Comparative study of light particles emission cross sections in the decay of compound nuclei ^{26,27,28,29}Al* at E^*_{CN} ~44 MeV

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Introduction

The compound nucleus (CN) formed in low energy heavy ion reaction decays mainly through binary decay channels, comprising light particles (LPs), intermediate mass fragments (IMFs) and fusion-fission (ff). Just after the formation of CN, it undergoes equilibrated stage followed by saddle and scission stages, finally emitting the above mentioned decay products. The aim of our present work is to study the emission of LPs or evaporation residues (ERs) from various isotopes of Al* having an excitation energy E^*_{CN}~44 MeV.

In our earlier studies [1], one of the above mentioned isotopes ^{28}Al*, formed in the reactions ^{18}O+^{10}B and ^{17}O+^{11}B, has been studied using the Dynamical cluster-decay model (DCM) of Gupta and collaborators [2]. The system was considered to decay into IMFs having Z=3, 4, 5 and 6, for only spherical considerations of nuclei. In this work, the only parameter of the DCM, the neck-length ΔR, was individually fitted. Later, this work was extended for simultaneous fitting of the IMF's data. We found our results independent of the choice of the individual or simultaneous fitting of ΔR's for different fragments.

In present study, we investigate the LPs or ERs cross sections in the decay of ^{26,27,28,29}Al*, formed in heavy ion reactions ^{16}O+^{10,11}B and ^{18}O+^{10,11} with deformations (and orientations) of the interacting nuclei included upto quadruple deformations. We have calculated the ERs cross sections for the aluminium isotopes ^{26,27,28,29}Al* at a comparable

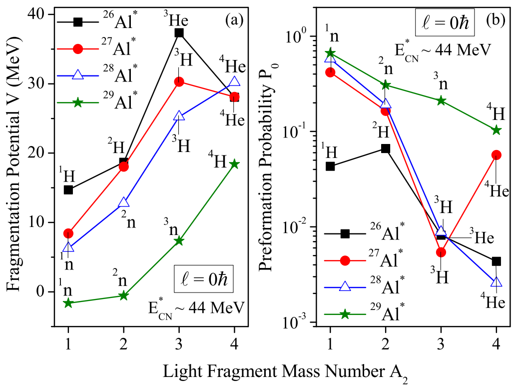

FIG. 1: (a) The fragmentation potentials $V(A_2)$, (b) Preformation Probability $P_0(A_2)$, for the compound systems ^{26,27,28,29}Al* formed in ^{16}O+^{10,11}B and ^{18}O+^{10,11} reactions at an excitation energy E_{CN} ~44 MeV for ℓ=0 $\hbar$.

excitation energy E^*_{CN} ~44 MeV. The effect of adding neutron in the LPs decay of Al* isotopes will be quite interesting to investigate. The experimental data [3] are available for the comparison with the DCM calculated results of light particles cross sections σ_{LPs}.

Methodology

The DCM of Gupta and collaborators [1, 2] is worked out interms of the collective co-ordinates of mass (and charge) asymmetries. In terms of these co-ordinates, for ℓ-partial waves, the compound nucleus decay cross-section is given by

$$\sigma = \frac{\pi}{k^2}\sum_{l=0}^{l_{max}}(2l+1)P_0P; \qquad k=\sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \tag{1}$$

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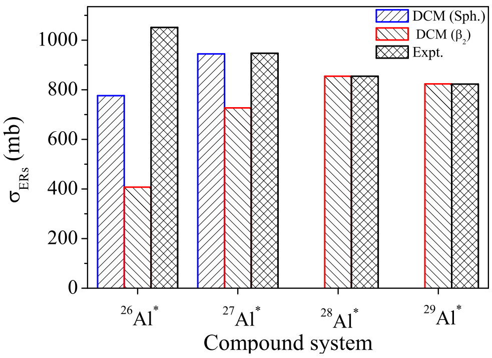

FIG. 2: The DCM calculated evaporation residue cross sections (σ_{ERs}) with the increasing mass of the isotopes of Al* at comparable excitation energy E^*_{CN} ∼44MeV, compared with the experimental data [3].

where, $\mu = [A_1A_2/(A_1 + A_2)]m$ is the reduced mass, with m as the nucleon mass and ℓ_{max} is the maximum angular momentum where light particles cross section $\sigma_{LPs} \to 0$. P is the penetrability of interaction barrier (of the preformed clusters with preformation probability P_0), calculated as the WKB tunneling probability, around the Coulomb barrier. The P_0 is obtained by solving the stationary Schrödinger equation in η, at a fixed $R = R_a$.

Calculations and discusions

Figs. 1 (a) and 1(b) show, respectively, the fragmentation potential and preformation probability for the decay of ^{26,27,28,29}Al* into LPs for deformed nuclei at an excitation energy E^*_{CN} ∼44 MeV. LPs having mass A=1 (i.e.^1n for ^{27,28,29}Al* and ^1H for ^{26}Al*) are more favored as compared to other fragments. In Fig. 1(a) we see that ^1n or ^1H are minimized as compared to other LPs, which means that these have higher preformation probability among all the LPs, as shown in Fig. 1(b). Thus, in all isotopes of Al*, A=1 contributes more for the corresponding ERs cross section in comparison to their neighbors. As we see in Fig. 1(a) the potential energy surface (PES) lies lower with increase in mass of the compound system. Hence, the preformation probability is more for heavier mass compound nuclei, as we can see in Fig. 1(b).

Despite some common features in the decay of the compound systems ^{26,27,28,29}Al*, the neutron addition effect in these isotopes is quite evident from the fragmentation potential. Fig. 1 shows that in case ^{26,27,28}Al*, ^{4}He is emitted, whereas in case of ^{29}Al*, ^{4}H is emitted. Moreover, n-decay with different masses from heavier or neutron rich isotopes of Al* is quite evident i.e. neutron emission is stronger for these Al* composite systems.

The calculated evaporation residue cross section (σ_{ERs}) is presented in Fig. 2 for ^{26,27,28,29}Al* in comparison with the available experimental data [3]. We find that σ_{ERs} are in good agreement with the experimental data. It may be reminded here that deformations of the interacting nuclei are taken upto quadruple deformations. For ^{26,27}Al* systems spherical considerations lead to better comparisons with the experimental data. This work is now being extended to ff cross sections, in addition to ERs at different excitation energies.

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