Study of entrance channel mass-asymmetry effect on incomplete fusion of ^{16}O with ^{175}Lu at E < 10 MeV/nucleon

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Introduction

In recent years, the study of ICF is still an active area of investigations at lower projectile energies due to complex nature of incomplete mass transfer mechanism and its ambiguous dependence on various entrance channel parameters: imparted angular momentum to the system, projectile energy and structure of projectile, α-separation energy and mass-asymmetry of the target-projectile system. It is now well established that incomplete fusion (ICF) reactions start competing with the complete fusion (CF) reactions at projectile energies just above the Coulomb barrier. In CF processes, the entire projectile fuses with the target nucleus. However, in case of ICF, the break-up of projectile may takes place into two fragments, near to the target nuclear field. One of the fragments fuses with the target while remnant moves as spectator in the forward direction with approximately beam velocity [1-4].

Most of the ICF reaction studies have been centered to medium mass target (A≤100) and detailed information regarding the effect of mass-asymmetry, multiplicity of linear momentum transfer, role of different *l*-bins associated with incomplete fusion dynamics could not be drawn and is still limited for few heavier mass target nuclei (A≥150) at lower projectile energies ≈ 3-8 MeV/nucleon. In case of heavier target nuclei, the evaporation of α-particle from the compound nucleus has the less probability due to the high Coulomb barrier, thereby, ICF fraction is observed to be dominating as that of CF fraction in α-particles emission products. Literatures show the role of entrance channel mass-asymmetry influence on the onset and strength of ICF reaction dynamics [2, 5]. In order to reach on some definite conclusions regarding mass-asymmetry effects and for the better understanding of nuclear reaction dynamics, more and more experimental data using deformed heavier target nuclei are needed at lower projectile energies.

In the present work, we have measured and analyzed the excitation functions of evaporation residues produced in ^{16}O + ^{175}Lu system at energies 4 -7 Mev/nucleon. An attempt has been made to estimate the ICF contribution of the cross-section from the measured excitation function data and the dependence of ICF fraction on projectile energy and mass-asymmetry of the projectile–target combination.

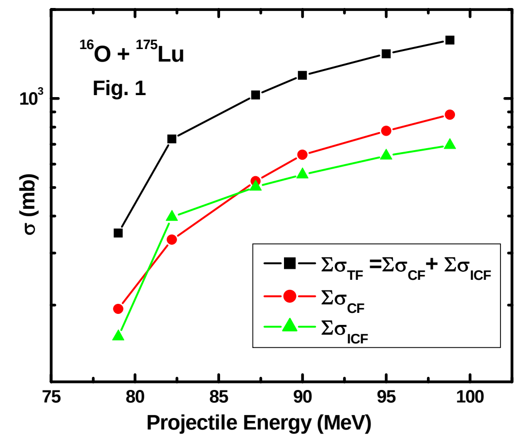
Experimental Procedure

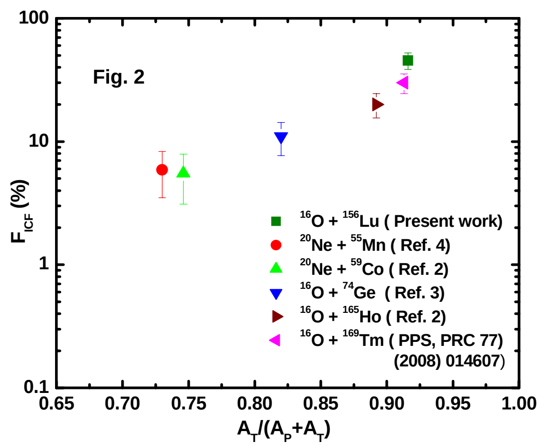
For excitation functions (EFs) measurement, the experiment was carried out using the facilities of 15UD Pelletron accelerator at Inter University Accelerator Centre (IUAC), New Delhi. Self supporting target foils of thickness ranging from 1.0-1.5 mg/cm^2 were prepared using the rolling machine technique. Two stacks, each having four target foils backed by Al-catcher foils having thickness ranges ≈ 1.5-2.0 mg/cm^2 were irradiated by $^{16}O^{+7}$ beam for about 2 to 6 hours in the General Purpose Scattering Chamber (GPSC) at energies ≈ 100 and ≈ 95 MeV. A pre-calibrated, 100 cc HPGe detector coupled to a CAMAC based FREEDOM software was used for recording the γ-ray activities induced in each target-catcher assembly.

Results and Discussion

Excitation function of various evaporation residues produced via CF and/or ICF have been measured for the system ^{16}O + ^{175}Lu at energies ranging from 4-7 MeV/nucleon. Special care has been taken to remove the precursor decay contributions in the production of several evaporation residues to get the independent production cross-sections of the residues [6]. The measured EFs are then compared with the predictions of statistic al model code PACE-2 [7], which gives only the CF contribution. So any enhancement in the measured cross-section from theoretical prediction may be due to ICF reaction process in addition to CF process.

The ICF contribution of individual break-up α-emission channels (ICF products) for ^{16}O + ^{175}Lu system, has been deduced by subtracting the theoretically calculated cross-section by PACE-2 from the experimentally measured cross-section at each incident beam energy. The sum of cross-sections from all measured ICF channels $(\sum\sigma_{ICF})$ and sum of cross-sections from all CF channels $(\sum\sigma_{CF})$ [obtained from PACE-2], are plotted along with total fusion cross-sections $(\sum\sigma_{TF}=\sum\sigma_{CF}+\sum\sigma_{ICF})$ at each projectile energies, as shown in Fig. 1. It can be pointed out from this figure, that the difference between $(\sum\sigma_{TF})$ and $(\sum\sigma_{CF})$ increases with the projectile energy, which reveals that ICF yields are larger at higher projectile energies. Hence, it may be concluded that ICF contribution, in general, increases with projectile energy. This observation also shows that break-up probability of the projectile into α-clusters [i.e. break-up of ^{16}O into ^{12}C + ^{4}He and/or ^{8}Be + ^{8}Be and/or ^{4}He + ^{12}C], increases with projectile energy. The ICF fraction has been deduced using the relation $[F_{ICF}=\sum\sigma_{ICF}/(\sum\sigma_{CF}+\sum\sigma_{ICF})]$. As suggested by Morgenstern *et al.*, [5], the onset of ICF process is governed by relative velocity (V_{rel}). This expression takes into account the difference in Coulomb barrier between each two interacting partners. The ICF fraction has been deduced for the present system and plotted along with the previously measured systems, as a function of mass-asymmetry $[A_T / (A_T + A_P)]$ at same relative velocity (V_{rel}) = 0.044c, and shown in Fig. 2. It may be observed from this figure that ICF fraction some how depends on projectile-target mass-asymmetry and is relatively higher for mass-asymmetric system than those of mass-symmetric system, which supports the finding of Morgenstern *et al.*, [5]. The authors are grateful to Dr. Amit Roy, the Director, IUAC, New Delhi, for providing the necessary facilities.





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