Fusion studies in ^{19}F + ^{165}Ho

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Introduction

The phenomenon of fusion hindrance, observed initially in symmetric systems involving medium-heavy nuclei at deep sub-barrier energies, has inspired current activities related to challenging low cross-section measurements [1, 2]. Theoretical models suggested to explain this behavior have different physical basis [3, 4]. However fusion hindrance is a generic property of heavy-ion collision below certain threshold energy in all the models. The data corresponding to asymmetric systems, presently scarce [5–7], are important to understand the origin of the fusion hindrance and to establish the generic nature of this phenomenon.

We have recently investigated the evolution of the fusion hindrance as a function of increasing mass and charge of relatively light projectiles (both weakly bound and stable) on heavy targets [7]. A sensitive off-beam-γ-spectroscopy method to obtain the cross-section of residues from fusion, utilizing a coincidence between characteristic KX-rays and γ-rays from the daughter nuclei, has been developed for this purpose. It has been observed that the fusion hindrance gradually becomes larger in moving from lighter (^{6,7}Li) to heavier (^{11}B, ^{12}C, ^{16}O) projectiles [7]. This result has been interpreted employing the adiabatic model [3] that reveals a weak effect of the damping of coupling to collective motion for lighter projectiles as compared to that obtained for heavier projectiles. In order to extend our study to heavier projectile and to probe further the behavior of fusion hindrance observed in asymmetric systems, we have performed a measurement of fusion excitation function with ^{19}F beam on ^{165}Ho target. Measurements with ^{19}F beam have not shown presence of fusion hindrance so far. Fusion data for this system already exist at few energies near the barrier [8] and we have extended it to still lower energies.

Experimental Details and analysis

Measurement of the excitation function of residues resulting from fusion and direct reactions were performed for ^{19}F + ^{165}Ho using off-beam γ-ray counting method. The ^{165}Ho targets were irradiated with beams of ^{19}F from Pelletron-LINAC Facility-Mumbai in the range of 67 to 94 MeV. The targets were self supporting rolled foils of ^{165}Ho ($\sim$ 1.0 to 2 mg/cm^2 thick) followed by an Al catcher foil of thickness $\sim$ 1 mg/cm^2. Efficiency calibrated HPGe detector with an Al window was used for detecting γ-ray of the decay radiations from the irradiated sample. The measurements were performed in a low background setup with a graded shielding. The residues ($^{179-181}$Os) arising from fusion reaction were identified from the characteristic γ-radiation emitted by grand-daughter nuclei after decay of the daughter nuclei ($^{179-181}$Re), as branching ratio for decay to the daughter nuclei are not known in this case. A typical

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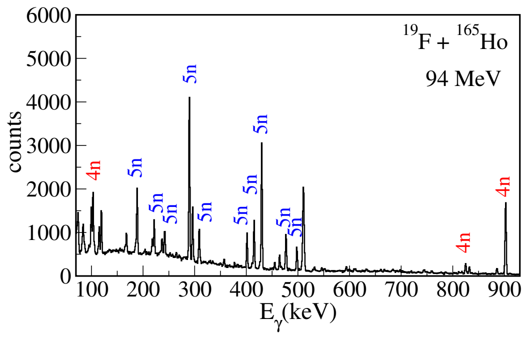

FIG. 1: An offbeam γ-ray spectrum following irradiation at 94 MeV. The labels on the γ peaks indicate the evaporation residue channels they arise from.

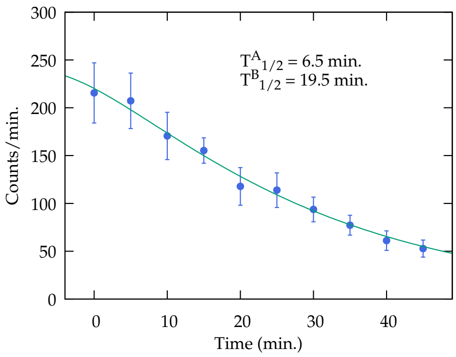

FIG. 2: Decay curve plotted for 430.24 keV transition from ^{179}W, obtained by fitting two components from decay of residue ^{179}Os to ^{179}Re with half life 6.5 minutes followed by decay of ^{179}Re to ^{179}W with half life 19.5 minutes.

gamma ray spectrum at beam energy of 94 MeV is shown in Fig. 1. The half lives were also followed to confirm the identification of the residues and ensure against any contamination of the γ-ray peak arising from other sources. Shown in Fig.2 is decay curve for 430.24 keV transition from ^{179}W, obtained by fitting two components from decay of residue ^{179}Os to ^{179}Re with half life 6.5 minutes followed by decay of ^{179}Re to ^{179}W with half life of 19.5 minutes. This γ-ray transition corresponds to 5n evaporation channel.

Fusion cross-section was obtained by summing neutron evaporation residue channels. Fission cross-section measured at higher energy was found to be negligible fraction of total fusion cross-section. The charged particle evaporation channels are predicted to be very small percentage (3-4 %) of the total and have not been considered. The fusion cross-sections obtained in the present work is found to be consistent with values obtained in reference [8] at overlapping energies. Fusion excitation function and its comparison with the coupled channels calculations will be presented.

Acknowledgments

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