Effect of projectile structure on incomplete fusion reaction dynamics for vanadium

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Introduction

Incomplete fusion (ICF) has conspicuous importance in the study of heavy ion (HI) induced reaction. The recent study [1-6] shows the significant contribution of ICF at projectile energies near the Coulomb barrier where complete fusion (CF) is assume to be the sole contributor to the total reaction cross-section. It has been observed that at projectile energy near the Coulomb barrier, both the complete fusion (CF) and incomplete fusion (ICF) may be considered as dominant reaction mechanisms. The incomplete fusion (ICF) reactions are quite specific due to complex nature of incomplete mass transfer and its dependence on various entrance channel parameters like type of projectile, energy of projectile, transfer of input angular momentum (***ℓ***), deformations of the interacting nuclides, mass-asymmetry and α-break up energy (Q_α). These reactions provide very detailed information for the studies on nuclear structure as well as nuclear dynamics.

At low projectile energies (3-7 MeV/A), the influence of the projectile breakup on fusion is not yet well understood and also in most of the recent studies α-cluster structure beams have been used. Thus the present study is motivated to study the effect of projectile structure on incomplete fusion at low bombarding energies for neutron rich projectile also.

In extension to our earlier work [5], the present paper deals with the study of dependence of ICF entrance channel parameters and the comparison of probability of incomplete fusion (F_{ICF}(%) or ICF(%)) of the present system with the other systems of same target but different projectile have been presented and discussed.

Experimental Details

This experiment was performed at 15UD Inter-University Accelerator Centre (IUAC), New Delhi (INDIA) by using the General Purpose Scattering Chamber (GPSC) facility. The experimental procedure, target preparation and description of data analysis used in this paper are similar to our earlier publication [5].

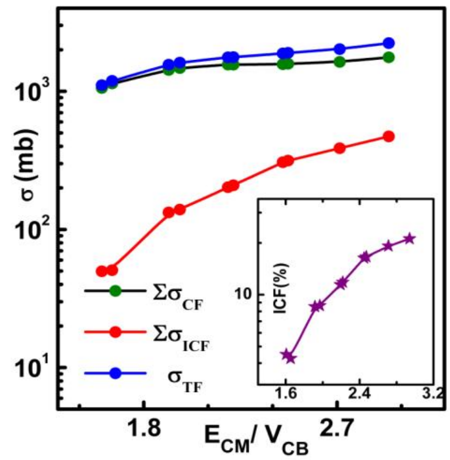

Fig. 1: The total fusion cross-section ($\sum\sigma_{TF}$) with the sum of complete (($\sum\sigma_{CF}$) and incomplete fusion cross-section (($\sum\sigma_{ICF}$) are plotted as a function of reduced incident projectile energy. Also the probability of incomplete fusion fraction as a function of normalized projectile energy is shown in the inset.

Results and Discussion

For the present work, by using the same remedy as used in Ref. [3], the values of complete fusion

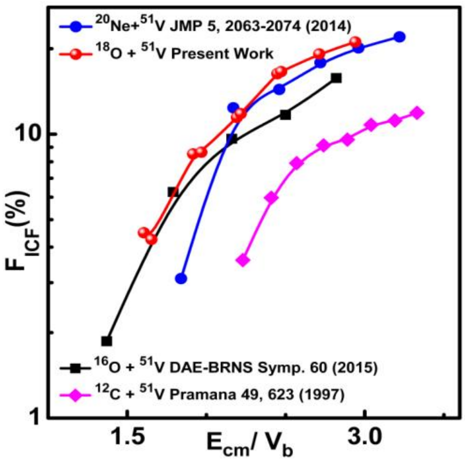

Fig. 2: The comparison of probability of incomplete fusion fraction (F_{ICF}(%)) of the present system plotted with other system having the same target but different projectile as a function of normalized projectile energy

cross-section ($\sum\sigma_{CF}$), incomplete fusion cross-section ($\sum\sigma_{ICF}$), and the total fusion cross-section ($\sum\sigma_{CF}$) have been deduced and plotted as a function of reduced projectile energy (Ecm/Vb) as shown in Fig. 1. To study the dependence of ICF on different entrance channel parameters the incomplete fusion fraction (F_{ICF}(%)) has also been obtained by using the same procedure as followed in our earlier study [6] and presented in inset of Fig.1. From this figure it can be seen that incomplete fusion cross-section ($\sum\sigma_{ICF}$) and also the incomplete fusion fraction (F_{ICF}(%)) increases with the increase of incident projectile energy which gives the indication of incomplete fusion of the projectile with target nucleus. Now to study the effect of projectile structure on ICF, the probability of incomplete fusion (F_{ICF}(%)) for four different systems of different projectile with the same target has been plotted and is shown in Fig.2. From this figure it can be seen that the different trends have been observed for different projectile-target systems. These different trends of F_{ICF}(%) may be due to the projectile structure effect and may be due to the α-Q-value of projectile. Hence, in order to check the validity of this aspect of α-Q-value, F_{ICF}(%) for four different systems (as shown in Fig. 3) with same target at three different relative (v_{rel}) velocities has been plotted. From this figure it can be inferred that with the increasing $v_{rel,}$ the ICF fraction increases while for a fixed v_{rel}, the ICF fraction decreases with the increase in α-Q-value except the $^{18}O+^{51}V$ system. The ICF fraction for the present system is larger than the $^{20}Ne+^{51}V$ system while the α-Q-value of the present system is larger than $^{20}Ne+^{51}V$ system. This is may be due to the neutron rich structure of the projectile.

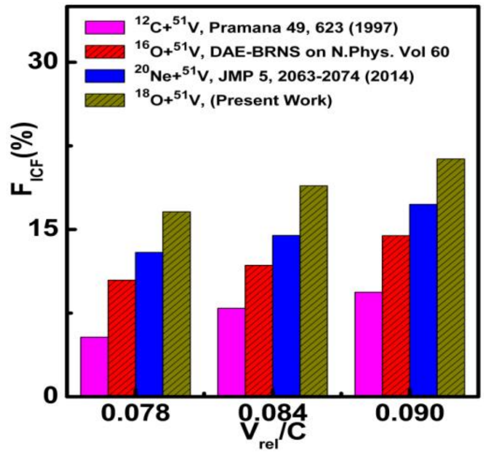

Fig. 3: Comparison of F_{ICF}(%) as a function of relative velocity(v_{rel}/c)

Conclusions

In the present work the ICF reactions has been found to be influenced by the projectile structure along with the incident energy of the projectile. During the analysis it has been found that with the increase in α-Q-value, the ICF fraction decreases but not in the case of neutron rich projectile. The detail of the work will be presented at time of symposium.

References

[1] H. C. Britt and A. R. Quinton, Phys. Rev. 124, 877 (1961)
[2] Abhishek Yadav et al., Phys. Rev. C 85, 034614 & Phys. Rev. C86, 014306 (2012), EPJ WC 117, 08022 (2016)
[3] Sunil Dutt et al., Euro. Phys. Jour. WC 66, 034214 (2014)
[4] Kamal Kumar et al., Phys. Rev. C88, 064613 & Phys. Rev. C87, 044608 (2013) and Phys. Rev. C89, 054614 (2014)
[5] Munish Kumar et al., DAE-BRNS Symp.on Nucl. Phys. Vol. 61, 642 (2016),
[6] Munish Kumar et al., DAE-BRNS Symp.on Nucl. Phys. Vol. 59, 612 (2014), Vol. 60, 610 (2015)