# Systematic study of alpha induced reactions at low excitation energies: Analysis of excitation functions

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Recent observations of pre-compound (PCN) emission even at relatively low incident energies where compound nucleus (CN) process dominates, has renewed interest in the study of reaction dynamics. The pre-compound reaction may be understood as a process in which emission of particles takes place at any stage during the redistribution of energy of the incoming particle amongst the nuclear degrees of freedom through a chain of particle-hole excitations well before the establishment of statistical equilibrium[1, 2]. The particles which are emitted well before to the establishment of statistical equilibrium are known as pre-compound or pre-equilibrium particles[3].

Although, there are several methods available to study the PCN process but the measurement and analysis of excitation functions (EFs) is well suited and is widely used to determine the contribution of PCN process. It is because of the fact that features of the EFs at the low, medium and high energies may give information about the reaction mechanism involved. The low energy portion of the EFs is dominated by the CN mechanism, however, with the increase in projectile energy, the strength of the PCN process becomes relatively more.

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Though, a large amount of data on the PCN emission is available in literature, but no systematics on this process with mass of target is available . With the motivation to develop a systematics for PCN process, a detailed analysis of EFs for reactions $^{139}$La($\alpha$, $n$)$^{142}$Pr, $^{159}$Tb($\alpha$, $n$)$^{162}$Ho, $^{181}$Ta($\alpha$, $n$)$^{184}$Re, $^{197}$Au($\alpha$,$n$)$^{201}$Tl, and $^{203}$Tl($\alpha$, $n$)$^{206}$Bi, respectively has been performed. It may be pointed out that EFs for reaction $^{179}$Au($\alpha$,$n$)$^{182}$Tl has been measured by our group by using stacked foil activation technique, while the cross-section data of other reactions has been taken from EXFOR data library[4]. The analysis of the measured EFs for above reactions has been performed with PACE and ALICE codes.

The contribution of PCN in each reaction has been deduced in terms of pre-compound fraction($F_{PCN}$) which is the ratio of the difference of the cross-sections for (PCN+CN) emission and the CN cross-sections to the cross-section values of (PCN+CN). In oder to get a systematics on the pre-compound emission, the effect of various parameters have been studied. It has been found that the excitation energy per nucleon available at the surface $E_S$ of composite system ($E_S = \mathrm{E}^*/\mathrm{A}^{2/3}$) may be a important and sensitive parameter which influences the PCN process. The deduced values of "$F_{PCN}$" for different mass number of target nuclei as a function of $E_S$ for the reactions $^{139}$La($\alpha$, $n$)$^{142}$Pr, $^{159}$Tb($\alpha$,

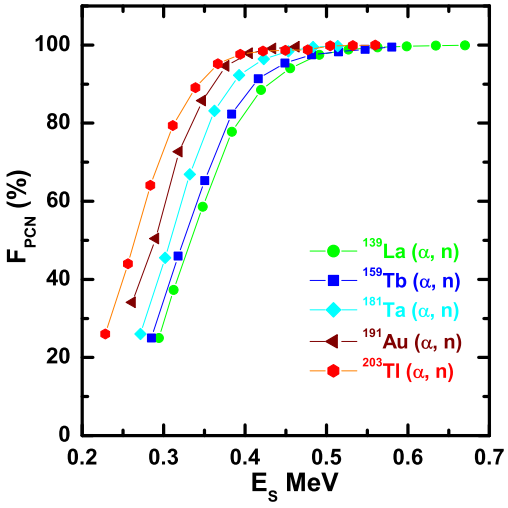


FIG. 1: The contribution pre-compound emission '$F_{PCN}$" as a function of excitation energy $E_S$ for the reactions $^{139}$La($\alpha$, $n$)$^{142}$Pr, $^{159}$Tb($\alpha$, $n$)$^{162}$Ho, $^{181}$Ta($\alpha$, $n$)$^{184}$Re, $^{197}$Au($\alpha$,$n$)$^{200}$Tl, and $^{203}$Tl($\alpha$, $n$)$^{206}$Bi, respectively.

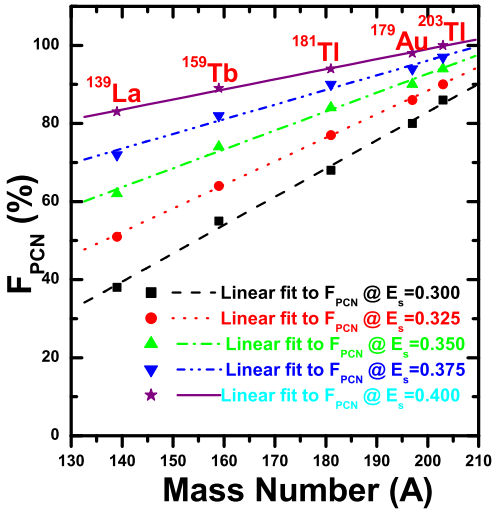


FIG. 2: The contribution pre-compound emission '$F_{PCN}$" as a function of mass number of the target nuclei with excitation energy $E_S$ for the reactions $^{139}$La($\alpha$, $n$)$^{142}$Pr, $^{159}$Tb($\alpha$, $n$)$^{162}$Ho, $^{181}$Ta($\alpha$, $n$)$^{184}$Re, $^{197}$Au($\alpha$,$n$)$^{200}$Tl, and $^{203}$Tl($\alpha$, $n$)$^{206}$Bi, respectively.

$n$)$^{162}$Ho, $^{181}$Ta($\alpha$, $n$)$^{184}$Re, $^{197}$Au($\alpha$,$n$)$^{201}$Tl, and $^{203}$Tl($\alpha$, $n$)$^{206}$Bi have been plotted and are shown in Fig. 1. As can be seen from this figure that a systematic trend of the "$F_{PCN}$" with mass number and $E_S$ has been achieved. This refers that in the PCN emission process all the nucleons of the composite system are not involved but nucleons on the surface may influence it more.

The conclusions drawn from above study may provide a new systematics for complex PCN process in $\alpha$ induced reactions and has been clearly shown in Fig. 2. The Fig. 2 shows variation of pre-compound fraction ("$F_{PCN}$") with mass number of target nuclei ($A$) at five different values of the excitation energy per nucleon $E_S$(=0.300, 0.325, 0.350, 0.375 and 0.400 MeV, respectively) available at the surface of composite systems. As can be seen from this figure that "$F_{PCN}$" increases linearly with mass number ($A$) of the target nuclei at each value of $E_S$ for presently studied systems. Further details of the analysis and systematics developed will be presented.

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