Measurement of evaporation residue cross section and spin distribution in $^{28}Si+^{176}Yb$ reaction

K. Sudarshan[1,*], R. Tripathi[1], S. Sodaye[1], S. K. Sharma[1], P. K. Pujari[1], J. Gehlot[2], N. Madhavan[2], S. Nath[2], G. Mohanto[2], I. Mukul[2], A. Jhingan[2], I. Mazumdar[3]
[1]*Radiochemistry Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[2]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA*
[2]*Deptartment of Nuclear and Atomic Physics,*
Tata Institute of Fundamental Research, Mumbai - 400 005 INDIA
* email: kathis@barc.gov.in

Introduction

Study of fusion hindrance in reaction systems with low Z_PZ_T has currently been an active area of investigation [1-5]. In a study of fission fragment mass distribution in different reaction systems forming the same compound nucleus ^{202}Po, Rafiei et al. [1] suggested the onset of fusion hindrance to be around Z_PZ_T value of ~1000. In another study of fission fragment mass distribution in $^{24}Mg+^{186}W$ [2], a broadening in the mass distribution was observed which was attributed to the contribution from quasi-fission. Fission fragments mass distribution in $^{27}Al+^{186}W$ was reported to be consistent with that expected for compound nucleus fission [3]. Study of the onset of fusion hindrance as well as equilibration in various degrees of freedom such as mass, energy and K-degree of freedom (*K* being the projection of the total angular momentum vector on nuclear symmetry axis) is important for our understanding of heavy ion fusion process. Such studies are particularly important for the reaction systems with low Z_PZ_T around the onset of fusion hindrance. In the pre-actinide region, fission occurs preferentially from higher *l*-wave trajectories. In a recent study by Mohanto et al. [5] in $^{30}Si+^{170}Er$ reaction, it was shown that the average angular momentum for the evaporation residues was lower compared to the statistical model calculations. The evaporation residue gated mean gamma-ray multiplicity was also lower compared to those for more asymmetric systems. This observation was attributed to the contribution from non-compound nucleus fission. Angular momentum of the fissioning nucleus also becomes an important parameter in the interpretation of fission fragment angular distribution data in the less fissile systems. Contribution from non-compound nucleus fission or quasi-fission also leads to areduction in the evaporation residue cross section.

In order to investigate fusion hindrance around Z_PZ_T~1000, evaporation residue cross sections and spin distributions were measured in $^{28}Si+^{176}Yb$ reaction in the beam energy range of 137 to 173 MeV.

Experimental details

Experiments were carried out at Inter University Accelerator Centre, New Delhi using the HYRA gas-filled separator coupled to a 4π spin spectrometer [6]. An electrodeposited target of ^{176}Yb on a thin aluminium backing was used for the experiments. Experiments were carried out with ^{28}Si beam of energy 150 to 185 MeV (in steps of 7 MeV) provided by the accelerator facility. The corresponding beam energies in the target were 137 to 173 MeV after the energy degradation. Evaporation residues were separated from the beam particles by the HYRA, operated in the gas-filled mode, and detected by a multi-wire proportional counter (MWPC) at the focal plane. In order to normalize for the target thickness and beam intensity, elastically scattered beam particles were detected using two monitor detectors placed at $\pm25^0$. For clear selection of ERs, TOF with respect to the beam pulse as well as energy loss signal from the MWPC were recorded.

Results and discussion

Typical plots of cathode spectrum of MWPC and RF TAC spectrum at beam energy of 158.5 MeV are shown in Figs. 1 and 2, respectively. In Fig. 1, The broad peak on the left side is due to the evaporation residues. The origin of the sharp peak on the right side was not clear. In order to determine the residue spin distribution, prompt gamma-rays emitted by the

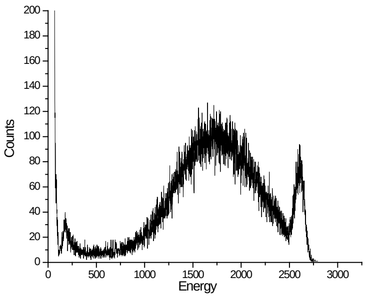

Fig. 1. MWPC cathode spectrum for $^{28}Si+^{176}Yb$ reaction at E_{lab}=158.5 MeV

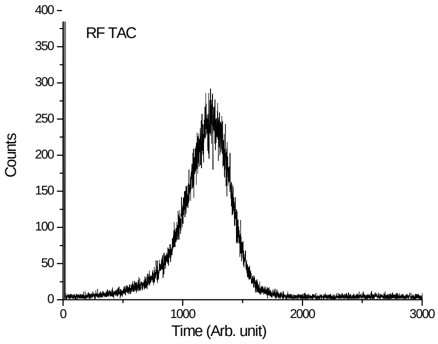

Fig. 2. RF TAC spectrum of the evaporation residues from reaction $^{28}Si+^{176}Yb$ reaction at E_{lab}=158.5 MeV

residues were detected by a 4π spin spectrometer consisting of NaI(Tl) detectors. Use of a nearly 4π geometry provided the fold data up to ~20 folds. A typical fold spectrum at E_{lab}=158.5 MeV is shown in Fig. 3. In order to obtain the residue spin distribution, ER gated fold distribution will be corrected for the response of the spin spectrometer. Further data analysis is in progress in this direction to extract the multiplicity distribution and evaporation residue cross section.

The spin distribution and cross section of evaporation residues would provide information about the fusion hindrance and contribution from non-compound nucleus fission in the present reaction system. Further, due to the comparable cross sections for evaporation residues and fission in the compound nucleus mass region ~200, information about the spin distribution of evaporation residues also becomes important for interpretation of angular distribution data. The results from the present studies on the evaporation residue cross section and spin distribution along with the results of our earlier study on fission fragment angular distribution [4] would also provide information about the onset of fusion hindrance in the pre-actinide region.

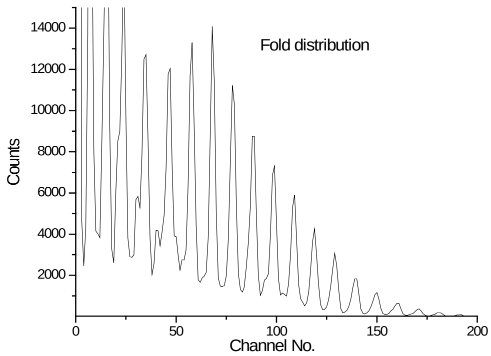

Fig. 3: Fold distribution for $^{28}Si+^{176}Yb$ reaction at E_{lab}=158.5 MeV

References

[1] R. Rafiei *et al.*, Phys. Rev. C **77**, 024606 (2008).
[2] E. Prasad et al., Phys. Rev. C **81**, 054608 (2010).
[3] Appannababu et al., Phys. Rev. C **83**, 034605 (2011).
[4] R. Tripathi et al., Phys. Rev. C **79**, 064607 (2009).
[5] G. Mohanto et al., Nucl. Phys. A **890-891**, 62 (2012).
[6] N. Madhavan et al., EPJ Web of Conferences, 14003 (2011)