^{58}Ni (n, p) ^{58}Co Reaction cross-section measurement at E_n=3.7 MeV

B.S. Shivashankar[1*], P.M. Prajapati[2,4], V. K. Mulik[3], D. Raj[4], S. V. Suryanarayana[5], H.Naik[6], K. C. Jagadeesan[7], S.V. Thakare[7], S.K. Mukherjee[2], Sarbjit Singh[6], A.Goswami[6], K.K. Rasheed[4], S. Ganesan[4], P.D.Krishnani[4], N. S. Nair[1] and K. M. Prasad[1]

[1]Dept. of Statistics. Manipal University, Manipal, [2].M S University of Baroda, Vadodara-390 002, [3]Dept. of Physics, University of Pune-411 007, [4]Reactor Physics Design Division, [5]Nuclear Physics Division, [6]Radiochemistry Division, [7]Radiopharmaceutical Division, BARC. Mumbai-400 085
*e-mail: bss.manipal@gmail.com

Nuclear data on neutron induced reaction cross-section of structural material such as Zr, Nb, stainless steel and Al are important from reactor point of view. This is because they are used as fuel cladding material in reactor. In stainless steel, Ni is one of the component. In reactor there is a broad neutron spectrum of energy ranging from 0 to 10 MeV [1]. So it is worth while to determine the reaction cross section of Ni with different mono energetic neutrons. In the present work we have determined the (n, p) reaction cross section of ^{58}Ni induced by 3.7 MeV mono-energetic neutrons using off-line γ-ray spectroscopic technique. The mono-energetic neutron beam was obtained from the ^{7}Li (p ,n) reaction using 5.5 MeV proton beam at BARC-TIFR Pelletron facility at TIFR, Mumbai.

Experimentally 0.1448 gm of natural nickel with ^{58}Ni (67.76%) and 0.1556 gm of natural indium metal foil were wrapped with 0.025 mm thick Al foil. These samples were irradiated for 6 hours at 3.7 MeV neutrons by using ^{7}Li (p, n) reaction of 5.5 MeV proton beam at the 6 meter height main line of BARC-TIFR Pelletron facility. The proton current during irradiation was 100 nA. After cooling of two hours the irradiated sample of Ni and In were mounted on Perspex plates and taken for γ-ray counting.

^{58}Co from ^{58}Ni (n,p) reaction has a half life of 70.78 d with characteristic γ-line of 811 keV [2]. Similarly ^{115m}In produced from ^{115}In (n, n') reaction has a half life of 4.4 h with γ-line of 336.3 keV [2]. The irradiated samples of Ni and In were counted for suitable time for their gamma ray activities using pre-calibrated HPGe detector coupled with PC based 4K MCA. The resolution of the detector system during counting was 2 keV at 1332 keV γ-line of ^{60}Co.

The observed photo-peak area (A_{obs}) for 811 keV of ^{58}Co and 366.3 keV for ^{115m}In were obtained from their total peak area after substituting the linear background due to Compton effect. From the A_{obs} ^{115m}In, neutron flux (φ) was obtained using decay equation [1]

$$A_{obs}=N\sigma\varphi\varepsilon a(1-e^{-\lambda t})\, e^{-\lambda T}\,(1-e^{-\lambda \Delta T})\,/\,\lambda \qquad -(1)$$

Where N is the total number of target atoms, σ is the (n, n') reaction cross section of In, 'a' is the γ-ray abundance, taken from the ref. [2]. ε is the efficiency of the γ-ray for the detector system, which was determined by using ^{152}Eu source. λ is the decay constant of the product nuclide. t, T and ΔT are irradiation, cooling and counting time respectively.

From the A_{obs} of ^{115m}In neutron flux was calculated at 3.7 MeV neutrons using equation (1) and found to be 1.1×10^{7} n cm^{-2} s^{-1}. The (n, n') reaction cross section of ^{115m}In at 3.7 MeV mono-energetic neutrons was taken from ref [3]. Using A_{obs} of ^{58}Co in the above equation, (n,p) reaction cross-section (σ) of ^{58}Ni was calculated, which is given in Table 1 along with the value from EXFOR [4] within the neutron energy range of 3-4 MeV for comparison.

Table 1. ^{58}Ni (n, p) reaction cross-section in barns at 3.7 MeV neutron energy

Present work	EXFOR	TALYS

0.317±0.036	0.298-0.333	0.297

The overall uncertainty represents contribution from random and systematic errors as well as precession from three measurements. The experimentally obtained (n,p) reaction cross-section of ^{58}Ni was compared with the data from EXFOR [4] and are found to be in good agreement within errors (Table 1). The ^{58}Ni (n,p) reaction cross section was also calculated theoretically using TALYS 1.0 [5] and plotted in Fig. 1 shown in line along with the value from present experiment (square). Theoretical value of 0.297 barn at mono-energetic neutron energy of 3.7 MeV is also given in Table 1 and was also found to be in agreement with value obtained from present work.

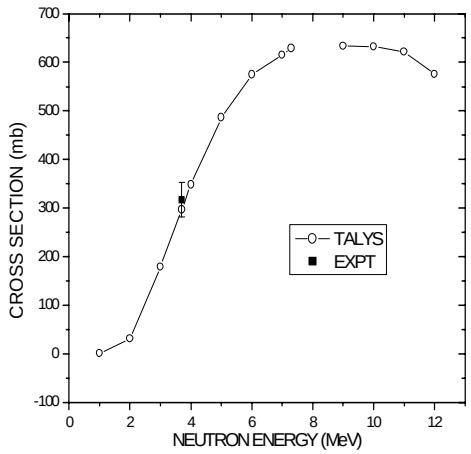

Fig.1. ^{58}Ni(n,p)^{58}Co reaction cross-section vs. neutron enertgy.

.

Acknowledgement

The authors sincerely thank to the staff of BARC-TIFR Pelletron facility for their excellent co-operation. We also thank Dr. V.K. Manchanda, Head, RCD for his kind help and permission to use RCD lab at TIFR and at RCD, BARC. One of the authors (BSS) like to acknowledge the financial assistance received from DAE-BRNS.

References

[1] H. Naik et al. Radiochimica Acta, **75**, 51 (1996).
[2] E. Brown and R,B, Firestone, Table of Radioactive isotopes (ed. V.S. Shirley), John Wiley ans sons, Inc (1986).
[3].Evaluated Nuclear Reaction libraries ENDF: available on the internet at http://www-nds.indcentre.org.in/endf
[4]. Experimental Nuclear Reaction Data EXFOR:available on the internet at http://www-nds.indcentre.org.in/exfor
[5]. A.J. Koning et al. Proc. International Conf. Nucl. Data for science and Tech.ND 2004, AIP Vol-769 (ed.R.C.Haightandetal.)P1154