International Journal For Technological Research In Engineering
Volume 10, Issue 4, December-2022 *ISSN (Online): 2347 - 4718*

THERMAL AND STRUCTURAL STUDY OF ION BEAM IRRADIATED POLYCARBONATE AND POLYSTYRENE DOUBLE LAYERED FILMS

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Abstract--Semicrystalline polycarbonate (PC) and polystyrene (PS) double layered films were irradiated under vacuum at room temperature by 55 MeV energy at various fluences range. The Electroactive properties of the ion beam irradiated double layered (i.e. polycarbonate and polystyrene) samples were illustrated by means of FTIR, thermally stimulated discharge current (TSDC) and DSC to understand change in polymer morphology and relaxation properties. The DSC characteristics of PC/PS pristine and ion beam irradiated double layered samples are shows that the glass transition temperature (Tg) are decrease with ion fluence. The FTIR spectra of carbon ion beam irradiated polycarbonate/polystyrene double layered samples shows the cross linking was observed at wavelength 1897.2 (C=O stretching) cm-1, however, the chain scissoring are found at 1582.7 cm-1(C=O stretching), 3040.6 (Aromatic CH stretching) cm-1.

Keywords--Polycarbonate, Polystyrene, TSDC, glass transition temperature, DSC.

1. INTRODUCTION

The double layer polymeric samples are very important in the field of electrical properties. This is because; polymer foil electret can be put into variety of applications due to their inductive power, the forces they generate, and also to convert energy from one form to another form. Recently the use of electrets has been suggested for sensors, replacement of heart valve, robotics, MEMS etc such development in this field have been revealed the new challenges in electrets research (1-5).

The polymer double layer electret may have extremely wide application in the field of actuators, transducers, microphone etc due to their relatively low cost; their fabrication techniques are quite simple.

For polymeric double layer sample we use polycarbonate (PC) and polystyrene (PS) because there are many similarities in PC and PS. The PC and PS both are amorphous, transparent, light weight, high stability and wide band gap materials. Therefore, the combinations of PC and PS have been chosen to develop polymeric double layer samples.

Preparation of the samples

The polycarbonate (PC) and polystyrene (PS) pellets were used in the present study was procured from Redox, India. PC and PS separate films have been prepared by solvent casting method with the help of different solvent dichloromethane (DCM) and Benzene respectively. Thin films of the two polymers (i.e. PC and PS) were then compressed together under the a compression molding machine at a temperature of 60° C and a pressure of 2700 lbin-2 to yield double layered sample with PC on one side and PS on the other side. The dried PC/PS pristine samples were subject to the room temperature out gassing at 10-5 torr, during the 24 h for remove any residual solvent (3-6).

Coating of samples

The samples prepared having diameter 5 cm and thickness 30 μm. For good ohmic contact, both the surface of the samples was vacuum aluminized using Vacuum Equipment (VEQCO) Delhi. Vacuum coating unit with Penning and Pirani pressure gauges, ST-A6P3; over central circular area of diameter 3.5 cm. both sides vacuum aluminized samples have been used for electrical conductivity measurements.

Irradiation of samples

For ion beam irradiation we used PC side samples and another side PS while the thicknesses of the samples were average 30 μm. The films were mounted on a vacuum shielded vertical sliding copper ladder and film size 1×1 cm2 were irradiated by C+ 5 beam with 55 MeV energy using in the general purpose scattering chamber (GPSC) at 15 UD Pelletron in Inter University Accelerator Center (IUAC), New Delhi, India. The ion beam fluence was varied from 1×1011 to 1×1013 ions/cm2 and during the irradiation the vacuum of the order of 5×10-6 torr was maintained. The ion beam was defocused using magnetic scanning system, so that an area of 1×1 cm2 was uniformly irradiated. The line current was 1 pna and was monitored intermittently with the help of a Faraday cup (7,8).

2. RESULTS AND DISCUSSION

Short-Circuit TSDC

Thermally stimulated discharge current (TSDC) technique is applied in variety of material for the study of dispersion phases such as disperse and porous metal oxides, polymers, liquid crystals, amorphous and crystalline solids, polymer nanocomposites, bio material, cells, tissues etc. The effects of dipolar, direct current (dc) and space charge relaxations are closely linked to the temperature dependent mobility of molecules, their fragments, protons, anions, electrons and depend on thermal treatment, temperature and field intensity of polarization and heating rate on depolarization or cooling rate on polarization. The nature of charge relaxation mechanisms is affected not only by the mentioned factors but also by morphological, structural and chemical characteristics of materials. TSDC plays very important role for the study the interface formed due to filling of macro/nano inorganic fillers in polymer matrix in recent years.

The samples were thermally charged at 1500C with 100 kV/cm of poling field. The TSDC was recorded by means of electrometer (Scientific Roorkee, India) at a heating rate of 30C/min. In order to avoid the effect of ground loop and extraneous electrical noise the electrometer was carefully shielded and grounded.

The short circuit TSDC spectra are recorded in the range of 30-180 0C. The short-circuit TSDC spectra of PC/PS Pristine double layer samples show two peaks about at 138 0C (i.e. α relaxation) and 99 0C (i.e. β relaxation) temperature. α and β relaxation peak temperatures shifting to the lower temperature side with increase in the ion fluence.

The TSDC peak in pristine PC/PS is due to the motion of main chain segment and trapping of charge carriers in surface traps. The charge carriers of energy 0.6eV shows that surface traps are more dominant (7-9).

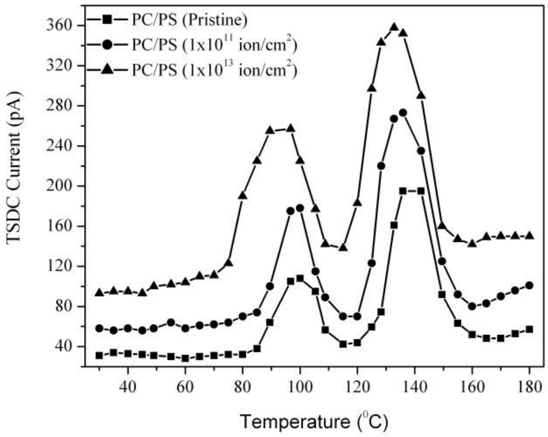


Fig.1. TSDC spectra of PC/PS Pristine and irradiated double layered samples at 100 kV/cm poling field and 150°C.

FTIR Analysis

Fig.2 shows the Fourier transform infrared (FTIR) spectra of pristine and carbon ion beam irradiated samples of PC/PS. The vibration modes of chemical bonds are characterized by the absorption bands of FTIR spectra. The various absorption bands are indicated in pristine and ion beam irradiated samples under different fluence. The comparison of absorption band position was made with respect to FTIR spectra of pristine PC/PS. It is observed that in the high fluence i.e. 3×1012 and 1×1013 ions/cm2 irradiated double layer samples at 1582.7 cm-1(C=O stretching), 3040.6 (Aromatic CH stretching) chain scissoring and at 1897.2 (C=O stretching) cross linking is also observed (1-4).

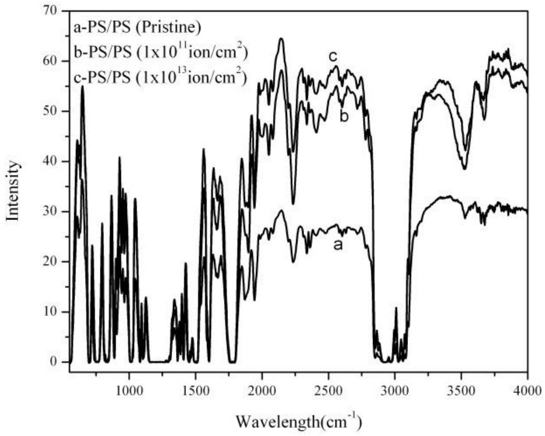


Fig. 2. FTIR Spectra of (a) pristine (b) 1×1011 (c) 1×1013 ion/cm2 with carbon (55 MeV) ion beam irradiated polycarbonate film

Differential scanning calorimetry Analysis

The DSC thermograms for the PC/PS Pristine and irradiated samples were obtained in the range of 50-190 0C at heating rate of 10 0C/min and liquid nitrogen medium from UGC-DAE Consortium Indore (M. P.) – India. The Figure 3 shows that the glass transition temperature of PC/PS Pristine double layers sample are 97.37 and 139.08 0C. Double layered samples show two Tg because double layered samples are made of polycarbonate (Tg= 144.37 0C) and polystyrene (Tg= 90.34 0C) both. The glass transition temperature is decreased with ion fluence due to the chain scissoring of the polymeric samples (10-12).

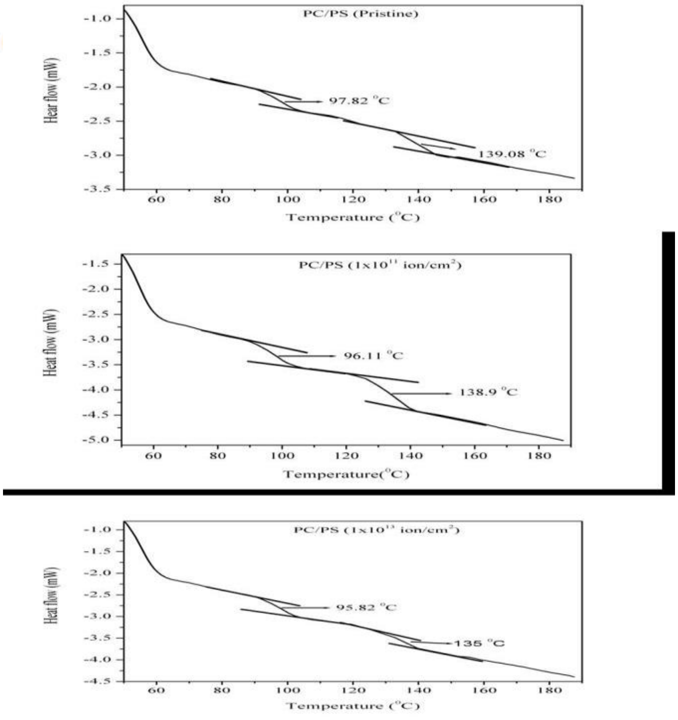
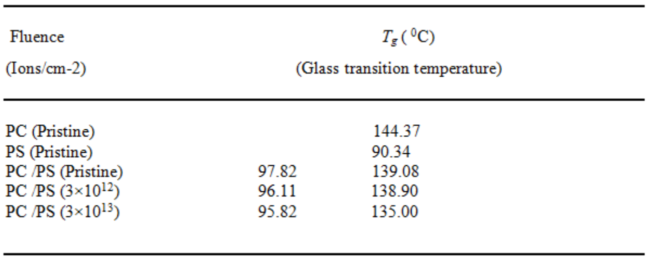


Fig. 3 DSC curve of PC/PS Pristine and irradiated double layered samples

Table 2
Relevant data of DSC pristine and ion beam irradiated PC/PS double layer samples



Fluence (Ions/cm-2)	T_g (^{0}C) (Glass transition temperature)	
PC (Pristine)		144.37
PS (Pristine)		90.34
PC /PS (Pristine)	97.82	139.08
PC /PS (3×10^{12})	96.11	138.90
PC /PS (3×10^{13})	95.82	135.00

3. CONCLUSION

The TSDC characteristics of PC/PS pristine and irradiated double layer samples indicate the distribution of energetic traps at different depth. This is due to the fact that the activation energy is different for TSDC peaks appeared with different polarizing field and temperature. The differential scanning calorimetry spectra of PC/PS and irradiated double layer samples gives the temperature position of phase change (i.e glass transition temperature), which is well agreed with the position of high temperature TSDC peak. Ion beam irradiated double layers samples show the glass transition temperature decrease with increase in fluence. This is due to the chain scissions and cross linking. The FTIR results reveal that the effective change in intensity of absorbance peak according to fluence is due to the bond scissions and cross link-ages followed by formation of nanoclusters. It is concluded that irradiation of PC/PS double layer samples using 55 MeV energy carbon ion beam created the nano clustures and reduces the energy band gap. The remarkable results are that the band gap energy is found to be a function of fluence and density of nano clusters. The decrease in crystallnity is an evidence for growth of nano clusters in PC/PS double layer samples after irradiation.

ACKNOWLEDGEMENTS

Authors are gratefully acknowledge the financial support of Inter University Accelerator Center (IUAC), New Delhi India. We are also highly thankful to Dr. Fouran Singh and other staff members of IUAC, New Delhi, for their help during irradiation and other experimental investigations.

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