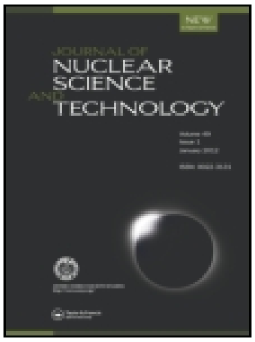

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Triton Production Cross Section in Interaction of keV Deuterons with ^{13}C Nucleus

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Triton production cross section has been measured in interaction of 200-350 keV deuteron with ^{13}C nuclei. In this study excitation functions of $^{13}C(d, t)^{12}C$ reaction have been measured at eight angles in 10 keV energy steps over 200-350 keV deuteron energy range while angular distributions of $^{13}C(d, t)^{12}C$ reaction were measured at 200, 250, 270, 290, 310, 330 and 350 keV deuteron energies. The angular distributions of $^{13}C(d, t)^{12}C$ reaction are forward-peaked and are in disagreement with shape of previously reported data of $^{13}C(d, t)^{12}C$ reaction at 410 keV deuteron energy. On the contrary the shape of angular distribution measured in this study has a better agreement with the shape of angular distribution of $^{13}C(d, t)^{12}C$ reaction at 410 keV deuteron calculated using zero-range Distorted Wave Born Approximation (DWBA) model.

KEYWORDS: 200-350 keV deuteron induced transfer reaction, Triton production cross sections, ^{13}C target

I Introduction

One nucleon pickup reactions such as (d, t) and (d, ^{3}He) reactions provide vital information about nuclear reaction mechanism as well as binding energy, electromagnetic form factor and charge radii of three-nucleon bound system[1-2]. Inspite of intensive experimental and theoretical studies in nuclear reaction over the last two decades, fundamental properties of three nucleon bound system are yet not completely understood [3]. This may be due to the either large uncertainities in some of experimental data or inadequacy of theoretical model calculations to take specific effects into account. One of such examples is $^{13}C(d, t)^{12}C$ cross section data at 410 to 810 keV deuteron energies, reported by Putt[1], in which experimental cross section was several times smaller than the value predicted by zero-range DWBA calculations[1]. Also DWBA calculations did not reproduce the shape of the experimental angular distribution. The discrepancy between the DWBA calculations and experimental data of $^{13}C(d, t)^{12}C$ reaction of Putt motivated us to measure $^{13}C(d, t)^{12}C$ cross section over 200-350 keV deuteron energies at 350 kV Accelerator Laboratory of the Center for Applied Physical Sciences (CAPS), King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia. Results of this study are presented in this paper.

II Experimental

The cross section data of $^{13}C(d, t)^{12}C$ reaction was acquired along with cross section data of $^{13}C(d, p)^{14}C$[4] and $^{13}C(d, \alpha_{0,1})^{11}B$ reactions[5] using the experimental setup and procedure described elsewhere[6]. Figure 1 shows a typical pulse height spectrum of reaction products from $^{13}C(d, p)^{14}C$, $^{13}C(d, t)^{12}C$ and $^{13}C(d, \alpha_{0,1})^{11}B$ reations[5]. The excitation functions of $^{13}C(d, t)^{12}C$ reaction were measured at 30°, 48°, 66°, 90°, 110°, 128°, 146° and 164° over 200-350 keV deuteron energy range with an energy interval of 10 keV. The angular distributions of $^{13}C(d, t)^{12}C$ reaction were measured at seven deuteron energies i.e. 200, 250, 270, 290, 310, 335 and 350 keV for 14 angles over 30° to 164°. The statistical uncertainty in excitation functions was 4 to 6 % while in angular distributions it was 5 to 8 %. The systematic uncertainties in cross section data due to charge integration, target thickness and the finite angular resolution were estimated to be 4 to 5 %.

III Results and Discussion

1 Angular Distributions of $^{13}C(d,t)^{12}C$ Reaction

The cross section for $^{13}C(d, t)^{12}C$ reaction at 200-350 keV deuteron energy does not vary strongly with the deuteron energy over 90°-165° is almost constant. Therefore excitation functions over 90° to 165° angular range overlap each other. All the excitation functions are structureless and cross section increases smoothly with deuteron energy indicating non-resonant behavior of reaction mechanism. Angular distributions of $^{13}C(d, p)^{14}C$ reaction at 200, 250, 270, 290, 310, 335 and 350 keV deuteron energies are plotted in Figs. 2 and 3. The angular distribution data was also fitted with the Legendre Polynomial.

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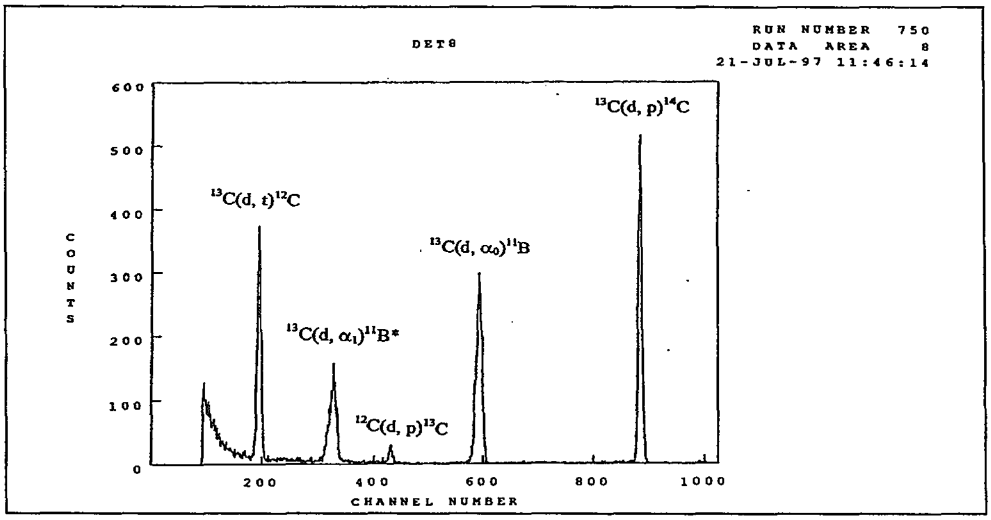

Fig. 1: Pulse height spectrum of the surface barrier detector showing proton, triton and alpha particle peaks from $^{13}C(d, p)\,^{14}C$, $^{13}C(d, t)\,^{12}C$ and $^{13}C(d, \alpha_{0,1})^{11}B$ reations [5].

The fit is plotted as a dashed line in Figs. 2 and 3. The angular distributions are forward peaked with minimum cross section around 120°. The cross section decreases with the deuteron energy and the angular distributions retain their forward peaked shape.

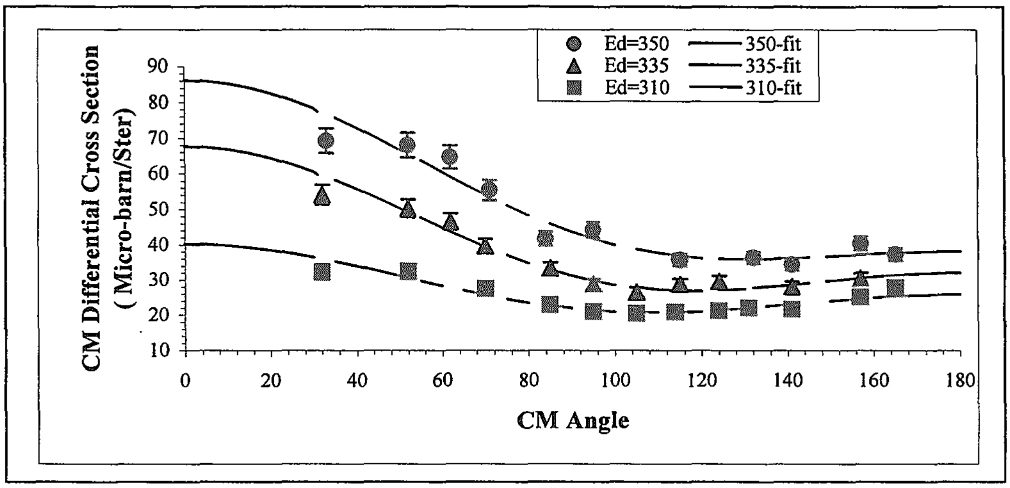

Fig. 2: Angular distribution of differential cross section for $^{13}C(d, t)^{12}C$ reaction at 310, 335 and 350 keV deuteron energies along with Legendre Polynomial fit shown with dashed lines.

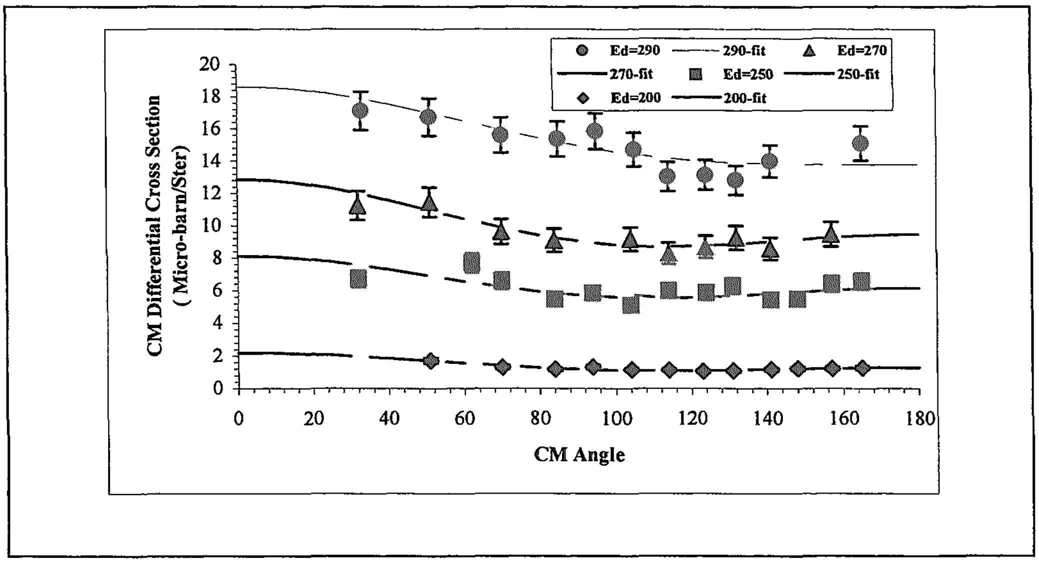

Fig. 3: Angular distribution of differential cross section for $^{13}C(d, t)^{12}C$ reaction at 200, 250,270 and 290 keV deuteron energies along with Legendre Polynomial fit shown with dashed lines.

The forward peaking of cross section is strongly deuteron energy dependent. Therefore ratio of the cross section at 30° to that at 110° (later called as cross section ratio) decreases with deuteron energy. For 350 and 335 keV deuteron energies the cross section ratio is 1.9 and at 310 keV it has been reduced to about 1.6. Due to difference in cross section ratios over 310-350 keV energy range, the angular distribution shown in Fig. 2 are not equally spaced. Over 200 to 290 keV deuteron energy, the cross section ratio has a constant value of about 1.3 to 1.4. Therefore the angular distributions over this energy range, as shown in Fig. 3, are almost equally spaced. The forward-peaked shape of angular distributions, as shown in Figs. 2 and 3, clearly indicates a dominant contribution from direct reaction channel over this energy range. This is in disagreement with Putt[1] results.

2 Total Cross Section of $^{13}C(d, t)^{12}C$ Reaction

The total cross section of $^{13}C(d, t)^{12}C$ reaction was calculated from Legendre Polynomials fit to angular distribution data. Figure 4 shows total cross section of $^{13}C(d, t)^{12}C$ reaction as a function of deuteron energy. For the sake of comparison, total cross section data of $^{13}C(d, t)^{12}C$ reaction at 410-810 keV taken from ref [1], is also plotted in Fig. 4. The cross section data measured in the present study show a smooth trend, similar to the one reported in ref [1]. In future differential cross section for $^{13}C(d, t)^{12}C$ reaction at 200-350 keV deuteron energy range will be calculated using finite-range DWBA model and will be compared with the experimental cross section data.

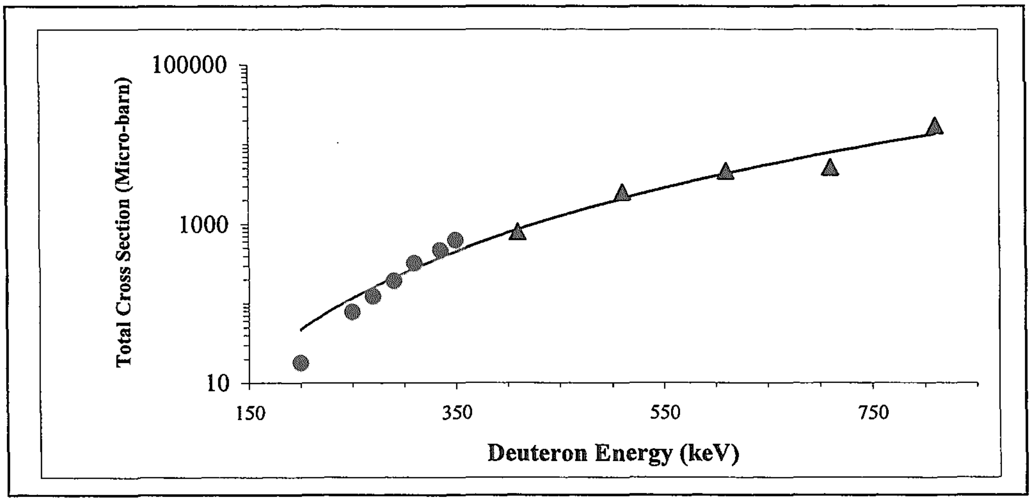

Fig. 4 : Total cross section of $^{13}C(d, t)^{12}C$ reaction over 200-350 keV deuteron energies (solid circles) along with data from Putt[1] (solid triangles).

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