Excitation function for $Cd^{106}(p,pn)^{105}$Cd Reaction upto 23 MeV

Muhammed Shan P T[1],* M.M Musthafa[1], Najmunnisa T[2], Mohamed Aslam P[3], Rajesh K K[1], Surendran.P[4], J.P.Nair[4], and Anil Shanbagh[4]
[1]*Department of Physics, University of Calicut, Calicut University P.O. Malappuram, Kerala 673635, India.*
[2] *Govt.Arts and Science college,Kasargod*
[3]*Govt.Arts and Science college, Kozhikode-18 and*
[4]*Pellatron group,Tata Institute of Fundamental Research, Mumbai - 400085, INDIA*

Introduction

Charged particle induced nuclear reactions are the key stone of the nuclear applications. In spite of the increasing need for well measured cross sections and the sometimes rich experimental information the status of the cross section data was not satisfactory at the end of the last decade. The cross section data were measured with relative high errors or they were missing in some energy regions or there are vacant of data in some isomers.

As part of on going program of measurement and analysis of excitation functions for some proton induced reaction we have measured and analysed excitation function for the production of ^{105}Cd from $Cd^{106}(p,pn)^{105}$Cd reaction over the energy range 8 to 23 MeV. To the best of our knowledge the excitation function for this reaction is being reported for the first time. Cadmium is an important material for nuclear technology. It is used in bearing alloys, electroplating and the activation of cadmium can therefore be used for estimation of depth distribution and dose also used for monitoring purposes[1]. Hence it is an important species for nuclear reaction studies. Theoretical understanding of nuclear reaction has been studied using two nuclear reaction codes EMPIRE and TALYS.

Experimental Analysis

The Experiment was done at Tata Instituit of Fundamental Research, Mumbai using stacked foil activation technique. The stack contained four samples of 5 mg/cm^2 thick self supporting cadmium foils where irradiated with proton beam of energy 23MeV and an average beam current of 23 nA for 1.28 hour. The beam current was monitored by the current integrator connected to the Faraday cup kept behind the target and rutherford monitoring detectors. Energy incident on each foil was calculated by taking into account of the beam energy loss on the thickness of the samples as well as other sandwiched samples and aluminium degraders and the covered energy range from 8.9 MeV to 21.96 MeV. The activity induced in each samples was followed using a 100 cc HPGe detector coupled to the ORTECs PC based multichannel analyzer. The detector calibration and geometry dependend efficiency have been done with standardized ^{152}Eu point source. Cross section for production of ^{105}Cd at each incident energy was calculated using the formula given below.

$$\sigma = \frac{A\lambda \exp(\lambda t_2)}{N_0 \phi \theta K G_\epsilon (1-\exp(-\lambda t_1)(1-\exp(-\lambda t_3)} \qquad (1)$$

The error included in the measurement indicated by error bar and are the sum of all the possible errors. A detailed error analysis of the similar measurements is given elsewhere [2].

Theoretical Analysis

Theoretical analysis of the data have been done using the two statistical model codes EMPIRE and TALYS which are widely used in the analysis of light ion induced nuclear

*Electronic address: shaminnath@gmail.com

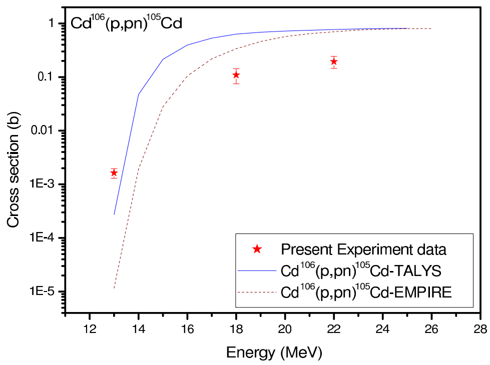

FIG. 1: Excitation functions of the $Cd^{106}(p, pn)^{105}Cd$ reaction

reaction cross sections. Both the codes includes different nuclear reaction models and nuclear data libraries. The code EMPIRE[3] consists of Hausbar Feshbach model for compound nuclear reaction part and exciton model for pre equilibrium regims. Exciton model (PCROSS) have been enabled with mean free path VAL set to 1.5, which will also explain the pre-equilibrium part of the reaction. In the case of level density parameter there are three major models GSM, GCM and microscopic HFB level densities are all involved in this code. Similarly the code TALYS[4] work on variety of phenomenological and microscopic level density models and GSM model is found to best suit in the present case.

Result And Discussion

The experiment cross section data for $Cd^{106}(p, pn)^{105}Cd$ reaction measured at various incident energies, decay characteristics are tabulated in table.1 and plotted in fig.1 along with theoretical calculations using pre equilibrium model computer codes TALYS and EMPIRE. In the present case Generalised super fluid model of Ignatyuk et.al[5] is found to show better reproducibility of the data for both the models. Mean free path parameter is taken as 1.5 to carry the contribution from higher exciton states. As can be seen from the figure it is observed that both the EMPIRE and TALYS reproduces the data satisfactorily over the measured range however the models over predicts the experimental data, even with best optimisation of the parameters. further code TALYS shows larger discripancy over the point of growing up of populations. Since the daata is being reported for first time no further comparison could be possible.

TABLE I: Decay characteristics and cross section data of Cd^{106}(p,pn)^{105}Cd Reaction.

Nuclide	Half life	E_γ	E(MeV)	σ(B)
Cd^{105}	55.5 ± 4	346	13±0.4	1.62E-3
		759	18±0.37	109E-3
			22±0.23	194E-3

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References

[1] Nuclear Medicin book by Wagner
[2] M. M. Musthafa et al, Phys. Rev. C 52 (1995) 6.
[3] M. Hermann et al.,EMPIRE-II, Nuclear Reaction Model Code 2.19 , Nuclear Data Section (IAEA, Vienna, 2005).
[4] A.J. Koning, S. Hilaire and M.C. Duijvestijn, Hermann et al.,TALYS-1.0, Proceedings of the International Conference on Nuclear Data for Science and Technology, April 22-27, 2007.
[5] Ignatyuk et.al Sov. J. Nucl.Volume 21 (1975)612