Experimental Validation of Surrogate Ratio Method for the (n,xp) Cross Sections

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For the better estimation of gas production due to activation from fast neutrons in the structural materials of the upcoming fusion reactors, knowledge of (n,xp) cross sections of radionuclide is important [1]. Long-lived radionuclide gets accumulated in the structural material of the reactor during its operation, and (n,xp) reactions from these radionuclide will contribute to the total hydrogen production in the material. Measurements of such cross sections using direct methods are very difficult due to unstable targets. In order to overcome this issue surrogate ratio method (an indirect method) has been used in past few years [1,2]. But validity of surrogate ratio method for (n,xp) cross sections has not been studied yet by comparing the cross sections from surrogate ratio method with that from direct measurements [3]. We have performed an experiment at BARC-TIFR Pelletron accelerator facility in Mumbai, to determine ^{56}Fe(n,xp) cross sections using surrogate ratio method and then we compared the cross sections to the available experimental data from the direct methods. We have used ^{52}Cr(n,xp) as our reference reaction, and used ^{6}Li(^{55}Mn,α)^{57}Fe and ^{6}Li(^{51}V,α)^{53}Cr surrogate reactions to populate the desired compound nuclei. The cross sections were calculated using the following ratio equation.

$$\frac{\sigma^{56Fe(n,xp)}(E_{ex})}{\sigma^{52Cr(n,xp)}(E_{ex})} = \frac{\sigma_{CN}^{56Fe+n}(E_{ex})P_{n,xp}^{57Fe}(E_{ex})}{\sigma_{CN}^{52Cr+n}(E_{ex})P_{n,xp}^{53Cr}(E_{ex})} \quad (1)$$

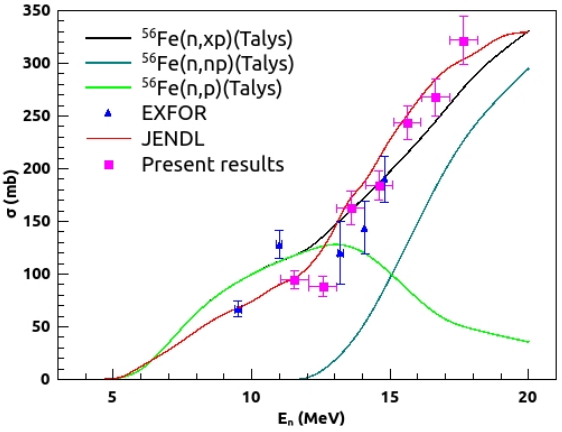

Fig. 1: ^{56}Fe(n,xp) cross sections obtained from surrogate ratio method along with the JENDL-3.3 and experimental data from EXFOR and TALYS predictions.

Where cross sections for ^{52}Cr(n,xp) were used from JENDL-3.3 library, and compound nucleus formation cross sections (σ_{CN}) were calculated using optical model calculations and decay probabilities (P^{CN}) were determined experimentally by taking ratio of the coincidence counts to the single counts. The measured cross sections are presented in Fig. 1, and it is observed that the cross sections are in agreement with the available experimental data and the evaluated data. This study established that the surrogate ratio method is valid to determine the (n,xp) cross sections.

References:

1. J. Pandey et al., *Physical Review C*, **99** (2019) 014611.
2. R. Gandhi et al., *Physical Review C*, **100** (2019) 054613.
3. A. Sharma el al, *Physical Review C*, **105** (2022) 014624.