Dielectric properties of 1,8 Anthraquinon phthalate films

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Abstract:

The dielectric properties of poly (1,8-antraquinon phthalate film's) have been studied through measuring the electrical equivalent circuit (lumped circuit) contained capacitance and resistance. The measurements were carried out in temperature range (305-343)K, at constant frequency (1KHz). The permittivity was found decreased with increasing temperature similar to the C_P , and the relaxation process was pointed in the temperature spectrum of the imaginary part of the dielectric constant $\varepsilon^{=}$ related to α- process. Another result that was obtained was the dissipation factor which at a high temperature decreased with increasing temperature.

Key words: Dielectric, permittivity, relaxation, dissipation factor, lumped circuit.

Introduction:

High performance polyimides are widely used in the microelectronic industry. The importance of these microelectronic applications is that, the polyimide has a low dielectric constant. Hence, the development of polyimides with increasing dielectric constant has been the focus of several investigations [1-5].

The polymeric materials are used in printed circuit boards and as insulators in wires cables [6], while the high dielectric constant materials can be used in the industry of capacitors [7].The aim of this study is to investigate the effect of temperature variation on dielectric properties of [1,8-antraquinon phthalate film's] , including permittivity, dielectric loss and loss tangent**.**

Experimental Procedure :

Poly (1,8-anthraquinon phthalate film's) were prepared by the following method adapted to that previously employed [8].The chemical structure confirms to the structure showed in figure(1) below.

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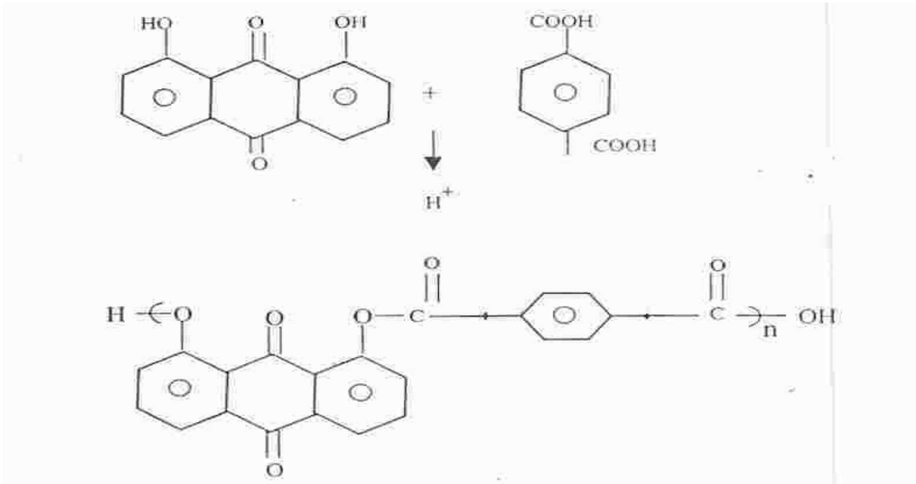

Fig (1) The chemical structure.

A three-neck flask equipped with a thermometer, mechanical stirrer and a condenser equipped with $CaCl_2$ guard tube was charged with (0.1) mol of 1,8-dihydroxy anthraquinone, (0.1) mol (16.6) gm of Terphthalic acid, (1) mol of conc. H_2SO_4 and (100) ml of Dimethylsulfoxide DMSO.
The reaction mixture was heated with continuous mixing at 100^oC for 5hrs, then the reaction mixture was cooled and neutralized and
the solvent was evaporated under vacuum with pressure of (10^{-4} torr) [8].
Samples have been prepared by casting the polymer from solution on aluminum substrates. Samples were heated gradually (10 ^oC /min) up to 100^oC and left 5hr's under 100^oC to evaporated the residual solvent.
In order to prepare the sample for electrical measurement, the upper contact circle in shape with radius (1mm) and thickness (1.56mm) was deposited on the upper surface of the film using the evaporation method to identify the ohmic contact.
Steady state current value can be obtained from the average value of charging current one minute after the application of the electric filed.[8]
The films have been kept at temperature range $(30\text{-}70)^oc$, where sample temperature was measured with a thermocouple copper constantan.

Measurements:

To study the dielectric properties of poly (1,8 - anthraquinon phthalate) one can represent the polymetric capacitor as an equivalent electric circuit which consists of pure capacitor and resistor connected either in series or in parallel.
Both circuits have an equivalent impedance, a.c resistance and power factor [9].
In order to calculate the real and imaginary part of dielectric constant ϵ' and ϵ'' respectively the following relations are used:
$\epsilon' = C_P / C_O$ and $\epsilon'' = 1 / R_p C_O \omega$

where C_P is the parallel capacitor, C_O is the capacitance of two metallic electrode in free space separated by a distance equal to the polymer thickness, ω is the angular frequency ($\omega=2\pi f$) and R_p is parallel resistance.

Results and Discussion:

The variation of permittivity ϵ' as a function of temperature for the poly (1,8-anthraquinon phthalate) is shown in Fig(2) . It is
Observed that the permittivity increases with the increase of temperature up to a maximum in the temperature range (305 - 343)K and then starts to decrease up to the measure range. This behavior may be attributed to the orientation of dipoles with the applied electric

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field which increases with the increase of temperature because a large part of the polymer's chain becomes mobile, and the accurance of structural change too [10].The high value of ϵ' may be related to the moisture, which we could not get rid of it easily because ϵ'=80 for water [11].

Figs (3&4) show the relation between the dielectric loss ϵ" at frequency (1KHz) and parallel resistance R_p versus temperature respectively. In fig (3) we can see that ϵ" is inversely proportional to R_p. This important result that was observed in fig (3) is α-process is ascribed to the micro-Brownian molecular motion of main chains [12].

Fig (5) shows the variation of loss tangent as a function of temperature. At high temperature tan δ decrease after a maximum value , this decreasing may be explained due to decrease in density of the dipole orientation, because the kinetic motion of molecules oppose the orientation effect is due to the applied electric field [12].

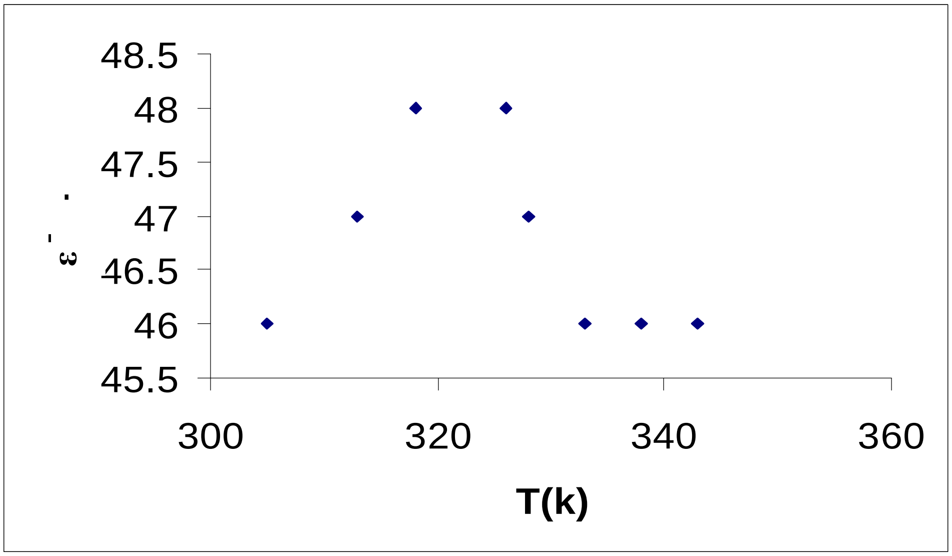

Fig (2) The variation of permittivity ε ⁻ as function of temperature.

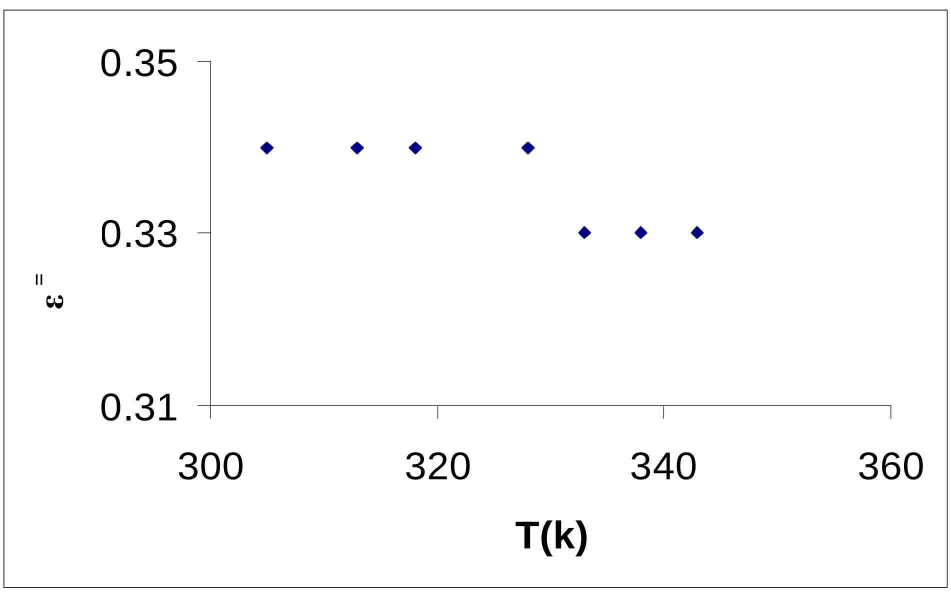

Fig (3) The variation of dielectric loss ε ⁼ as function of temperature.

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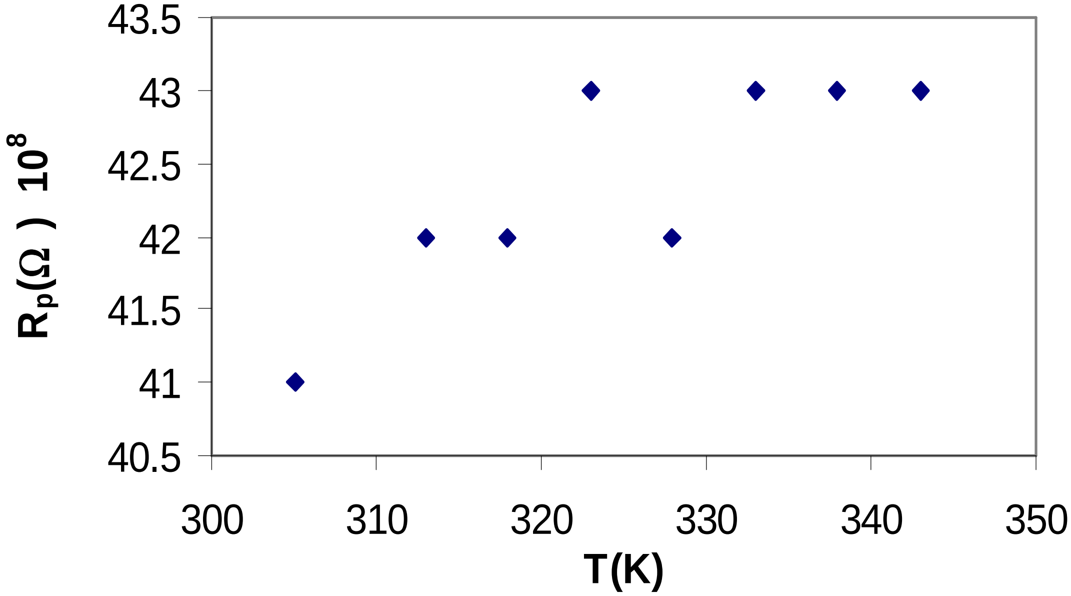

Fig (4) The variation of $R_P(\Omega)$ as function of temperature.

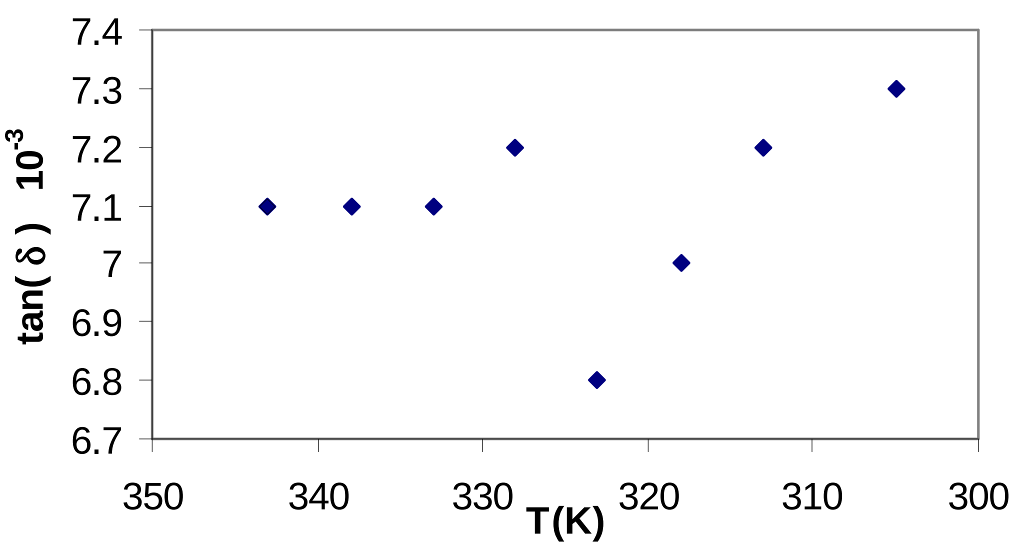

Fig (5) The variation of permittivity tan(δ) as function of temperature.

Conclusion:

The dielectric properties of poly (1,8-anthraquinon phthalate) films have been studied through measuring the real and imaginary part of dielectric constant versus temperatures and the relaxation process α was determined from the maximum variation of ε'' with temperature.

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المستخلص:

تم دراسة الخواص العازلية لشرائح بولي استر (1,8 – انترا كوينون فثاليت) من خلال تحليل الدائرة المكافئة التي تحتوي على متسعة ومقاومة. القياسات أخذت بدرجة حرارة (305–343)كلفن وعند التردد(1 كيلو هرتز).
وقد وجد عمليا إن السماحية تقل بزيادة درجة الحرارة . تم تحديد عملية استرخاء من نوع α من خلال دراسة العلاقة بين ثابت العزل الخيالي مع درجة الحرارة, وكذلك وجد إن عامل التشتت يقل بزيادة درجة الحرارة.

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