^{58}Fe induced fusion to synthesis Superheavy element Z=120

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Introduction

The elements with Z≥101 were produced using the projectiles such as ^{4}He, ^{12}C, ^{18}O and ^{22}Ne. The elements produced through these reactions having excitation energy 37 – 45 MeV and survive only 10^{-6} to 10^{8} s against fission and other decay process. The life time of the produced isotopes decreases with increase in mass number of the projectile. However, elements with Z= 102 – 106 were first time synthesized using these reactions [1], the elements with Z>106 were produced using cold fusion reactions with massive projectiles A≥40 [2]. Six elements Z=107 – 112 were synthesized in cold fusion reactions using massive ions ^{54}Cr, ^{58}Fe, ^{64}Ni and ^{70}Zn [3]. The superheavy elements with atomic number Z=114-118 are synthesized with ^{48}Ca as a projectile and actinide as a target. However, it is difficult to synthesize heavier elements with projectile ^{48}Ca. Thus to produce superheavy elements Z>118, heavier projectiles such as ^{50}Ti, ^{54}Cr, ^{58}Fe, ^{64}Ni should be used. In the present work, we have studied the 58Fe induced fusion reactions to synthesis superheavy element Z=120.

Theory

The interacting potential barrier for two spherical nuclei is considered as sum of coulomb and nuclear potential. Coulomb potential $V_c(R)$ is calculated by

$$V_C(R) = Z_1 Z_2 e^2 \begin{cases} \dfrac{1}{R} & (R > R_C) \\ \dfrac{1}{2R_c}\left[3 - \left(\dfrac{R}{R_c}\right)^2\right] & (R < R_C) \end{cases} \quad (1)$$

where $R_C = 1.24 \times (R_1 + R_2)$, R_1 and R_2 are respectively the radii of the emitted alpha and daughter nuclei. For nuclear part, we have used Denisov potential Vp(r) [4]

After calculation of total potential, we have calculated the the barrier height V_B and barrier position R_B using the procedure explained in previous work [5-8]. To study the fusion cross sections, we have used the model given by Wong [5]. In this formalism, the cross section for complete fusion is given by

$$\sigma_{fus} = \frac{\pi\eta^2}{2\mu \times E_{cm}} \sum_{l=0}^{l_{max}} (2l+1) \times T_l(E_{cm}) \bullet P_{CN}(E_{cm}, l) \quad (2)$$

where μ is the reduced mass. The center of mass energy is denoted by E_{cm}. In the above formula, l_{max} corresponds to the largest partial wave for which a pocket still exists in the interaction potential and $T_l(E_{cm})$ is the energy-dependent barrier penetration factor. P_{CN} is the probability for the compound nucleus (CN) formation by two nuclei coming in contact. The calculation of P_{CN} requires effective fissility which inturn depends on x_{thr} and c. x_{thr} and c are adjustable parameters [6-8]. 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 [9]

$$\sigma_{ER}^{xn} = \frac{\pi}{k^2} \sum_{l=0}^{\infty} (2l+1) T(E,l) P_{CN}(E,l) P_{sur}^{xn}(E^*, l) \quad (3)$$

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. The survival probability is the probability that the fused system emits several neutrons followed by observing a sequence of α decay from the residue. The survival probability under the evaporation of x neutrons is calculated using the procedure explained in previous work [6-10].

Results and discussions

We have studied the ^{58}Fe induced fusion reactions to synthesis superheavy element Z=120. Fig.1 shows the variation of compound nucleus probability with mass number of target. From this figure it is found that the compound nucleus probability increases with increase in the mass number of target. Fig.2 shows the comparison of calculated evaporation residue cross section among the different targets for 3n channel. From this figure, it is observed that evaporation residue cross section is maximum for ^{58}Fe+^{238}Pu. Fig.3 shows that the evaporation residue cross section of ^{58}Fe+^{238}Pu as function of energy E* for 3n, 4n and 5n channels. This figure is enable us to identify the excitation energies corresponding to the maximum production cross section. From this study, it can be concluded that ^{238}Pu is the best target to synthesis superheavy element Z=120 using ^{58}Fe induced reactions.

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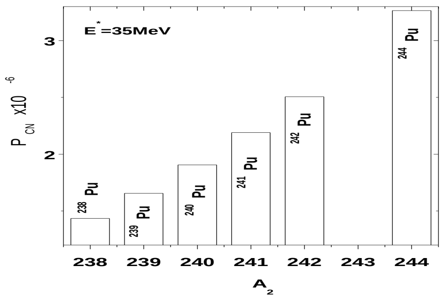

Fig.1: Variation of compound nucleus probability of Fe induced nuclei with mass number of target

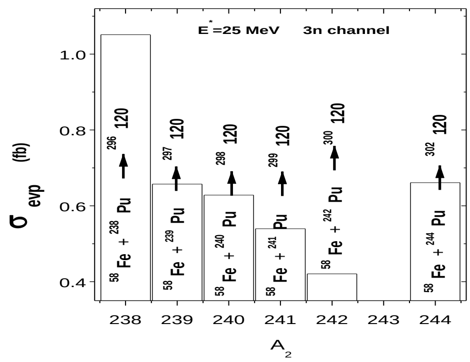

Fig.2: The comparison of calculated evaporation residue cross section among the different targets for 3n channel

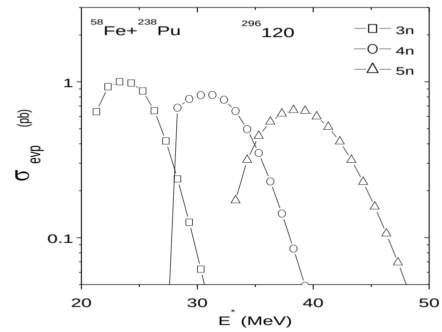

Fig.3: Evaporation residue cross section a function of energy E* for 3n, 4n and 5n channels.