Analysis of fusion excitation functions for reactions induced by ^{6}Li at near barrier energies

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The fusion induced by weakly bound nuclei at energies around the barrier is fundamentally different from that induced by well bound nuclei. Owing to a very low breakup threshold the weakly bound projectiles get dissociated very easily into their constituent fragments and hence some new reaction channels like incomplete fusion (ICF), sequential complete fusion (SCF) and transfer processes etc. are initiated in these processes. Experimentally, it is not possible to separate SCF events from direct complete fusion (DCF) events, however, the incomplete and complete fusion (CF) can be measured separately within reasonable accuracy. As a result a lot of studies, both experimental as well as theoretical, have been carried out to understand the relative importance of ICF and CF in total fusion (TF) cross section for reactions involving weakly bound projectiles on different targets at near barrier energies [1]. The conclusions drawn in these studies are very convincing for some specific reactions, nonetheless, in order to better pin down the relative contribution of ICF and CF in TF in all cases more precise data and more realistic theoretical models are needed. Here we have made an attempt to extract the CF cross sections from the TF cross sections, calculated by using simple Wong's formula in conjunction with the energy dependent Woods-Saxon potential (EDWSP) in near barrier energy region for ^{6}Li+^{152,154}Sm and ^{6}Li+^{159}Tb systems. The introduction of energy dependence in the potential simulates the channel coupling effects appreciably [2]. For a detail description of calculation methodology please see Ref. [3].

In Fig. 1a, the CF and TF (CF+ICF) cross sections are plotted as a function of incident beam energy for ^{6}Li+^{154}Sm system and are compared with the corresponding experimental data, available only at above barrier energies, taken from Ref. [4].

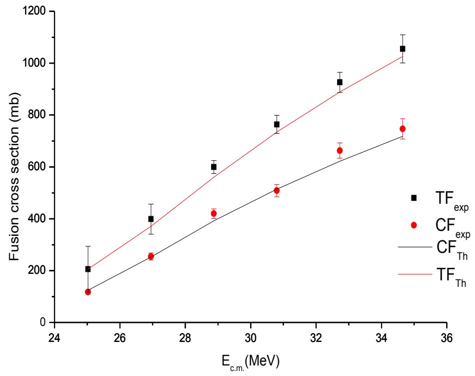

Fig. 1a *Fusion excitation functions for CF and TF processes for ^{6}Li+^{154}Sm reaction are compared with the experimental data taken from Ref.(4)*

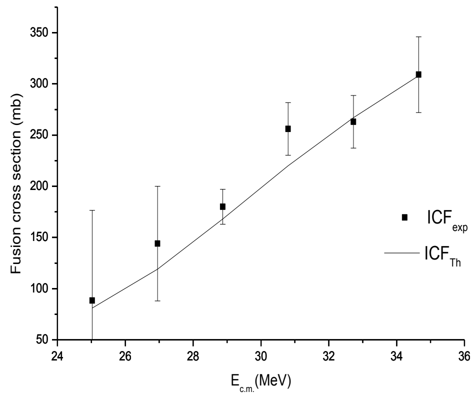

Fig. 1b *Fusion excitation functions for ICF processes for ^{6}Li+^{154}Sm reaction are compared with the experimental data taken from Ref.(4)*

Here it is assumed that the two third of the evets in TF are the CF events while the remaining one third goes to the ICF channel. In this case besides the observed CF and TF cross sections the ICF cross sections are also very well reproduced (see Fig. 1b). These results are as per expectation because at above barrier energies the data are measured quite accurately and the complicating factors in theory are not expected to play any serious role in the analysis.

In Fig. 2 the CF excitation function for $^{6}Li+^{152}Sm$ system is compared with the corresponding experimental data taken from Ref. [5]. It is clearly noticed from this figure that the observed CF fusion cross sections are over predicted at near and below barrier energies. It suggests that in this energy region the CF events are less than the two third of TF and hence the ICF cross section in enhanced in comparison to their contribution at above barrier energies.

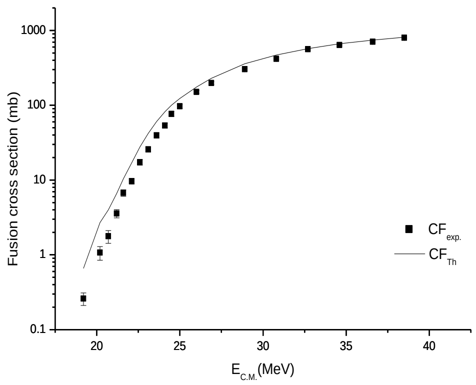

Fig. 2 *The CF excitation function for $^{6}Li+^{152}Sm$ reaction are compared with the corresponding experimental data taken from Ref.(5).*

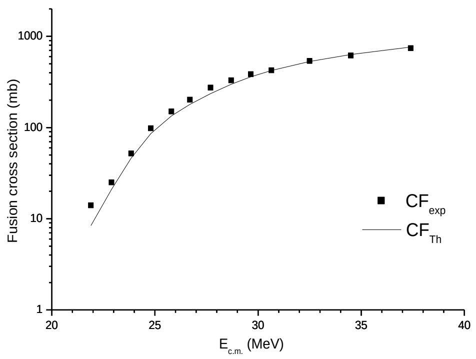

Fig. 3 *Same as Fig. 2 but for $^{6}Li+^{159}Tb$. The experimental data are taken from Ref.(6).*

On the other hand, the CF cross sections are slightly underestimated in below barrier energy region for $^{6}Li+\ ^{159}Tb$ system as shown in Fig. 3 leading to the fact that the contribution of ICF events is suppressed in comparison that at above barrier energies. These contradictory conclusions may be ascribed to the inadequacy of the assumption that one third of events are ICF in TF irrespective of the incident beam energy and structural aspects of targets. It is important to mention that the target ^{152}Sm is oblate with quadrupole moment value -1.7 b in its ground state while the target ^{159}Tb is prolate with quadrupole moment value 1.4 b in its ground state. Thus in order to draw unambiguous conclusion regarding the relative importance of ICF and CF in TF, an appropriate energy and target dependence is needed to be incorporated in the theoretical model and the work in this direction is in progress.

References

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