Variation of Dielectric Constant with Frequency of Silver Ion Induced PVDC (Poly vinylidene chloride)

Kusam Devgan
Department of Physics
S.R. Government College for Women, Amritsar, Pumjab, India

Abstract— Dielectric properties of silver ion induced Poly vinylidene chloride (PVDC) were examined. Dielectric constant (ε′) for pristine and irradiated samples has been calculated, which increases with the increase fluence, ranging from $1x10^{11}$ to $1x10^{12}$ ions/cm^2

Key words: PVDC

I. Introduction

Humans have taken benefit of the skillfulness of polymers for centuries in the form of oils, tars, resins, and gums. However, it was not until the industrial revolution that the innovative polymer industry began to grow. There are two processes by which swift heavy ion loses its energy i.e by interacting with target nuclei (nuclear stopping) and by interaction with target electrons (electronic stopping). Electronic stopping process due to ion irradiation is more eminent in case of polymers, which leads to the scissoring of original bonds, creation of radicals and excited atoms. Cross linking and relocation of bonds occur at higher ion fluences. All these processes are responsible for the modifications in structural, optical, thermal and chemical properties of the polymer due to creation of defects in the polymer [1]. The present investigation is to study the changes in structural properties of PVDC films caused by silver (120 MeV) ion irradiation by using Dielectric techniques.

II. Experimental Details

The flat polished thin films (25μm) 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 silver (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 silver (120 MeV) ions in PVDC polymer is ~25.77, 780.8 and 3.125eV/Å respectively [2]. The ion beam fluence was varied from 1 x 10^{11} to 1 x 10^{12} ions cm$^{-2.}$ Doses (Table 1) for the given fluence were calculated using the formula [3] as given below.

Dose = 1.602 x 10^{-10} x $\frac{1}{\rho}$ x $\frac{dE}{dx}$ x ϕ

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

Polymer	Ion Fluence (ions/cm^2)	Silver(120 MeV) (kGy)
PVDC	Pristine	0.00
	3 x10^{11}	767.39
	3 x10^{12}	7673.87

Table 1. Doses for given fluence of silver ion of studied polymer

The Precision impedance analyzer 6500B is used to measure dielectric constant (ε′) of pristine and irradiated samples of Poly vinylidene chloride at room temperature in the frequency range 20Hz-1MHz.

III. Results and Discussion

The dielectric spectrum for pristine and irradiated samples of PVDC irradiated with silver ions is shown in Fig. 1. It is detected that dielectric constant (ε′) decreases with increase in frequency. By using the relation $\varepsilon' = C_p/C_0$, the dielectric constant of pristine and irradiated samples of Poly vinylidene chloride (PVDC) was calculated, where C_p is capacitance measured by impedance analyzer and $C_o = \varepsilon_o A/t$, where ε_o is the permittivity in vacuum. The fact behind this is that the charge carriers drift through the dielectric and get trapped beside a defect site, where they induce an opposite charge; hence motion of charge carriers decelerate, which in turn lessens the value of dielectric constant (ε′). It is also remarked from Fig. 1 that the value of dielectric constant (ε′) of irradiated samples of Poly vinylidene chloride is to a greater extent as compared to that of pristine sample. This may be due to chain scission process due to which there is an enhancement in number of free radicals [4]. The enhancement in the value of dielectric constant (ε′) with increase in ion fluence contributes to the increase in hardness of polymer due to irradiation [5].

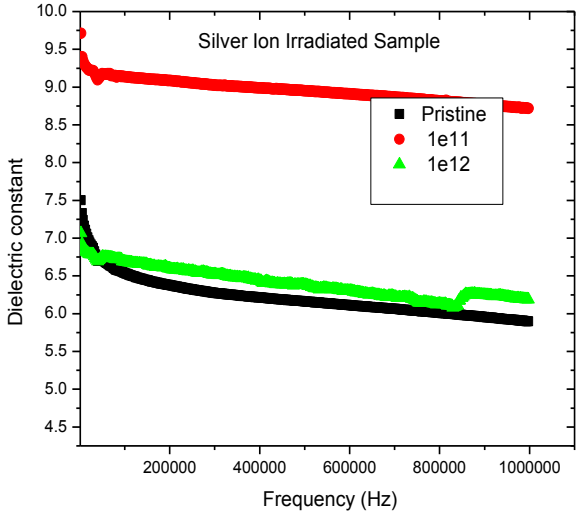

Fig. 1: Dielectric spectrum of Poly vinylidene chloride samples irradiated with different fluences of silver ions

IV. Conclusion

The increase in dielectric constant (ε′) with increase in ion fluence leads to the increase in rigidity of polymer due to irradiation.

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