Sn radioactivity of lanthanide nuclei using Skyrme density energy formalism*

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Theoretically predicted in 1980, the phenomenon of cluster radioactivity which involves the spontaneous emission of particles heavier than the alpha particle, was experimentally observed in 1984. The search for more possible cluster emissions is currently ongoing, however numerous clusters from light to heavy region including ^{14}C, ^{20}O, ^{23}F, ^{22,24,26}Ne, ^{28,30}Mg, and ^{32,34}Si have been experimentally detected from a number of actinides ranging from Z = 87 to 96. Knowing the significance of shell effects in the trans-lead region, it was predicted [1] that the trans-tin domain would also be a promising area for the potential existence of cluster radioactivity. Here, the role of closed shell daughters like ^{100}Sn or ^{132}Sn and their nearby neighbors may strengthen the likelihood of cluster emission. To explore this region, ground state (T = 0) decays of $^{108\text{-}116}$Xe, $^{112\text{-}120,146}$Ba, $^{116\text{-}124,152}$Ce, $^{120\text{-}130,156}$Nd, $^{124\text{-}130,160,162}$Sm and $^{128\text{-}136,166}$Gd nuclei have been analyzed in [2]. It has been observed that while neutron-rich radioactive nuclei decay by emitting clusters with a non-alpha-like structure, $A_2 = 4n+2$, regardless of the choice of spherical or deformed fragmentation, neutron-deficient parents emit with an alpha-like structure ($A_2 = 4n$) cluster along with doubly magic ^{100}Sn [2]. This study is conducted with preformed cluster model (PCM) [3], in which clusters of different sizes are preformed in the parent nucleus with different formation probability.

Motivated by the above analysis [2], here in the present work, we intend to investigate the ground state of even isotopes of lanthanide parents $^{120\text{-}124}$Ce, $^{124\text{-}128}$Sm, $^{130\text{-}132}$Gd using the Skyrme energy density formalism (SEDF) [4]. It may be noted that the Blocki-based nuclear potential [5] was employed in the previously published work [2], however the density-based formalism (SEDF) [4] is used in the current study. Within SEDF, SIII force is applied to obtain the cluster decay half-lives ($\log_{10} T_{1/2}$) for the considered parents. The explicit role of deformation and orientations is also studied by comparing the results with the spherical case. The calculations suggest least $\log_{10} T_{1/2}$ for the choice of deformed configuration in comparison to spherical case. Such a study emphasizes the significance of deformation effects in determining the clusterization process and hence will provide a testing ground for the future experiments on cluster decay studies in trans-tin region.

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