Synthesis of superheavy nuclei ^{310}125 via fusion

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Introduction

There has been much experimental progress in synthesizing superheavy elements. The island of stability was predicted theoretically more than 40 years ago. The existence of island of stability has been confirmed experimentally [1-2] during previous decade. The evaporation-residue cross section of fusion reactions depends on the projectile-target combinations and the incident energy. The study of dependences of fusion reactions is useful while synthesizing the superheavy nuclei with Z > 118, because evaporation-residue cross section of reactions with these nuclei is very small, which makes the experiment much more difficult.

A detailed theoretical study is useful before the synthesis of super heavy nuclei Z=125. Hence in the present work, We have identified the most probable projectile-target combination by studying the fusion cross section, evaporation residue cross section, compound nucleus formation probability (P_{CN}) and survival probability (P_{Surv}) of different projectile target combinations to synthesis super heavy element ^{310}125.

Theory

The total interaction potential is taken as the sum of coulomb and nuclear potential. For the coulomb part, we have used the equation suggested by the previous worker [3]. The nuclear potential $V_N(R)$ is calculated using the proximity method suggested by Myers and Swiatecki. The fusion barrier has two basic features: one is the barrier position (R_B) and the other is barrier height (V_B). Since fusion happens at a distance larger than the touching configuration of colliding pair, the above form of the Coulomb potential is justified. One can extract the barrier height V_B and barrier position R_B using the following conditions

$$\left.\frac{dV(r)}{dr}\right|_{r=R_B} = 0 \quad \text{and} \quad \left.\frac{d^2V(r)}{dr^2}\right|_{r=R_B} \leq 0 \qquad (1)$$

We have used the Wong [4] procedure to calculate fusion cross section. To calculate the fusion cross section, the probability for the compound nucleus formation is required. We have used the procedure to calculate the P_{CN} suggested in our previous works [5]

After the fusion of two nuclei, the corresponding compound nuclei comes to ground state by emitting neutrons. The evaporation residue cross section of SH element production in a heavy-ion fusion reaction with subsequent emission of x neutrons is given by

$$\sigma_{ER}^{xn} = \frac{\pi}{k^2}\sum_{l=0}^{\infty}(2l+1)T(E,l)P_{CN}(E,l)P_{sur}^{xn}(E^*,l) \qquad (2)$$

P_{sur} is the survival probability and it is the compound nucleus to decay to the ground state of the final residual nucleus via evaporation of neutrons/light particles. P_{sur} is calculated using procedure explained in our previous work [7].

Results and discussions

We have studied more than 100 possible projectile target combinations to synthesis super heavy nuclei ^{310}125. The comparison of survival probability (P_{surv}) among the studied mass number of projectile at 35MeV (for 3n) to synthesis super heavy nuclei ^{310}125 is as shown in figure 1. From this figure it is found that survival probability is maximum for projectile ^{56}Co. Figure 2 shows the variation of evaporation residue cross section for ^{310}125 with mass number of the projectiles. The evaporation residue cross section decreases with increase in the mass number of the projectiles. The variation of evaporation residue cross section (pb) with E* at different energies for 2n, 3n & 4n reactions are respectively as shown in figure 3. We have also calculated the relative yield based on the survival probabilities. It is the ratio between the survival probabilities of a given projectile-target combination over the sum of survival probabilities of all possible projectile-target combinations. The comparison of yield with mass number of projectile for the synthesis of super heavy nuclei $^{310}125$ is as shown in figure4. From this comparison, it is clear that the projectile-target combination Co+Cf is having maximum evaporation residue cross section than the other studied projectile-target combinations.

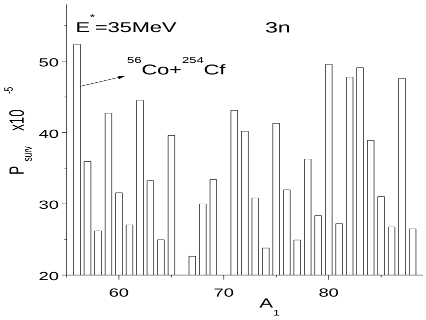

Fig.1: Variation of survival probability of $^{310}125$ with mass number of projectile

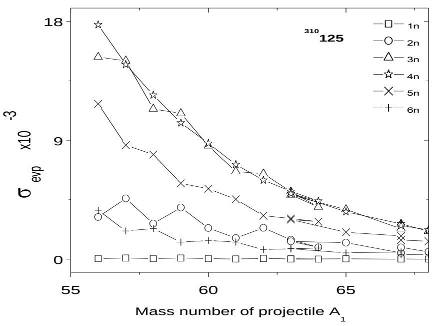

Fig. 2: Variation of evaporation residue cross section as a function of mass number of projectile

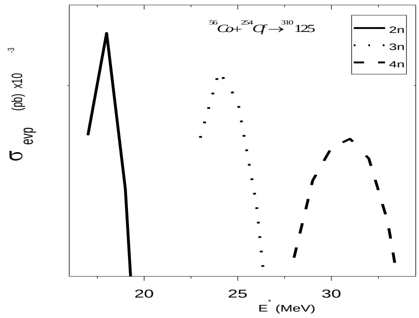

Fig.3: Variation of evaporation residue cross section a function of energy E* for 2n, 3n and 4n channels.

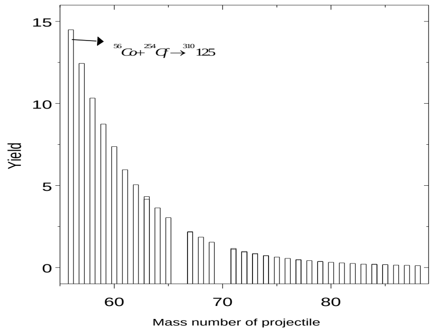

Fig. 4: Variation of yield as a function of mass number of projectile

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