# Reaction mechanism studies in some $^{28}Si + ^{54}Fe$ systems

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## Introduction

There are different reaction mechanisms in heavy ion reactions at energies well above the coulomb barrier. At moderate excitation energies, however, there are indications that pre-equilibrium emission also contributes to the reaction processes. Many measurements have shown the importance of complete and incomplete fusion as well as of pre-equilibrium emission and compound nucleus processes in heavy ion reactions at energies around the coulomb barrier [1,4]. The main objective of this study is to understand different reaction mechanism of heavy ions on a medium target nucleus. This is accomplished by the study of the excitation functions of the residues produced in the system $^{28}Si + ^{54}Fe$. Excitation functions for five $^{54}Fe$ ( $^{28}Si$ , 2p) $^{80}Sr$; $^{54}Fe$ ( $^{28}Si$ ,3p)$^{79}Rb$; $^{54}Fe$( $^{28}Si$ , 2p+n )$^{79}Sr$; $^{54}Fe$ ( $^{28}Si$, )$^{78}Sr$, and $^{54}Fe$ ( 28Si , 2n) $^{76}Kr$ reactions produced in the $^{28}Si$ + 54Fe system have been measured in the energy range ≈75-130 MeV to study complete fusion, incomplete fusion reactions, compound, pre-compound and direct directions in heavy ion reactions. The measured excitation functions extracted from EXFOR data source are compared with theoretical calculations obtained using the computer programs PACE4 and COMPLET [2, 5].

## Methodology

PACE4 evaluates the cross-sections for evaporation residues formed in the complete fusion reaction process of the projectile with the target without taking the incomplete fusion reaction process into account. COMPLET evaluates the cross-sections for compound and pre-compound reaction process. In the present work, measured CSs for five reactions were taken from literature and CSs have been compared with theoretical predictions based on PACE4 and COMPLET codes. Here the nuclear level density parameter (LDP) is an important ingredient in the statistical model calculation of nuclear cross section for the codes PACE4 and COMPLET whereas the Exciton number and mean free path (MFP) multiplier in the pre-equilibrium model calculation only for COMPLET code. The analysis of the results from theoretical predictions and experimental findings obtained from EXFOR data source using uniform parameters for all five reactions has been discussed. Finally, conclusions are drawn from the comparisons and analysis of graphs of excitation functions on the reaction mechanisms.

## Results and discussion

Nuclear reaction mechanism for five reactions produced in the interaction of $^{28}Si + ^{54}Fe$ system have been studied in the projectile energy range ≈75-130 MeV. Experimentally measured cross-sections extracted from EXFOR data source have been compared with the theoretical values calculated using the computer programs COMPLET and a statistical model based Monte-Carlo simulation code PACE4. Most suitable parameters have been chosen in the computer codes to best fit the measured excitations functions. CF, ICF, Compound and Pre-Compound reaction mechanism have been studied to analyse the data. It has been observed that for emitting channels, the experimental excitation functions exhibit a significant enhancement in the production cross-section. For 2p, 3p channels direct reaction mechanism dominates in the energy range 75-130 MeV. For 2p+n channel CF reaction mechanism has been observed in the energy range 80-90 MeV. No signatures of equilibrium and pre-equilibrium have been observed for the system in the energy range 75 to 130 MeV. Complete fusion,

Table 1. Theoretical and Measured cross-section for the $^{54}$Fe ( $^{28}$Si , 2p+ n ) $^{79}$Sr

| Energy (MeV) | σ – experimental (mb) | σ – PACE4 (mb) | σ – compound (mb) | σ – pre-compound (mb) |
|---|---|---|---|---|
| 75 | 17.1 | - | 14.8 | 18.5 |
| 80 | 35.3 | 27.6 | 73.3 | 73.3 |
| 85 | 56.8 | 64.8 | 113 | 113 |
| 90 | 98 | 81.3 | 126 | 126 |
| 95 | 106 | 54,4 | 121 | 121 |
| 100 | 80 | 25.1 | 119 | 119 |
| 105 | 70.2 | 9.32 | 113 | 113 |
| 110 | 36 | 3.02 | 111 | 113 |
| 115 | 17.3 | 0.538 | 103 | 102 |
| 120 | 11.6 | 0.317 | 99.5 | 99.4 |
| 125 | 6.3 | 0.0628 | 99.4 | 99.3 |
| 130 | - | - | 96.3 | 96.2 |

incomplete fusion and direct reaction emission processes play important roles in heavy ion reactions at these energies.

The excited CN formed from fusion of $^{28}$Si with $^{58}$Fe emits two protons and a neutron subsequently during de-excitation. From the figure 1 it can be seen that the theoretically obtained, especially PACE4, results are comparable to the experimentally measured data in the energy range 80-90 MeV showing some signs of CF reaction but above 90 MeV energy there is a large disparity between theoretically obtained cross-section and measured cross section. This may be due to direct reaction mechanism. Cross section due compound and pre-compound reaction mechanism also do not match with experimentally measured cross sections. So there is no signature of compound and pre-compound reaction mechanism in the energy range of 75 to 125 MeV.

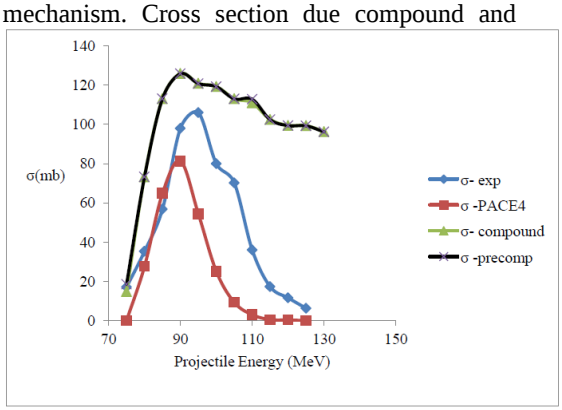


Fig1. Theoretical and measured cross section for the reaction $^{54}$ Fe( $^{28}$Si, 2p+n) $^{79}$Sr

## References

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