Mass–asymmetry effects in heavy ion incomplete fusion reactions

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Introduction

The study of heavy ion (HI) induced reactions is important in understanding the decay of excited nuclei and the reaction dynamics. There are many ways to classify the mechanism involved in HI interactions. In terms of impact parameter, at higher values of impact parameter, the direct reactions may play a significant role leading to few nucleon transfer process. However, at smaller values of impact parameter, complete fusion (CF), incomplete fusion (ICF) and deep inelastic collision (DIC) process may be dominant**.** The recent study [1, 2] shows that incomplete fusion (ICF) process starts competing with the complete fusion (CF) at projectile energies in the vicinity of coulomb barrier. The incomplete fusion reactions dynamics at energies near the coulomb barrier has been a area of extensive discussion due to complex nature of incomplete mass transfer and its dependence on various entrance channel parameters like projectile tpe/energy, transfer of input angular momentum (ℓ), mass-asymmetry and α-break up energy (Q_α).

In this paper we present the dependence of ICF on entrance channel parameters, e.g., type/energy of projectile and mass- asymmetry for our system along with different systems. The variation of percentage of ICF fraction ($\%F_{ICF}$) with reduced incident projectile energies for ^{16}O and ^{12}C induced reactions mentioned in figure, are also studied.

Experimental Details

For both the systems $^{16}O+^{51}V$ and $^{12}C+^{59}Co$, the experiment was performed at 15UD Inter-University Accelerator Centre (IUAC), New Delhi (INDIA) by using the General Purpose Scattering Chamber (GPSC) facility. The experimental details for these two systems are mentioned in Ref. [3, 4]

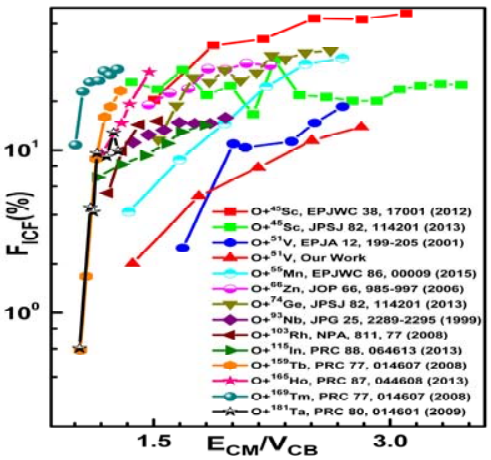

Fig. 1 Variation of percentage of incomplete fusion fraction ($\%F_{ICF}$) for different ^{16}O induced systems as function of reduced incident projectile energy.

Results and Discussion

For the determination of percentage of incomplete fusion ($\%F_{ICF}$) for $^{16}O+^{51}V$ and $^{12}C+^{59}Co$ system we use the same formulation as suggested in Ref.[4] and the other data is taken from the respective reference as given in figure 1 and 2. The probability of incomplete fusion ($\%F_{ICF}$) at different projectile energies has been calculated by using the formula $F_{ICF}(\%) = (\sum\sigma_{ICF}/\ \sigma_{TF}\ )\times100$, where $\sum\sigma_{ICF}$ is the sum of incomplete fusion cross-section and σ_{TF} is the total fusion cross-section. These calculated percentages of ICF fraction is plotted as function of reduced incident projectile energy (E_{CM}/V_{CB})

along with the other available systems separately for ^{16}O and ^{12}C induced reactions.

From the Fig. 1 it can be seen that the ICF fraction increases with the incident projectile energy. For more asymmetric projectile target system, ICF fraction increase more rapidly than for less asymmetric system. For example, the ICF fraction for $^{16}O+^{181}Ta$, $^{16}O+^{169}Tm$, $^{16}O+^{165}Ho$, $^{16}O+^{159}Tb$ systems increase more rapidly as compared to other system for a given projectile energy range. The ICF probability is different for different target with same projectile and generally increases with projectile energies. The same trend follow for ^{12}C induced reactions as shown in Fig. 2.

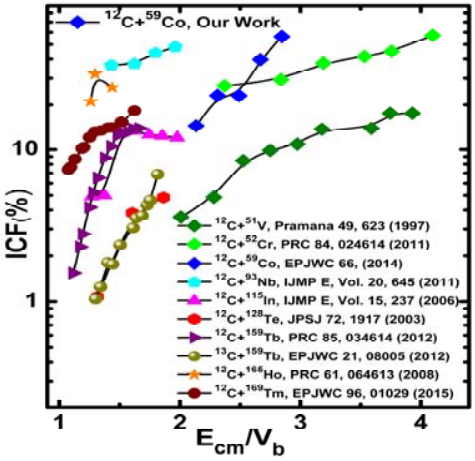

Fig. 2 Variation of percentage of incomplete fusion fraction for different ^{12}C induced systems as function of reduced incident projectile energy.

To test the dependence of the ICF probability ($\%F_{ICF}$) with entrance channel mass-asymmetry ($\mu=A_T/A_T+A_P$), the value of F_{ICF} in our system $^{16}O+^{51}V$ (shown in Fig. 3) has been compared with other studied systems at a constant relative velocity V_{rel} = 0.061c. The value of F_{ICF} is not shown for $^{12}C+^{59}Co$ because F_{ICF} is not available at this relative velocity. As seen from the Fig. 3 the data point suggest the ICF probability increases with the mass-asymmetry i.e more ICF probability for more mass-asymmetric than symmetric system which support Morgensten et al. study [5]. The different trends have been observed for two projectiles viz. ^{12}C and ^{16}O systems. However, the value of F_{ICF} mainly for the O+Sc, O+Zn, O+Ge and C+Nb, C+In systems are slightly away from the increasing own trend. This trend may be due the projectile structure effects and may be due to the α-Q value of the projectile as suggested in the previous studies [1, 2]. In general it can be conclude that the ICF fraction strongly depends upon entrance channel effect such as incident projectile energy and mass-asymmetry.

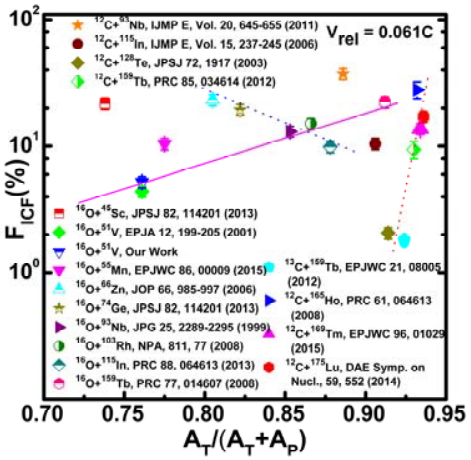

Fig. 3 The probability of ICF (%ICF) for system $^{16}O+^{51}V$ along with the previously studied systems as a function of mass-asymmetry is shown.

Conclusions

For the present work it has been found that the incomplete fusion reaction is influenced by projectile structure along with the incident projectile energy, projectile-target combination and mass-asymmetry of interacting partners. The systematic behavior of incomplete fusion probability with mass-asymmetry at different relative velocity will be presented at time of symposium.

References

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