Studies of neutron-induced fission and nuclear reaction for AHWR and ADS applications

P. M. Prajapati

Physics Department, Faculty of Science, The M. S. University of Baroda, Vadodara – 390 002, India

E-mail ID:paresh_21soft@yahoo.co.in

The development of accelerator driven sub-critical systems (ADS) and advanced heavy water reactor programme requires significant amount of new and improved nuclear data [1] in the extended energy regions as well as for a variety of new materials. The importance of nuclear data needs at the very beginning of the evolution of the concept of energy amplifier (EA) has also been recognized by C. Rubbia [2]. In ADS, the actual conversion of fertile to fissile nuclei (e. g ^{232}Th to ^{233}U) or the transmutation of radioactive nuclei to stable ones takes place in blanket favorably in the resonance energy region and thermal regions where the capture cross-section is the largest. Thus, nuclear data to predict nuclear collision, isotope production, formation of gases and heat generation are needed at this very first step. Further, the energy produced in ADS or any nuclear reactor is due to neutron-induced fission of actinides. Therefore for the design of ADS, it is also necessary to have accurate knowledge of nuclear data of actinides such as yields of fission products, neutron capture cross-sections and decay data including half-lives, decay energies, branching ratios etc. Further, Nuclear data for the calculation of displacement damage cross-sections with hydrogen and helium production cross-section up to high energies for structural materials (e. g, Zr, Ni, Fe, Al) are required. These requirements demonstrate the immediate need for experimental research, the result of which would be incorporated with the basic nuclear data. The generation and use of nuclear data are considered fundamentally important, as accurate nuclear data are essential inputs to simulate nuclear interactions to obtain the engineering parameters. The above measurements of neutron-induced reactions and fission cross-section data have been compiled into IAEA-EXFOR data base. In addition to these, the Indian experimentally measured nuclear physics data from various Indian laboratories and institutions have also been compiled into IAEA-EXFOR database as per NDS, IAEA guideline and requirements.

In view of the above discussions and explanations about the requirements of accurate and precise nuclear data to develop advanced nuclear systems, the main objectives achieved and discussed in the present thesis were the following:

(1) Fission products yield measurements in the fast neutron-induced fission of ^{232}Th using recoil catcher and gamma-ray spectrometry technique.

(2) Measurements of neutron capture cross-section, namely, for ^{232}Th(n,γ) and ^{232}Th(n, 2n) reactions at various neutron energies from 3 MeV to 16 MeV.

(3) Determination of ^{233}Pa(2n$_{th}$, f) fission cross-section using the solid state nuclear track detector technique.

(4) Neutron-induced reaction cross-section measurements for zirconium isotopes.

The author has utilized various national facilities generating various types of neutron sources for the neutron cross-section presented in the thesis. The average neutrons (e.g., 3 MeV to 16 MeV) were generated by ^{7}Li (p, n) reaction using BARC-TIFR Pelletron Facility at Mumbai, India. APSRA reactor Facility at BARC, Mumbai was used for thermal neutrons (e.g., 0.025 eV). On the other hand, D+D fusion reaction was used to produce neutrons of energy 2.45 MeV. The details of experimental procedure and data analyses have been provided by author [3-7]. The measured neutron cross-sections have been generated theoretically using nuclear model based computer code TALYS 1.2 and compared with experimental data. Further, the experimentally measured neutron cross-sections data were also compared with latest available evaluated nuclear data libraries from ENDF/B-VII, JENDL 4.0, JEFF 3.1 and TENDL 2010.

The measurements presented in the thesis have added new and important data points to the existing database, providing an important guidance to theoretical calculations as well as for choosing better among the data evaluations libraries. In addition to our own measurements, the author has himself contributed more than 30 new Indian Exfor entries in IAEA-EXFOR database which are accepted by NDS, IAEA. Further, the author has contributed in training the students at various EXFOR workshop organized by IAEA and BARC.

The author takes this opportunity to thank his thesis supervisor Dr. S. Mukherjee, MSU Baroda for his keen interest and guidance. The author gratefully acknowledges Drs. H. Naik, S.V. Suryanarayana and S. Ganesan from BARC, Mumbai for their valuable support and continuous encouragement. The financial assistance received from DAE-BRNS through major research project (No.2008/36/27-BRNS/1844) at MSU Baroda is also gratefully acknowledged.

References

[1] S. Ganesan, Pramana J. Phys., **68**, 257 (2007)

[2] C. Rubbia, et al., CERN/AT/95-44 (ET) 1995

[3] **P.M. Prajapati** et al., Nucl. Sci. Eng (communicated)

[4] **P.M. Prajapati** et al., Eur. Phys. J. A **48**, 35 (2012)

[5] **P.M. Prajapati** et al., Nucl. Sci. Eng. **171**, 78 (2012)

[6] H. Naik, **P. M. Prajapati** et al., Eur. Phys. J. A **47**, 100 (2011)

[7] H. Naik, **P. M. Prajapati** et al., Eur. Phys. J. A **47**, 51 (2011)