Exploring the importance of neutron skin thickness parameter in heavy ion induced Incomplete fusion reactions

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Introduction

Experiments to explore the various fusion reaction dynamics involved in heavy-ion reactions with all kinds of projectile and target has been performed and discussed in the literature for couple of decades [1-3]. It has been observed and well established that above the barrier energies, both complete fusion (CF) and incomplete fusion (ICF) processes may be considered as dominant reaction mechanisms even at energies as low as 4 – 7 MeV/A. In case of CF reaction, the projectile is completely absorbed with the target nucleus and the highly excited compound nucleus decays by evaporating low-energy nucleons and α-particles. However, in case of ICF reaction process, only a part of the projectile fuses with target nucleus, while the remaining part moves in the forward direction as that of incident projectile. The ICF reactions are quite specific due to partial linear and angular momentum transfer to the composite system in the first stage of interaction. In existing studies, the strength of ICF has been co-related with mass-asymmetry of interacting partners, incident energy, neutron skin thickness, negative alpha-Q-value, and input l-values and work is still in progress to have a decisive entrance channel systematics on Incomplete Fusion dynamics. The studies of these reactions are of vital importance as they provide very detailed information for the studies on nuclear structure as well as nuclear dynamics.

Earlier most of the experimental studies on CF and ICF dynamics have been confined with the heavy mass target nuclei (A>150) using α cluster structure projectile [4-5], while experimental studies on CF and ICF with medium mass target nuclei using non α-cluster structure projectile are still scarce. Therefore, the efforts have been made to study the effect of projectile structure on incomplete fusion at low bombarding energies for neutron rich projectile.

It may be noteworthy to point out here that one of the entrance channel parameters i.e., neutron skin thickness is found to play an important role to understand the phenomenon of ICF. The excessive neutrons in heavy nuclei are responsible to produce a huge contrast in Fermi energy of neutrons and protons, in turn, making a decoupling between neutron and proton distribution and as a result, nuclear skin structure is formed. In view of these aspects, the present paper deals with the study of dependence of ICF on neutron skin thickness.

Experimental Details

The present experiment was designed and 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 [1].

Result and discussion

In order to study the effect of neutron skin thickness on ICF probability, experimental data of present system ^{13}C+^{93}Nb along with ^{12}C induced reaction with ^{115}In [2], ^{159}Tb [3], ^{165}Ho

[4], ^{175}Lu [5], and ^{13}C induced reaction with ^{159}Tb [6], ^{165}Ho [7], and ^{175}Lu [5] have been analyzed. Since the target nuclei considered, corresponding to ^{13}C and ^{12}C projectiles have different mass and charge, leading to dissimilar Coulomb barrier of respective projectile-target systems. To eradicate the Coulomb effect, ICF fraction data is obtained at constant relative velo-

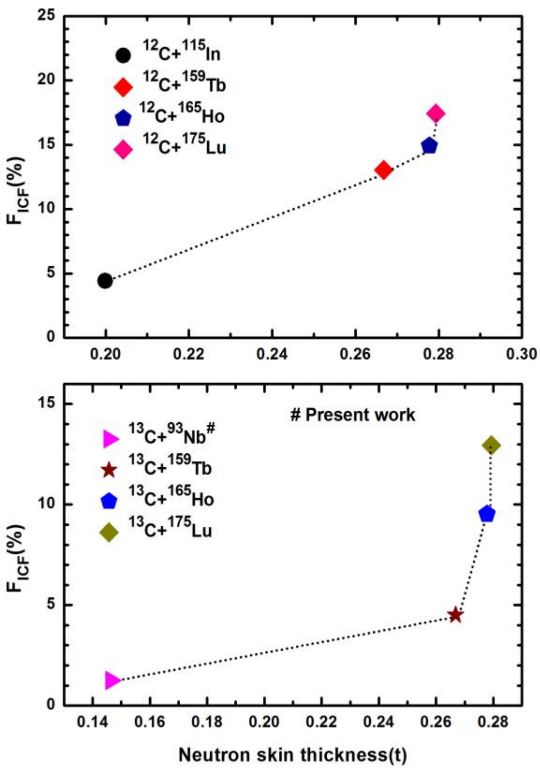

Fig. 1 The variation of incomplete fusion fraction with neutron skin thickness (t_N) at relative velocity, $V_{rel} = 0.074c$.

-city V_{rel} = 0.074c, given by $V_{rel} = \sqrt{2(E_{cm} - V_b)/\mu}$.

The neutron skin thickness may be calculated as the difference between matter radius (*Rm*) and charge radius (*Rz*) of a nucleus, i.e., $t_N = (Rm - Rz)$. The value of t_N may be defined as

$$t_N = 2/3 r_0 A^{1/3}(I - \delta),$$

Where, *A* is the mass number of the target nuclei, *I* is a factor define $(N\text{-}Z)/A$, and δ represents the density dependent factor [1]. The ICF fraction for the present system ^{13}C+^{93}Nb has been compared with those obtained for ^{12}C and ^{13}C induced reactions with different targets as a function of neutron skin thickness is shown in Fig. 1. The value of ICF fraction increases with t_N, indicating the ICF dependence on neutron skin thickness. This may be because the Coulomb potential which is inversely proportional to radius, also decrease as mass number increase and therefore neutron skin thickness increases. It may be pointed out that the F_{ICF} increases with t_N individually for ^{12}C and ^{13}C for different targets. This indicates that the projectile structure, along with the neutron skin thickness plays an important role in ICF reactions at low energies.

Conclusions

The effect of neutron skin thickness is explored in the present work along with other entrance channel parameters. It is observed that Neutron thickness is one of the important entrance channel parameters for ICF reaction dynamics, as it significantly affects the ICF fraction. One of the possible reasons may be that, the neutron skin thickness is proportional to the target mass. The details of the work will be presented at time of symposium.

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