Investigating Nuclear Reactions in ^{9}Be+^{116}Sn System Around the Coulomb Barrier Energies

Nancy Garg[1],[*] Rupinderjeet Kaur[1], Priyanka Raizada[1], Soni Devi[1], Katyayni Tiwari[1], Swati Thakur[1], V. Nanal[2], A. Shrivastava [3], S. Pal[4], S. K. Pandit[3], V. V.Parkar[3], Mahesh S. Pose[2], Mallikarjunachary [2], and Pushpendra P. Singh [1]
[1] *Department of Physics, Indian Institute of Technology Ropar, Rupnagar - 140 001, Punjab, India*
[2] *DNAP, Tata Institute of Fundamental Research, Mumbai - 400 005, India*
[4] *PLF, Tata Institute of Fundamental Research, Mumbai - 400 005, India and*
[3] *NPD, Bhabha Atomic Research Centre, Mumbai - 400 085, India*

Introduction

Nuclear reactions involving exotic/radioactive projectiles at energies around the Coulomb barrier offer widespread opportunities to explore different aspects of nuclear structure and dynamics [1]. The weakly bound nuclei, ^{6,7}Li, ^{9}Be, and ^{10,11}B, are often characterized by their low breakup threshold energies, α+x cluster structure, and the extended mass and radius distributions. The break up of these nuclei into constituent clusters may lead to a two-fold impact on reactions, which is (*i*) enhanced breakup probability that suppresses the fusion of the entire projectile with the target nucleus and (*ii*) reduced elastic scattering, which does not necessarily suggest a decrease in transmitted flux available for fusion probability at sub barrier energies. Further, if the breakup is treated as inelastic excitation to a bound state, it may enhance fusion cross-sections. However, it may cause attenuation in the incoming flux, which leads to suppression in fusion cross-sections if it is considered excitation into the continuum.

Withal, recent studies with ^{9}Be and ^{6,7}Li projectiles suggest substantial CF suppression at above barrier energies [1]. However, the underlying dynamics of CF suppression involving different weakly bound projectiles is not yet fully established. The fusion cross-sections of ^{9}Be induced reactions on light to heavy mass targets have been reported that the breakup of ^{9}Be projectile hinders the CF by the cross-sections deduced for the ICF [2], which is contrary to what has been found for ^{6,7}Li projectiles, where $\sim$ 20 % to 30% suppression have been observed irrespective of the target. CF suppression factor for ^{9}Be has been found to vary from 10 % to 40 % without any particular behavior for target, charge, or mass [3, 4]. In order to further investigate different aspects of nuclear reactions involving ^{9}Be+^{116}Sn system, an experiment was performed at energies 22.5 - 33.5 MeV at the Pelletron-Linac facility in Mumbai.

Experimental Details and Data Analysis

In this experiment, self-supporting target foils of ^{116}Sn ($\sim$ 1.9 - 2.1 mg/cm^{2}) were irradiated using ^{9}Be beam, keeping the beam current typically in the range of 10-35 pnA. Aluminum catcher foils of sufficient thickness, $\sim$ 2.5 mg/cm^{2}, were placed behind the targets to stop the recoiling evaporation residues during the irradiation. Beam current was recorded at 30 or 60-second intervals using a CAMAC scaler. The irradiated target-catcher foil assemblies were counted off-line using pre-calibrated high-purity Germanium detectors. The energy calibration and efficiency measurement of the detector was performed using a standard ^{152}Eu source. In order to reduce the ambient background and back-scattered gamma rays, the detectors were shielded with lead rings. At sub-barrier energies, the targets were counted in a close geometry (on the face

[*]Electronic address: nancy.22phz0004@iitrpr.ac.in

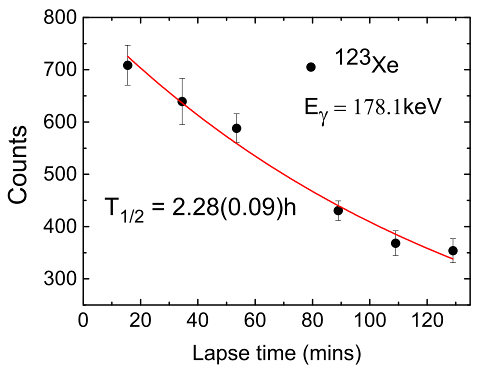

FIG. 1: Typical decay curve of ^{123}Xe evaporation residue expected to be populated via 2n-channel in ^{9}Be+^{116}Sn system. A half-life of 2.28 h is obtained by following Eγ-178.1KeV at E$_{lab}$ = $30MeV$, which is indicating the confirmation of ^{123}Xe residue.

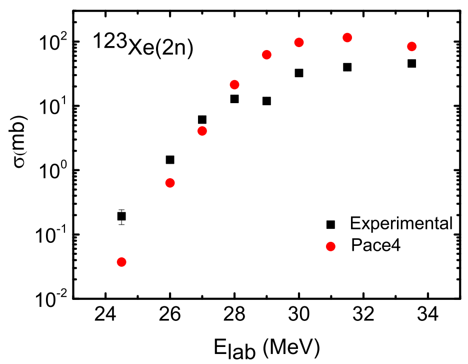

FIG. 2: The excitation function of ^{123}Xe(2n) channel populated in the ^{9}Be+^{116}Sn system. Symbols are self-explanatory

of the detector) to tackle the issue related to the reduced count rate. A digital data acquisition system employing a CAEN digitizer (14-bit ADC, 100MHz sampling rate) was used to record the data, and the offline data analysis was performed using LAMPS software.

The preliminary identification of the reaction products is carried out by identifying the characteristic γ-lines (Eγ) and confirmed by the decay curve analysis. The yield of a γ-line has been followed at particular beam energy with increasing lapse time from the stop of irradiation. Fig. 1 shows the yield of the γ-line plotted as a function of time, indicating a half-life of (2.28 $\pm$ 0.11 h), which corresponds to ^{123}Xe evaporation residue populated via emission of two neutrons (2n-channel) from the excited compound nucleus ^{125}Xe. The same procedure has been followed for the identification of other reaction products. The yields of characteristic gamma rays are used to extract the cross-sections following the procedure prescribed elsewhere [6]. The cross-sections of evaporation residues have been measured in the energy range of 0.8 - 1.2 V$_c$ (V_c =28.31MeV). From the preliminary data analysis, the excitation function (EF) of ^{123}Xe populated via 2n-channel is plotted in FIG.2. As seen in this figure, the cross-section of this channel drops steeply at lower energies. It shows substantial suppression at above-barrier energies, as expected. The detailed analysis of the data and its interpretation in the framework of theoretical model codes is underway. Conclusive evidences of fusion suppression and detailed results of the investigations will be presented during the symposium.

Acknowledgments

The authors would like to thank the Pelletron crew for the smooth operation of the accelerator during the experiment and, Mr. R. D. Turbhekar and Mr. Nitin for help in target preparation. One of the authors, N. Garg acknowledges the financial support given by the MoE and DST.

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