Incomplete fusion dynamics in ^{16}O + ^{154}Sm system by using particle gamma coincidence technique

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Introduction

The study of incomplete fusion (ICF) of heavy ions with different targets has been a topic of growing interest. In these reactions complete fusion (CF) and incomplete fusion (ICF) process are the dominant mode. In ICF reaction, only a part of projectile fuses with the target nucleus, while remaining part of projectile moves in the forward cone. In the complete fusion (CF) process, the projectile is completely fused with the target nucleus, forming a highly excited composite system from which nuclear particles and/or γ-rays may be emitted subsequently during its de-excitation at equilibrium stage. The first experimental evidence of ICF dynamics was given by Britt and Quinton [1], who observed the break-up of the incident projectiles like ^{12}C, ^{14}N and ^{16}O into alpha clusters in an interaction with the surface of the target nucleus at ≈10.5 MeV/nucleon bombarding energies. However, major advances in the study of ICF dynamics has taken place after the charged particle-γ coincidence measurements by Inamura *et al* [2] for ^{14}N + ^{159}Tb system at beam energy ≈7 MeV/nucleons. Recent studies [3] have been carried by using HI projectile with spherical target. However, the experimental studies of ICF dynamics using HI projectile with deformed target nuclei are scarce. To the best of our knowledge these measurements have been reported for the first time.

Experimental Details

The present experiment have been carried out by using Gamma Detector Array (GDA) coupled with Charged Particle Detector Array (CPDA) for the system ^{16}O + ^{154}Sm@100 MeV at Inter University Accelerator (IUAC), New Delhi, India. A self-supporting target of ^{154}Sm (enrichment ≈98.69%) of thickness ≈3.1 mg/cm^2 were prepared by rolling machine. GDA consists of 12 Compton suppressed high purity germanium detectors at angles 45^0, 99^0, 153^0 with respect to the beam direction and there are 4 HPGe detectors at each of these angles. The CPDA is a group of 14 Phoswich detectors. In the CPDA scattering chamber, seven CPD were placed on top and seven on bottom of the chamber. All 14 detectors of CPDA are divided into three angular zone. There are 4 CPDA detectors at 'forward angles (F)' (10^0-60^0), 4 detectors at 'backward angles (B)' (120^0-170^0) and 6 detectors 'sideways (S)' i. e. between 60^0-120^0. In the present experiment two groups of α-particles are expected to be detected by forward angles (F) CPDs: (i) the fusion-evaporation (CF) α-particles of average energy Eα-CF≈17 MeV and (ii) the ICF 'fast' α-particles of energy Eα-ICF≈25 MeV. In front of the each four forward cone CPDs, aluminum absorbers of appropriate thickness were used to stop 'evaporation' α-particles (Eα-CF≈17 MeV). Hence, only 'fast' α-particles' with energy greater than 17 MeV have been detected in the forward cone.

Analysis and Results

In the present experiment the multiplicity spectra of charged particles (Z=1, 2) and α-particles has been recorded for ^{16}O + ^{154}Sm system at 100 MeV projectile energy in the CPDA and shown in Fig. 1(a)-(b). The multiplicity spectra of charged particles (Z=1, 2) and α-particles are define the coincidence between charged particles and prompt γ-rays. In Fig. 1(a), three peaks has been observed, which indicates that the maximum three groups of α particle will be emitted along with proton and/or neutrons during the CF and ICF process. In Fig. 1(b), two peaks has been observed, which indicates that the maximum two groups of α particle emitted along with neutrons or without neutrons during CF and ICF process.

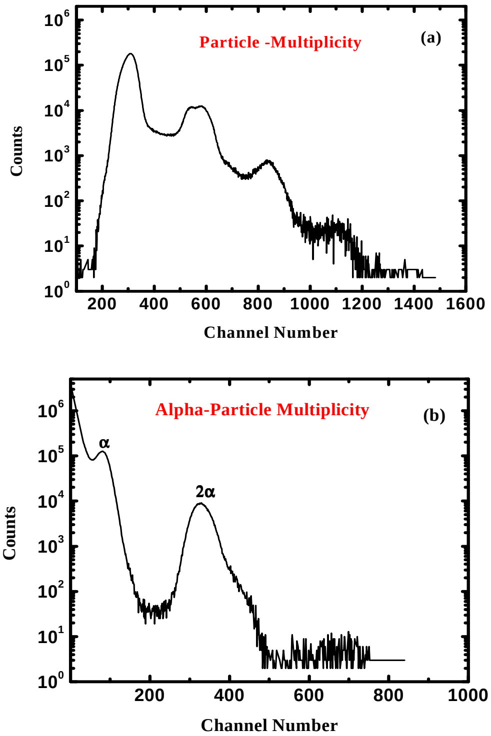

Fig. 1 (a) Charged particle multiplicity spectra and **(b)** α-particle multiplicity spectra obtained from the ^{16}O + ^{154}Sm system at 100MeV.

The gamma ray energy spectrum observed for ^{16}O + ^{154}Sm system at 100MeV projectile energy is shown in Fig. 2. The data analysis has been carried out during the experiment by using software CANDLE. The four evaporation residues ^{165}Yb(5n), ^{164}Yb (6n), ^{164}Er(α2n) and ^{162}Er (α4n) has been indentified from the gamma rays energy spectra. The evaporation residues ^{165}Yb and ^{164}Yb, produced through the emission of 5 and 6 neutrons from the compound nucleus, respectively. It means that these residues produced only through complete fusion of ^{16}O with ^{154}Sm. The evaporation residues ^{164}Er produced though the emission of one α and 2 neutrons, while ^{162}Er produced though the emission of one α and 4 neutrons. These ERs may be populated through the ICF process. The analysis of the experimental data is still in progress. The Final results will be presented in Symposium.

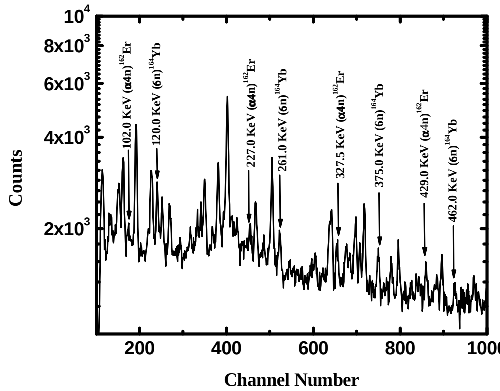

Fig. 2 Gamma ray energy spectrum observed from ^{16}O + ^{154}Sm system at 100MeV.

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