Fusion and transfer studies in ^{7}Li+^{124}Sn reaction by offline gamma counting technique

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Introduction

The fusion of stable weakly bound nuclei (^{6,7}Li, ^{9}Be, and ^{10,11}B) on light, medium and heavy mass targets has given some interesting conclusions about systematics of fusion suppression factor over a target mass range [1]. In continuation of this activity, we have recently carried out measurement of fusion cross-sections for ^{7}Li+^{124}Sn reaction. In our previous paper [2], We have reported the cross-sections for Evaporation Residues (ER) measured around the Coulomb barrier energy from online gamma ray technique. The dominant ERs from complete fusion (CF) are $^{126-128}$I (3n-5n). Since all these residues are odd-even nuclei, the total cross-section for the particular ER was extracted by adding all the gamma-ray cross-sections feeding the ground state of that ER. Hence, there is slight unambiguity in measured cross-sections because of incomplete level scheme as well as weak feeding transition strengths. The most reliable method for extracting the residue cross-sections is by offline gamma counting, if the residues are unstable. In the present case, ^{128}I (3n) and ^{126}I (5n) along with the ERs from Incomplete fusion (ICF), viz. ^{124}Sn(t,3n)^{124}Sb, ^{124}Sn(t,1n)^{126}Sb and transfer products ^{125}Sn (1n pickup) and ^{123}Sn (1n stripping) decay to daughter nuclei by beta emission with measurable half-lives. Hence we carried the offline gamma measurement at few energies for unambiguous extraction of these residues.

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TABLE I: List of identified residues in the ^{7}Li+^{124}Sn reaction along with their radioactive decay half-lives ($T_{1/2}$), γ-ray energies and intensities following their decays.

Reaction	ER	$T_{1/2}$	E_γ (keV)	I_γ (%)
^{124}Sn(^{7}Li,3n)	^{128}I	24.99 min	442.9	12.6
			526.6	1.2
^{124}Sn(^{7}Li,5n)	^{126}I	12.93 d	388.6	35.6
			753.8	4.2
^{124}Sn(t,1n)	^{126}Sb	12.35 d	414.7	83.3
			573.9	6.7
			593.2	7.5
			720.7	53.8
			856.8	17.6
^{124}Sn(t,3n)	^{124}Sb	60.20 d	602.7	97.8
			1690.97	47.6
^{124}Sn(^{7}Li,^{6}Li)	^{125}Sn	9.52 min	331.94	97.3
^{124}Sn(^{7}Li,^{8}Li)	^{123}Sn	40.06 min	160.32	85.7

Measurement Details

The experiment was performed at 14UD BARC-TIFR Pelletron accelerator, Mumbai using ^{7}Li beam incident on ^{124}Sn target. Five targets having thicknesses in the range of 1.5-2.5 mg/cm^2 were used at five different bombarding energies of 18.8, 24.8, 28.8, 33 and 35.9 MeV matching with that of previously measured online gamma measurement. Each target followed by Al catcher foil (1 mg/cm^2 thick) was irradiated for $\sim$ 6-10 hrs. The irradiated targets+catcher assembly was then placed in front of energy calibrated HPGe detector for gamma counting. The residues from fusion and transfer reactions were identified by their characteristic gamma lines as shown in Fig. 1 and listed in Table I.

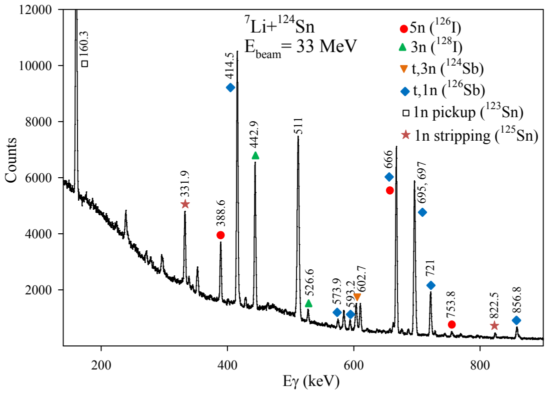

FIG. 1: Typical offline γ-ray spectrum obtained in ^{7}Li+^{124}Sn reaction at projectile energy E_{lab} = 33 MeV. Identified gamma lines from different residues are marked with symbols.

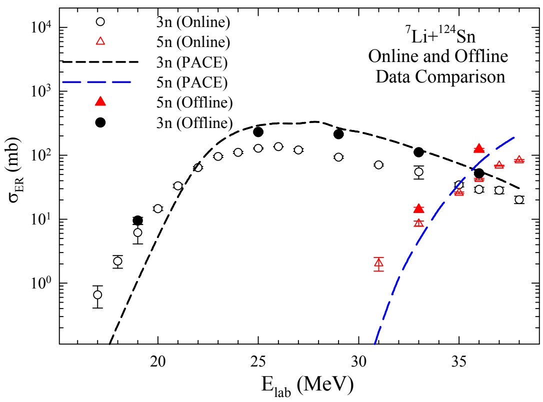

FIG. 2: Comparison of ER cross-sections from online and offline gamma measurements in ^{7}Li+^{124}Sn reaction. The lines are from the statistical model calculations.

Results and Conclusion

The residue cross section (σ_R) at a particular beam energy E was obtained using the expression as follows:

$$\sigma_R = \frac{Y\lambda}{(1-e^{-\lambda t_{irr}})(1-e^{-\lambda \Delta t})(e^{-\lambda t_{cool}})(N_T N_P I_\gamma \varepsilon)}$$

where, Y is the area under the γ-peak acquired during the interval Δt corresponding to the residual nucleus with decay constant λ, t_{irr} is the time duration for irradiation, N_T is the number of target nuclei per unit area, N_P is the number of projectile nuclei incident on the target per unit time, t_{cool} is the time elapsed between the end of irradiation and start of counting, ϵ is the efficiency of the HPGe detector at the peak energy and I_γ is the intensity branching ratio associated with the particular gamma line corresponding to the residual nucleus.

The cross-sections from the present (offline) measurement and the previously measured (online) data are compared in Fig. 2 along with the statistical model predictions, the details of which are given in our previous paper [2]. As can be seen from Fig. 2, that there is slight discrepancy in measured cross-sections from two methods. Hence, finally we will normalize the online ER cross-sections to that of offline data and get the correct excitation function. Remaining data analysis of ICF/transfer channels from both online and offline data is under progress.

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