Evidence of partial linear momentum transfer in ^{20}Ne + ^{51}V system at energy 7 MeV/nucleon

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Introduction

During last few years, there is an emergence of interest to study the nuclear reaction using the light heavy ions (Z $\leq$ 10)[1]. There are several reaction mechanism which are important in interactions involving light heavy ions, even at energies as low as 5 MeV per nucleon. These processes may be broadly classified into complete fusion (CF) and incomplete fusion (ICF) in terms of degree of momentum transferred from projectile to the target in first stage of reaction. In 1961, Britt and Quinton[2] observed, in reactions of ^{12}C, ^{14}N and ^{16}O with heavy targets, in addition to the spectrum of α particles evaporated from the compound nucleus, a significant yield of α particles emitted at forward angles with velocities close to that of the beam; these have generally been attributed to breakup of the incident projectile in peripheral collisions. Since then, breakup processes have been observed in several systems at low energies. For a particular reaction, measurement of the recoil velocity of the heavier product, or, equivalently, its recoil range distribution (RRD) in some stopping medium, can be used to determine the degree of momentum transferred from projectile to the target. RRD proves to be an important technique to distinguish these different ICF processes involving light heavy ion where the same product may be formed by more than one fusion process, followed by different degrees of charged particle evaporation in the deexcitation process.

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Experimental details

Beam of $^{20}Ne^{6+}$ at 145 MeV from Variable Energy Cyclotron Centre (VECC), Kolkata, was used for the study of RRD using ^{51}V target. The target used was foil of ^{51}V, 99.97% pure, mounted normal to beam axis. The target was placed in a stack consisting of ^{51}V foil followed by a series of thin Al-catcher foils to trap the recoiling residues. For irradiation, the target consisted of $\approx$ 250 μg/cm^2 ^{51}V evaporated onto a support of 200 μg/cm^2 Al. This target was mounted with the Al support facing towards the incident beam, followed immediately by a stack of 12 thin Al-catcher foils, each of thickness between 200 to 250 μg/cm^2. The thickness of each Al-catcher foil and target had been determined prior to use by weighing as well as by α-transmission method. The $^{20}Ne^{6+}$ beam was collimated to a spot of diameter 8 mm and the stack was irradiated with beam current varying between $\approx$ 15-20 nA for $\approx$ 11 hrs. Following the irradiation, the catcher foils were counted using HPGe detector coupled to a PC based data acquisition system developed by VECC, at interval over a period from about 25 min after irradiation up to few days later. The γ-ray spectroscopy software package RADWARE has been used for analyzing the spectrum. Details of the formulations and data reduction procedures used in the present work are similar to those outlined in the work of Ahmad *et al.* [3].

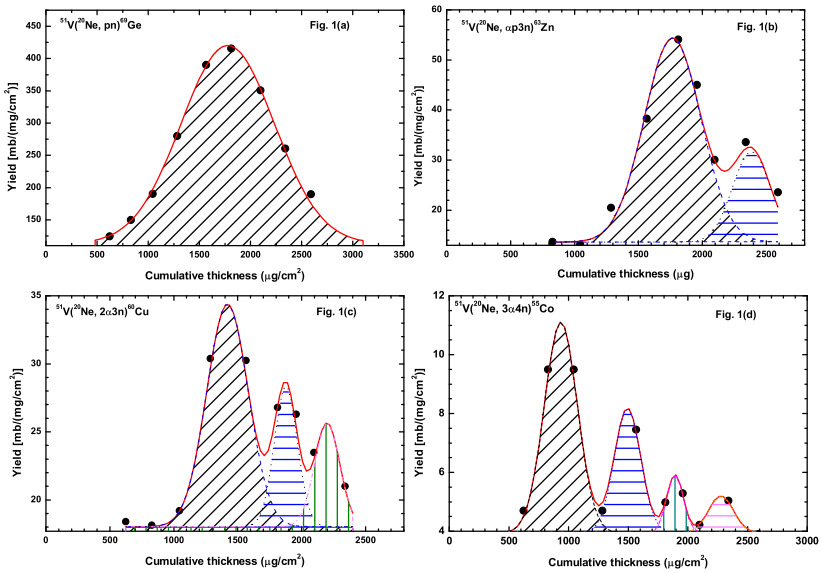

FIG. 1: RRD of ^{69}Ge, ^{63}Zn, ^{60}Cu, and ^{55}Co populated via pn, $\alpha p3n$, $2\alpha 3n$, and $3\alpha 4n$ channels respectively at $\approx$ 143 MeV.

Results and Discussion

The identification of the trapped recoiling reaction products in the Al catcher foils were made by their characteristic γ-radiations as well as by measuring their half-lives. The production cross sections (σ_{ER}) for identified reaction products were computed using the standard formulation given in Ref.[3]. In order to obtain the normalized yields as a function of cumulative depth in the Al stopping medium, the cross section of the reaction products in each catcher foil was divided by its thickness. The resulting normalized yields have been plotted against cumulative catcher foil thicknesses to obtain the recoil range distributions for the identified residues namely ^{70}As(n), ^{69}Ge(pn), ^{66}Ge($p4n$), ^{66}Ga(αn), ^{65}Ga($\alpha 2n$), ^{63}Zn($\alpha p3n$), ^{62}Zn($\alpha p4n$), ^{61}Co($2\alpha 2p$), ^{61}Cu($2\alpha 2n$), ^{60}Cu($2\alpha 3n$), ^{56}Mn($3\alpha 2pn$), and ^{55}Co($3\alpha 4n$). As a representative case, to show CF and ICF components, the RRDs for ^{69}Ge(pn), ^{63}Zn($\alpha p3n$), ^{60}Cu($2\alpha 3n$), and ^{55}Co($3\alpha 4n$) residues have been presented in Figs. 1(a-d), at lab energy $\approx$ 143 MeV. A good agreement was observed between the experimental and theoretically calculated most probable range using code SRIM[4].

Conclusion

The RRDs of total twelve residues populated in ^{20}Ne + ^{51}V reaction at $\approx$ 143 MeV have been measured. The analysis of the measured RRD of reaction products reveals a contribution from partial linear momentum transfer of the projectile associated with ICF in α emitting channels.

References

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