Competition between d/t-capture and α-capture in $^6,^7\text{Li}^+124\text{Sn}$ and $^6,^7\text{Li}^+159\text{Tb}$ reactions

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Introduction

In our recent work, we have shown some remarkable differences in individual ICF channel cross-sections in $^6,^7\text{Li}$ induced nuclear reactions [1]. It is observed that the cross-sections for deuteron-capture are of similar magnitude as the α-capture, in case of $^6\text{Li}$ projectile, while the triton-capture is dominant than α-capture in case of $^7\text{Li}$ projectile. Intuitively, we expect this behavior as triton while approaching the target sees lower Coulomb barrier compared to alpha particle approaching the target, hence the cross-section for t-capture is more compared to α-capture in case of $^7\text{Li}$ projectile. Intuitively, we expect this behavior as triton while approaching the target sees lower Coulomb barrier compared to alpha particle approaching the target, hence the cross-section for t-capture is more compared to α-capture in case of $^7\text{Li}$ projectile. Intuitively, we expect this behavior as triton while approaching the target sees lower Coulomb barrier compared to alpha particle approaching the target, hence the cross-section for t-capture is more compared to α-capture in case of $^7\text{Li}$ projectile.

Experimental details

The online and offline gamma ray measurements were carried out at 14UD BARC-TIFR Pelletron-Linac accelerator facility, Mumbai. The targets of $^{124}\text{Sn}$ were bombarded with $^6,^7\text{Li}$ beams while $^{159}\text{Tb}$ was bombarded with $^6\text{Li}$ beam. In the online gamma measurement, a Compton suppressed clover detector placed at a distance of 25 cm from the target centere, at 125°, was used for the estimation of absolute cross section of populated reaction channels. In the offline gamma measurement, the targets with Al catcher (∼1 mg/cm$^2$ thick) were placed normal to the beam direction so that the recoiling residues are stopped in target-catcher assembly and irradiated for 7-18 hrs. The irradiated target-catcher assembly was then stuck to the perspex sheet and the sheet was kept at a fixed distance (∼10 cm) in front of the HPGe detector. The HPGe detector was surrounded by 2 mm thick Cu and Cd sheets and 5 cm thick Pb sheets to reduce the background. The energy calibration and absolute efficiency of both Clover and HPGe detector was carried out by using a set of calibrated radioactive $^{152}\text{Eu}$, $^{133}\text{Ba}$ and $^{241}\text{Am}$ sources placed at the same geometry as the target.

Results

The extracted cross-sections for α-capture and d-capture/t-capture for $^{6,7}\text{Li}^+124\text{Sn}$ are plotted in Figs. 1 (a-d). The available α-capture and t-capture data for $^7\text{Li}^+159\text{Tb}$ is taken from Ref. [2] and plotted in Figs. 2(a) and (c). The d-capture data was available for $^6\text{Li}^+159\text{Tb}$ in Ref. [3]. For α-capture, we have extracted the cross-sections from measured offline gamma data and plotted in 2 (b) and (d).

In Figs. 1 and 2, we have plotted the results for $^{6,7}\text{Li}^+124\text{Sn}$ and $^{6,7}\text{Li}^+159\text{Tb}$ reactions. As can be seen from the figures, (a) and (b) the α-capture is less than the t or d-capture at all the measured energies. In Figs. (c)
FIG. 1: (a) Comparison of α-capture and t-capture cross-sections in 7Li+124Sn reaction (b) Comparison of α-capture and d-capture cross-sections in 6Li+124Sn reaction. Individual percentage contributions of α-capture and t-capture in 7Li and d-capture 6Li is shown in (c) and (d) respectively.

(d), we have plotted the percentage contribution of α-capture and t-capture/d-capture. It is observed that for 7Li, t-capture is almost constant at all the energies and consumes 90% of Total ICF while α-capture only contributes 10%. For 6Li, d-capture contribution in Total ICF decreases with increasing energy while α-capture increases with energy. Also the d-capture contribution varies from 92-76% in Total ICF from lowest to highest energy. This feature is not seen with heavy targets like 209Bi and 197Au, where α-capture and d-capture have similar contribution in Total ICF [1]. More α-capture and d-capture data is required with 6Li projectile for detailed understanding.

Summary and Conclusion

In summary, from the available experimental data, we have highlighted the differences in individual ICF cross-sections for 6Li and 7Li projectiles on 124Sn and 159Tb targets. The individual ICF cross-sections imply that the d/t-capture cross-section is more than α-capture cross-section for both the targets contrary to observation made with 209Bi, 197Au and 198Pt [1]. It is also observed that the t-capture cross-section is consuming more than 90% of Total ICF for 7Li+124Sn and 7Li+159Tb reactions at all the measured energies. In the case of 6Li+124Sn and 6Li+159Tb reactions, d-capture cross-section decreases from 92% to 76 % while α-capture cross-section increases from 8% to 24 % from below to above barrier energies. More data of d-ICF, α-ICF and t-ICF simultaneously for various systems is required for systematic understanding of ICF.

References


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