Cross-section measurement of the ^{103}Rh(n,2n)^{102}Rh reaction at 22 MeV Energy

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I-Introduction

Study of the neutron induced reactions are of immense interest in reactor applications. Nuclear reactor consists of structural materials, control rods, fuel and shielding materials, therefore, when neutrons originated from fusion or fission reaction interact with these materials, they change mechanical and physical properties of materials. It is necessary to have cross section data for these materials at all possible neutron energies [1]. Lots of measured experimental nuclear data is available in the EXchange FORmat (EXFOR) library. In present work, we have studied ^{103}Rh(n,2n)^{102}Rh reaction at neutron energy of 20.12 ± 12.03. The cross section was measured using neutron activation analysis (NAA) technique. This cross-section data useful for develop theoretical model and to explain reaction mechanism. Rhodium is inert transition metal which have single natural occurring isotopes ^{103}Rh (100%) and Rhodium used as alloying agent to harden palladium and platinum. Cross-section of (n,xn) reactions are necessary, e.g., for activation detectors (also known as radiochemical detectors) which are used to probe energy components of a neutron fluence. ^{103}Rh is used for radiochemical diagnostic of integrated neutron fluence since nuclear reactions (n,γ), (n,2n) and (n,3n) lead to isotopes of rhodium with lifetimes in the useful range for neutron activation measurements [2]. EMPIRE-3.2.2 and TALYS-1.8 computer codes were used for the theoretical measurement. The experimentally measured neutron cross-section data is also compared with evaluated nuclear data libraries from ENDF/BVII, JEFF 3.2. The measured cross section is important to enhance the nuclear data, as well as for nuclear reactor applications.

II- Experimental Details

The experiment was performed using 14UD BARC-TIFR Pelletron facility at Colaba Mumbai, India. ^{7}Li(p,n)^{7}Be reaction was used to produce the neutron using 22 MeV proton beam, which was made to incident on natural lithium (Li) foil of thickness 3.4 mg/cm^2, sandwiched between the two tantalum (Ta) foils of different thicknesses. The front tantalum foil facing the proton beam was the thinnest to avoid the proton beam degradation. The back tantalum foil was comparably thick to stop the proton beam. The sample used for irradiation was wrapped in 0.025 mm thick aluminium foil to prevent radioactive contamination. Indium (In) and Aluminium (Al) were used as the flux monitor. The natural sample Rhodium (Rh) (99.9%) of weight 0.2862 g and area 9 to 8 mm used for the neutron irradiation. The Rhodium sample were irradiated with beam current 160 nA for 5 hours 15 minutes at 22 MeV proton energy. The irradiated sample was counted using the precalibrated high-purity germanium detector (HPGe). The energy calibration of the HPGe detector was done using the standard ^{152}Eu γ-ray source. The (n,2n) reaction cross section was calculated using the following equation,

$$\sigma = \frac{A\,\lambda\,\frac{t_c}{t_r}}{N\epsilon\varphi I_\gamma (1-e^{-\lambda t_{ir}})e^{-\lambda t_d}\,(1-e^{-\lambda t_c})} \quad (1)$$

Where A is the total area under the respective gamma peak λ the decay constant (sec^{-1}), N is the number of target nuclei $/cm^2$, ϵ is the photo-peak detection efficiency of measured γ-rays, I_γ is the γ -ray transition probability, t_d cooling time (sec), t_c counting time (sec), t_{ir} irradiation time (sec), t_r real time (sec), φ is the neutron flux (n/cm^2.sec). The spectroscopic data for present work is given in TABLE-I [3].

TABLE-I

(spectroscopic data for ^{103}Rh(n,2n)^{102}Rh reaction)

Nuclear reaction	E_{th} (MeV)	Half-life ($\tau_{1/2}$)	E_γ (keV)	I_γ (%)
^{103}Rh(n,2n)^{102}Rh	9.41	207.3 day	475.06	46.0

III-Theoretical Calculation

The statistical nuclear model code EMPIRE-3.2.2 and TALYS-1.8 used for the theoretical cross section measurements. Both Code used different nuclear model and gives nuclear reaction data for neutron, gamma, proton, deuteron, triton and alpha from keV to MeV energies. The nuclear reaction mechanism compound, pre-equilibrium, direct reaction and effect of level density consider in the EMPIRE-3.2.2 and TALYS-1.8 both code uses different reaction parameters from Reference Input Parameter Library (RIPL) library [4]. In present work, the theoretical calculation has been done with the default parameters and calculated cross section value shown in the TABLE-II its compare with different available data.

TABLE-II

(cross section data of $^{103}Rh(n,2n)^{102}Rh$ nuclear reaction at 22 MeV Energy)

Present work (mb)	609.405±108
EXFOR (mb)	763.102
ENDF (mb)	783.571
EMPIRE 3.2.2 (mb)	890.984
TALYS 1.8 (mb)	620.955

IV-Result and Discussion

The cross section of $^{103}Rh(n,2n)^{102}Rh$ reaction measured at the neutron energy 20.12±12.03 by equation-1 using the neutron activation analysis technique. This measured cross section data compared with the EXFOR [5] and ENDF[6] nuclear data libraries. EMPIRE-3.2.2 and TALYS-1.8 theoretical nuclear model code also used for cross section measurements of (n,2n) reaction and its cross-section value compared with measured experimental cross section. Experimental measured cross section data matched with the TALYS-1.8 theoretical calculation.

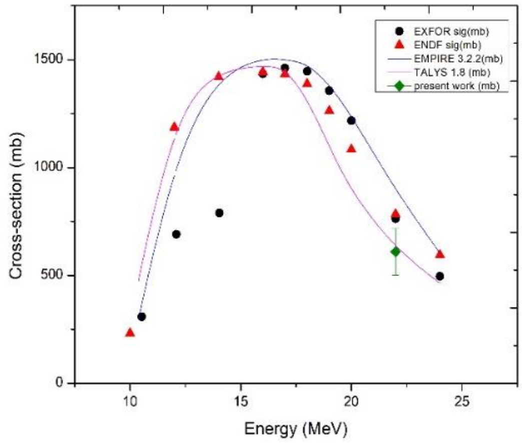

Fig. 1 Comparison of experimental measured cross-section for $^{103}Ag(n,2n)^{102}Ag$ with EMPIRE-3.2.2, TALYS-1.8, EXFOR and ENDF data libraries.

V-Acknowledgment

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