Transfer Followed α-Production in Strongly Bound ^{13}C+^{51}V System

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Introduction

In recent studies, large α-particle production is reported for weakly bound nuclei originated due to transfer reactions. In the case of weakly bound stable projectiles like ^{6,7}Li and ^{9}Be, the inclusive α-cross sections form a substantial portion of the corresponding reaction cross sections. However, in the case of strongly bound projectiles like ^{12}C,^{14}N and ^{16}O, the α-cross sections are significant but are not more than 10-20% of the corresponding reaction cross sections [2]. Direct break up and cluster transfer have been shown to be responsible for α-production [1] for strongly bound projectiles. The direct α-production cross sections show an interesting correlation with the α-binding energies of the projectiles [3]. It turns out that in the case of projectiles with mass numbers lying between 6 and 20, the α-binding energies of the projectiles are the smallest when compared to proton and neutron binding energies. In the case of ^{13}C, the neutron binding energy is 4.95 MeV which is less than its α-binding energy of 10.65 MeV. Hence the neutron transfer from ^{13}C is expected to be significant and it is conceivable that in the case of ^{13}C induced reactions, α-particles can arise not only from direct break up and cluster transfer but also from break up following neutron transfer. With a view to understand the various mechanisms responsible for α-emission in general and α-emission following neutron transfer in particular, measurements have been carried out for α-particles emitted in the ^{12,13}C induced reactions on ^{51}V. A detailed analysis of the α-particles spectra from ^{13}C have been compared and the α-particles from breakup following neutron transfer have been clearly identified

Experimental details

The experiment was carried out at BARC-TIFR Pellteron LINAC facility, Mumbai, India. A self-supporting ^{51}V target of thickness ∼550 μg/cm^2 was bombarded with 60 MeV ^{12,13}C beams in a 1.5m diameter scattering chamber. Four silicon surface barrier detector (ΔE-E) telescopes and two strip detectors were used to detect the outgoing Projectile Like Fragments (PLF) with Z=3-7 along with lighter fragments like ^{4}He. Monitor detector was kept at 10° for absolute normalization. The angular distributions of PLFs and ^{4}He were measured in the angular range of 11° – 140°. Thorium source was used for energy calibration along with elastic peaks at different angles to obtain α-energy spectra. One HPGe detector was also kept at 120° to measure in-beam γ-rays from complete/incomplete fusion residues. This data will be also used for offline coincidence between different reaction channels and charge particles. In the present work, preliminary α-spectra and their angular distributions are discussed.

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Results and Discussion

Inclusive angular distribution of measured α-spectra was obtained (Fig. 1). Statistical model code PACE2 was used to get the compound nuclear contribution. Direct α-angular distribution was integrated to get the integral cross-section. Ratio of the direct α-production cross-section is given in Table I. If we assume that the α-cross section scales with the inverse of α- separation energy value (S_α) similar to neutron separation energy [4], then the ratio of the cross sections should be 10.65/7.37 = 1.45. The values are close to 1.2 - 1.3 gives an indication that some α-particles are produced through other reaction mechanisms. Detailed analysis of the α-energy spectra was carried out to understand the mechanisms responsible for α- production. The peak energy centroid of the reaction channels were obtained kinematically at 11.3 MeV(Breakup,α+^{9}Be), 15.3 MeV (1n-transfer followed ^{12}C breakup) and 18.5 MeV (^{9}Be transfer) for ^{13}C projectile and at 13.6 MeV (3α), 17.5MeV (α transfer and ^{8}Be breakup) and 18.8 MeV (^{8}Be transfer) for ^{12}C projectile. Area under peaks are used to get cross-sections for ^{13}C at 26° for breakup (42%), 1n-transfer+breakup (15%),^{9}Be transfer(43%) which are close to that obtained for ^{93}Nb[5]. In summary, measurement of α-particle spectra in ^{12,13}C induced reactions on ^{51}V at a bombarding energy of 60 MeV has been reported. A significant contribution of α-particles resulting from the process like neutron transfer followed by break up of ^{12}C in the case of ^{13}C projectile is observed. The exclusive particle-γ measurements are under analysis and will be presented.

TABLE I: Ratio of the direct α-particle production for ^{12,13}C with various targets.

Target	α-ratio(^{12}C/^{13}C)
^{93}Nb	1.21± 0.15
^{48}Ti	1.30± 0.21
^{51}V	1.28± 0.11

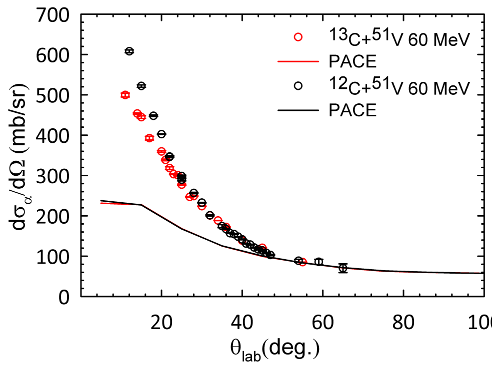

FIG. 1: Angular distribution of the α-production cross-section for ^{12,13}C+^{51}V system at 60 MeV.

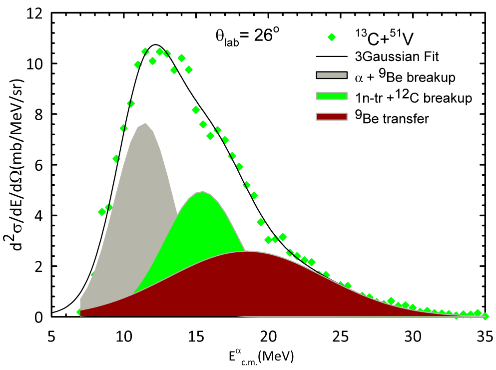

FIG. 2: Direct α-energy spectra for ^{13}C+^{51}V system at θ_{lab}=26°. The α-particles peak at 11.3 MeV(Breakup,α+^{9}Be), 15.3 MeV (1n-transfer followed ^{12}C breakup) and 18.5 MeV (^{9}Be transfer).

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