Mass-asymmetry effects on Incomplete Fusion Fraction

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In recent years the unexpected influence of incomplete fusion over total fusion cross-section has been observed at projectile energy as low as 4-7 MeV/A [1]. The complex nature of incomplete mass transfer and its ambiguous dependence on various entrance channel parameters like projectile type, energy, imparted angular momentum (*l*) to the system, Q_{α}-value, mass asymmetry of the interaction partners, etc. has renewed the interest among nuclear physicists to probe the exact dynamics of incomplete fusion. Parker et al. [2] observed forward α-particles in low Z- heavy ion interactions on ^{51}V target at energies ≈ 6 MeV/A. Morgenstern et al.[3] studied the velocity spectra of evaporation residues and also showed that, incomplete fusion reactions significantly contributes to total reaction cross section for mass asymmetric systems as compared to mass symmetric systems at the same relative velocity. Later on, studies by Vineyard et al.[4] and Chakrabarty et al.[5] also supported the findings of Morgenstern et al. [3,4].

In the present work, to explore the dynamics of incomplete fusion fraction (%F_{ICF}) with mass-asymmetry $[A_T/(A_T+A_P)]$, we have studied incomplete fusion fractions of different projectile-target combinations. The variation of %F_{ICF} with the normalized projectile energy is also studied.

The percentage fraction of incomplete fusion (%F_{ICF}) for the $^{16}O+^{45}Sc$ and $^{12}C+^{59}Co$ systems has been calculated as suggested in Ref.[1] and rest of the data is taken from the respective references as given in Fig 1. The value of F_{ICF}, which is a measure of relative strength of incomplete fusion to the total fusion, is calculated by using the formula, defined as $(\%)F_{ICF} = (\Sigma\sigma_{ICF}/\sigma_{TF})\times 100$, and is plotted as a function of normalized projectile energy (E_{Proj}/V_B ; where V_B is fusion barrier) along with several other systems available in the literature, and is shown in Fig. 1. It is clear from figure that the value of F_{ICF} increases invariably with the projectile energy (as the probability of the breakup of incident projectile into α-clusters also increases with the increasing energy) and establish it as an important tool to probe ICF.

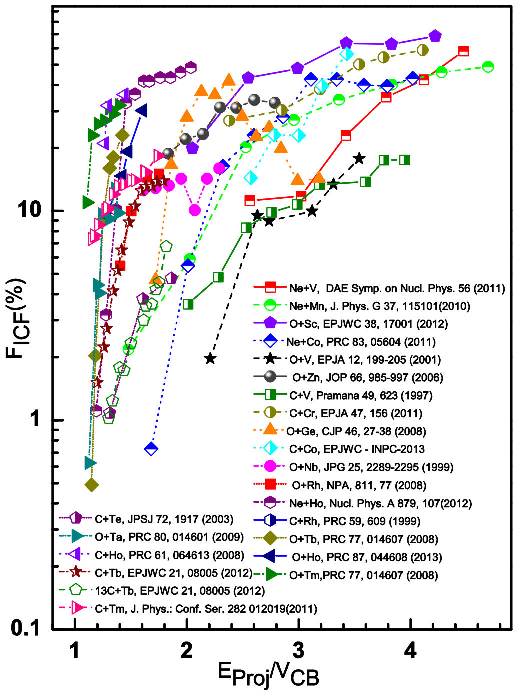

Fig. 1 Variation of % incomplete fusion fractions for different target-projectile systems as a function of normalized projectile energy.

In succession, as inferred by Morngenstern et al.[3], the ICF reaction dynamics is governed by the relative velocity of the projectile and mass-asymmetry of the interacting partners. The

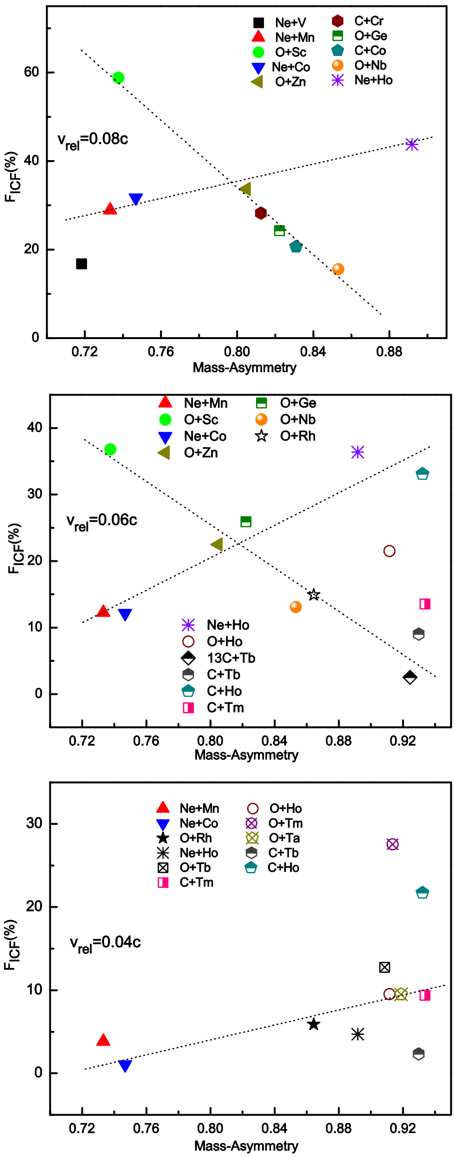

Fig. 2 Variation of % incomplete fusion fraction with mass-asymmetry at relative velocities 0.04c, 0.06c, 0.08c.

value of $\%F_{ICF}$ for $^{12,13}C$, ^{16}O, and ^{20}Ne projectiles with different targets has been calculated at three different velocities (viz. v_{rel} =0.08c, 0.06c, 0.04c) and are plotted against mass-asymmetry as shown in Fig. 2. Being different Coulomb barriers for different combinations of target-projectile, the following expression has been used for the calculation of relative velocity

$$v_{rel} = [2(E_{CM} - V_B)/ \mu]^{1/2}$$

where μ is the reduced mass of the system, E_{CM} is the centre of mass energy, and V_B is the fusion barrier. This expression takes in to account the difference in the Coulomb barrier between each two target-projectile systems.

From Fig.2, it is observed that F_{ICF} is decreasing with mass-asymmetry at projectile velocities 0.06c and 0.08c. , which contradicts the predictions of Morgenstern et.al. and other groups. Also, for the Ne projectile, F_{ICF} is found to increase with Z of target at these projectile velocities, which could not be explained at this stage. Further, at relative velocity 0.04c the value of F_{ICF} is found more, for more mass-asymmetric systems, that is consistent with findings of Morgenstern et.al. Attempts are in process to have a systematic on the behavior of incomplete fusion probability with mass asymmetry of the projectile target systems and will be presented at the time of conference.

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