STUDY OF ELECTRICAL PROPERTIES OF GAMMA-IRRADIATED POLYVINYL ALCOHOL/ $CRCL_3$ COMPOSITES FILMS

دراسة الخصائص الكهربائية لشرائح المتراكبات بولي فاينيل الكحول/كلوريد الكروم المشععة بكاما

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Abstract

Casting films method for polyvinyl alcohol (PVA) doped with $CrCl_3$ have been prepared. The electrical conductivity (σ), and dielectric constant (ε'), for unirradiated and irradiated polyvinyl alcohol (PVA) samples doped with $CrCl_3$ with three different concentration (10, 12, and 20%wt) were studied. The samples were deposited to three different doses f γ-irradiation (56.1, 112.2, and 224.4KGy). The electrical conductivity, and dielectric constant in the frequency (200-10^5 Hz) were measured at room temperature. The electrical conductivity increase with increasing in dopant concentration as well as γ-irradiation.

الخلاصة

تم دراسة التوصيلية الكهربائية (σ)، ثابت العزل (ε') للعينات المشععة وغير المشععة لعينات بولي فاينيل الكحول المطعمة بكلوريد الكروم وبثلاث تراكيز مختلفة (10, 12, 20wt%). عُرضت العينات الى ثلاث جُرع مختلفة من اشعة كاما (56.1, 112.2, and 224.4KGy). قيست التوصيلية الكهربائية وثابت العزل ضمن مدى الترددات (200-10^5 Hz) وفي درجة حرارة الغرفة. لوحظ ان التوصيلية الكهربائية تزداد بزيادة التطعيم و بزيادة الجرع .

Keywards: polyvinyl alcohol, $CrCl_3$, electrical properties, γ-irradiation

Introduction

Polymers play a huge important role in modern society. The significant of these materials is often taken for granted, yet polymers are fundamental to most aspects of modern life such as building, communication, transportation, clothing and packaging this due to their features low cost, high environmental stability, ease of handling, electrical, optical and mechanical properties and this is why the researchers provide a great interesting to study the mechanical and physical properties of the polymers. The polymer composites have growing needs in specific optical and electrical properties. Also the nature of interaction between additives and polymer molecules is usually controlled by different techniques. Many types of additives are added to the polymers in the purpose of improve and modify its properties [1, 2]. The doping of transition metals to polymeric network is of very interest for scientific and technological purpose [3,4].

Poly (Vinyl Alcohol) (PVA) is the most important polymeric material since it has several interesting physical properties which are important in material science; PVA is non-toxic, highly crystalline and water soluble polymer, also it is a good insulating material with low conductivity and so it is so important to microelectronic industry [2, 5]. It has many other important applications like surgical devices, sutures, hybrid islet transplantation [6].

The change in polymer structure is very essential in many technical applications. So the electrical studies of polymer structure give convenient and sensitive methods [7, 8]. The electrical properties are controlled by many factors including the structure, nature of dopant and its application and preparation methods [9, 10]. The polymer composites containing salt are very interesting composite because they are of both scientific and practical interest, which give good electrical applications, many researchers have studied the electrical properties of polymer/salt composites and they show the highly amount of dopant of a salt filler enhances the ionic conductivity and affects the bulk properties of the composites[11,12]. γ-irradiation is a process gives a modification in physical, morphological and chemical structures [6].

The aim of the present work is to study the electrical conductivity (σ), dielectric constant (ε') for unirradiated and irradiated of γ-irradiated PVA/$CrCl_3$ composite films of three different dopant concentrations at a range frequency (200Hz-100KHz) at room temperature.

Experimental

-Materials

The PVA and chromium chloride $CrCl_3$ used in this study were supplied by BDH chemical, England. Both were in the powder form. The two materials were nominally free from impurities.

-Preparations

The casting method was used in this work. PVA was added to distilled water at room temperature. To prevent thermal decomposition of polymer the water bath method was used by heating the solution, and it stirred until the polymer is completely dissolved and forming a clear viscous solution. The weight amount of $CrCl_3$ was added to the polymer; the mixture was cast on glass plate and dried in an air oven at 40°C for 12h in order to minimize gelatin effects. Three samples were made in weight percentage (10, 12, and 20 wt%). Thickness measurements were made using a micrometer.

-Gamma Irradiation

Irradiation to the required does was carried out by gamma cell at nuclear Lab. for higher studies in physics department/ college of science/ Baghdad University/ Iraq. Strips of cast films were placed in the irradiation chamber in such a way that each one was exposed to the same dose. Irradiation was carried out under air atmosphere with constant dose rate.

-Electrical Measurements

The capacitance C of the investigated sample was measured in the room temperature and frequency range between 200Hz- 100KHz using PM 6308 automatic RCL (Philips) meter. The A.C. conductivity $\sigma_{a.c.}$, dielectric constant ε` of the prepared PVA/$CrCl_3$ composites were calculated from the following relation: $\sigma = \frac{t}{RA}$ [13]

Where $\varepsilon_\circ$ is the permittivity of free space = 8.85×10^{-14} F/cm, t and A thickness and surface area of the sample respectively. R : resistance.

Results and Discussions

AC Electrical Conductivity

Figures (1-4) represent the regular frequency dependence of $\sigma_{a.c}$ at different doses. It can be notice that lnσ increases linearly with regular frequency.

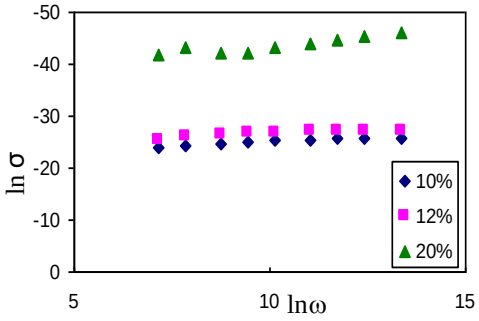

Figure (1): ln ω dependence of ln σ at different concentrations of unirradiated

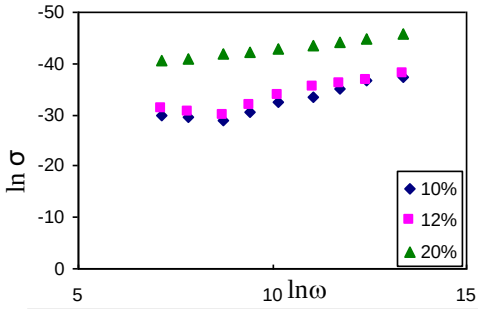

Figure (2): ln ω dependence of ln σ at different concentrations at dose 56.1KGy.

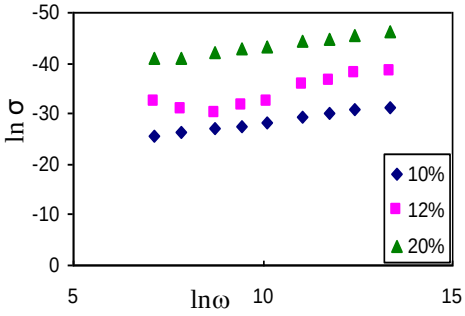

Figure (3): ln ω dependence of ln σ at different concentrations at dose 112.2KGy.

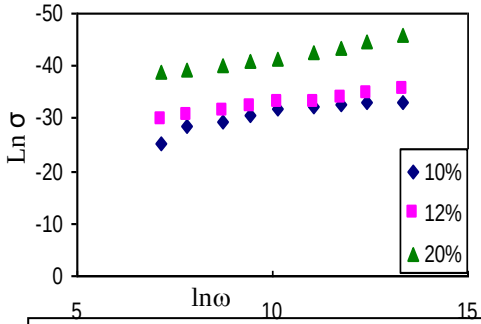

Figure (4): ln ω dependence of ln σ at different concentrations at dose 224.4KGy.

From these figures it found as the radiation doses increase the electrical conductivity increases and this is satisfy with previous study [6,12,13,14] which can be attributed to the cross-linking of γ-irradiation which effect on the dipole orientation of polymers. Due to γ-irradiation, ions and free radicals are formed and some of them are trapped in the sample. the gaseous ions around the films might have been produced in the surface of the film since the irradiation was carried out in the air [10,12].

The effect of dopant concentration was obvious, as the dopant concentration increase the ln σ decreases where Cr ions coordinates through the ionic bonds with hydroxyl group which belong to the different chains in PVA . the effect of this is appear in reduce the intermolecular interaction between chains and the dopant ($CrCl_3$) increases increase the volume required for ionic mobility. As the dopant increase the conductivity increase [11].

- Dielectric Constant

The dielectric constant (ε') measurement of doped PVA films before and after γ-irradiation as a function of angular frequency figures (5-8), which was calculated by using the equation $\varepsilon' = \frac{Ct}{\varepsilon_\circ A}$ [13].

These figures shows an irregular behaviour of the magnitude of ε' due to increasing the dopant and γ-irradiation. The effect of induced radiation on doped polymer may decrease the disorder of the dipole groups so the permittivity and the dielectric properties increase [13].

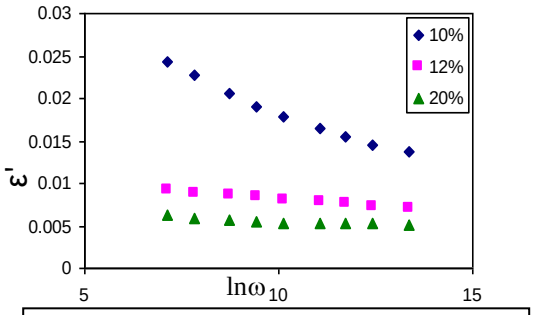

Figure (5): ln ω dependence of ε' at different concentrations of unirradiated

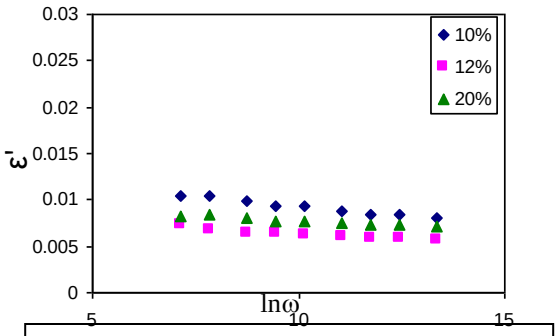

Figure (6): ln ω dependence of ε' at different concentrations at dose 56.1KGy.

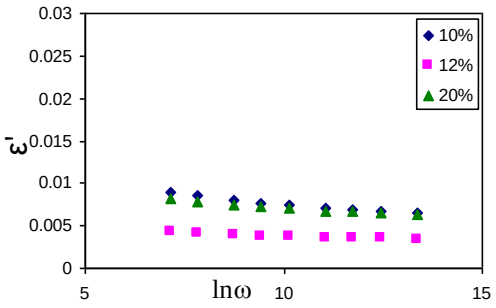

Figure (7): ln ω dependence of ε' at different concentrations at dose 112.2KGy.

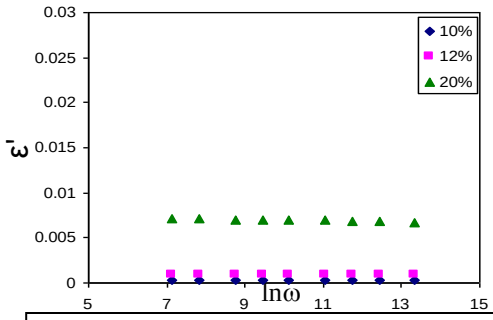

Figure (8): ln ω dependence of ε' at different concentrations at dose 224.4KGy.

Conclusions

The electrical properties of $CrCl_3$ doped PVA is effect by dopant concentration and γ-irradiation dose . The increase in dopant increase the electrical conductivity which explained according to Cr ions coordinates through ionic bonds with hydroxyl group in PVA which in turn causes reduces in the intermolecular interaction between chains of PVA. In other word Cr will increase the volume required for ionic carriers to drift PVA. γ-irradiation increase the electric conductivity since it rupture the ionic bond and release ions, electrons and free radicals which it move free in the polymer causing change in electrical properties**.**

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