# Excitation Functions of $^{61,62,64}$Ni(n,p) reactions from threshold to 20 MeV



H.C. Pandey, Bhawna Pandey and H.M. Agrawal

*Department of Physics, G. B. Pant University of Ag. & Technology, Pantnagar-263145 India*

*Email:hemgbpuat@gmail.com*

## Introduction

Nickel is an important structural material in fission and fusion reactor technology. Thus the precise knowledge of (n,p) reaction cross-section on nickel isotopes is very important. The theoretical understandings of nuclear reactions have been developed to the extent that with appropriate parameterization, nuclear models can be used for consistency checks of experimental cross-section data and for reasonably accurate prediction of "unmeasurable data". TENDL, a nuclear data library is primarily based on TALYS[1] nuclear model code system with Constant Temperature Model + Fermi Gas Model (ldmodel1) for nuclear level density option in calculations. However, there is a disagreement between TENDL and experimental values for $^{61}$Ni, $^{62}$Ni and $^{64}$Ni isotopes. In the present work, we have calculated (n,p) reaction cross-sections for these three Ni isotopes in the energy region from threshold to 20 MeV by using parity dependent microscopic model(ldmodel5) in TALYS-1.4 and compared these values with experimental as well as with TENDL-2011. Adequate experimental data are available for $^{61}$Ni(n,p)$^{61}$Co whereas very few data are available for $^{62}$Ni(n,p)$^{62}$Co, $^{64}$Ni(n,p)$^{64}$Co reactions for comparison with the theoretically predicted data.

## Nuclear Model Calculations

The nuclear reaction model calculations performed by using TALYS-1.4 includes the direct interaction, pre-equilibrium and compound nucleus contributions. The two component exciton model using Kalbach[2] systematic, with the particle hole state density by Dobes and Betak[3] has been adopted in pre-equilibrium calculation. The nuclear structure inputs like nuclear masses, discrete energy levels and level densities of nuclide involved in the calculations are taken from latest compilation available in RIPL-3[4].

The optical model potentials for neutrons and protons used in these calculations are the global parameterization of Koning and Delaroche[5] and the compound nucleus contribution was calculated by the Hauser Feshbach model[6]. Nuclear level density plays an important role in determining the (n,p) reaction cross-section. Therefore we have studied the effect of two level densities formalism Viz. (i) Constant temperature model + Fermi gas model[TENDL-2011] (ii) Microscopic level densities from Hilaire's table which is a parity dependent nuclear level density model.

## Results and Discussions

The computed cross-sections together with experimental data taken from EXFOR data library[7] are plotted for all cases. Figure-1 shows the illustrative case of $^{61}$Ni (n,p) reaction with parity dependent microscopic level density option and TENDL-2011, whereas figure 2 shows the direct, pre-equilibrium and compound nucleus contribution to reaction cross-section of $^{61}$ Ni(n,p) using parity dependent level density model in TALYS 1.4. The theoretical study indicates that in total (n,p) cross-section, the compound nucleus contribution is dominated by the low energy protons and the pre-equilibrium contribution mainly comes from the high energy emitted protons.

We conclude that the parity dependent level densities along with Koning global optical potential parameter for neutron in entrance channel and proton in exit channel are quite suitable in predicting (n,p) reaction cross-section for isotopes of nickel from threshold to ~ 20 MeV.

## References


[1] Koning, A. J. et al., Talys-1.4, A Nuclear reaction program,user manual, NRG-1755 ZG Petten,The Netherlands(2011).

[2] Kalbach,C.et al, Phys. Rev.C.,**33**,818-833(1986).

[3] Dobes, j. et al., Z. Phys.A 310, 3229 (1983).

[4] Capote, R. et al.,RIPL-3 Reference input parameter library for Calculation of nuclear reactions and nuclear data evaluations. Nucear Data Sheets **110**, 3107-3214(2009). <http://www-nds.iaea.org/RIPL-3/>

[5] Koning, A.J.et al., Nucl Phys.A **713**, 231-310(2003).

[6] Hauser, W. et al., Phys. Rev. **87**, 336(1952).

[7] EXFOR, Experimental Nuclear Reaction Data (2011). <http://www-nds.iaea.org/exfor>


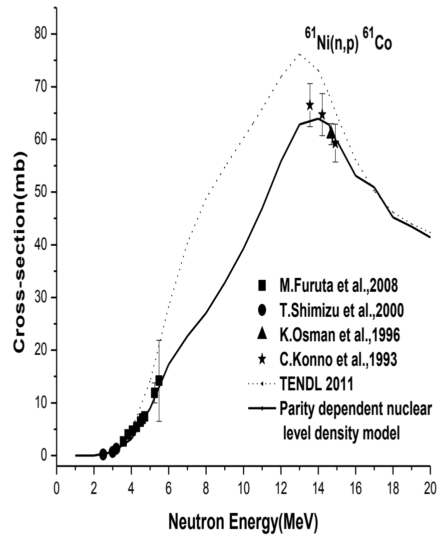


**Figure-1** TALYS 1.4 based excitation curve for $^{61}$Ni(n,p) along with experimental andTENDL-2011.

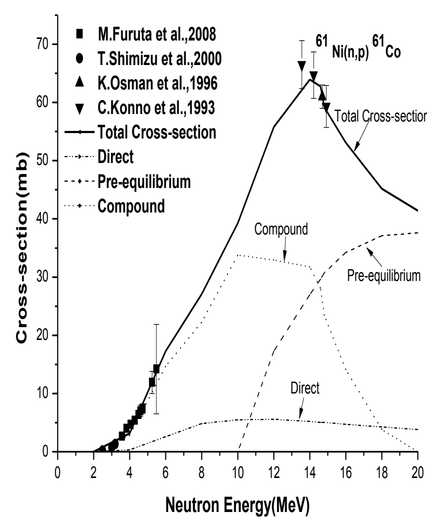


**Figure-2** Excitation curve for $^{61}$Ni(n,p) reaction along with direct, pre-equilibrium and compound nucleus contributions and experimental data .