CHAPTER 7

SUMMARY AND CONCLUSION

7.1 Summary and conclusion

7.2 Future scope

7.1 Summary and conclusion

Present thesis throws light on the effect of neutron exposure on various materials of Accelerator Driven Sub-critical system (ADSs). The technology of ADSs may be a prospective future source of energy generation. The ADSs system works as energy generator as well as an incinerator. Present thesis deals with the measurement of (n,γ) reaction cross-sections using fast neutrons, on the materials related to application of ADSs. Lack of the accurate reaction cross-section data in the literature was the prime motivation for the present work. We have experimentally measured the (n,γ) reaction cross-sections of the actinides (Th, U), structural materials (Mn) and flux monitor (Au). After rigorous literature survey, it was found that the reaction cross-section data in the literature for the above mentioned cases to be insufficient.

The experimental facilities of Folded Tandem Accelerator (FOTIA) and Bhabha Atomic Research Centre-Tata Institute of Fundamental Research (BARC-TIFR) Pelletron facility have been used for the purpose of experimental measurement. The experimental data obtained from the experimental format (EXFOR) as well as theoretical (ENDF) data are available in the literature. Nuclear model codes, TALYS and EMPIRE have been utilized to perform the theoretical interpretation of the experimental cross-section results.

Measured cross-section data for neutron induced reactions with Au, Mn, Th and U targets are in general agreement with the nuclear model codes TALYS and EMPIRE and in good agreement with the data available in the literature (EXFOR and ENDF). Following conclusions have been drawn from the present work.

- For ^{197}Au(n,γ) reaction, cross-section data only between 0.024 to 3 MeV and 14.7 MeV neutron energy are available. There are no experimental data available within 3 to 14.7 MeV neutron energy range.
- The ^{55}Mn(n,γ)^{56}Mn reaction cross-section data are available below 4 MeV neutron energy range and around 13.4 to 15 MeV. From 4 to 19.4 MeV energy range, only one data set, reported by Menlove et al. is available in the literature. Within thermal to 4 MeV neutron energies, discrepancies are present among the available data from various authors.
- Experimentally measured data for ^{232}Th(n,γ) reaction are available between thermal to 3 MeV neutron energy. Beyond 3 MeV, measured data of the ^{232}Th(n,γ) reaction are available at 3.7, 5.9, 8.04, 9.85, 11.9, 13.5, 14.55, 14.8, 15.5 and 17.28 MeV neutron energies.
- Reaction cross-section data for ^{238}U(n,γ) reaction are available within thermal to 3 MeV neutron energy range. Above 3 MeV neutron energy, ^{238}U(n,γ) reaction cross-section data are

available at 3.033, 3.5, 3.7, 4, 5, 5.9, 6, 7, 7.2, 7.6, 8.04, 8.2, 9.2, 9.85, 10.2, 11.2, 11.9, 12.2, 13.2, 14, 14.2, 14.5, 13.5, 14.8, 15.5, 17, 17.28 18, 19 and 20 MeV neutron energies.

- Neutron Activation Technique is used for the generation of the nuclear reaction cross-section data in the present work. Off-line γ-ray spectrometric technique is used for the measurement of γ-ray activity.
- ^{197}Au(n,γ) and ^{55}Mn(n,γ) reaction cross-sections measured experimentally at the neutron energies of 1.12, 2.12, 3.12 and 4.12 MeV.
- ^{232}Th(n,γ) and ^{238}U(n,γ) reaction cross-sections measured experimentally at the neutron energies of 5.08, 8.96, 12.47 and 16.63 MeV.
- Reaction cross-sections are computed for ^{197}Au(n,γ), ^{55}Mn(n,γ), ^{232}Th(n,γ) and ^{238}U(n,γ) reactions theoretically in fast neutron energy range i.e., 1 to 20 MeV with the help of TALYS and EMPIRE nuclear model codes.
- For ^{197}Au(n,γ) the reaction cross-section values are measured for the very first time at the neutron energies of 3.12 and 4.12 MeV. Presently measured cross-section data at 1.12 and 2.12 MeV neutron energies are in good agreement with the literature data. ^{197}Au(n,γ) reaction cross-sections at the neutron energies of 1.12, 2.12, 3.12 and 4.12 MeV are 82.50 ± 3.50, 56.30 ± 2.40, 25.00 ± 1.10 and 14.93 ± 1.73 mb, respectively.
- ^{55}Mn(n,γ) reaction cross-section data are measured for the very first time at 4.12 neutron energy. All the four cross-section data in the present measurements at the neutron energies of1.12, 2.12, 3.12 and 4.12 MeV, which fall well within the range of available experimental as well as theoretical data in the literature (EXFOR and ENDF). ^{55}Mn(n,γ) reaction cross-sections at the neutron energies of 1.12, 2.12, 3.12 and 4.12 MeV are 3.374 ± 0.487, 1.563 ± 0.147, 1.407 ± 0.136 and 1.137 ± 0.178 and 2.382 ± 0.344, 2.062 ± 0.126, 1.184 ± 0.117 and 1.066 ± 0.167 mb, respectively based on the different flux values.
- ^{232}Th(n,γ) reaction cross-sections measured experimentally at the neutron energies of 5.08, 8.96, 12.47 and 16.63 MeV, the reaction cross-sections for these neutron energies are 2.26 ± 0.37, 1.46 ± 0.21, 1.33 ± 0.26 and 0.78 ± 0.12 mb, respectively.
- ^{238}U(n,γ) reaction cross-sections measured experimentally at the neutron energies of 5.08, 8.96, 12.47 and 16.63 MeV. The reaction cross-sections for these neutron energies are 1.87 ± 0.34, 1.17 ± 0.16, 1.88 ± 0.31 and 0.75 ± 0.10 mb, respectively.
- Overall, almost all the present data are in good agreement with the previously measured data and where there are no measured data available, theoretical data are taken for the comparison.

- Thus, neutron activation technique followed by the proper analysis generates the reliable data with minimal errors. Using these data, one can build advanced reactors and accelerators or may be ADSs.

7.2 Future scope

Fission and reaction cross-section data are lacking for many targets in the nuclear data library and there are discrepancies in some of the data, available in the literature. These data are quite useful in various fields. Fast neutron, proton and photon induced reactions are quite useful from the point of view of Fast Breeder Reactor (FBR), Advanced Heavy Water Reactor (AHWR) and Accelerator Driven sub-critical System (ADSs). Reliable neutron induced reaction cross-section data for different targets, which can serve as fuels, shielding, structural and blanket materials for the advanced reactors can be generated. These advanced reactors bear the attractive features like superior safety characteristic, incineration of long lived actinides, transmutation of long lived products and more importantly energy production. One can explore more experimental aspects with the help of advanced machinery and the data measurement methods, which can minimize the errors in the measured cross-section data. Covariance analysis of the uncertainties of the present cross-sections data can be done and EXFOR entries of the present work can be made.