Study of fusion suppression in $^{16}O+^{174}Yb$ system

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Investigation of break-up fusion (BUF) processes in heavy-ion (HI) interactions at energies ≈ 4–7 MeV/nucleon has garnered attention in recent years. It has been observed that at these energies, BUF competes with dominant complete fusion (CF) [1] and its contribution increases with energy. The BUF reactions are important because they allows us to investigate the nuclei populated far away from the stability valley. In order to study the projectile breakup during interaction with a heavy target, it is essential to follow a rigorous data analysis procedure and remove any geometrical effects present[2]. The experimental data from different systems can be appropriately compared with theoretical predictions, both with and without coupling through breakup channels. Several data reduction methods have been proposed to study the effects of projectile breakup near Coulomb barrier energies [3–5]. These studies did not reveal a clear systematic behavior in CF suppression concerning target charge. As such, it is needed to systematically investigate the influence of projectile breakup on CF cross-sections. While many reactions involving weakly bound projectiles have shown CF cross-section suppression above the Coulomb barrier due to breakup processes [6], there is lack of comprehensive studies on reactions involving strongly bound projectiles. Thus, additional investigations into these strongly bound projectiles are necessary.

In the present work, the analysis of the system $^{16}O+^{174}Yb$ within the universal fusion function (UFF) approach [2] has been done. In order to measure the cross-sections, the experiment was carried out at the Inter University Accelerator Center (IUAC), New Delhi. The stacked foil activation technique followed by γ-spectroscopy has been used. The residues populated via CF channels were identified from their characteristic γ-lines and measured half-lives. The intensities of γ-lines were used to determine the cross-section for the residues populated via CF. The total fusion cross-section (σ_F) was obtained by summing all the measured fusion channels. The measured excitation function (EF) further was found to agree well with the predictions of CC-FULL code. The presently measured EF could not be directly compared due to different geometrical and static effects caused by the interaction potential. To eliminate these effects, the method proposed by Canto et al., [7] is employed to normalize the fusion cross-section. In this method, the fusion cross-section (σ_F) is normalized by barrier curvature ($\hbar\omega$) and barrier radius (R_b) and converted into a dimensionless quantity $F(x)$ referred to as fusion function. Incident energy is normalized by $\hbar\omega$ and represented as a dimensionless variable x. Further, Wong [8] developed the reduction process for fusion cross-sections given as Eq. 1. If σ_F is substituted by σ_F^W in $F(x)$, the fusion function reduces to another dimen-

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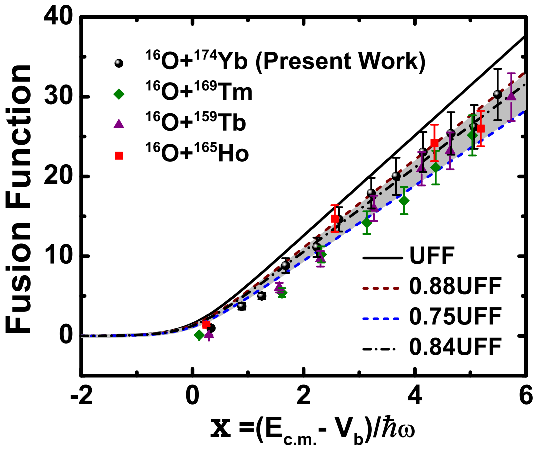

FIG. 1: A comparison of UFF with the experimental $F(x)$ for the projectile ^{16}O on different targets. The black solid line represents the UFF.

sionless function given as Eq. 2.

$$\sigma_F^W = \frac{R_b^2 \hbar\omega}{2E_{c.m.}} \ln\left[1 + \exp\left(\frac{2\pi(E_{c.m.} - V_b)}{\hbar\omega}\right)\right] \tag{1}$$

$$F_o(x) = \ln[1 + \exp(2\pi x)] \tag{2}$$

The above relation (Eq. 2) is known as UFF, where $F_o(x)$ is a function of dimensionless variable x and is independent of the system properties. In the UFF approach, the fusion cross-section is considered as the effective area where the incident flux interacts with the nucleus, represented by a black disc of radius R_b. A reduction in the experimentally observed FF may occur if part of the projectile remains unfused outside this interaction zone. This leads to a greater contribution from incomplete fusion, ultimately decreasing the overall fusion cross-section. To examine this feature, the experimental fusion function $F(x)$ deduced for the ^{16}O+^{174}Yb system has been compared with the deduced values for the systems, viz., ^{16}O + ^{169}Tm [9], ^{16}O + ^{159}Tb [9] and ^{16}O + ^{165}Ho [10] and are shown in Fig. 1. In this figure, the range of suppression of the fusion cross-section data for $^{16}O + Targets$ is represented by the colored dashed lines. The experimental $F(x)$ values for all the systems are found to be suppressed with respect to the UFF line. The suppression factor $F_{B.U.}$ for the ^{16}O projectile was determined by fitting the experimental fusion function data. The best fit is obtained by multiplying the UFF by 0.84 and is represented by dotted dashed line in Fig. 1. The CF is found to be suppressed by 16% for ^{16}O projectile. This suppression could be attributed to partial fusion resulting from projectile breakup. This suggests that the CF suppression is consistent irrespective of the specific target with which the projectile interacts. The suppression factor is also found to depend on the breakup threshold energy ($E_{B.U.}$) of the projectile. Further details of measurements and analysis will be presented.

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