Excitation function measurement of ^{16}O + ^{175} Lu system below 6 MeV/nucleon

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Introduction

The study of heavy ion induced reactions plays a major role in understanding of the decay of excited nuclei and the reaction dynamics. It is understood that complete fusion (CF) and incomplete fusion (ICF) of the projectile with the target are the most probable reaction modes at energies above the Coulomb barrier [1]. For CF process, the projectile nucleus completely fuses with the target nuclei forming a highly excited compound system. This compound system decays by particle emission along with their characteristic γ-rays. On the other hand, for ICF process, the break-up of projectile takes place into two fragments, one of which fuses with the target and the other moves as spectator in forward direction with almost same velocity as that of target. Both the processes are also characterized by the angular momentum ℓ carried by the projectile.

Britt and Quinton observed the ICF process experimentally for the first time [2], while the study by Inamura *et. al*. [3] gave more strength to the ICF process. To explain ICF mechanism, several theoretical models have been proposed, viz, Sum-rule model of Wilczynski *et. al.* [4], Break-up fusion model [5] of Udgawa and Tamura, etc. Unfortunately, all these models are applicable only if beam energy is above 10 MeV/nucleon but no model exists so far which may reproduce the data successfully at energies below 10 MeV/nucleon.

In present work, we have measured and analyzed the excitation functions of evaporation residues produced in ^{16}O + ^{175}Lu reactions at energies ranging from 4.3-6.2 MeV/nucleon to study both the CF and ICF processes involved. To the best of our knowledge no earlier measurements are reported in the literature for this system.

Experimental Details

The experiment has been performed at Inter University Accelerator Centre (IUAC), New Delhi. 15UD-Pelletron accelerator which has delivered the ^{16}O-beam, of energy 100 MeV. The experiment is performed using General Purpose Scattering Chamber (GPSC) having diameter 1.5 meter and also having in-vacuum transfer facility. The self-supporting lutetium (^{175}Lu) targets of thickness lying between 1.0-1.5 mg/cm^2 are prepared by rolling machine. The thickness is measured by energy loss of the α-particle from ^{241}Am-α source. Al-catchers of thickness 1.5-2.0 mg/cm^2 were used as catcher foils, kept behind each target. To have energy range from 70-100 MeV, two stacks, each having four foils along with catchers were used. Keeping in view the half-lives of interest each stack was irradiated independently with ^{16}O beam of beam current $\approx$16 nA, for appropriate time. The activities induced in the samples were recorded using 100cm^3 pre-calibrated and high resolution HPGe γ-ray detector coupled to CAMAC based FREEDOM software. The spectrometer is calibrated both for energy and efficiency using standard γ-sources like ^{60}Co, ^{133}Ba, ^{137}Cs and ^{152}Eu.

Results and discussion

We have measured the excitation functions (EFs) for the residues ^{186}Au(5n), ^{187}Pt(p3n), ^{186}Pt(p4n), ^{187}Ir(α), ^{184}Ir(α3n), ^{183}Ir(α4n), ^{181}Os(αp5n) and ^{178}Ta(3αn) by using recoil catcher activation technique. Special care has been taken to remove the precursor decay contributions in the production of several evaporation residues to get the independent production cross-sections of the residues. Measured EFs are then compared with the predictions of statistical model code PACE-2 [6] which is based on the statistical model and uses the Monte-Carlo simulation procedure for the de-excitation of compound nucleus and analyses of the results have been discussed. It is worth to mention that PACE2 calculations give only CF cross-section and does not take into account the ICF processes. Excitation functions of two residues ^{186}Pt(p4n) and ^{183}Ir(α4n) are shown in Figs. 1 and 2 respectively. As a representative case the measured cross-section of ^{186}Pt has also the contribution from the decay of its higher charge precursor ^{186}Au(5n) and hence the independent cross-sections have been obtained using Cavinato formulation [7].

$$\sigma_{ind}\left(^{186}Pt\right)=\sigma_{cum}\left(^{186}Pt\right)-1.06\sigma_{ind}\left(^{186}Au\right)$$

The measured independent cross-section values match well with PACE calculations at level density parameter constant K=10, which shows that as expected, the evaporation residue ^{186}Pt(p4n) is populated by CF process. As such for the residue ^{183}Ir(α4n) an enhancement in the measured cross-section values from the theoretical prediction has been obtained . This may be due to the contribution from ICF process along with the CF process, where the projectile breaks up into fragments [^{12}C+^{4}He(α)], one of the fragment, α-particle moves forward with same angular momentum as that of the projectile and the other fragment fuses with the target^{175}Lu, forming the excited compound system ^{187}Ir, which decays by emitting four neutrons to from ^{183}Ir. This can be represented as,

$$^{16}O\left(^{12}C+{}^{4}He\right)+{}^{175}Lu\rightarrow{}^{187}Ir+{}^{4}He$$

→ α as spectator

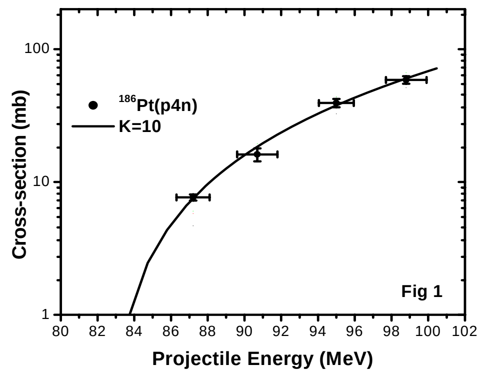

Fig 1

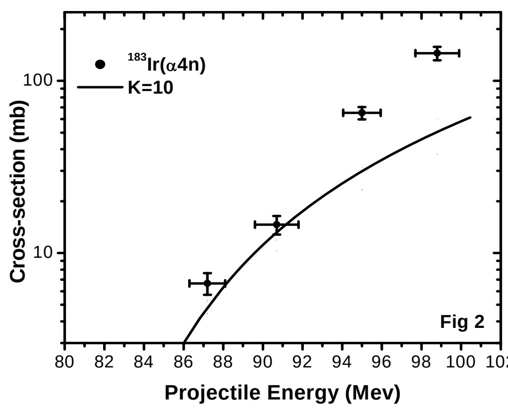

Fig 2

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References

[1] B.S.Tomar *et. al.*, Phys. Rev. C **49** (1994) 941.

[2] H.C. Britt and A.R. Quinton, Phys. Rev. **124** (1961) 877.

[3] T. Inamura *et al*, Phys. Lett. B **68**, 51 (1977).

[4] J. Wilczynski, *et al*, Nucl. Phys. A **373** (1982) 109.

[5] T. Udagawa, T. Tamura, Phys. Rev. Lett. **45** (1980) 1311.

[6] A. Gavron, Phys. Rev. C **21** (1980) 230.

[7] M.Cavinato *et al*, Phys. Rev. C **52** (1995) 2577