Production cross section of ^{210}Po using the reaction ^{18}O+^{192}Os

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1. Introduction

The search for SHE is very important today since the existence of the island of stability in the nuclear landscape. Due to the stabilizing effect of shell structure at N=126, studies in this region is an interesting one. So in the present study the fusion-evaporation reactions that produce CN having N= 126 have been studied using the reaction ^{18}O+^{192}Os. The ER cross section for the synthesis of heavy and superheavy elements depend on many factors such as the entrance channel Coulomb barrier, center of mass energy, excitation energy, probability of CN formation, fission barrier, survival probability etc. Initially the projectile and target combine, form an excited compound nucleus, then the CN cools down by the evaporation of neutrons and finally form the evaporation residue or heavy element.

In the present work, the yields of evaporation residue cross section in xn (x=2 to 10) for the reaction ^{18}O+^{192}Os leading to ^{210}Po are systematically studied using the phenomenological model for production cross section, PMPC [1].

2. Phenomenological model for production cross section (PMPC)

2.1. The potential

The interaction barrier for two colliding nuclei is given as

$$V = \frac{Z_1 Z_2 e^2}{r} + V_P(z) + \frac{\hbar^2 \ell(\ell+1)}{2\mu r^2} \quad (1)$$

$V_P(z)$ is the proximity potential given as

$$V_P(z) = 4\pi\gamma b \frac{C_1 C_2}{C_1 + C_2}\phi(\xi) \quad (2)$$

with $\gamma = 0.9517[1 - 1.7826(N-Z)^2/A^2]$ is the nuclear surface tension coefficient, z is the distance between the near surfaces of the projectile and target, ℓ is the angular momentum, μ is the reduced mass, C_i is the Sussmann central radii. Here $\xi = z/b$, and diffuseness parameter b is taken as 1 fm.

$$\phi(\xi) = -4.41\exp(-\xi/0.7176), \quad \text{for } \xi \geq 1.9475$$

$$\phi(\xi) = -1.7817 + 0.9270\xi + 0.01696\xi^2 - 0.05148\xi^3 \quad \text{for } 0 \leq \xi \leq 1.9475$$

$$\phi(\xi) = -1.7817 + 0.9270\xi + 0.0143\xi^2 - 0.09\xi^3 \quad \text{for } \xi \leq 0 .$$

2.2. The cross section

The cross section of SHE production in a heavy ion fusion reaction with subsequent emission of *x* neutrons is given by

$$\sigma_{ER}(E^*) = \sigma_{capture} P_{CN}(E) W_{sur}(E^*) \quad (3)$$

Wong [2] obtained the following analytic expression for the capture cross section, approximating the barrier by a parabola.

$$\sigma_{capture} = \frac{R_0^2 \hbar\omega_0}{2E} \ln\left\{1 + \exp\left[\frac{2\pi(E - E_0)}{\hbar\omega_0}\right]\right\} \quad (4)$$

This formula depends on Coulomb barrier position R_0, barrier height E_0, and $\hbar\omega_0$. P_{CN} is the probability of compound nucleus formation and is taken from Ref. [3].

$$\sigma_{fusion} = \sigma_{capture} P_{CN}(E) \quad (5)$$

The survival probability under the evaporation of x neutrons is,

$$W_{sur} = P_{xn}(E^*) \prod_{i=1}^{i_{max}=x} \left(\frac{\Gamma_n}{\Gamma_n + \Gamma_f}\right)_{i,E^*} \quad (6)$$

where the index 'i' is equal to the number of emitted neutrons, P_{xn} is the probability of emitting exactly *xn* neutrons, *E** is the excitation energy of the compound nucleus, Γ_n and Γ_n represent the decay width of neutron evaporation and fission respectively. Vandenbosch and Huizenga have suggested a classical formalism to calculate Γ_n/Γ_f:

$$\frac{\Gamma_n}{\Gamma_f} = \frac{4A^{2/3} a_f (E^* - B_n)}{K_0 a_n [2a_f^{1/2}(E^* - B_f)^{1/2} - 1]} \times \exp[2a_n^{1/2}(E^* - B_n)^{1/2} - 2a_f^{1/2}(E^* - B_f)^{1/2}] \quad (7)$$

where A is the mass number of the nucleus considered, B_n is the neutron separation energy. The constant K_0=10MeV. The parameters $a_n = A/10$ and $a_f = 1.1a_n$ are the level density parameters of the daughter nucleus and the fissioning nucleus at the ground state and saddle configurations respectively and B_f is the fission barrier.

3. Results and Discussion

In the frame work of phenomenological model for the production cross section, the evaporation residue excitation functions for the reaction $^{18}O+^{192}Os$ leading to ^{210}Po have been studied. The calculated potential barrier for this reaction is 69.609 MeV and barrier radius is 11.809 fm. The probability of compound nucleus formation is taken as 0.88 [3]. The capture and fusion cross section as a function of center of mass energy is shown in Fig 1.

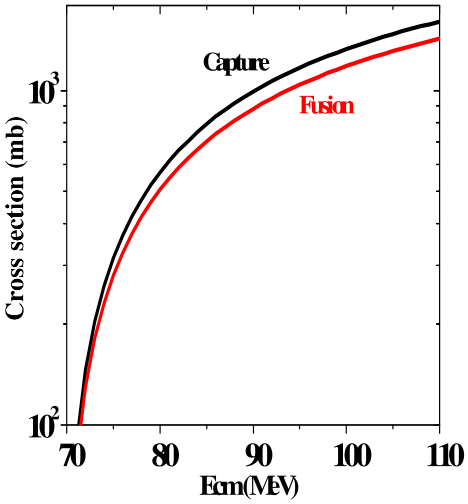

Fig.1. Capture and fusion cross for the reaction $^{18}O+^{192}Os$ leading to ^{210}Po.

The calculated xn channel (x=2 to 10) cross section is presented in Fig. 2 (line with label as 2n, 3n, 4n, 5n, 6n, 7n, 8n, 9n and 10n). The sum of the all the xn channel cross section [ER(Σxn)] is also calculated and shown as thick black line in Fig. 2. Symbols in the Fig. 2 are the corresponding experimental values [4] for the same reaction. It is found that, our calculated cross section [ER (Σxn)] is well agreement with experimental values within the error bars. This proves the effectiveness of our calculation. So in future, we can predict the production cross section of other isotopes of Po using various projectile and target which are not yet synthesized.

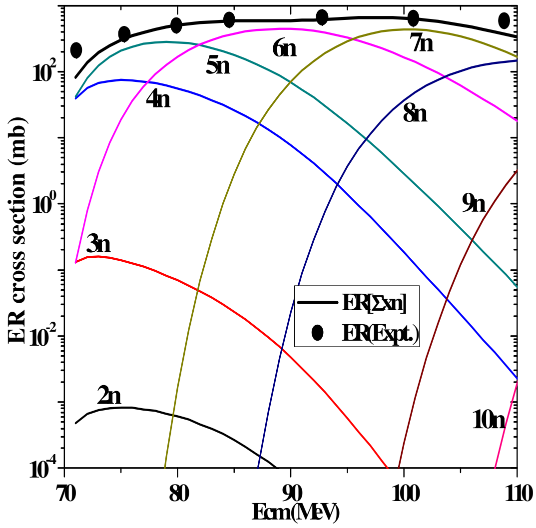

Fig.2. ER cross section in xn evaporation channel (x = 2 to 10) for the reaction $^{18}O+^{192}Os$ leading to ^{210}Po.

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