Excitation Functions of neutron induced reactions on Ytterbium isotopes

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Introduction

Neutron induced cross-section data up to 20 MeV are required for several physical applications especially in designing future fusion reactors, advanced fission reactors, in neutron dosimetry and developing refined nuclear theory. Most of neutron induced reaction cross-section data for Yb are available at ~ 14 MeV. New nuclear energy systems require significant amount of nuclear data in extended energy region and improvement of presently available nuclear data. Ytterbium is one of the rare-earth isotopes. Beside reactor technology, knowledge of these cross-sections is also important for reliable activation analysis of samples containing rare-earth elements.

In the present work, the model based calculations with the code EMPIRE-3.0 and TALYS-1.2 have been performed on seven reactions ^{174}Yb(n,p)^{174}Tm, ^{174}Yb(n,α)^{171}Er, ^{176}Yb(n,p)^{176}Tm,^{176}Yb(n, α)^{173}Er, ^{176}Yb (n,n')^{176m} Yb, ^{nat}Yb (n,x)^{172} Tm, ^{nat}Yb (n,x) ^{173} Tm, in the energy range from threshold to 20 MeV and the results are compared with the different experimental values as reported in EXFOR[1] data library, along with the experimental values of Agrawal and Pepelnik, obtained using 14 MeV neutron generator 'KORONA' at GKSS research centre.

Nuclear Model calculations

The theoretical values have been performed within the framework of Hauser Feshbach statistical model with per-equilibrium effects by invoking suitable options in both codes i.e. DEGAS for (n,p) (n,n') reactions and PCROSS for (n,α) reactions in EMPIRE-3.0 code. Two component exciton model using Kalbach systematic, with the particle-hole state density by Dobes and Betak, has been adopted for (n,p), (n,α), (n,n') reactions in TALYS-1.2 code. The required inputs like nuclear masses, discrete energy levels and level densities of the nuclides involved in the calculations have been taken from latest RIPL-3[4]. The optical potential for neutrons and protons used in both codes are the global parameterization of Koning and Delaroche [5]. For α- particle in the exit channel, optical model potential of Avrigeanu and Watanabe have been used in EMPIRE and TALYS codes, respectively. In both codes for all cases microscopic parity dependent nuclear level density (NLD) within the HFB plus combinatorial method has been used [6]. The excitation functions for the formation of ^{172,173} Tm in the interaction of neutrons with natural Ytterbium have been obtained by considering all exit channels and then summing all fractional components according to the natural abundance of each Yb isotope.

The illustrative cases are shown in Fig. 1 & 2 with previous experimental data, evaluated data file (JENDL-4.0) and calculated values based on EMPIRE-3.0 and TALYS-1.2 code, with pre-equilibrium (CN+PE) and without pre-equilibrium [only compound nucleus (CN)]. The calculated values of cross-sections with pre-equilibrium and HFB parity dependent nuclear level density for all reactions are in reasonable agreement with the available experimental data in EXFOR and the data measured by Agrawal and Pepelnik.

Conclusion

The present work on the (n,p), (n,α) and (n,n') reaction cross-section for isotopes of Ytterbium is thus significant in the context of the scanty and /or discrepant nuclear data

base available for these isotopes. The results of the present study reveal that parity dependent NLD option which has been incorporated in both codes recently, is quite suitable in predicting the cross-section for (n,p), (n,α) and (n,n') reaction in MeV region.

Acknowledgment

The author (Bhawna Pandey) is thankful to Dr. Roberto Capote Noy, IAEA, Dr.Arjan Koning, NRG Petten, the Netherlands for their valuable suggestions during "ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced Reactor Technologies" (SMR-2141), Trieste, Italy (3-14 may 2010) .

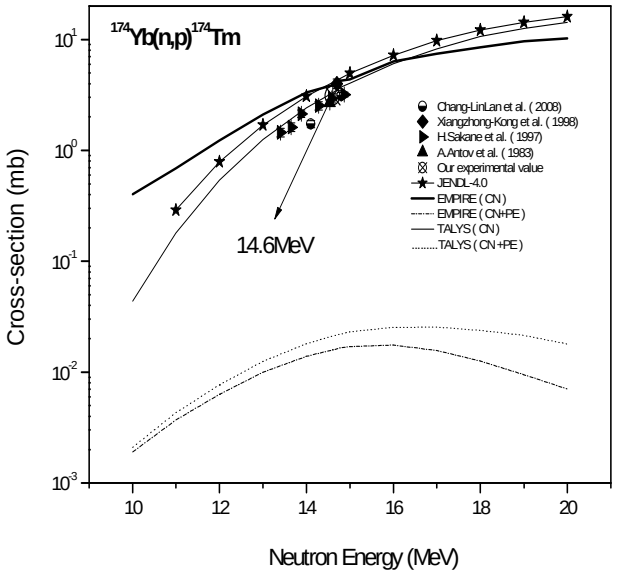

Fig.1.

References

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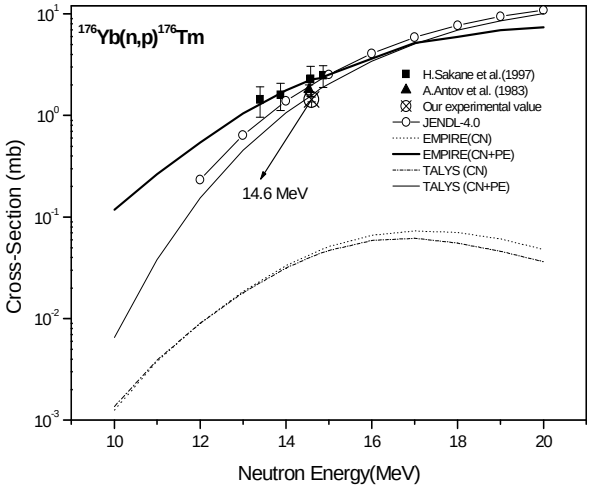

Fig.2.

Figs. 1 & 2 : EMPIRE-3.0 and TALYS-1.2 based excitation functions of ^{174,176}Yb(n,p) reactions with pre-equilibrium (PE+CN) and without pre-equilibrium (CN)

CN refer to Compound Nucleus Mechanism
PE refers to pre-equilibrium emission