Resistivity Variations of Nickel ion induced Poly vinylidene chloride (PVDC)

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ABSTRACT

The resistivity variations were studied of Poly vinylidene chloride (PVDC) sample irradiated with nickel ion. The variation of ion beam fluence was from 1 x 10^{11} to 3 x 10^{12} ions cm^{-2}. Resistivity of the PVDC films decreases with increasing frequency and also decreases due to irradiation.

KEY WORDS: Irradiation, Polymer, Resistivity, nickel ions, PVDC.

INTRODUCTION

In past years, the use of polymer films has enhanced significantly due to having immense commercial and scientific interest. The irradiation of a polymer is of great significance with a view to accomplish some desired improvements in polymer properties. The ease of production and comparatively low cost make them desirable materials for modification by ion beams. The irradiating ions, which are incident on polymeric material, experience two stopping powers which cause them to lose energy as they traverse the polymer. These stopping powers originate from the electrons and the nuclei and are termed the electronic stopping (Se) and nuclear stopping (Sn) respectively (Ziegler et al.,2010). Irradiating ion beams have been used to alter the electrical, electronic and optical properties of material by depositing energy in the polymer. The irradiation of polymeric materials with ion-beam results to the formation of new carbonaceous materials which show improved electrical conductivity (Ila et al., 1994; Evelyn et al., 1994; Venkatesan et al., 1985; Sofield et al., 1992; Wang et al.,1993; Calcagno and Foti,1991). At the same time the optical absorption of the polymer also enhances (Ila et al., 1994; Evelyn et al., 1994; Davenas et al, 1989). These modifications result from alterations in the chemical structures which is caused by change of the chemical bonding as the incident ions scissor the polymer chains, break covalent bonds and encourage cross-linking, while releasing certain volatile species. According to the nature of modifications and at least degradations induced by irradiation, the polymers can be divided into three types; (a) Polymers in which scissions take place primarily in the backbone of the chain (Le Moel et al., 1986). (b) Polymers in which scissions takes place primarily between the carbons of the backbone and the side substituents, which lead to the formation of double bonds in the main chain and also a few crosslinkages between the chains (Le Moel et al.,1987). (c) Polymers in which predominantly a high level of crosslinking takes place and hence rapidly attain a carbonized structure (Le Moel et al.,1988). The present study is about the variation of AC electrical resistivity with frequency of PVDC irradiated with nickel ion at varying fluences.

Experimental details

The flat polished thin films (50μm) of Poly vinylidene chloride (PVDC) were procured from Good Fellow Ltd. (England). These films were used without any further treatment in the size of 1 cm x 1 cm. The samples were mounted on the sliding ladder and irradiated with nickel (120 MeV) ion beams using 15 UD pelletron facility for the general purpose scattering chamber (GPSC) under vacuum of ~10^{-6} Torr at Inter-University Accelerator Center, New Delhi. The electronic energy loss and nuclear energy loss, ion range, of characterize nickel (120 MeV) ions in PVDC polymer is as given in table 1 (Ziegler et al., 2010). The ion beam fluence was varied from 1 x 10^{11} to 3 x 10^{12} ions cm^{-2}. Doses (Table 2) for the given fluence were calculated using the formula (Geiβ et al., 1998) as given below.

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

ϕ : Ion fluence, ρ: Density of polymer, $\frac{dE}{dx}$: Stopping power of ion

Table (1) Electronic, Nuclear Energy Loss and Ion Range of PVDC

Polymer	Ion Beam	Ion range (μm)	Electronic Energy loss (eV/Å)	Nuclear Energy loss (eV/Å)
PVDC	Nickel (120MeV)	34.57	455.4	7.127 E-01

Table (2) Doses for given fluence and ion type of studied PVDC

Polymer	Ion Fluence ($ions/cm^2$)	Nickel (120 MeV) (kGy)
PVDC	Pristine	0.00
	1 x10^{11}	447.58
	3 x10^{11}	1342.73
	6 x10^{11}	2685.46
	1 x10^{12}	4475.77
	3 x10^{12}	13427.32

Ihe Precision impedance analyzer 6500B is used to measure variation of resistivity of pristine and irradiated samples of Poly vinylidene chloride at room temperature in the frequency range 20Hz-1MHz.

Results and Discussion

Fig. 1 depicts the variation of ac electrical resistivity with frequency of pristine and nickel ion irradiated (at varying fluences of 1×10^{11} to 3×10^{12} ions/cm^2) films. Logarithmic scale is for plotting the graphs. The decrease of resistivity with increasing frequency is observed from the plots. It is also depicted from the fig 1 that the resistivity decreases further due to irradiation. Due to irradiation the structure of the polymer is converted to a hydrogen exhausted carbon network. This carbon network results in to make the polymer more conductive (Wang et al., 2004).

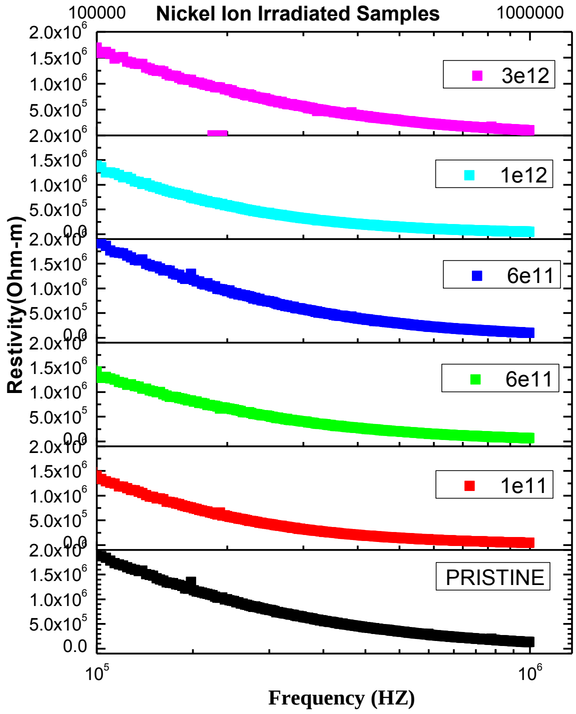

Fig. (1). variation of resistivity of nickel ion irradiated PVDC at varying fluences

CONCLUSIONS

It has been concluded that the resistivity of polymer decreases with increasing frequency. Also the conductivity of polymeric structure is enhanced as the polymer is converted to a hydrogen exhausted carbon network.

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