Effect of projectile structure on angular distribution of recoiling residues

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Introduction

A considerable amount of work has been done to study the complex nature of incomplete fusion reactions at energy 4-8 MeV/A [1–5]. However, the role of incomplete fusion mass transfer in heavy-ion induced reactions is still an open area of research. The existing theoretical models are not appropriate for reproduction of experimental incomplete fusion data satisfactory at energies below 10 MeV/A. Recently various systems have been studied using the α-cluster projectiles like ^{12}C, ^{16}O and ^{20}Ne etc, on targets of moderate mass (A$\leq$150) and fewer studies were available with heavier mass targets (A$\geq$150) bombarded by non α-cluster structured projectiles like ^{13}C, ^{18}O and ^{19}F etc. One of the characteristic features of the ICF reactions is the outgoing alpha particle as a spectator, carries the most probable energy corresponding to the beam velocity. In incomplete fusion reactions, outgoing α-particles escape at forward angles carrying a significant part of the kinetic energy and angular momentum of the projectile while the remaining part fuses with the target. However, the influence of the projectile breakup on fusion is not yet well understood, therefore, to understand the effect of α and non-α clustered structure of projectile on the recoiling residues, we have measured angular distribution(AD) of residues produced in $^{13}C+^{175}Lu$ and $^{12}C+^{175}Lu$ systems at $\approx$ 88 MeV energy. In order to find out some systematics on projectile structure, a comaprison have been carried out in between the residues produced in both the systems.

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Experimental Details

For the mesurement of AD's of recoiling residues the experiment was performed at Inter University Accelerator Center (IUAC), New Delhi. Recoil catcher technique followed by the OFF-Line γ-ray spectroscopy was used for the measurement of produced evaporation residues. Self supporting target of ^{175}Lu ($\approx 1.4\ mg/cm^2$) was followed by a stack of six annular concentric Al- catcher rings of appropriate thickness ($\approx 0.5mm$). The Al-catcher stack was placed at $\approx 2cm$ behind the target ladder to trap the recoiling residues at different angles ranging between $0^o - 55^o$. ^{12}C and ^{13}C-ion beams of energy $\approx$ 88 MeV was bombarded on the ^{175}Lu target for about 5-7 hours in the General Purpose Scattering Chamber (GPSC). A pre-calibrated 100cc HPGe γ-ray detector of high resolution coupled to CAMAC based software CANDLE at IUAC, New Delhi was used for the recording of induced γ-ray activities in each annular catcher ring. The evaporated residues are then identified by using characteristic γ-rays and following their half-lives.

Results and Discussion

In the present work, AD's of several residues such as $^{184-182}Ir$, $^{183,182}Os$ and $^{183-181,179}Re$ have been measured for $^{12}C+^{175}Lu$ and $^{13}C+^{175}Lu$ systems. To suppress the effect of solid angle, measured cross-sections were nor-

malised and plotted against the recoiling angles. As the representative case the angular distribution of residues ^{182}Ir and ^{179}Re are shown in FIG.1(a) and FIG.1(b) respectively.

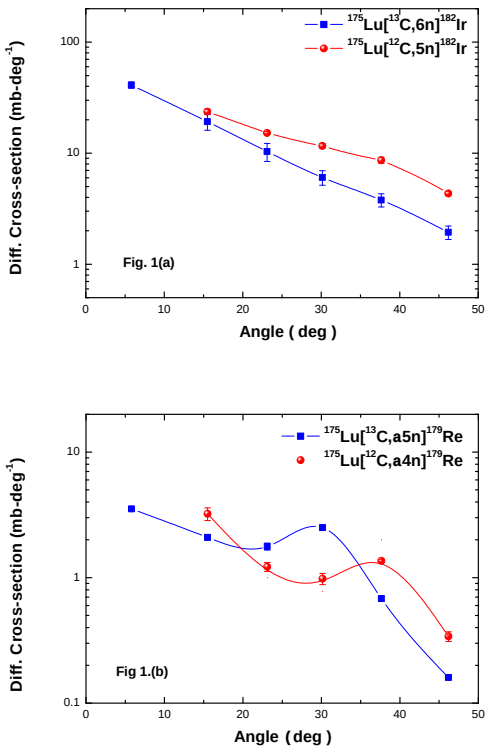

FIG. 1: **(a).** Experimentally measured Angular distribution for residue ^{182}Ir and **(b).** for residue ^{179}Re.

It can be easily observed from FIG.1(a) that the AD's for ^{182}Ir have an enhancement around $\leq 10^o$ for both the reactions, which infers that this residue is populated by the complete fusion(CF) process via emission of neutrons. The forward peaked distribution suggests that the emission of neutrons from the compound nucleus is symmetric in 4π space. Therefore, the formation of ^{182}Ir is in good agreement with the compound nucleus mechanism and hence, the residue observed to be populated by the CF process [5]. On the other hand, the AD's of ^{179}Re exhibit an enhancement in cross-sections at an angle around $\leq 10^o$ as well as at larger angles, which is an indication that another process is also taking part in the formation of ^{179}Re residue along with the CF process, termed as in-complete fusion(ICF). It is observed that the enhancement at lower angles is due to CF process while the enhancement at larger angles is because of the participation of ICF process in the production of recoiling residues.

It may also be concluded from Fig.1(b), the enhancement in the cross-sections arised at larger angles around 38^o for $^{175}Lu[^{12}c, \alpha 4n]^{179}Re$ reaction and around 30^o for $^{175}Lu[^{13}c, \alpha 5n]^{179}Re$ reaction. The composite system formed in $^{13}C + ^{175}$ Lu system is heavier than that formed in $^{12}C + ^{175}$ Lu system, carried more linear momentum than the later, therefore, the residues produced by $^{13}C + ^{175}$ Lu system are observed at slightly lower angles as compared to those populated in $^{12}C + ^{175}$ Lu system [5].

Thus, the present findings clearly indicate the ICF-dependency on the recoiling angles. The mass of the composite system and the projectile structure also affect the angular distributions of recoiling residues.

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