International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 09, September 2017
ISSN: 2455-3778
http://www.ijmtst.com

# Study of Optical Properties of Carbon ion Irradiated Ethylene - Chlorotrifluoroethylene (ECTFE)

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**To Cite this Article**
Kusam Devgan, "Study of Optical Properties of Carbon ion Irradiated Ethylene - Chlorotrifluoroethylene (ECTFE)", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 09, September 2017, pp.-53-56.

## ABSTRACT

*The swift heavy ion irradiations activated Chlorotrifluoroethylene (E-CTFE) copolymer films were studied in relationship with the applied doses. Samples were irradiated in vacuum at room temperature by carbon (85 MeV) ions with the fluence in the range of 1 x $10^{11}$–3 x $10^{12}$ ions $cm^{-2}$. Optical properties of the irradiated as well as virgin E-CTFE films were examined using UV–visible technique. Swift heavy ion irradiation was found to stimulate changes in E-CTFE depending upon the applied doses.*

***KEYWORDS:*** *Ethylene-Chlorotrifluoroethylene; UV-VIS; Polymer; Thin films; Irradiation; Heavy ion.*



## I. INTRODUCTION

The significance of polymers has enhanced very rapidly during the last decades because of their easy process ability, low cost and their small weight. Fluorinated polymers are frequently manufactured by radical co-polymerization of fluoroalkenes. These fascinating materials have exceptional properties such as thermal stability, low refractive index, permittivity, chemical inertness (to solvents, oils, water, acids, and bases), dissipation factor and water absorptive, as well as superb weather ability, durability, and resistance to oxidation [1]. The consequences of ionizing radiations, such as gamma rays, X-rays and electrons on polymers have been widely reported in the literature [2-3] since a long time, while the consequences induced by keV-MeV heavy ions have attracted large curiosity only in the last years [4-6]. Ion irradiation of polymers can persuade permanent modifications in their macroscopic properties such as electrical and optical properties [7] Chain scission and cross-links as well as mass losses induced by electronic excitation and ionization are accepted as the primary actions that give rise to the observed macroscopic alterations [8-9]. Although it has been shown that the modifications caused by irradiation depend on the energy deposition processes, a comprehensive acquaintance about the role of the different energy deposition mechanisms in the modification processes is still missing [10-11].

The swift heavy ion irradiations fabricate dramatic alterations in the optical, structural, thermal, mechanical and electrical properties of polymers due to dislodgment of their original chemical bonding. This dislodgment occurs as chain scission, cross linking, carbonization, degassing of volatiles, as well as oxidation processes upon exposure to air [12-19]. The early work on E-CTFE was the gamma irradiation of E-CTFE escort to modification in mechanical properties and hardening [20-21]. The gas emitted from E-CTFE induced by synchrotron radiation

was studied and results showed that HCl was the most intensely emitted gas [22]. The γ ray sensitivities of E-CTFE with other fluorinated polymers were also compared [23]. The membranes prepared via L–L phase separation had excellent hydrophobicity, high permeate flux and salt rejection ratio, and excellent anti-fouling properties, was reported [24]. Thermally sprayed fluoropolymer, polyvinylidene fluoride (PVDF), ethylene chlorotrifluoroethylene (ECTFE), perfluoroalkoxy alkane (PFA) and fluorinated perfluoroethylenepropylene (FEP) coatings were fashioned by flame and plasma spraying processes were studied by optical microscope, salt spray test and liquid immersion tests [25]. The aim of the present investigation is to study the alterations in optical properties of E-CTFE films caused by carbon (85 MeV) ion irradiation. Since the electronic energy loss of these ions in the polymeric material is very high therefore the alteration process activated by swift heavy ions can be very different from those stimulated by low energy ion beams [26].

## II. Experimental Section

The specimens of E-CTFE, in the form of flat polished films were procured from Good Fellow Ltd. (UK) having

TABLE 1

| ELECTRONIC, NUCLEAR ENERGY LOSS AND ION RANGE OF POLYMER | | | | |
|---|---|---|---|---|
| **Polymer** | **Ion Beam** | **Ion range (µm)** | **Electronic Energy loss (eV/Å)** | **Nuclear Energy loss (eV/Å)** |
| ECTFE | Carbon (85MeV) | 236.71 | 30.4 | 1.149 E-02 |

thickness range 25µm. The films of E-CTFE were used as- pelletron facility for the general purpose scattering chamber received form without any further treatment in the size of 1 cm x 1 cm. The samples were mounted on the sliding ladder and irradiated with carbon (85 MeV) ion beams using 15 UD (GPSC) under vacuum of ~$10^{-6}$ Torr at Inter-University, Accelerator Center, New Delhi, India. The ion range, electronic energy loss and nuclear energy loss of characterize carbon (85MeV) ions in E-CTFE polymer is shown in table 1 [27]. The ion beam fluence was varied from 1 x $10^{11}$ to 3 x $10^{12}$ ions $cm^{-2}$. In order to expose the whole target area, the beam was scanned in the x-y plane. The beam current was kept low to suppress thermal decomposition and was monitored intermittently with a Faraday cup. The samples were analyzed with UV-VIS spectroscopy using Lambda 35 Perkin Elmer UV-Vis spectrophotometer in the range 200-800 nm to observe the variation in optical properties of the polymer. Doses for the given fluence and different studied ion types were calculated using the formula [28] as given below.

$$\text{Dose} = 1.602 \times 10^{-10} \times \frac{1}{\rho} \times \frac{dE}{dx} \times \phi \qquad (1)$$

$\phi$ : Ion fluence,

ρ: Density of polymer,

$\frac{dE}{dx}$ : Stopping power of ion

TABLE 2

| DOSES FOR GIVEN FLUENCE AND ION TYPE OF STUDIED POLYMER | | |
|---|---|---|
| **Polymer** | **Ion Fluence (ions/cm²)** | Carbon (85 MeV) (kGy) |
| E-CTFE | Pristine | 0.00 |
| | 1 x$10^{11}$ | 28.95 |
| | 3 x $10^{11}$ | 86.86 |
| | 6x$10^{11}$ | 173.71 |
| | 1x$10^{12}$ | 289.52 |
| | 3 x $10^{12}$ | 868.57 |

## III. Results and Discussion

Fig.1. depicts UV-Visible spectra of swift heavy ion irradiated E-CTFE films. It has been observed that there is a shifting of absorption edge from ultraviolet to visible region. and hence decrease in optical band gap *Eg* due to ion irradiation. The change in colour of irradiated samples is also observed, which may be due to the formation and growth of cluster size due to unsaturation [29].

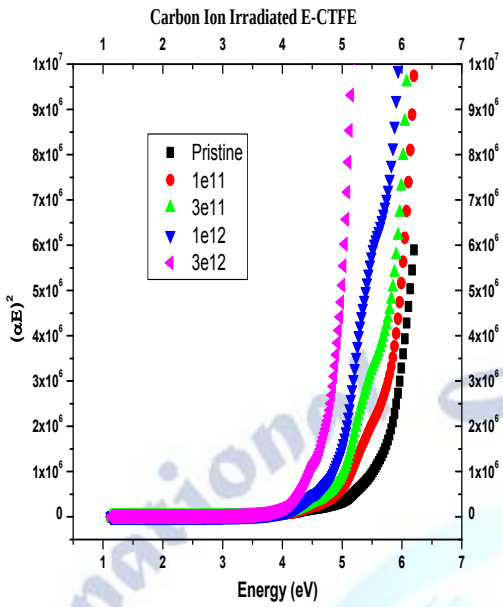


*Fig. 1. UV-VIS spectra of carbon ion irradiated E-CTFE at varying fluence*

## IV. Conclusion

Results summarized in this paper suggest that swift heavy ion irradiation of E-CTFE leads to optical degradation. It is revealed from current investigations that increase in dose of irradiating ion result in complete distortion of original structure of investigated polymer because the energy deposition mechanisms.

## ACKNOWLEDGEMENTS

Authors are thankful to DST, New Delhi for providing financial assistance for project under grant number SR/S2/CMP-34-2008. IUAC, New Delhi, is highly acknowledged for providing swift heavy ion facility.

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