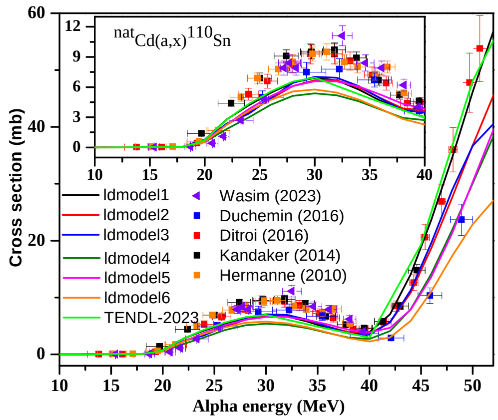

FIG. 1: The theoretical calculation for CS of the ^{nat}Cd(α,x)^{110}Sn reaction compared with the experimental values reported by Ditroi *et al.* [9], Duchemin *et al.* [10], Hermanne *et al.* [11] and Kandaker *et al.* [12], taken from EXFOR [6] along with the results reported by Wasim *et al.* [7] together with TENDL-2023 database [8]. For TALYS calculations, different level density models have been used in the default mode.

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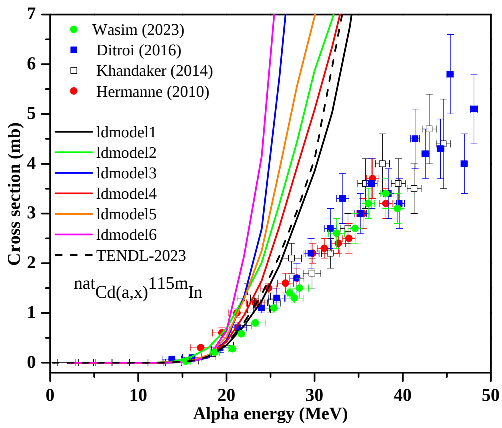

FIG. 2: Similar to Fig. 1, the theoretical calculation for CS of the ^{nat}Cd(α,x)^{115m}In reaction compared with the experimental values reported by Wasim *et al.* [7], Ditroi *et al.* [9], Hermanne *et al.* [11] and Kandaker *et al.* [12] together with TENDL-2023 database [8].

density models in the default mode have been compared with the experimental data for the cross-section of ^{nat}Cd(α,x)^{110}Sn and ^{nat}Cd(α,x)^{115m}In reactions taken from literature [6, 7] and also the TENDL-2023 database [8].

Results and Conclusion

In case of ^{nat}Cd(α,x)^{110}Sn reaction, the theoretical CS predicted by ldmodel1 matches well with the experimental data. From 10-40 MeV range, all the level density models reproduces successfully the trend of variation of the experimental data reported in literature. After 40 MeV, the dependence of the CS on the level density parameter is evident from the differences of the estimated CS based on the level density model. From 40-47 MeV, ldmodel2 and ldmodel3 matches well with the data reported by Wasim *et al.* [7] and Ditroi *et al.* [9]. ldmodel3, ldmodel4 and ldmodel5 matches well with the data reported by Duchemin *et al.* [10] in the 40-50 MeV range. Of the various level density models, ldmodel4 and ldmodel6 underestimates the CS values in comparision to that predicted by the other level density levels in the 20-40 MeV range. Similarly, in Fig. 2, the results of theoretical estimation of the CS for ^{nat}Cd(α,x)^{115m}In reaction has been presented. It has been observed that none of the level density models could reproduce the experimental data well when used in the default mode beyond 20-22 MeV.

In order to minimize the discrepancies between the theoretical and experimental results in Fig. 1 and Fig. 2, the effect of using different nuclear model combinations or variation of model parameters on the estimated CS values need to be explored.

Acknowledgments

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