Fission barrier of ^{210}Po

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Introduction

Determination of fission barrier height continues to be challenging problem in nuclear fission. Although a number of studies have been made, there are still ambiguities in choosing various input parameters for the statistical model analysis. In our earlier statistical model analysis [1, 2] of fission and evaporation residue cross-sections along with pre-fission neutron multiplicities (ν_{pre}) data for ^{12}C+^{198}Pt system yielded fission barriers much smaller ($\sim$ 13 MeV) than those ($\sim$ 21 MeV) obtained for same compound nuclei from the analysis of light ion induced reactions [3]. In the present study, we have analyzed the fission excitation functions for p+^{209}Bi, α+^{206}Pb, ^{12}C+^{198}Pt and ^{18}O+^{192}Os systems leading to the same compound nucleus.

Statistical Model Calculation

Statistical model calculations were performed using the code PACE [4] with a modified fission barrier and level density prescription. The fission barrier height is expressed as

$$B_f(J) = c_f \times B_{LD}(J) - \Delta_n + \Delta_f, \qquad (1)$$

where, B$_{LD}(J)$, Δ_n and Δ_f are the angular momentum dependent liquid drop component of the fission barrier, shell correction at the ground state and shell correction at the saddle point, respectively. The liquid drop component of the fission barrier is taken from rotating finite range model (RFRM) [5] with a scaling factor c_f. The shell correction at the ground state is taken as the difference of experimental mass [6] and the liquid drop mass [7]. The shell correction at the saddle point is assumed to be $k_f \times \Delta_n$, where k_f is to be determined from the fit to the experimental data. An energy dependent shell correction of the level density parameter [8]

$$a_x = \tilde{a_x}[1 + \frac{\Delta_x}{U_x}(1 - e^{-\eta U_x})] \qquad (2)$$

is employed with x = n or f corresponding to equilibrium or saddle deformation. The asymptotic liquid drop value $\tilde{a_n}$ is taken as A/9. The ratio of the asymptotic value of the level density parameter at the saddle deformation to that at the equilibrium deformation, $\tilde{a_f}/\tilde{a_n}$, is determined from the fit to the experimental data. Experimental masses are used to calculate excitation energy of the compound nucleus as well as particle separation energies. Intrinsic excitation energy at the equilibrium deformation, U_n, is taken as $U_n = E^* - E_{rot} - \delta_p$, where E^*, E_{rot} and δ_p are the total excitation energy, the rotational energy and the pairing energy, respectively. The intrinsic excitation energy at the saddle deformation is taken as $U_f = U_n - B_f$.

Fusion cross section is an important input parameter for the statistical model calculation. Previous analysis [3, 9] used reaction cross-sections from optical model as fusion cross sections or have used different model to estimate fusion cross sections. There can be significant deference between the total reaction cross section and the fusion cross section. For heavy compound nuclei, the fusion cross section can be estimated better from the sum of the xn and fission cross sections than the reaction cross section. For p + ^{209}Bi, ^{12}C+^{198}Pt and ^{18}O+^{192}Os systems, the sum of the experimental xn and fission cross sections have been used as fusion cross section. In case of $\alpha +^{206} Pb$ system, the xn cross sections in the relevant energy region are not available. However, the measured xn and fission cross sections are available in case of $\alpha +^{209} Bi$ sys-

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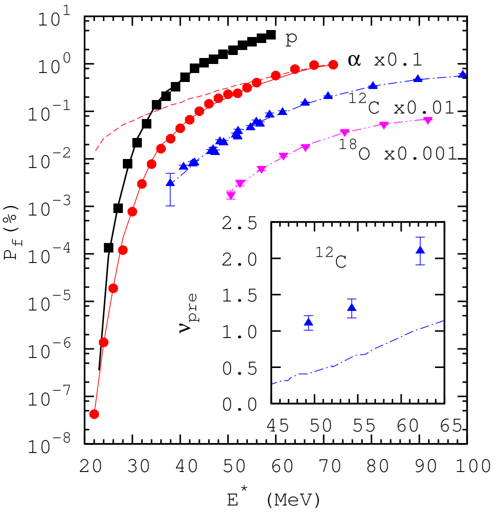

FIG. 1: Experimental fission probabilities are compared with statistical model calculation. The thick (black) continues, thin (red) continues, (blue) dot-dashed and the (pink) dot-dot-dashed lines are the statistical model prediction with no shell correction at the saddle point for p $+^{209}$Bi, $\alpha+^{206}$Pb, ^{12}C+^{198}Pt and ^{18}O+^{192}Os system, respectively. The (red) dashed line is the prediction of the statistical model with 70% of ground state shell correction at the saddle point for $\alpha+^{206}$Pb system. Experimental pre-fission neutron multiplicity data is compared with statistical model calculation with no shell correction at the saddle point for ^{12}C+^{198}Pt system in the inset.

tem. Sum of the xn and fission cross section were found to agree well with the Bass systematics [10]. Hence fusion cross sections for $\alpha+^{206}Pb$ system are taken from Bass systematics.

Result & Discussion

Experimental fission probabilities are compared with the statistical model predictions in Fig. 1. As can be seen from the figure, for all the systems excitation function could be explained with no shell correction at the saddle point. However, it fails to reproduce the measured pre-fission neutron multiplicity data. Statistical model calculation with 70% (k_f =0.7) of ground state shell correction at the saddle point, required to explain the fission probability and ν_{pre} data simultaneously for ^{12}C+^{198}Pt system, fails to explain the low energy part of the fission excitation functions for p (not shown) and α induced reactions.

In summary, it is possible to obtain a consistent description of the fission excitation functions for projectiles- p, α and heavy ions populating the same compound ^{210}Po which is a neutron shell closed nucleus, without requiring shell correction at the saddle point and with use of large value of B_f. However, this prescription yields too small values of ν_{pre} when compared to the experimental data. Role of pre-equilibrium emission in case of p and α induced reaction and contributions of post-saddle emission and other processes in the measured ν_{pre} should be investigated to arrive at a definite conclusions about the fission barrier.

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