Investigation of incomplete fusion dynamics in ^{16}O + ^{74}Ge interactions at energies ≈ 4–8 MeV/A

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Introduction

The study of incomplete fusion dynamics of heavy ions has been the subject of interest at projectile energies above the Coulomb barrier. It has been observed that at projectile energies above the Coulomb barrier, both the complete fusion (CF) and incomplete fusion (ICF) may be considered as dominant reaction mechanisms. In case of CF reaction, the projectile completely fuses with the target nucleus and the highly excited nuclear system decays by evaporating low energy nucleons. In the ICF reaction process, the projectile is assumed to break-up into the fragments and one of the fragments fuses with the target nucleus, while remaining part moves in the forward direction. The first experimental evidence of ICF reactions was given by Britt and Quinton [1]. However, major advances in the study of ICF reactions took place after the work of Inamura *et al.* [2].

Several dynamical models have been proposed to explain ICF dynamics. The break-up fusion model [3], sum-rule model [4] and promptly emitted particle model [5] etc have been used to fit the experimental data above 10 MeV/nucleon energies. However, at energies below 8 MeV/nucleon, no theoretical model is available to explain ICF data satisfactorily. However, the experimental data on heavy ion interaction with light target are scarce.

In the present work, we have made an attempt to identify the CF and ICF channels, in ^{16}O-ion interactions with light target ^{74}Ge by using activation technique. Excitation functions (EFs) of two reactions: ^{81}Rb (αp4n) and ^{76}Br(2αp5n) have been measured. In the present measurement special care has been taken to remove the precursor decay contributions in the production of these ERs to get the direct production cross-sections of the residues. The measured EFs have been compared with the theoretical predictions of the code PACE-2 [6]. Using the present and published data in Ref. [7], total ICF cross-section and ICF fraction are also calculated and reported in this paper.

Experimental Details

The experiment was carried out using the ^{16}O-ion beam at Variable Energy Cyclotron Centre (VECC), Kolkata, India. Targets of enriched isotope of ^{74}Ge (with enrichment 98.9%) were prepared by vacuum evaporation technique. Targets for irradiation were taken in the form of stack. Two irradiations were carried out to cover the beam energy range ≈ 66-114 MeV. Stack of the targets were irradiated for about 9 hours, keeping in view the half-lives of the evaporation residues of interest. The gamma-ray activities produced in various target samples along with its catcher foils were then identified by counting the foils successively on an HPGe detector. The energy calibration of the detector was done using ^{152}Eu γ-ray source of known strength. The ERs were identified by their characteristic γ-rays as well as following their half-lives. The experimentally measured reaction cross-sections were calculated using the standard relation [7].

Results and Discussion

The measured excitation functions have been compared with statistical model code PACE-2. The code PACE-2 is based on the statistical model approach and uses the Monte-Carlo simulation procedure for the de-excitation of compound nucleus. In this code 'K' is level density parameter constant, which may be varied to match the experimental data. In this code the most of required input parameters have been used as default except the charge and mass of the projectile and target nucleus. The EFs corresponding to the evaporation residues ^{81}Rb(αp4n) and ^{76}Br(2αp5n) have been measured and compared with theoretical predictions done by using PACE-2 with the same set of parameters used in Ref. [7] are displayed in Figs. 1(a)-1(b).

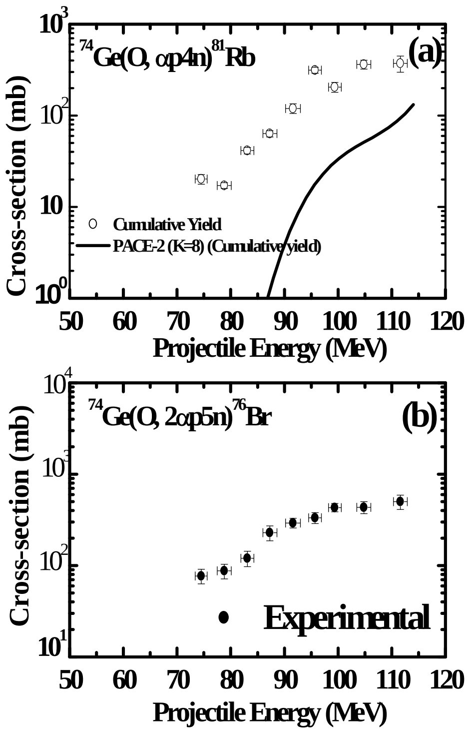

Fig. 1 Excitation functions for the ERs ^{81}Rb and ^{76}Br.

Measured cumulative cross-sections of the production of residue ^{81}Rb in the reaction ^{81}Rb(αp4n) are compared with cumulative PACE-2 predictions and are displayed in Fig. 1(a). The large enhancements in the measured values show that this residue is predominantly produced by ICF process of the projectile. The residues ^{81}Rb is produced via two different channels, directly and through the β^+-decay of higher charge precursor isobar ^{81}Sr.

The EFs for residue ^{76}Br produced via 2αp5n emission channel, in the reactions ^{76}Br (2αp5n) is displayed in Fig. 1(b). It is evident from Fig. 1(b) that the measured EF for the reaction ^{76}Br(2αp5n) is found to be large by orders of magnitude than PACE-2 prediction, hence suggests dominant contribution from ICF process of the projectile ^{16}O, where as the fusion of one ^{8}Be fragment of ^{16}O (if ^{16}O undergoes breakup into two ^{8}Be fragments) with the target ^{74}Ge takes place and the composite system ^{82}Kr decays by the emission of 1 proton and 5 neutrons. The analysis of the data also suggests that ICF probability increases with projectile energy. Hence, it has been found that the ICF fraction also increases with projectile energy. The analysis of the present data also suggests that the projectile break-up probability increases with projectile energy.

Acknowledgments

The authors are grateful to the VECC, Kolkata, for providing the experimental facilities to carry out the experiment. The authors are also thankful to operational staff of cyclotron, VECC, Kolkata for good co-operation during the course of this experiment. Financial support provided by UGC-DAE-CSR, Kolkata is acknowledged gratefully. D. Singh is also thankful to the CSIR, New Delhi for providing the financial support during this research work.

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