ER cross section studies for the ^{35,37}Cl + ^{181}Ta reactions.

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Introduction

Significant effort has been made in recent years to explore the process of super heavy elements (SHE) production in various laboratories. SHE are basically the evaporation residues (ER) and the theoretical modeling to understand the mechanisms are progressing from various groups [1]. The primary interest of such a study is to understand the dynamics of the survival of ER from the hot compound nucleus (CN) formed by the collision of the heavy projectile with massive target nuclei. The main hindrance to fusion is the reseparation of the dinuclear system during its shape evolution prior to the saddle point of CN and this quasi-fission (QF) process [2–4] deflects CN formation probability from unity. The present study aims to calculate the excitation functions of ^{35,37}Cl + ^{181}Ta reactions.

Evaporation residue cross sections were measured for the ^{35,37}Cl + ^{181}Ta reactions using the Hybrid Recoil Mass Analyzer at IUAC, New Delhi and the experimental details were described elsewhere [5]. Theoretical model calculations were performed using the dinuclear system (DNS) and the statistical models. Calculations are performed in two steps. In the first step, the DNS model is employed to extract the CN formation probability (P_{CN}) and partial fusion cross section and in the next step, the results were fed as input to statistical model code.

Theoretical approach and results

ER formation in heavy ion induced reactions depends mainly on the probabilities of

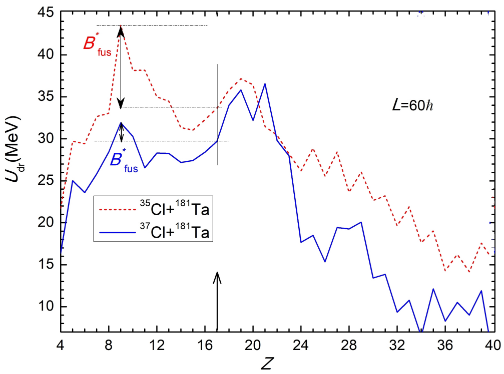

FIG. 1: Driving potentials calculated for the ^{35}Cl + ^{181}Ta and ^{37}Cl + ^{181}Ta reactions in collisions with orbital angular momentum L = 60 $\hbar$ as the function of fragment charge number (Z).

capture, fusion, QF and the fission competition of the fused system. The fusion and QF probabilities are controlled by the evolution of the system after capture over the multidimensional potential energy surface (PES). The important feature of PES is it dependence on repulsive Coulomb and attractive nuclear potentials. Structural effects also play an important role in determining the shape of PES. The factors like beam energy, deformations of nuclei in the entrance channel and their relative orientations in the contact configuration of PES have crucial role in determining final observables. PES can be estimated from the reaction energy balance and nucleus-nucleus potential [6]. The present method of calculation of P_{CN} is based on the peculiarities of PES.

The intrinsic fusion barrier (B^*_{fus}) mainly depends on the charge and mass asymmetry at fixed values of R corresponds to the minimum of the potential well of the nucleus-

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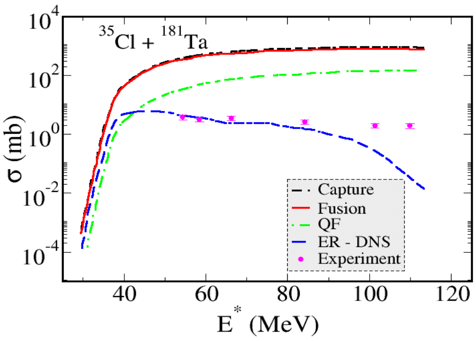

FIG. 2: Experimental total ER cross sections for the ^{35}Cl + ^{181}Ta reactions compared with the theoretical calculations.

nucleus interaction connecting the dinuclear system fragments. The driving potentials calculated for the ^{35,37}Cl + ^{181}Ta reactions at the value of the orbital angular momentum L = 60 $\hbar$ shows that higher value of B^*_{fus} for the reaction with ^{35}Cl causes more hindrance to fusion than the one of the reaction with ^{37}Cl (see Fig. 1).

In the calculation of the ER cross section by statistical model [7] the CN excitation energy is reduced for the amount of rotational energy of CN : $E^* = E_{c.m.} + Q_{gg} - E_{rot}$, where $E_{rot} = \frac{L(L+1)\hbar^2}{J_{CN}}$, J_{CN} is the moment of inertia of CN. The cross section obtained in the present calculations along with experimental data are shown in Fig. 2 and Fig. 3. The present results indicates that significant QF contribution in both the reactions. The experimental total ER cross sections are well reproduced by the model calculations except at the higher excitation energies. Similar observations were found in the literature [8, 9]. It could be either due to the projectile break up process or due to the increase of contribution of the incomplete fusion associated with the increase of B^*_{fus} at higher angular momentum collisions. More experimental ER measurements at high excitation energies required to explore it further.

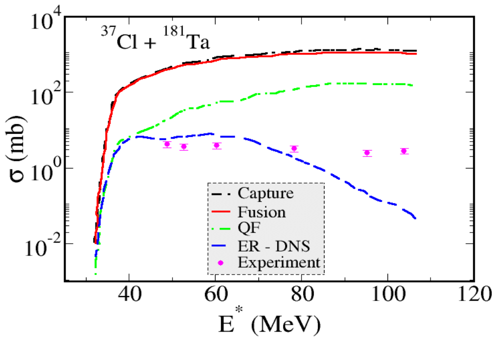

FIG. 3: Experimental total ER cross sections for the ^{37}Cl + ^{181}Ta reactions compared with the theoretical calculations.

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