# Dielectric properties of Poly Crystal Violet Terephthalate ( PCVT )

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G. M. Shebeeb[1] A. F. Abdul Kader[1] A. Q. Abdullah[2]
[1] Department of Physics, College of Education ,
[2] Department of Physics, College of Science ,University of Basrah
(Basrah ,Iraq)
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## Abstract

The AC electrical conductivity $\sigma_{AC}$ ,dielectric constant Є′ and dielectric loss Є″ for poly (Crystal Violet Terephthalate ) have been studied at frequencies that range from 100 KHz to 1300 KHz and in temperature range ( 22 –70 ) °C. The experimental result shows that the value of dielectric constant Є′ slightly increases with increasing frequency which indicates that the major contribution to the polarization comes from orientation polarization , also the value of dielectric constant Є′ increased with increasing temperature , and is due to the greater freedom of the movement of the dipole molecular chains .The dielectric loss Є″ and AC electrical conductivity $\sigma_{AC}$ increase with increasing frequency, such as Є and $\sigma_{AC}$ dependant on frequency.

**Key Words**: Dielectric constant, Dielectric loss, AC Electric Conductivity, Orientation polarization, Crystal violate

## Introduction

Most of the interesting properties of polymer are attributable to the complex motions within their molecular matrix. In the polymer system molecular relaxations exhibit various transitions [1].

The dielectric properties of non conducting material describe the interaction of the material with electric fields. The two interactions of primary interest are the absorption and storage of electric potential energy in the farm of polarization within the dielectric material, and the dissipation or the loss of part of this energy when the electric field is removed [2].

Therefore, it has become essential to study the effect of interfaces on the charge-carrier generation, transport and storage in polymeric systems.

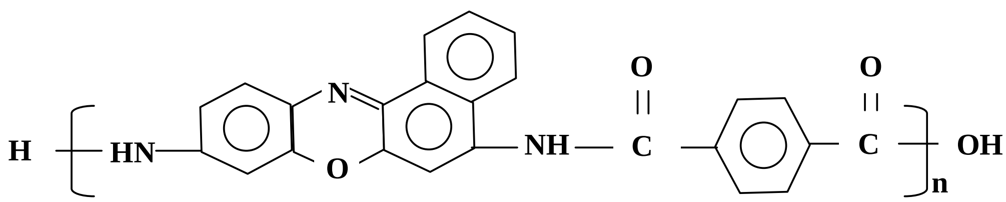
The study of dielectric constant and dielectric loss, as a function of temperature and frequency is one of the most convenient and sensitive methods of studding polymers structure.

The polymer composites in the solid or viscoelastic state, the physical structure is of great importance in determining the dielectric behavior [3].

The intention in the present work is to study dielectric properties of such a system. The polymeric interfaces act as charge-carrier trapping sites [4].

## Experimental

PCVT has been synthesized by condensation polymerization. The chemical structure for polymer has semi crystalline as shows in figure (1) [5].



Crystal Violet Terphthalate(PCVT)

**Fig (1) :** Chemical structure of PCVT

Dielectric constant Є′ and loss factors Є″ were measured in the Frequency range (100 KHz – 1300 KHz) and temperature range ( 22 – 70 ) °C. The dielectric measurements were made using electrical equivalent circuit (lumped circuit) contained capacitance and resistance. In order to prepare the sample for dialectical measurement , thin film was prepared by casting dilute polymer solution with DMSO solvent on aluminum substrate and then dried at room temperature for 3 hrs . Aluminum substrates supported by lower aluminum electrode deposition by evaporation method under low pressure $10^{-6}$ torr. Aluminum electrode was evaporated as appear-electrode through a circular mask with area (12.56 $cm^2$ ) to obtain sandwich configuration.

The sample temperature was measured with a thermocouple of copper constant, and for measuring we used EM 1634 Function Generator. Capacitance ($C_p$) measured with RLC model ( METRAWATT ) with range ( 1000PF - 1µF ) . The film thickness were measured by micrometer model ( koller ) with range ( 1 - 1000µm ) .

The dielectric constant Є′ has been calculated by the following equation, using the measured values of specimen capacitance ($C_p$) and the capacitance of the electrode ($C_o$) [6] ;

$$\epsilon' = C_p / C_o \qquad (1)$$

The dielectric loss Є″ has been calculated by the following equation, using the measured value of tanδ and the calculated value of Є′ from equation (1) ;

$$\epsilon'' = \epsilon' * \tan\delta \qquad (2)$$

The AC conductivity $\sigma_{AC}$ can be calculated by following equation, using the calculated value of Є″ from equation (2) ,where $\epsilon_o$ is the permittivity of free space and w is the angular frequency [7] ;

$$\sigma_{AC} = \epsilon_o * w * \epsilon'' \qquad (3)$$

## ***Results and Discussion***

Figure (2) shows the variation of dielectric constant Є′ with frequency at room temperature for sample of poly Crystal Violet Terephthalate. An important observation is that dielectric constant Є′ slightly increases with increasing frequency. This can be attributed to the enhancement of Є′ value due to the ohmic interfacial polarization (Maxwell – Wagner process) [8], of the structure of polymer which compensates for the decreasing of the decrease caused by the orientation polarization.

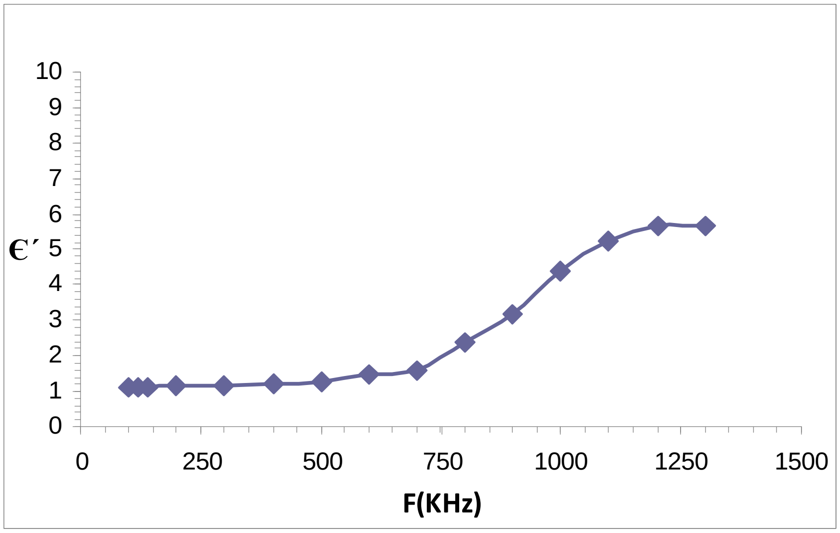



**Fig (2) : The variation of dielectric constant €′ with frequency at room temperature**

Figure (3) shows the variation of dielectric loss €″ with frequency at room temperature . It is evident from this figure that dielectric loss €″ slightly increase with increased frequency at a range from 100 KHz to 500 KHz , at higher frequency up to 500 KHz dielectric loss €″ which start to sharply increased to even higher value at 1300 KHz. The oscillatory behavior of dielectric loss €″ may be due to some relaxation processes which usually occur in heterogeneous system. The slightly increase of dielectric loss €″ in low frequency region is attributed to interfacial polarization caused by the heterogeneous nature of the system [9] , while the sharp increase of dielectric loss €″ at high frequency region is due to on setting of ohmic conductivity of the charge carrier .

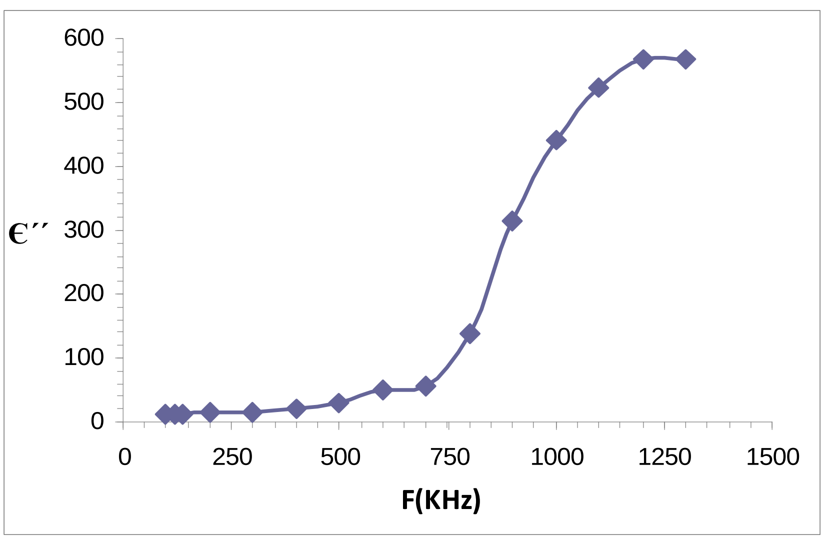



**Fig (3) : The variation of dielectric loss €″ with frequency at room temperature**

Figure (4) show the variation of AC electrical conductivity $\sigma_{AC}$ of ( PCVT ) as a function of the frequency at room temperature . The conductivity $\sigma_{AC}$ increases with increasing frequency . At higher frequency a transition point exist where the response starts to bend upward a little sharper . This behavior can be explained in terms of polarization effect and hopping between adjacent pairs randomly distributed with different barrier heights [10].

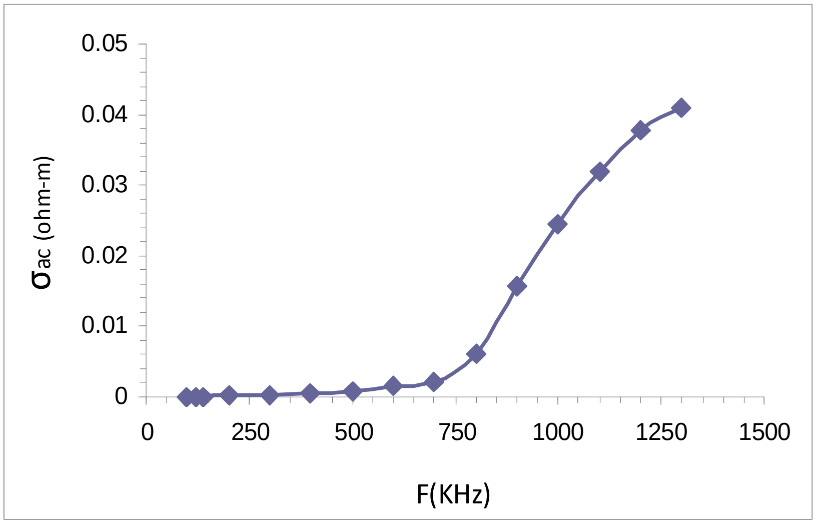



**Fig (4) : The variation of AC electrical conductivity $\sigma_{AC}$ with frequency at room temperature**

Figure (5) gives the variation of dielectric constant Є′ with frequency at different temperature. An important observation is that Є′ slightly increases as the increasing of frequency for each temperature. This can be attributed to the enhancement of Є′ value due to the ohmic interfacial polarization (Maxwell – Wagner process) [8] .

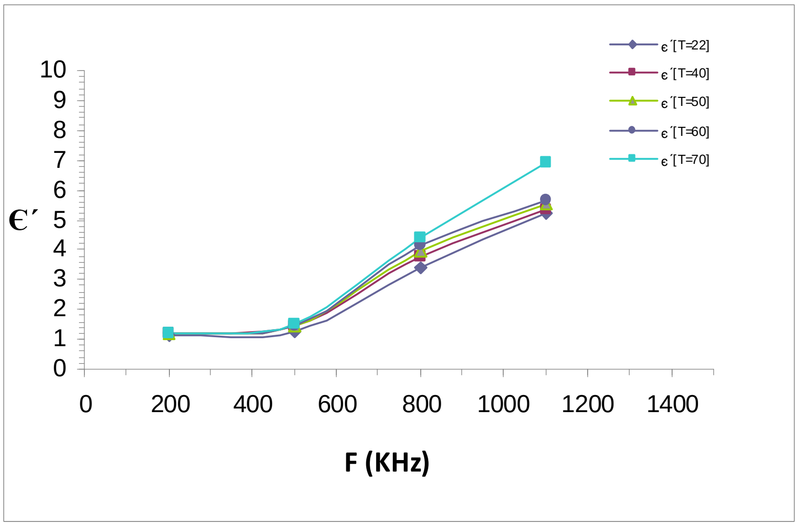



**Fig (5) : The variation of dielectric constant Є′ with frequency at different temperature.**

Figure (6) show the variation of loss factor Є˝ with frequency at different temperature. The value of Є˝ increases according to the increases the dissipation factor.

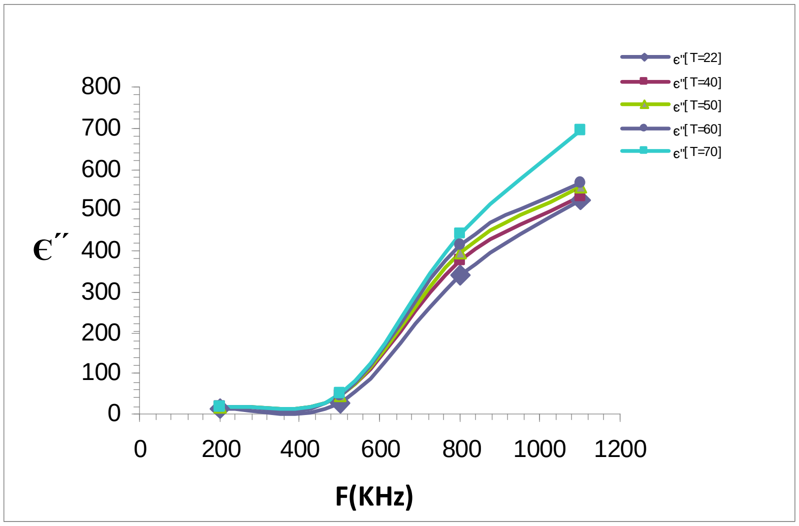



**Fig (6) : The variation of loss factor Є˝ with frequency at different temperature.**

Figure (7) shows the variation of Є΄ with a temperature at different frequencies. The value of Є΄ at low frequency was constants, at higher frequency Є΄ starts to slightly increase with a temperature at fixed frequency. As the temperature increases the dipoles comparatively become free and they respond to the applied electric field. Thus, polarization increased and hence dielectric constant also increased with the increase of temperature [11].

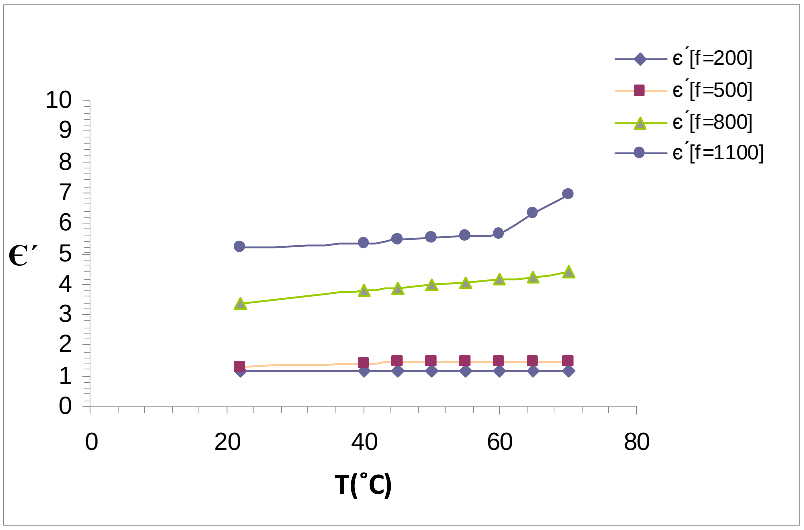



**Fig (7) : The variation of Є΄ with temperature at different frequencies.**

Figure (8) shows the variation of Є˝ with a temperature at different frequencies. The dielectric loss at low frequency was slightly increased with increasing temperature, at higher frequency Є˝ starts to increase with a temperature at fixed frequency. At high temperatures the chains motion will an increase leading to an increase in the free volume which means an increase in the number of dipoles that orient with applied electric field leading to increase the Є˝ values with temperature [12].

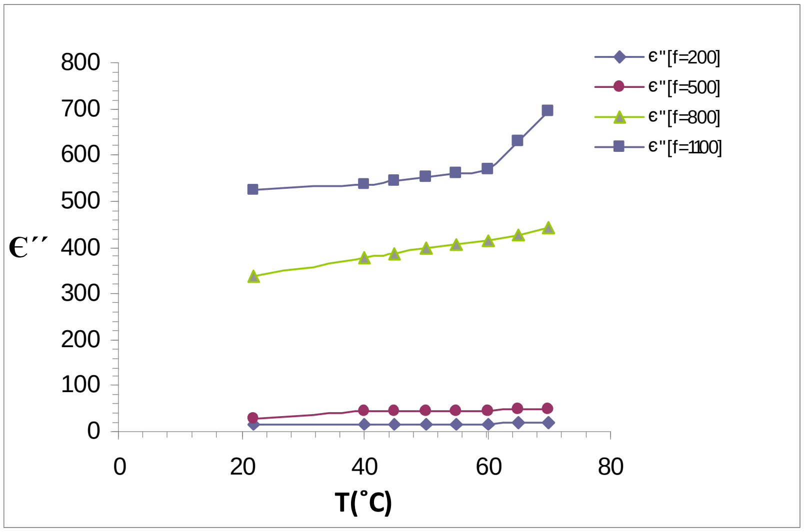



**Fig (8) : The variation of Є˝ with temperature at different frequencies.**

## Conclusion

Frequency and temperature dependence of dielectric constant Є΄, dielectric loss Є˝ and AC electrical conductivity $\sigma_{AC}$ in poly crystal violet terephthalate have been studied in the frequency range (100 KHz – 1300 KHz) and in the temperature range ( 22 – 70 ) °C. The experimental results indicate that $\sigma_{AC}$ ,Є΄ and Є˝ increased with increasing frequency and also the increased Є΄ and Є˝ with an increase of temperature is due to the polarization that comes from the orientation polarization and there is a greater freedom of movement of the dipole molecular chains of poly Crystal Violet Terephthalate .

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***المستخلص:***

تمت دراسة الخواص العازلية لبوليمر ( PCVT ) تضمنت الدراسة ثابت العزل الكهربائي $\epsilon'$ وعامل الفقد $\epsilon''$ والتوصيلية الكهربائية $\sigma_{AC}$ في مدى من الترددات ( 100KHz-1300KHz ) ولمدى من درجات الحرارة ℃ ( 70-22 ) ومن النتائج العملية تم الحصول على زيادة طفيفة لثابت العزل الكهربائي مع زيادة التردد يصاحبها زيادة ملحوظة في قيمة عامل الفقد والتوصيلية الكهربائية مع زيادة التردد.