Excitation function for the $^{nat}Cd(p,x)^{111m}Cd$ reaction and it's isomeric cross section ratio

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Introduction

Measurement of proton activation cross-section of different reactions has widespread applications in different field. Especially the metastable state cross section and the isomeric cross section ratio have very much important to deduce the dependence of various reaction parameters in a nuclear reaction, also it is of considerable importance for testing nuclear models. A systematic study of excitation functions on metallic targets is in progress, in order to prepare a recommended database in the vacant energy region. Cadmium is one of the important metallic material for nuclear technology and in the industrial application[1].

The relative probability of forming isomeric states in a nucleus is mainly governed by the spin of the isomeric state, the isomeric levels involved, and the spin distribution of the excited states of the residual nucleus. The previous study shows that the isomeric cross-section strongly depends on the spin of the isomeric and the ground-state of the nucleus, as well as in the channels where it produced[2][3]. With a view to the study of isomeric state, A detailed study of the $^{nat}Cd(p,x)^{111m}Cd$ reaction at energies range from 8.9 MeV to 21.91 MeV have been reported. The experimental data compared with the previous literature data and with both the theoretical statistical model codes EMPIRE-3.2 and TALYS-1.8 are plotted in figure.1. As well as, the isomeric cross-section ratio(ICR), have been analysed for the betterment.

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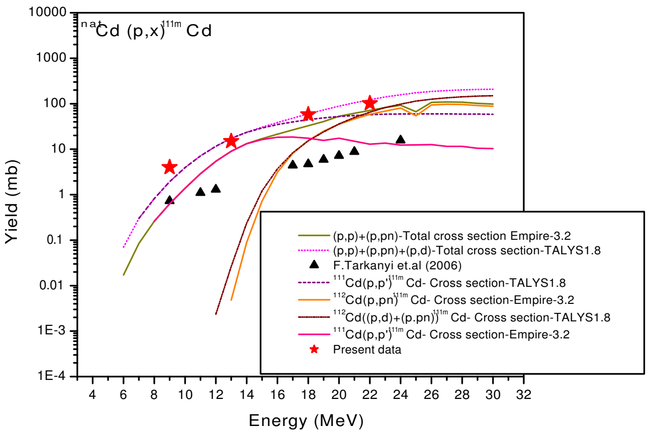

FIG. 1: Experimentally measured and theoretically calculated excitation functions for the reaction $^{115}In(n,g)^{116m}$In.

Analysis of the Data

The Experiment was done at Tata Instituit of Fundamental Research, Mumbai using stacked foil activation technique. The samples of 5 mg/cm^2 thick self-supporting cadmium foil where irradiated with proton beam of energy 23 MeV 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, the beam energy loss on the thickness of the samples and the covered energy

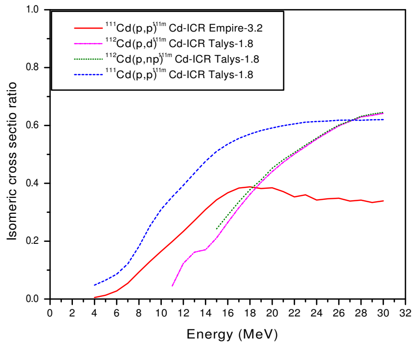

FIG. 2: Theoretical isomeric cross-section ratio for the isomeric pair ^{111m}Cd.

range from 8.9 MeV to 21.96 MeV. The activity induced in each sample was followed using a 100 cc HPGe detector. The detector calibration and geometry dependent efficiency have been done with a standardized ^{152}Eu point source. Thus the cross section for production of ^{111m}Cd at each incident energy, by accounting all the uncertainties caused in the reaction was calculated. The cross sections thus calculated for the above isomer and their characteristic decay scheme are tabulated in Table1.

Result And Discussion

The excitation function thus calculated for the reaction $^{nat}In(p,x)^{111m}$Cd have been compared with the literature experimental data as well as with the theoretical statistical model codes EMPIRE-3.2 and TALYS-1.8 are shown in figure 1. ^{111m}Cd nucleus may be produced from different natural isotope of cadmium, through two different reaction channels viz $^{111}Cd(p,p)^{111m}$ Cd and $^{112}Cd(p,pn)^{111m}$ Cd with threshold energies 0 MeV and 9.48 MeV. It has one stable ground state and a metastable state. Isomeric state of 396.2 keV decays, with a half-life of 48.50 m, decay to the ground state by 100% IT. In this case, the theoretical value is in agreement with the present data in the lower energy region, but there is a slight overprediction in the higher energy regime. It is due to the sum of the cross section production of the (p,p), (p,pn) and (p,d) channel in the higher energy region. So the theoretically predicted total cross section, exactly match with the present data. The data reported by F. Tarkanyi et al. shows a significantly lower, of more than one order, in all energy region. However, the theoretical representation (ALICE-IPPE) and experimental data differ significantly in their report [19].

Isomeric cross-section ratio for the above reaction has been deduced from the theoretical model code calculations, are plotted in figure.2. In the case of isomeric production of ^{111m}Cd through different channels, the isomeric cross-section ratio shows a steady population of isomeric state (I = 11/2-) at energy 127 keV and ≈ 15% ground state (I = 1/2+) favoring the population of the higher spin metastable state, it is our one of the previous observation[2]. A slightly higher population of the isomeric state is seen in the case of single particle emission than multiparticle emission. This indicates that multiparticle emission carries away larger angular momentum.

TABLE I: Decay characteristic of ^{111m}Cd and isomeric cross section

E_{inc} MeV	$T_{1/2}$	Ground S_p/π	Meta S_p/π	E_γ (keV)	I_γ (%)	Data (mb)
8.9	54.29m	(1/2)+	(11/2)-	245.39	94	4±0.36
12.91				150.82	29.1	15 ± 1.48
17.89						57.8±4.4
21.9						102±12.22

Acknowledgments

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