Statistical model calculation for evaporation residue cross-section for ^{28}Si + ^{142}Ce and ^{32}S + ^{138}Ba systems.

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Introduction

For synthesis of heavy compound nucleus (CN), the heavy-ion induced reaction plays a key role. When a projectile hits the target nucleus, then along with the evaporation residue (ER) formation, there are other processes such as fission, quasi-fission (QF) and fast-fission etc. [1]. that can take place, which hinders the formation of heavy-residues. The detailed study of these reaction products is required to understand the reaction mechanism of heavy compound nucleus. Apart from this, there are other factors like entrance channel, deformation and shell effect etc. that can also influence the formation of ER's.

To investigate the effect of entrance channel on the fusion-fission dynamics, we have planned to study the systems leading to the same CN ^{170}Hf. Our aim was to choose the systems for which the experimental data on ER cross-section is already available. In the present work, we have chosen the ^{28}Si + ^{142}Ce and ^{32}S + ^{138}Ba systems for theoretical calculations because the experimental data for these systems are available [2]. Theoretical calculations are performed using statistical model code.

Theoretical calculations

The analysis of experimentally obtained fusion cross-section is obtained from the coupled channel (CC) code CCFULL [3], which take into account the nonlinear couplings of all orders. In the present calculations, we have included the coupling to the first 2+ and 3- states for both target and projectile. The projectiles ^{28}Si and ^{32}S has a permanent quadrupole deformation. The parameters used in these calculations are summarized in Table 1. The fitted experimental fusion cross-section for systems is shown in Fig. 1. We have performed the CC calculations at each energy point and fitted the fusion cross-section by adjusting the potential adjustable parameters.

Table 1. The input parameters used in CCFULL calculations. The double columns under each system indicate the strength values associated with the projectile (left) and target (right).

	^{28}Si + ^{142}Ce	**^{32}S + ^{138}Ba**
β_2	-0.41 0.12	0.31 0.09
E_x(MeV)	1.74 0.68	2.23 1.44
β_3	0.40 0.13	0.48 0.13
E_x(MeV)	6.88 1.65	5.01 2.88
Transfer FF (ln)	1.0	1.0
Q_{transf} (MeV)	1.31	0.03
V_b (MeV)	71.94	73.97
R_b (fm)	9.72	9.83
r_b (fm)	1.18	1.18
A_0 (fm)	0.67	0.67

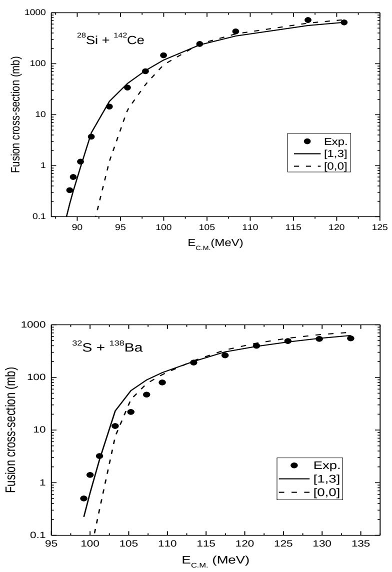

Fig. 1 The coupled channel calculations for ^{28}Si + ^{142}Ce and ^{32}S + ^{138}Ba systems. Dashed line is without coupling and solid line is with coupling.

The final theoretical calculations are performed using statistical model that are based on the assumption that whole of the incident flux led to the CN formation i.e., complete fusion between the target and projectile after capture while the possibility of non-compound events is neglected. The ER cross-sections are calculated using Bohr-Wheeler (BW) formalism [4] including shell-correction in the level density. The CN spin distribution obtained from CCFULL code at each energy point is subsequently used as an input in the statistical model code. For reproducing the data, different scaling factors in the range 0.5 to 1.0 has been used. The best-fit value of K_f is found to be 0.8 as shown in Fig. 2.

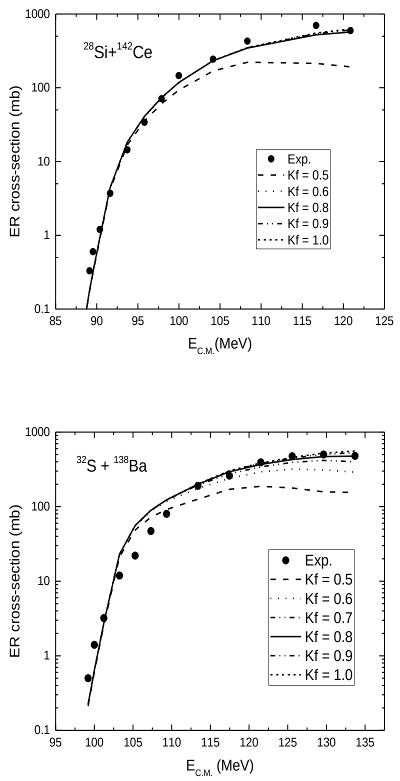

Fig. 2 Dots are the experimental data and different lines are the theoretical calculations for different scaling factor, K_f (a) ^{28}Si + ^{142}Ce (b) ^{32}S + ^{138}Ba systems.

Results and discussions

From the Fig. 2, it is found that the ER cross-sections fits the experimental data for the entire range of barrier factor (K_f) from 0.6 to 1.0 for both systems. However, for $K_f = 0.5$, the ER cross-sections are close to experimentally obtained values at lower energies. On the other hand, the significant deviation in the ER cross-sections has been observed for higher values of energies for both ^{32}S + ^{138}Ba and ^{28}Si + ^{142}Ce systems. This deviation from the general trend is not understood at present. Hence, more measurements are necessary to understand the ER and the fission competition for heavy-ion induced reactions in this mass region. Such measurements are also necessary to disentangle QF versus shell effect. For these systems, we are planning to measure ER and fission cross-sections at different energy points.

References

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