Effect of weak binding of ^{9}Be in complex fragment emission

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Introduction

The study of nuclear reactions involving weakly bound nuclei have been an active field of research in recent times. There are several stable weakly bound nuclei e.g. ^{6,7}Li, ^{9}Be etc. whose break up thresholds range from 1.48 MeV to 2.55 MeV for various break up processes. These nuclei are prone to break in the field of other nucleus and influence the reaction mechanism. There have been plenty of studies to probe the role of break up of such weakly bound nuclei on fusion cross section in light as well as heavy mass region. In light mass region, there are some contradictory results of fusion suppression above Coulomb barrier (V_B) involving ^{9}Be in the entrance channel. In the present study, we have investigated the reaction mechanism involved in the emission of the intermediate mass fragments (IMF) from the reaction ^{20}Ne + ^{9}Be, with energy available in the centre of mass frame ($E_{c.m.}$), much above the V_B. It will be interesting to see whether and how the break up of weakly bound nucleus influences the yileds of IMFs. Another reaction ^{16}O + ^{12}C, with strongly bound nuclei, forming the same composite element (1 n less) at similar excitation energy, has been studied to compare with the outcomes of the reaction ^{20}Ne + ^{9}Be.

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Experimental Details

The experiment has been performed at the Variable Energy Cyclotron Centre, Kolkata, using ^{20}Ne and ^{16}O ion beams on ^{9}Be (∼1.78mg/cm^2) and ^{12}C (∼100μg/cm^2) targets, respectively. The detailed target projectile combinations and beam energies are tabulated in TABLE I. The emitted fragments have been identified using a telescope consisting of ΔE ∼50μm, single-sided silicon strip detector (SSSD) and E ∼1000μm, double-sided silicon strip detector (DSSD) of ChAKRA [1]. Different emitted fragments were well separated isotopically in ΔE-E telescope as shown in Ref.[2]. The inclusive energy distributions of the fragments ^{6,7}Li and ^{7,9}Be have been measured in the angular range of 15° to 28° in laboratory frame.

TABLE I: Details of experimental parameters

Beam	Target	E_{lab} (MeV)	$E_{c.m.}$ (MeV)	V_B (MeV)	E^*_{CN} (MeV)
^{20}Ne	^{9}Be	157.2	48.8	6.58	75.0
^{16}O	^{12}C	135.9	58.2	7.95	75.0
^{20}Ne	^{9}Be	193.0	59.9	6.58	86.1
^{16}O	^{12}C	161.6	69.3	7.95	86.0

Results and Discussion

The inclusive energy spectra of Li and Be isotopes for both the reactions were found to be nearly Gaussian in shape and the centroids of the distributions were very close to the predicted values of the Viola systemat-

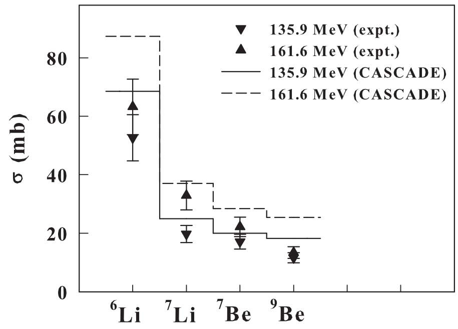

FIG. 1: Experimental yields of the fragments compared with the statistical model prediction for ^{16}O + ^{12}C reaction. The solid triangle down (up) represents 135.9 MeV (161.6 MeV) data points and corresponding CASCADE values are shown by solid (dashed) line.

ics [3]. The angular distributions of the fragments followed $\sim 1/\sin\theta_{c.m.}$ in the centre of mass frame. All these observations indicate that the fragments are emitted from a fully energy relaxed composite. The cross sections (σ) of the fragments have been extracted for the two reactions and plotted in Figs. 1 & 2 along with the predicted values of the statistical model code CASCADE [4]. Here, we see that the yields of all the fragments are comparable with the predictions of the CASCADE for the reaction ^{16}O + ^{12}C (see Fig. 1). The yields also show an increasing trend with the increase in beam energy which is expected for the binary decay of a compound nucleus [5] up to a certain excitation and is also reflected in the statistical model predictions. However, for the system ^{20}Ne + ^{9}Be, it has been observed that the experimental yields of the fragments are very less (∼30-60%) compared to the CASCADE prediction and do not increase with increase in excitation energy as shown in Fig. 2.

Conclusion

The equillibrium yields of the fragments (Z=3,4) were appreciably lower than the respective statistical model predictions for the reaction ^{20}Ne + ^{9}Be at two different energies.

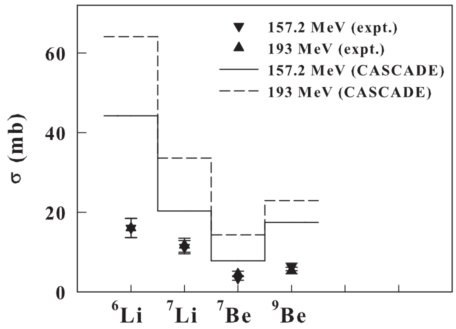

FIG. 2: Same as Fig. 1 but for ^{20}Ne + ^{9}Be reactions at 157.2 MeV and 193.0 MeV energies.

Moreover, the measured yields remained almost constant for all fragments under present study at both the energies though the statistical model showed an increasing trend with energy. However, for the similar composite with only one neutron less and produced at similar excitation energy through the reaction ^{16}O + ^{12}C, the yield of the fragments are comparable with the statistical model prediction. This discrepancy may be attributed to the break up of weakly bound ^{9}Be involved in the ^{20}Ne + ^{9}Be reaction. The flux from the fusion channel may have been removed partly due to the break up of the ^{9}Be, a phenomenon which is not incorporated in the conventional statistical models.

References

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