Probing dissipation effects via evaporation residue excitation function for the $^{16,18}O$ + ^{198}Pt reactions

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Introduction

The measurement of evaporation residue (ER) cross section can reveal information about the pre-saddle dissipation and is known to be a sensitive probe [1]. In an earlier work we reported the effect of N/Z on nuclear dissipation via neutron multiplicity measurements [2]. Here we report the statistical model analysis, and study the effect of N/Z on nuclear dissipation through ER excitation function, for the $^{16,18}O+^{198}Pt$ reactions. These reactions populate the compound nuclei with same Z (Z=86, Rn) but different value of N (i.e different N/Z and (N-Z)/A).

Experimental Details

The experiment for measuring ER excitation function was performed at the 15 UD Pelletron accelerator facility of the Inter University Accelerator Centre (IUAC), New Delhi., using the HYRA facility [5]. A detail of the experimental arrangement and analysis procedure is given in Ref. [3].

Analysis and Results

The total ER cross section was calculated using the expression

$$\sigma_{ER} = \frac{Y_{ER}}{Y_{mon}}\left(\frac{d\sigma}{d\Omega}\right)_R \Omega_{mon}\frac{1}{\varepsilon_{HYRA}}$$

where, σ_{ER} is the ER cross section in mb, Y_{ER} is the ER yield at the focal plane, Y_{mon} is the yield in the monitor detector, ε_{HYRA} is the HYRA transmission efficiency, and Ω_{mon} is the solid angle subtended by the monitor detector. $(d\sigma/d\Omega)_R$ is the differential Rutherford cross section in the laboratory system. We followed the method outlined in Ref. [4] to get transmission efficiency of the HYRA for the given reactions. ER angular distributions for the reactions $^{16,18}O+^{198}Pt$ along with the $^{16}O+^{194}Pt$ at 96 MeV beam energy were simulated using the Monte Carlo code TERS [6]. Experimentally extracted ER excitation functions for the two systems are shown in Figs. 1 and 2.

In the statistical model calculations the CN, formed in a complete fusion reaction, decays via particle evaporation (mainly neutron, proton, and α particle), GDR γ emission, and fission. The rotational energy of the compound nucleus is obtained using the shape-dependent rigid body moment of inertia and is included in the finite-range liquid drop model (FRLDM) potential. In these calculations, to obtain the dissipation effects we have used free energy [7] as a driving force in a thermo dynamical system such as a hot nucleus. The free energy F is given by the Fermi gas model as $V(q,t) = V(q) - a(q)T^2$ where, q represents the collective coordinates and the collective potential $V(q)$ is obtained from FRLDM potential. We have used the Kramers' formula [8] for the fission width to incorporate the effect of nuclear dissipation.

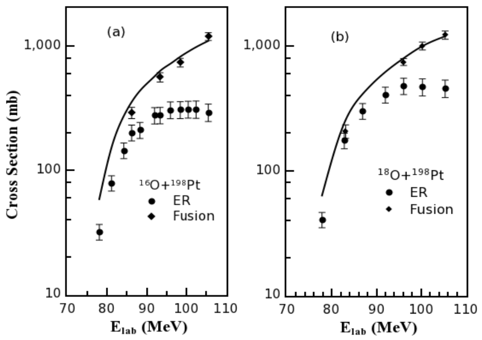

Fig. 1: The experimental ER and fusion cross section for the $^{16,18}O+^{198}Pt$ systems, solid lines shows the fusion cross section from CCFULL calculations.

The CN spin distribution was first obtained with the coupled-channels code CCFULL [9] by matching the experimental fusion cross sections as shown in Fig 1 for both the reactions. In the statistical model calculations, we have performed calculations only for beam energies above the Coulomb barrier in the entrance channel. In these calculations the shell effect is considered in the level density parameter and shell correction in fission barrier is not included. The dissipation strength (β) in the units of 10^{21} s^{-1} was treated as an adjustable parameter in the statistical model calculations in order to fit the experimental data. Theoretical calculations along with the ER cross sections and the fitted dissipation coefficient for $^{16,18}O+^{198}Pt$ systems are shown in the Fig 2 and Fig. 3 respectively. From the calculations it is clear that $^{18}O+^{198}Pt$ (higher N/Z value) needs higher values of β=2, compared to $^{16}O+^{198}Pt$ where ER cross sections matches at β=1. Calculations with β=0 are also shown.

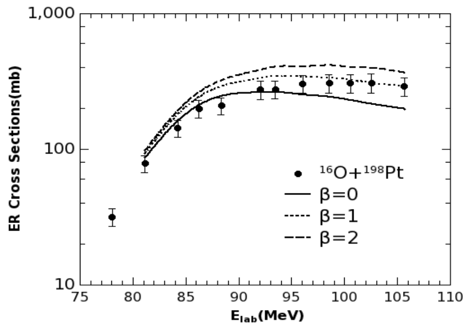

Fig. 2: The experimental ER cross section for the $^{16}O+^{198}Pt$ system compared with statistical model calculations.

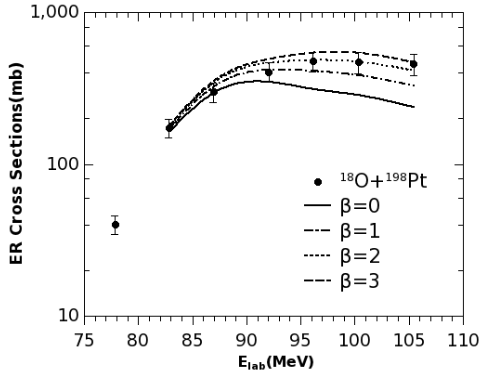

Fig. 3: The experimental ER cross section for the $^{18}O+^{198}Pt$ system compared with statistical model calculations.

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