Measurement of ^{93}Nb(n,2n)^{92}Nb cross-section at different neutron energies

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Introduction

There is a need of precise neutron induced reaction cross-section data of different materials for neutron transport simulations, the design and safety application of fusion reactor and in evaluation and development of nuclear reaction database. [1]

Niobium (Nb) is an important structural material in reactors due to its high temperature resistant, corrosion resistant and long term induced activity. Niobium alloys is also considered as an important material for the super conducting magnet coils used in high power accelerators.[2-3] The present paper describes the measurement of neutron induced cross-section of Niobium at average neutron energies 10.72±0.93, 14.72±0.93 and 18.72±0.93 by off line γ-ray spectroscopy technique. The experimental data is compared with the data predicted by the nuclear modular codes TALYS-1.8 and the cross-section data available in EXFOR [4], ENDF/B-VIII.0 [5] and JENDL-4.0[6] nuclear data libraries.

Experimental details:

The experiment was carried out using 14UD BARC-TIFR Pelletron facilities at Mumbai, India. The neutron beam was produced from the ^{7}Li(p,n)^{7}Be reaction [7] at the 6m high line above the analyzing magnet to utilize the maximum proton current from the accelerator. Natural lithium0 foil of thickness of 3.7mg/cm^2 was used as target to produce neutrons. This Li foil wrapped with tantalum foil of thickness 3.7 mg/cm2 in the front side which was facing proton beam and 4.12 mg/cm2 thickness on the back side to stop protons which were reflected back. Behind Ta-Li-Ta different target samples were stacked at a distance of 2.1cm from Li target in the forward direction for the irradiation. In and Au foil was used as a flux monitor via ^{115}In(n,n')^{115m}In and ^{197}Au(n,γ)^{198}Au reactions. The natural niobium of different weight was irradiated at different neutron energies. In off-line γ-ray spectrometry, the γ-ray spectrum was measured by using High Purity Germanium (HPGe) detector. For short lived isotopes, Pre calibrated HPGe detector couples to a PC-based 4K channel analyzer was used for γ-ray spectrometry and γ-ray spectra was measured by MAESTRO spectroscopic software. The energy and efficiency calibration of the detector system was done by counting the γ-ray energies of standard ^{152}Eu source having multi γ-ray energies.

Calculations:

The reaction cross-section was measured from the measured counts of photo peak using the activation formula.

$$\sigma = \frac{A_\gamma \lambda \frac{CL}{LT}}{N\Phi I\gamma\, \varepsilon(1-e^{-\lambda t_i})e^{-\lambda t_c}(1-e^{-\lambda t_{cL}})}$$

Where, Aγ is number of counts of photo peak of daughter nucleus, λ is the decay constant of product nucleus (sec^{-1}), N is the number of atoms in target material , Φ is the neutron flux, Iγ is the absolute γ-ray intensity per decay of the residual nucleus, ε is the photo peak efficiency of the gamma ray, t_i is the irradiation time(sec), t_c is a cooling time (time elapsed between the end of irradiation and start of counting in sec), CL and LT are the clock time and live time for counting, respectively and CL/LT term is used for dead time correction.

Result and Discussions:

The reaction cross-section of ^{93}Nb(n,2n)^{92}Nb measured at average neutron energies 10.72±0.93, 14.72±0.93 and 18.72±0.93. The measured cross-section data were compared with the theoretically predicted data by TALYS-1.8 and the data available in data available in ENDF/B-VIII.0 and JENDL-4.0 nuclear data libraries. Comparison of the experimental and predicated data is shown in Fig. 1 which shows that the experimentally predicted data are in good agreement with the predicated data.

Table-1: Measured Cross-section data of ^{93}Nb(n,2n)^{92}Nb

Energy (MeV)	Cross-section (mb)		
	Measured	EXFOR	ENDF
10.72±0.93	691±35	735±46	775
14.72±0.86	1283±88	1276±96	1370
18.72±0.95	1212±62	1337±97	1317

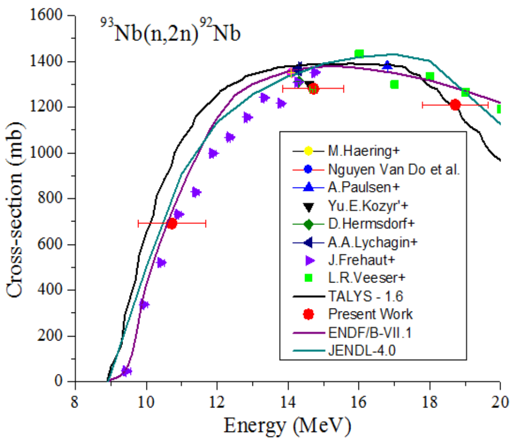

Fig.1 Comparison of ^{93}Nb(n,2n)^{92}Nb cross-section at different neutron energies

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