Investigation of decay of $^{44}Ti^*$ compound system formed in $^{32}S+^{12}C$ reaction

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Introduction

The characteristic features of complex fragments emissions from composite systems formed in light mass region (20 < A < 80), has been studied extensively to unveil the fragment emission mechanism. These studies divulged the origin of complex fragments from either fusion-fission (FF) or/and deep inelastic orbiting (DIO) processes. The emission of different complex fragments in $^{26-29}Al^*$ and $^{31}P^*$ systems is interpreted in terms of FF decay mode both experimentally as well as theoretically [1, 2]. On the other hand, it has been observed that DIO plays a significant role in fragment emission from alpha cluster nuclei. The study of $^{28}Si+^{12}C$, $^{20}Ne+^{12}C$, $^{16}O+^{12}C$ reactions leading to $^{40}Ca^*$, $^{32}S^*$, $^{28}Si^*$ alpha conjugate composite nuclei show enhanced yields near the projectile and target like nuclei [3, 4]. This enhancement is explained on the basis of dinuclear orbiting configuration which decays back to entrance channel owing to its strong memory of entrance channel.

The decay of light mass alpha and non-alpha conjugate composite systems $^{20,21,22}Ne^*$, $^{28}Si^*$, $^{39}K^*$, $^{40}Ca^*$ formed in light heavy ion reactions has been studied within collective clusterization approach of dynamical cluster-decay model (DCM), which reveals the presence of FF and DIO competing reaction mechanisms in different exit channels [4]. It is interesting to look whether such effects prevail in heavier alpha cluster systems. With this impetus, in the present work the emission of complex fragments, having Z = 6, in the decay of $^{44}Ti^*$ (alpha conjugate nuclei) formed in $^{32}S+^{12}C$ reaction with E_{lab} = 220 MeV, is studied using DCM [2, 4, 5] in reference to available experimental data [6].

Methodology

The DCM for the decay of hot and rotating compound systems is based on quantum mechanical fragmentation theory [2, 4, 5]. It is worked out in terms of collective coordinates of mass asymmetry η and relative separation (R) with effects of temperature, deformation and orientations duly incorporated in it. In terms of these collective coordinates, for ℓ partial waves, the decay cross-section is defined as

$$\sigma = \frac{\pi}{k^2}\sum_{\ell=0}^{\ell_{max}}(2\ell+1)P_0P;\ k=\sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (1)$$

where preformation probability P_0 refers to η motion (calculated by solving Schrödinger equation) and penetrability P refers to R motion (calculated using WKB approximation) both dependent on angular momentum ℓ and temperature T, ℓ_{max}, is maximum angular momentum defined for light particles, LPs cross-section such that $\sigma_{LP} \rightarrow 0$ and μ is the reduced mass.

Calculations and Discussion

The calculated fragmentation potential for the decay of $^{44}Ti^*$ compound system is shown in Fig.1(a) at $\ell = 0$ $\hbar$ and $\ell = \ell_{max}$. The LPs become less favorable at ℓ_{max} and competition between different intermediate mass fragments (IMFs) with Z = 4-7 is observed. The binary symmetric splitting is in strong competition with ^{12}C and ^{14}N fragments and consequently these minimized fragments are having more P_0 within DCM. These fragments depending upon their P through interaction

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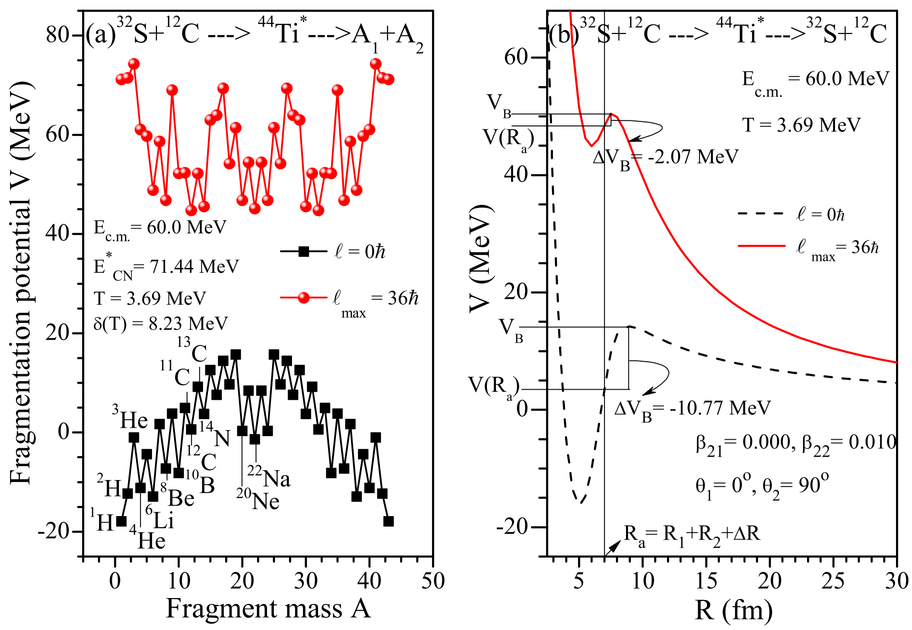

FIG. 1: For the decay of $^{44}Ti^{*}$, a) fragmentation potential and, b) scattering potential for the outgoing channel ^{32}S+^{12}C, at $\ell = 0\ \hbar$ and $\ell = \ell_{max}$.

TABLE I: The calculated FF cross-section for Z = 6 fragments in the decay of $^{44}Ti^{*}$ using DCM and its comparison with the experimental data [6].

$E_{c.m.}$ (MeV)	E^{*}_{CN} (MeV)	T (MeV)	ℓ_{max} ($\hbar$)	ΔR (fm)	σ_{DCM} (mb)	σ_{Expt} (mb)
60.0	71.44	3.69	36	0.93	10.73	10 ±1.4

barrier, contribute to the cross-section. The P of ^{12}C and complementary fragment through scattering potential is shown in Fig.1(b), which shows that barrier lowering (ΔV_B) decreases at $\ell = \ell_{max}$.

We have calculated the cross-section of target like yield i.e. for IMFs with Z = 6 for which the fragments with A = 11, 12, 13 are minimized, by fitting the neck length parameter (ΔR) within the range of proximity potential. For Z = 6, the ^{12}C (α-like) fragment is the most stable among all fragments with Z=6 having strong competition with symmetric fragment ^{22}Na. The calculated cross-section of Z = 6 fragments using DCM is shown in Table I and compared with experimental data. The results shows presence of FF process of compound nucleus origin in consonance with the experimental results [6]. Further it will be of interest to study the emissions of other competing IMFs with reference to experimental data to explore the fragment emission mechanism.

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