Measurement of the ^{184}W(n, α)^{181}Hf reaction cross-section using quasi-monoenergetic neutrons

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Introduction

Nuclear reaction cross-section data are of prime importance for upcoming fission Accelerator Driven Subcritical System (ADSs), Advance Heavy Water Reactor (AHWR), and fusion device International Thermonuclear Experimental Reactor (ITER) [1]. In fission reactor (ADSs), Tungsten (W) is used in different componants, while reactor in its operating stage all the componants face high energy neutrons [2]. It can be seen from the compilation of the EXchange FORmate (EXFOR) [4] data library that, there is a very few cross-section data have been availabel for the ^{184}W(n, α)^{181}Hf reaction from threshold to 22 MeV neutron energies. Therefore, it is crusial to generate nuclear reaction cross-section data for W material, at all possible neutron enegies. In the present work, we have measured the (n, α) reaction cross-section for ^{184}W isotopes at average neutron energy of 16.10±0.61 MeV. The quasi monoenergetic neutrons at 16.10±0.61 MeV have produced from the ^{nat}Li(p,n) reaction. The measured result was also compared with literature data taken from EXFOR [3] data library and the theoritical nuclear code TALYS-1.9 [4].

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Experimental Details

The neutrons required to carry out this experiment were obtain from ^{nat}Li(p,n) reaction with the help of 14UD Pelletron facility at Bhabha Atomic Research Center-Tata Institute of Fundamental Research (BARC-TIFR) Mumbai, India. The cross-section were measured by using Neutron Activation Analysis (NAA) technique followed by γ-ray spectroscopic technique. A setup for the neutron irradiation was fabricated in the straight section, just below the accelerator beam pipe at 6-m height above the analysing magnet with a special provision to mount the target assembly to utilize the maximum proton current from the accelerator. Further a collimator of 6 mm diameter was used before the lithium target. The W (sample) foil of thickness $\approx$ 0.1 mm was used together with the Aluminium (Al) and Indium (In) (monitor) foils of similar thickness for the irradiation. The sample and monitor foils wrapped separately with Al foil of thickness 10.5 micron to prevent radioactive contamination during irradiation. The stack of samples and monitor mounted on a 0 degree angle with respect to the proton beam direction at a distance of 2.1 cm behind the Ta-Li-Ta stack. A schematic diagram of the irradiation arrangement can found in Ref. [6]. After the irradiation the samples were allowed to cool for a enough time to prevent then the high dose of radiation. The samples as well as the monitor were saperately counted using a pre-calibrated 80 cc single crystal HPGe

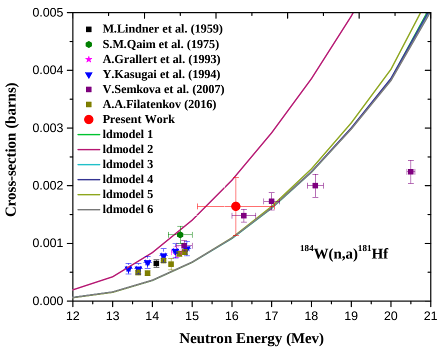

FIG. 1: Comparison of the ^{184}W(n,α)^{181}Hf reaction with the literature data and the theoretical predictions using TALYS-1.9 [4] code.

detector coupled with a PC based 4K multichannel analyzer. The energy and efficiency calibration of the detector was done by using a standard ^{152}Eu source. The resolution of the detector system was measured as 1.88 keV during the counting. The dead time of the detector was kept $< 3\%$ by placing the samples at an appropriate distance from the detector endcap.

Data Analysis

A brief of the generation of the neutron spectra using ^{nat}Li(p,n) reaction has been given elsewhere [5]. The neutron flux in present measurement were measured from ^{27}Al(n, α)^{24}Na and ^{115}In(n,n$'$)^{115m}In reactions. The decay statistics of the 1368.68 keV and 336 keV γ-line of the ^{24}Na ($t_{1/2} = 14.997$ hours) and ^{115m}In ($t_{1/2} = 4.486$ hours) were used for the calculation of the neutron flux using the weighted ^{27}Al(n,α) and ^{115}In(n,n$'$) reactions cross-section from the EXFOR [3]. By taking this calculated neutron flux, the cross-section for the ^{184}W(n,α) reaction have been calculated using decay statistics (C_{obs}) of the 133.021 keV γ- line of the ^{181}Hf ($t_{1/2} = 42.39$ days) using the following relation,

$$\sigma_R = \frac{C_{obs}(C_L/L_T)\lambda(e^{\lambda T_c})}{N_0 \epsilon I_\gamma \phi K (1-e^{-\lambda T_i})(1-e^{-\lambda T_{LT}})} \quad (1)$$

Where all the symboles in this equation have their usual meaning. A tailing correction [6] were applied to the measured reaction cross-section to discard the contributions from the lower energy neutrons.

Result and Discussion

The cross-section of the ^{184}W(n,α)^{181}Hf reaction at average neutron energy of 16.10$\pm$0.61 MeV was measured. A comparison of the present result with the previous published data from the EXFOR [2], as well as preliminary calulations of the different ldmodels available in the theoretical nuclear code TALYS-1.9 [5] were plotted as a function of neutron energy shown in Fig.1. It can be observed from the figure that the measured cross-section is in agreement with the trend of the literature data also the data point lies in betwwen the different ldmodel pridiction and further calculation is in progress. The present measurement have added new data point to the existing data set, at the given neutron energy.

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