Probing the incomplete fusion dynamics in ^{118}Sn(^{12}C,x) reaction through the measurement of forward recoil ranges at E_{lab} = 6.5 MeV/nucleon

Priyanka [1,*] Amanjot[1], Malika Kaushik[1], Arshiya Sood[3], Yashraj Jangid[2], Manoj K. Sharma[3], and Pushpendra P. Singh[1]

[1] *1Department of Physics, Indian Institute of Technology Ropar, Rupnagar - 140 001, India*
[2] *Inter-University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110 067, India*
[3] *Physics of Department, University of Lucknow, Lucknow - 226 007, UP, India and*
[3] *Institut Pluridisciplinaire Hubert Curien (IPHC)-DRS, 28 rue du Loess - BP 28, Strasbourg cedex 2, 67037, France*

In heavy-ion (HI) induced reactions at energies ≈3-7 MeV/A, the most dominant reaction mechanisms are observed to be complete fusion (CF) and incomplete fusion (ICF) mainly in α-cluster structure nuclei [1]. For a better insight into the underlying reaction dynamics of the formation of CF and ICF residues, it is crucial to distinguish different pathways. One of the direct ways to distinguish CF and ICF residues is the measurement of forward recoil ranges, which convincingly reveals two distinct linear momentum-transfer components for a given residue. In the case of CF, entire linear momentum transfer takes place from projectile to target nuclei, resulting in a residue attaining maximum recoil range in the stopping medium [2]. In contrast, smaller recoil ranges indicate fractional linear momentum transfer as a characteristic of ICF. This work is an extension of our recently concluded experiment for channel-by-channel excitation function measurement of evaporation residues populated via CF and/or ICF in ^{12}C+^{118}Sn system over an energy range of ≈ 3-7 MeV/A using model-dependent methods [3]. However, this study employs a model-independent approach to provide a more direct and comprehensive understanding of CF and ICF contributions, offering valuable insights into reaction dynamics.

We have carried out an experiment at IUAC New Delhi to measure forward recoil ranges of different reaction products for the same system at energy ≈ 6.5 MeV/A. A target-catcher assembly comprised of a self-supporting ^{118}Sn target with a thickness t = ≈ 0.3 mg/cm^2,

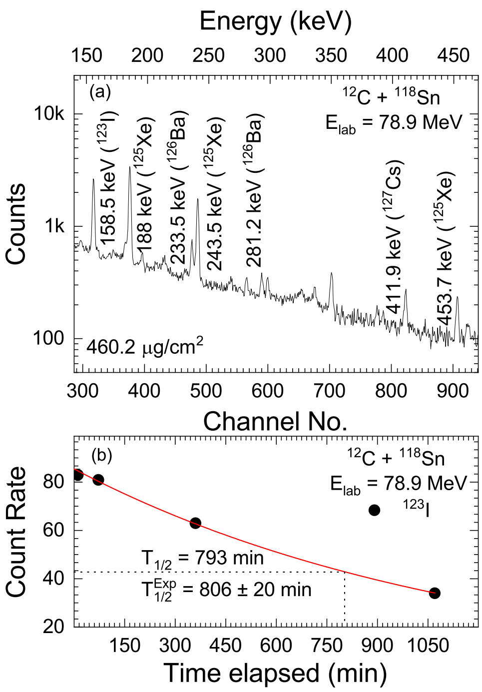

FIG. 1: (a) The off-line gamma spectra measured in ^{12}C+^{118}Sn system at E_{lab} = 78.9 MeV. Gamma lines of interest are labeled in the spectra, and (b) the decay curve of the αp2n channel (^{123}I) is presented.

*Electronic address: priyanka.21phz0015@iitrpr.ac.in

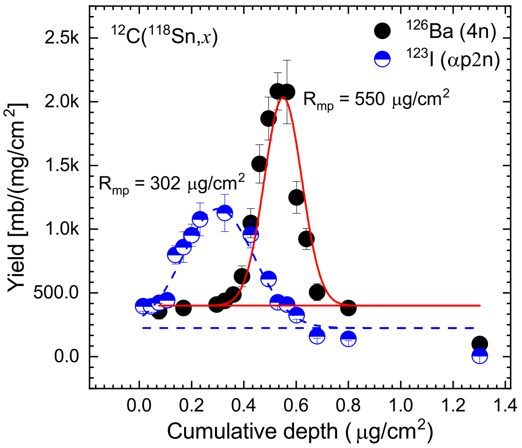

FIG. 2: The experimentally measured forward recoil ranges of ^{126}Ba populated via 4n channel, and ^{123}I residue populated via αp2n channel in ^{12}C+^{118}Sn system at energy $\approx 79 MeV$.

followed by 21 ultra-thin aluminum catcher foils, each with thickness ranging from ≈ 0.03-0.04 mg/cm^2, all fabricated using a high-vacuum evaporation technique, was irradiated with ^{12} beams for a duration of 24.4 hours. It may be pointed out that using multiple thin catcher foils enhances recoil range resolution. The in-vacumm transfer facility (ITF) technique reduces the interval between irradiation and sample counting, allowing samples to be removed from the GPSC within 4-5 minutes without breaking the vacuum, thereby enabling prompt measurement of short-lived activities. The activities were recorded with high-resolution HPGe clover detectors, shielded by 5 cm thick lead to minimize background, and counted 1 cm away to reduce dead time.

Explicit identification of reaction residues was performed through characteristic gamma rays and decay-curve analysis. The offline gamma spectrum measured in the ^{12}C+^{118}Sn system at E_{lab} = 78.9 MeV is shown in Fig.1(a), where the gamma lines of interest are labeled. The decay curve of the αp2n channel (^{123}I) is presented in Fig.1(b). The yields of characteristic gamma rays were used to calculate the cross-sections as described in Ref.[4]. The Recoil Range Distributions (RRDs) of various reaction products, including ^{126}Ba, ^{127,126,125}Cs, ^{125,123,122}Xe, and ^{124,123}I, have been determined. All residual cross-sections are verified with the excitation functions (EFs) measured in the experiment [3]. In Fig.2 preliminary results of RRDs for the 4n(^{126}Ba) channel and αp2n(^{123}I) channel are presented. As can be seen from this figure, the most probable range for ^{126}Ba nuclei is found to be 550 μg/cm^2. In this figure, a larger range signifies residue population via CF, while a smaller range indicates population via ICF. Detailed results and their interpretation will be presented during the symposium.

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References

[1] Amritraj Mahato et al., Phys. Rev. C 107, 014601 (2023).

[2] E. Gadioli et al., Phys. Rev. C 32, 4, (1985).

[3] Priyanka et al., Phys. Rev. C (in review).

[4] Mohd. Shuaib et al., Phys. Rev. C 110, 014621 (2024).