Excitation functions for some Ne induced Reactions with Holmium: Incomplete Fusion Vs Complete Fusion

Avinash Agarwal[1*], Munish Kumar[1], I. A. Rizvi[2], Anjali Sharma[1], Tauseef Ahamad[2], S. S. Ghugre[3], A. K. Sinha[3] and A. K. Chaubey[4]

[1]*Department of Physics, Bareilly College, Bareilly - 243005, INDIA*
[2]*Deptartment of Physics, Aligarh Muslim University, Aligarh – 202002, INDIA*
[3]*UGC-DAE Consortium for Scientific Research, III/LB-8, Bidhan Nagar, Kolkata - 700098, INDIA*
[4]*Deptartment of Physics, Addis Ababa University, P.O. Box 1176, Addis Ababa, ETHIOPIA*
** Email: avibcb@gmail.com, avi_ag@rediffmail.com*

Introduction

Recently appreciable efforts have been devoted to study heavy ion induced reactions at incident energies from coulomb barrier to about 7 MeV/A [1 – 4]. Reactions induced by light particles are better known both from a theoretical and an experimental point of view. However the knowledge in the case of heavy ion induced reactions is much less systematic and often essential experimental information is lacking, which is in fact of great importance due to their increasing applications in interdisciplinary fields such as hadrontherapy [5] and space radiation protection [6]. It is now well established that different reaction mechanisms, more particularly complete fusion (CF) and incomplete fusion (ICF) contribute to reactions induced by heavy ions at rather low energies.

The complete fusion (CF) involves full momentum transfer while in incomplete fusion (ICF) only a part of the projectile fuses with the target, leading to partial momentum transfer of the incident momentum while the remainder behaves essentially as a spectator. Recent reports show the breakup of ^{12}C, and ^{16}O, projectile into ^{4}He, ^{8}Be and ^{12}C projectile fragments and their subsequent fusion with the target [1 – 4]. Reactions induced by ^{20}Ne are expected to be considerably more complex than those of ^{12}C, and ^{16}O. As a part of our ongoing program to understand CF and ICF reaction mechanisms, it is of great interest to see whether the same experimental technique yield similarly valuable information for ^{20}Ne induced reactions. In this present work we have made an attempt to measure the excitation functions for fifteen evaporation residues (ERs) identified in the interaction of ^{20}Ne + ^{165}Ho system in the energy range 4 -7 MeV/A.

Experimental details

The experiment was performed at Variable Energy Cyclotron Centre (VECC) Kolkata. The self supporting targets of ^{165}Ho of thickness ~1.3 mg/cm^2 were made by rolling at Target lab of Inter University Accelerator Centre (IUAC), New Delhi. The stacks comprising of target foils and suitable Aluminum energy degrader foils were irradiated using a special arrangement made for this purpose for about 8 hrs. The beam current as well as the total charge collected was used for the incident flux calculations and good agreement was found between both. After irradiation the activities produced in the target catcher assembly were followed offline using pre-calibrated HPGe detector with associated electronics and data acquisition system just after few minutes and continued for two weeks. The various ERs were identified by their characteristics γ-rays and decay curve analysis. The Detailed analysis of the data was done using CANDLE software developed by IUAC for nuclear data analysis. Nuclear data like half-lives, gamma ray energies, branching ratio etc has been adopted from Table of Radioactive Isotopes by Brown and Firestone [7]. The excitation functions for various evaporation residues have been calculated using the home made software based on the formulation given elsewhere [4].

Results and Discussion

The excitation functions for fifteen ERs populated through (Ne, p2n), (Ne, p3n), (Ne, α), (Ne, α2n), (Ne, αp3n), (Ne, αp4n). (Ne, αp6n), (Ne, αp6n), (Ne, 2α), (Ne, 2αn), (Ne, 2α2n), (Ne, 2α3n), (Ne, 2α4n), (Ne, 2αp3n) and (Ne, 4α3n) have been measured in the energy range 4 MeV/A – 7 MeV/A. It is important to mention here that there is extensive feeding of many of the observed radionuclide by beta decay precursors. Meaningful results can be obtained only if the half-lives of the precursors are shorter than that of the observed product to a sufficient extent that the detected yield can be treated as the cumulative chain yield including precursors.

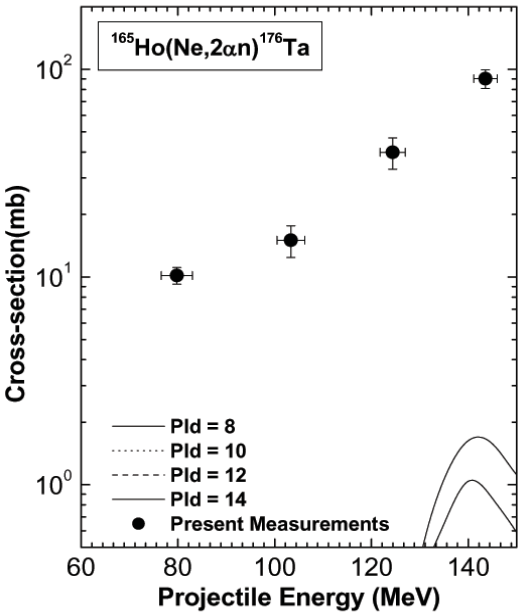

Fig.1. Experimentally measured and theoretically predicted EFs of (2αn) channel

In this present work the independent yield of various evaporation residues has been obtained using the formulation proposed by Cavinato *et. al* [8]

The measured values have been compared with the theoretical predictions obtained from statistical model code PACE-4[9]. The sensitivity of production cross-sections in PACE-4 over level density parameter (PLD) has also been studied. As a representative the excitation functions for (Ne, 2αn) channel are shown in Fig.1. It is observed that for alpha emission channels the measured EF's are much higher than the theoretically predicted values demonstrating that these residues are populated not only by complete fusion process alone, but some other dynamics is also involved which may be Incomplete fusion. The details of the study is planned to be presented in symposium.

Conclusion

The comparative study of experimentally measured EFs with theory show considerable enhancement in cross-sections for some isotopes indicating that the process other than Compound nucleus decay play important role in the production of these residues. This large difference gives clear signature that the role of ICF for these channels is important in the considered energy range, which can be further established by Recoil Range Distribution (RRD), particle gamma coincidence measurements and spin distribution studies.

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