Study of complete and incomplete fusion dynamics in the interaction of ^{14}N with ^{148}Nd

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Introduction

In the study of Heavy Ion (HI) Induced fusion nuclear reactions above the Coulomb barrier has been the subject of growing interest from past few decades. In the interaction of two heavy ions a number of reaction channels open and transfer of clusters of nucleons and angular momentum takes place. The complete fusion (CF) and incomplete fusion (ICF) are most dominant reaction process above the Coulomb barrier. In CF process, the projectile completely fuses with the target and formed highly excited compound nucleus decays by emitting evaporating nucleons and particles like element at equilibrium stage. Hence the total linear and angular momentum of projectile is transferred to the target. In ICF process, only a part of the projectile fuses with the target and remaining part moves in the forward direction with almost same velocity as incident ion beam velocity [1]. In this process partial linear and angular momentum is transfer to the composite system. Because of complex nature of the ICF, reveling of various possibility of it has been a fascinating field of interest from the several decades. So far it is not been clearly established that ICF processes are governed by the entrance channel or by the nature of the formed composite system due to the fusion of only a part of the fragments in the vicinity of target nuclear coulomb field range. Excitation function (EFs) measurements of evaporation residues is one of the inimitable tool for the investigation of CF and ICF dynamics in heavy ion induced reactions at energies range of 3-7 MeV/nucleon [2].

Earlier most of the experimental studies on CF and ICF dynamics have been confined with the heavy mass target nuclei (A>150) using α-cluster structure projectile [3], while experimental studies on CF and ICF with medium mass target nuclei using non α-cluster structure projectile is very limited. However, the experimental data on non α-cluster structure projectile with medium mass target are scarce. Keeping the above aspect in view an attempt has been made to study the CF and ICF dynamics using ^{14}N beam with ^{148}Nd target at projectile energy above the Coulomb barrier.

Experimental Details and Identification of Evaporation Residues

Present experiment has been carried out using General Purpose Scattering Chamber (GPSC) at Inter University Accelerator Centre (IUAC), New Delhi, India. Enriched target material of ^{148}Nd (Enrichment ≈95.44% ± 0.1%) isotope was used in the present experiment. Targets of enriched ^{148}Nd were prepared by vacuum evaporation technique. Target material of ^{148}Nd was deposited on thick natural aluminum (^{27}Al) foils in a vacuum chamber. The thickness of the each aluminum foil before and after the deposition was determined by weighing individual foil using micro-balance as well as the α-particle transmission method. In vacuum transfer facility was used in the present experiment. In this experiment, a single stack of target (^{27}Al-^{148}Nd-^{27}Al sandwiched) assembly was irradiated using $^{14}N^{+6}$ ion beam of 85 MeV energy. The activities induced in the irradiated targets along with aluminum catchers has been recorded using a high purity germanium (HPGe) detector coupled with a PC based data accusation system employing with CANDLE software [3]. The calibration of the HPGe detector was carried out using ^{152}Eu-source of known strength. The

ERs were identified by their characteristic γ-rays as well as following their half-lives.

Experimental Results and Discussion

The excitation function for the three evaporation residues ^{157}Ho (5n), ^{156}Ho (6n), and ^{154}Tb (α4n) produced in the interaction of ^{14}N with ^{148}Nd are measured between projectile energy range 3-7 MeV/nucleon.

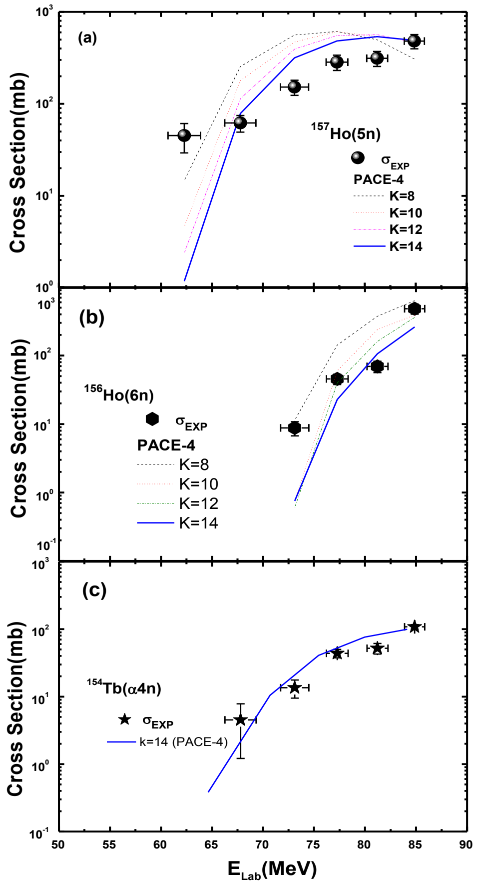

Fig. 1 (Colour Online) Experimentally measured excitation functions for the reactions (a)^{148}Nd(^{14}N, 5n)^{157}Ho (b) ^{148}Nd(^{14}N, 6n)^{156}Ho and (c) ^{148}Nd (^{14}N, α4n) ^{154}Tb along with the theoretical predictions of PACE-4.

The experimentally measured and theoretically calculated EFs for these three ERs are displayed in Figs. 1(a)-(c). The effect of variation of level density parameter 'K'(=8,10,12, 14) on the calculated EFs for the ERs produced in the reaction ^{157}Ho (5n) and ^{156}Ho (6n) are shown in Figs.1(a)-(b). It is quite clear from these figures that PACE-4 predictions corresponding to K=14 reproduce the measured EFs satisfactorily and these reaction channel are produced through CF process. Further, the experimentally measured and theoretically calculated EFs for evaporation residue ^{154}Tb (α4n) is shown in Fig. 1 (c). As can be seen from this figure that the experimentally measured EF are agree well with the theoretically calculated EF (k=14). The good agreement between the experimentally measured EF and theoretical predictions may be attributed to the CF process.

Possible Reaction Rout

(1)^{14}N (^{10}B+α) +^{148}Nd→(^{158}Tb)* →^{154}Tb+4n
→ α (fast α)
(Q=-39.09 MeV)

(2)^{14}N+^{148}Nd→(^{162}Ho)*→^{154}Tb+2p+2n+4n
(Q=-67.39 MeV)

It has been also observed that from the Fig. 1(c) that the experimental and theoretical cross sections are populated above the E_{lab}= 67 MeV. The present result may also indicate that the evaporation residue ^{154}Tb will be populated through complete fusion via the reaction route (2p+2n+4n) due to the Q-value (Q=-67.39 MeV), this reaction will not be populated through the reaction route (α4n) due to the Q-value (Q=-39.09 MeV).

Acknowledgements

Authors are thankful to the Director, operational staff of Pelletron Accelerator and target laboratory of IUAC, New Delhi for providing the necessary facilities to carry out the experiment. Pankaj K. Giri thankful to the IUAC, New Delhi for Project Fellowship in the UFUP research project (Ref: IUAC/XIII.3/UFR/54321) under Dr. Dharmendra Singh. D. Singh acknowledges encouragement from the Vice-chancellor and the Head, Centre for Applied Physics, Central University of Jharkhand (CUJ), Brambe, Ranchi for providing the required facilities.

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