Entrance channel effects in the fission of ^{192,202,206,210}Po compound nuclei.

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Introduction

Studies on the nature and magnitude of nuclear dissipation have emerged as a topic of considerable interest in recent years. It is now well established that dissipation causes delay of the fission process with respect to the statistical picture of compound nucleus (CN) decay. Apart from nuclear dissipation, the fission time scale is also sensitive to the shell effects in fission barrier height and the density of nuclear levels [1]. The feasibility of synthesis of super heavy elements is based on the expectation of their stability against fission due to shell effects [2]. Recently, Singh et al. [3] and Sandal et al. [4] studied the effect of shell closure by neutron multiplicity measurements for the CN ^{213,215,217}Fr and ^{210,212,214,216}Rn. In the present work, experimental measurement of pre-scission multiplicity (M_{pre}) is extended over a wider range of N/Z and fissility for CN of Po isotopes. Here, we have measured the M_{pre} for two systems: (i)^{48}Ti+^{144}Sm and, (ii)^{48}Ti+^{154}Sm at 72 MeV of excitation energy. This experiment was performed using the National Array of Neutron Detectors (NAND) at Inter University Accelerator Centre (IUAC), New Delhi. For more details on the experimental set up reader is refered to ref [5]. In the present study, we also include the systems ^{12}C+^{194}Pt and ^{18}O+^{192}Os populating ^{206}Po and ^{210}Po respectively for which experimental data for M_{pre} are already available [6, 7]. The chosen systems span the neutron deficient ^{192}Po (N_{CN}=108) to neutron rich ^{210}Po (N_{CN}=126) CN. We also perform a detailed statistical model analysis for the four systems.

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Statistical Model Caculations

In the framework of statistical model the CN can either undergo fission or reduce to a evaporation residue along with the emission of light particles like neutrons, protons, and α particles and γ rays. The fission width Γ_{BW} is obtained from the transition-state model of fission due to Bohr and Wheeler[8]. The particle and γ emission widths are obtained from the Weisskopf formula[9].

We obtain the fission barrier in the present calculation by including shell correction in the liquid-drop nuclear mass. The shell correction term δM is defined as the difference between the experimental and the liquid-drop model (LDM) masses (δM= $M_{experimental}$ - M_{LDM}). The fission barrier of a compound nucleus carrying angular momentum then given as:

$$B_f(l) = B_f^{LDM} - (\delta_g - \delta_s) \quad (1)$$

where ${B_f}^{LDM}$ is the liquid drop model fission barrier [10] and δ_g and δ_s are the shell correction energies for the ground state and saddle configurations respectively. The level

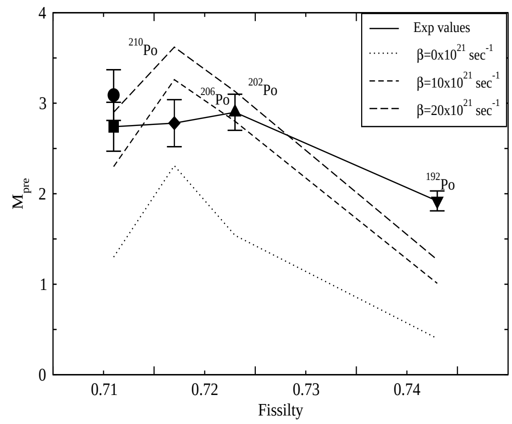

FIG. 1: M_{pre} as function of fissility for different systems.

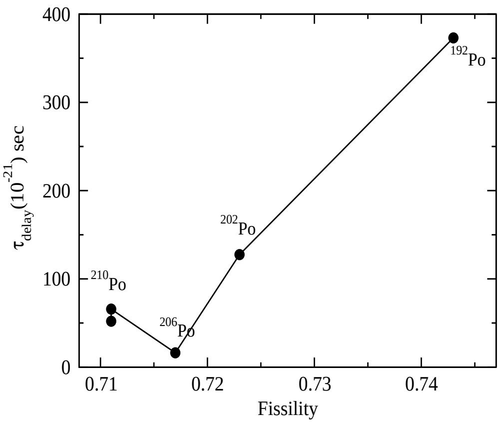

FIG. 2: τ_{delay} as function of fissility for different CN.

density parameter used in the present work has been taken from the work of Ignatyuk et al. [11], which includes shell effects at low excitation energies and goes over to its asymptotic form at high excitation energies.

Results and Conclusion

Statistical model (SM) calculations are performed for different values of dissipation coefficient (β) and the variation of M_{pre} with fissility is given in FIG. 1. The experimental values for ^{48}Ti+^{144,154}Sm (present work) are at excitation energies 72.6 and 72.3 MeV respectively, those of ^{12}C+^{194}Pt and ^{18}O+^{192}Os are at excitation energies 76.7 and 73.5 MeV respectively. We find that while β values in the range (10-20)$\times 10^{21}$ sec^{-1} can reproduce the experimental M_{pre} for the ^{18}O+^{192}Os and ^{48}Ti+^{154}Sm systems forming compound nuclei ^{210}Po and ^{202}Po respectively, a smaller value of β is required for the ^{12}C+^{194}Pt system leading to the CN ^{206}Po. However, for the ^{48}Ti+^{144}Sm reaction forming the CN ^{210}Po, number of pre-scission neutrons falls much short of the experimental value even with a strong β=20$\times 10^{21}$ sec^{-1}.

Another set of calculations are performed where a delay time (τ_{delay}) is introduced in the saddle-to-scission stage of fission in order to get a direct estimate of time delay required for emission of the experimentally observed number of pre-scission neutrons. The τ_{delay} values required to reproduce the experimental M_{pre} are given in FIG. 2. Analysis with the introduction of a delay time in the SM calculation suggests that a substantial part of M_{pre} for the reaction ^{48}Ti+^{144}Sm$\rightarrow^{192}$Po may originate during CN formation in the entrance channel. In the N/Z dependence of the pre-scission neutron multiplicity, no specific trend at shell closure of N=126 is observed for Po isotopes.

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