

## Effect of chromium chloride ( $\text{CrCl}_2$ ) on the electrical properties for (PVA-PVP- $\text{CrCl}_2$ ) films.

Raya Ali Abed, Majeed Ali Habeeb

*Babylon University, College of Education for pure science, Department of Physics, Iraq*

E-mail:rayaali\_88@yahoo.com

E-mail:majeed\_ali74@yahoo.com

### Abstract

In this study, the samples have been prepared by using casting method from adding chromium chloride to poly vinyl alcohol and poly vinyl pyrrolidone with different weight percentages (3,6 and 9) wt.%. The D.C electrical properties have been studied with temperature (50-90) $^{\circ}\text{C}$ , also the A.C electrical properties have been investigated with frequency ranged from (100-  $5 \times 10^6$ ) Hz at room temperature. Results showed that the D.C electrical conductivity increase with increasing of concentration also the activation energy changed with increasing of concentration, as well as the dielectric constant and dielectric loss decrease with increasing of frequency but the A.C electrical conductivity increase with increasing of frequency, generally the dielectric constant, dielectric loss and A.C electrical conductivity increase with increasing of concentration for all samples.

**Keywords:**(D.C, A.C) electrical properties, (PVA-PVP) composites, chromium chloride.

### Introduction

Composite polymers are the process of adding some material to homogeneous polymers in order to change in some of its characteristics and the entering of new recipes on it [1]. Composite materials, especially with found plastic (polymeric) are one of the modern materials that play a role in most applications of engineering and technology, because the use of these materials requires possession good durability and high technically performance to resist foreign stresses affecting them and the circumstances surrounding the pressure, temperature and humidity and others [2]. In the recent years, water soluble polymers such as PVA, PVP and others have been found to be more significant, because of their possessing different applications, these polymers films have interestingly been found to be easily accepting various transition metal and rare earths as the do pant ions in required concentrations in their transformation as brightly luminescent polymer films of technical importance [3]. The poly vinyl alcohol (PVA) is a polymer with exceptional properties such as water solubility, biodegradability, biocompatibility, non-toxicity, and non-carcinogenetic that possesses the capability to form hydrogels by chemical or physical methods [4]. PVA has high enough tensile strength and satisfactory flexibility. To improve deformability PVA is usually plasticized by the variety of low molecular compounds mostly containing polar groups [5] PVP is potential material having a good charge storage capacity and dopant-dependent electrical and optical properties. Chemically PVP has been bound to be inert, non-toxic and interestingly, it displays a strong tendency for complex formation with a wide variety of smaller molecules [6].

### Experimental work

The materials used in this study are poly vinyl alcohol and polyvinyl pyrrolidone mixing with  $\text{CrCl}_2$ , samples have been prepared by mixing (0.08)g of PVA with (0.02)g of PVP in (30)ml of distilled water, and by using magnetic stirrer for the mixing process to obtain more homogeneous solution with temperature of 100  $^{\circ}\text{C}$ , by using casting method we get the films from this mixture and casting each one of these ratios in the template (Petri dish). The resistivity was recorded by temperature from (50 to 90) $^{\circ}\text{C}$  by using Keithley electrometer type (616 C). The volume electrical conductivity  $\sigma_v$  defined by: [7]

$$\sigma_v = 1/p = 1/RA \quad (1)$$

A: guard electrode effective area.

R: volume resistance

L: average thickness

The activation energy was calculated using equation:[8]

$$\sigma = \sigma_0 \exp(-E_a / k_B T) \quad (2)$$

$\sigma$  : electrical conductivity at T temperature,  $\sigma_0$ : electrical conductivity at absolute zero of temperature,  $K_B$  : Boltzmann constant and  $E_{act}$ : activation energy.

The A.C electrical properties have been measured by LCR meter type HIOKI 3532-50 LCR HI TESTER and by different frequencies from (100-  $5 \times 10^6$ ) Hz, the capacity ( $C_p$ ), resistivity ( $R_p$ ), dissipated factor (D) and reluctance (Z) have been recorded for all samples. The capacitance of a capacitor constructed of two parallel plates is given by the equation:[9]

$$C = \epsilon \epsilon_0 A/d \tag{3}$$

The dielectric constant has been calculated by using equation:

$$\epsilon' = C_p / C_0 \tag{4}$$

$\epsilon'$ : dielectric constant,  $C_p$ : the capacity and  $C_0$ : vacuum capacitor

The dielectric loss has been calculated by using equation:

$$\epsilon'' = 1/w R_p C_0 \tag{5}$$

$\epsilon''$ : dielectric constant,  $w$ : angular frequency,  $R_p$ : resistivity

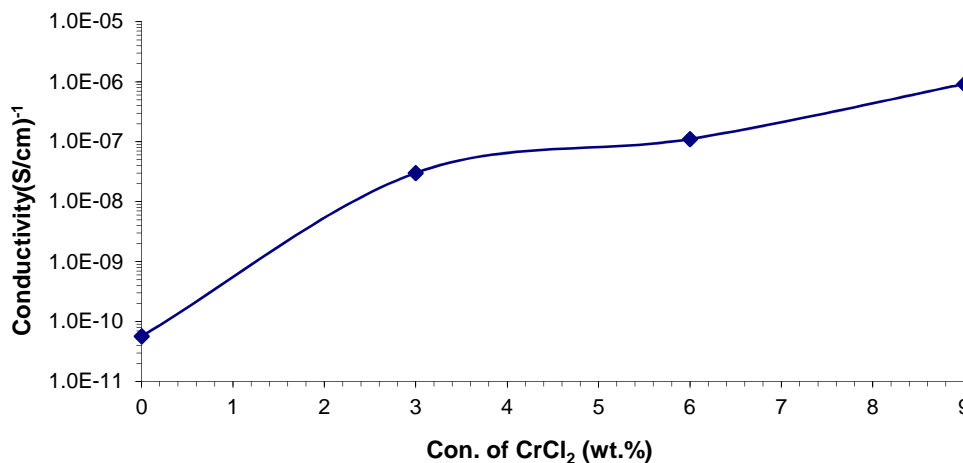
The A.C electrical conductivity has been calculated from this equation:

$$\sigma_{A.C} = w \epsilon'' \epsilon_0 \tag{6}$$

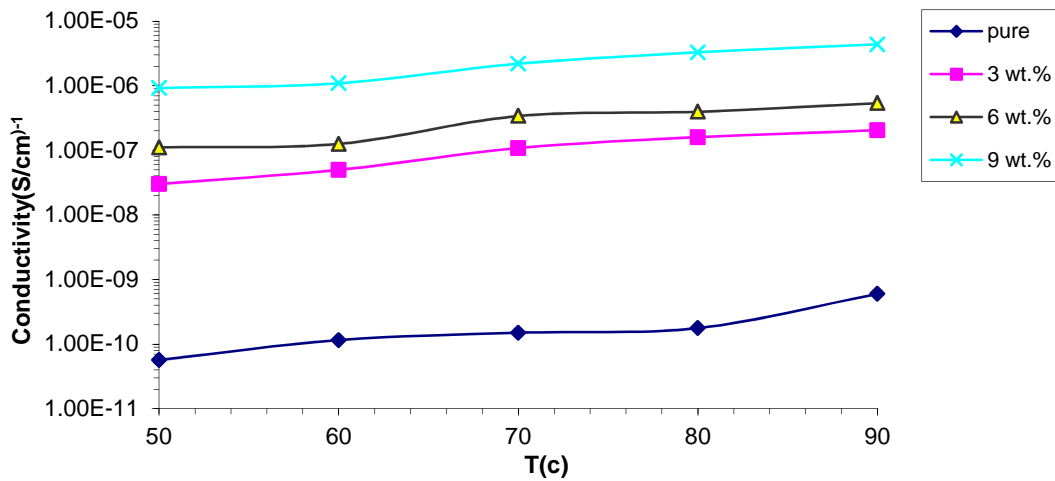
$\sigma_{A.C}$ : A.C electrical conductivity,  $\epsilon_0$ : permittivity of free space.

### Results and Discussion

Figure (1) shows the volume electrical conductivity ( $\sigma_v$ ) for (PVA-PVP) with various concentrations of  $CrCl_2$ . From this figure notice that the electrical conductivity increase with increasing of concentration. Interpretation of increased conductivity is at low concentrations the ions impurities are the form of isolated areas from each other into the middle overlapped, but when high concentrations are connected network inside the material overlapped is containing paths allow for charge carriers to passing through it pass charge carriers through the tracks that are less irresistible electrical [10]. Figure (2) shows the variation of electrical conductivity for (PVA-PVP- $CrCl_2$ ) with temperature. The volume electrical conductivity increases with increasing of temperature this is means that these materials have resistance of negative thermal coefficient (i.e. that resistance decrease with temperature increased).The explanation of this behavior is the polymeric chains and impurity ions act as traps to make charge carriers moving by hopping process. The conductivity of all samples will increase because of the increasing charge carriers and its movement [11].

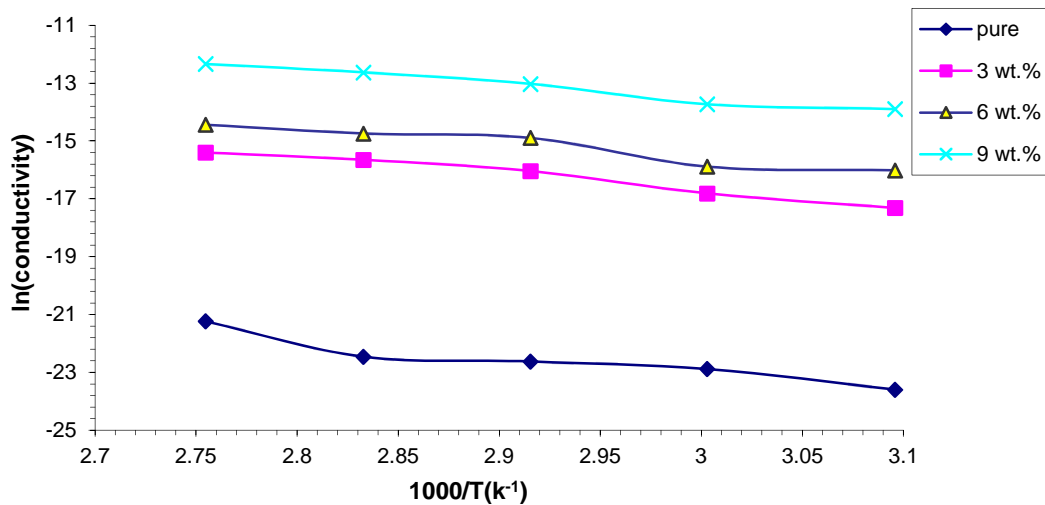


**Figure(1): Variation of D.C electrical conductivity with  $CrCl_2$  concentration for (PVA-PVP- $CrCl_2$ ) composite.**

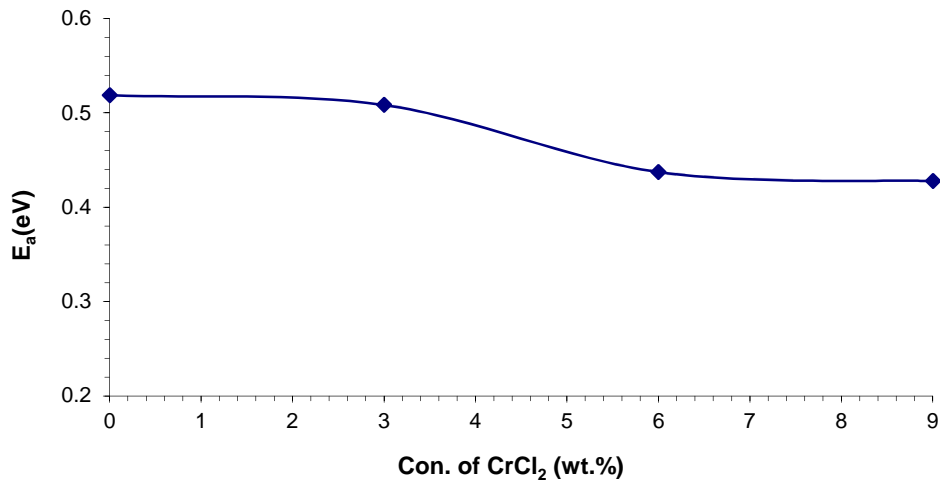


**Figure (2): Variation between D.C electrical conductivity and temperature for (PVA-PVP-CrCl<sub>2</sub>) composite.**

Figure(3) shows that the relationship between Ln D.C electrical conductivity with inverted absolute temperature for (PVA-PVP-CrCl<sub>2</sub>) composite. The activation energy was determined from equation (2). Results show that the activation energy equal to (0.50) at 3wt.% but at 9 wt.% reached to (0.42) for (PVA-PVP-CrCl<sub>2</sub>) composite, this is mean that the activation energy has high values at low concentration while at high concentration it has low values these due to the increase the local levels in the distance between conduction band and valence band. This is consist with the finding of the researchers [12,13]. The decrease in activation energy with increasing of (CrCl<sub>2</sub>) concentration shown in figure (4).

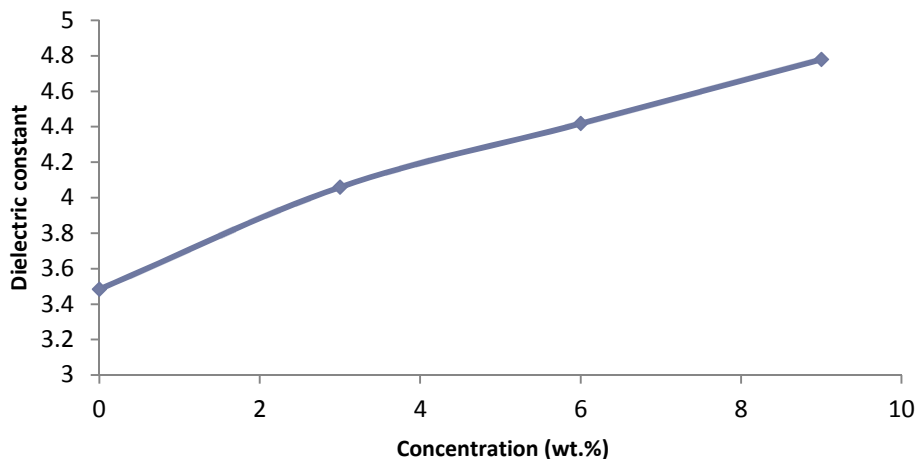


**Figure (3): Relationship between Ln conductivity and inverted absolute temperature for (PVA-PVP-CrCl<sub>2</sub>) composite.**



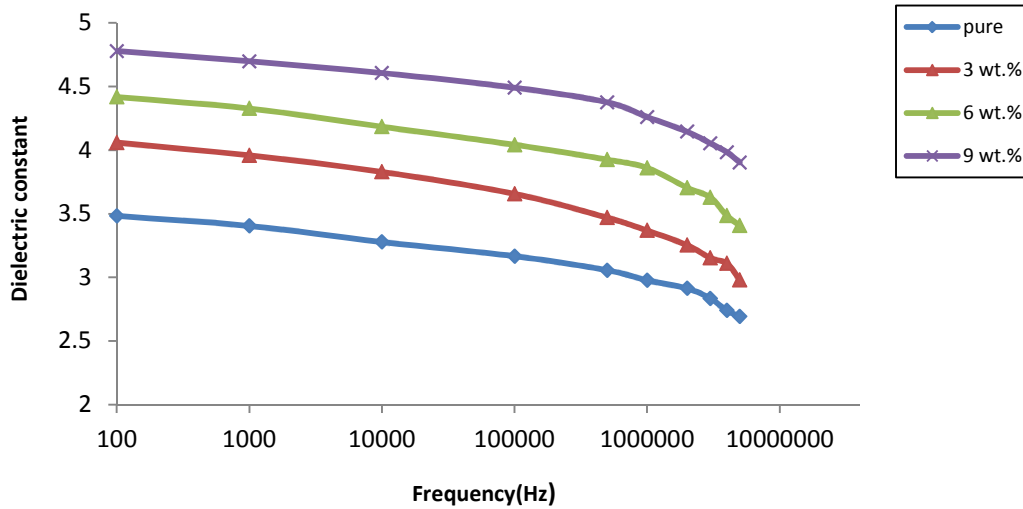
**Figure (4): Variation of activation energy with CrCl<sub>2</sub> concentration for (PVA-PVP-CrCl<sub>2</sub>) composite.**

The effect of concentration on the dielectric constant for (PVA-PVP-CrCl<sub>2</sub>) composite at 100 Hz shown in figure (5). From this figure we note that the dielectric constant increased with increasing of concentration. The reason of this increase attributed to formation of a continues network of (CrCl<sub>2</sub>) salt inside the composite. This is similar to the results was reached by researchers [14,15].



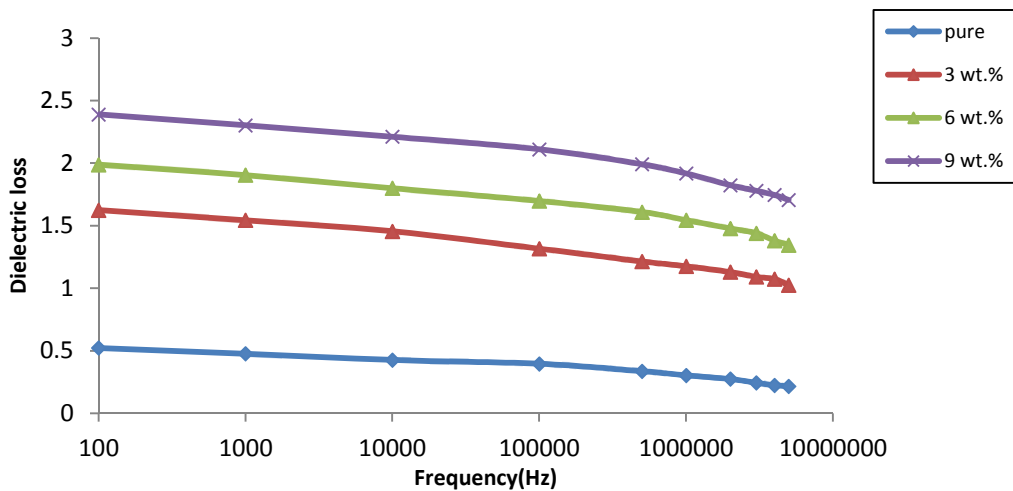
**Figure (5): Variation between dielectric constant and concentration for (PVA-PVP-CrCl<sub>2</sub>) composite at 100 Hz.**

Figure (6) show the variation of the dielectric constant with frequency for (PVA-PVP-CrCl<sub>2</sub>) composite. This figure show that the dielectric constant decrease with increasing of frequency. The increase in frequency lead to decrease polarization contribution to the total polarization interface which is the most common types of polarization contribution in low frequencies and it is decrease with increasing of frequency this is lead to decrease the values of dielectric constant for (PVA-PVP-CrCl<sub>2</sub>) composite with increasing of applied frequency from (100-5\*10<sup>6</sup>)Hz. The another types of polarization appear in the following frequencies and the response to the change applied frequency of ionic polarization is less than the electronic polarization because of ions mass larger than electrons mass where the electrons response to the oscillate of filed even the high frequencies because of the small electron mass which made the electronic polarization is the only at high frequencies thus the dielectric constant approximately fixed for all samples at high frequencies [12,15].

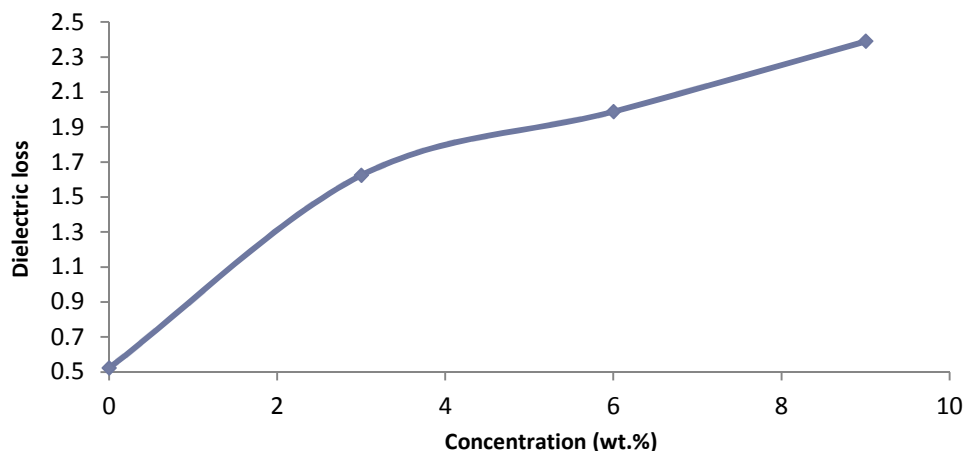


**Figure (6): Dielectric constant as a function of frequency for (PVA-PVP-CrCl<sub>2</sub>) composite.**

The variation of dielectric loss with frequency for (PVA-PVP-CrCl<sub>2</sub>) composite shown in figure (7). It is obvious from this figure that the values of dielectric loss are high at low frequencies but they are decrease with increasing of frequency this is attributed to decrease of contributed the ionic polarization with increasing of frequency [15], while at high frequency which is reached to ( $5 \cdot 10^6$ )Hz, the dielectric loss is approximately fixed this is due to another polarization mechanisms which are occur in high frequencies, also notice the value of dielectric loss increased with increasing of (CrCl<sub>2</sub>) concentration as shown in figure (8) this is due to increase of ionic charge carriers with increasing of concentration. This is similar to results of researchers [16,15,12].

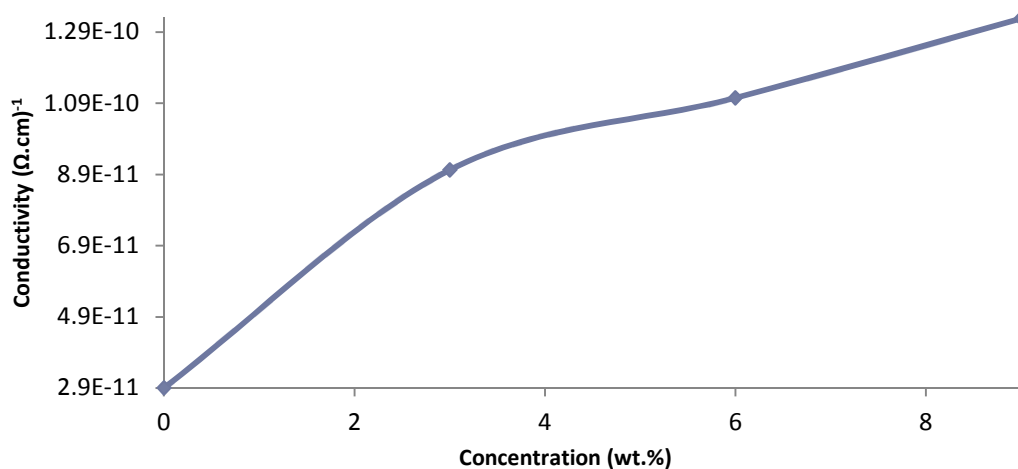


**Figure (7): Dielectric loss as a function of frequency for (PVA-PVP-CrCl<sub>2</sub>) composite.**



**Figure (8): Variation of dielectric loss with concentration at 100 Hz for (PVA-PVP-CrCl<sub>2</sub>) composite.**

The variation of A.C electrical conductivity ( $\sigma_{a.c}$ ) for (PVA-PVP) with various concentration of (CrCl<sub>2</sub>) at 100 Hz shown in figure (9). It is clear from this figure the A.C electrical conductivity increase with increasing of (CrCl<sub>2</sub>) concentration this is due to the effect of the space charge. The ions of ferric chloride take the form of clusters or separated groups at low concentration. The conductivity is increase with increasing of concentration as a result of the increase in ionic charge carriers and the formation of a continuous network of chloride ions inside the composite consequently, the conductivity is increasing with the increase of chloride concentration [17].



**Figure (9): Variation between A.C electrical conductivity and concentration at 100 Hz for (PVA-PVP-CrCl<sub>2</sub>) composite.**

Figure (10) show the variation of conductivity with frequency for (PVA-PVP-CrCl<sub>2</sub>) composite. This figure appear that the A.C electrical conductivity increase considerably with the increase of frequency ranged of (100-5\*10<sup>6</sup>)Hz, this is attributed to the ionic polarization which occurs at low frequency, also the motion of charge carriers by hopping process. The increasing of conductivity is small at high frequencies, this is due to the electronic polarization and the charge carriers which travel by hopping process [18].

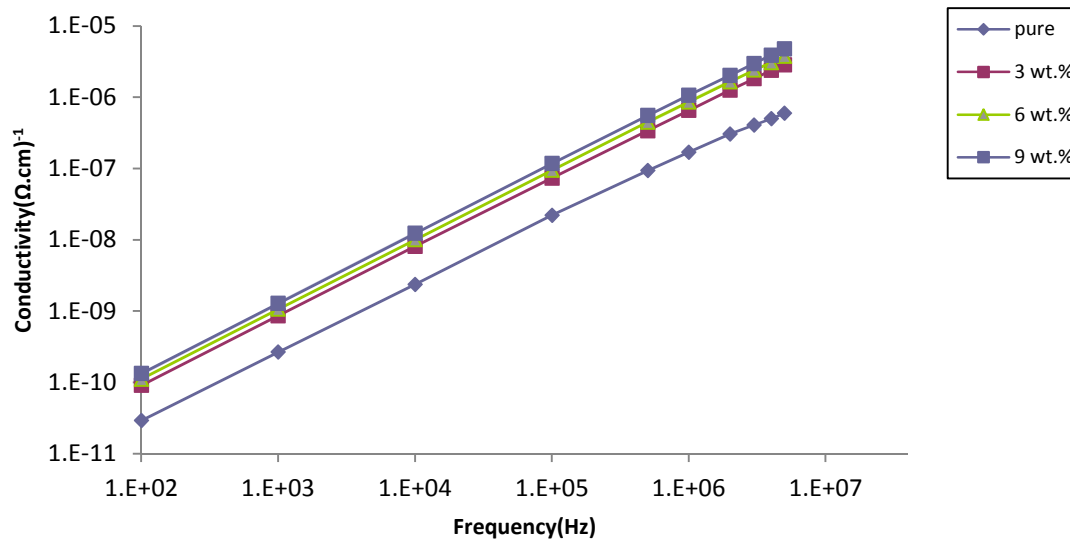


Figure (10): Variation between A.C electrical conductivity and frequency for (PVA-PVP-CrCl<sub>2</sub>) composite.

## Conclusions

1. D.C electrical conductivity for (PVA-PVP-CrCl<sub>2</sub>) composite increase with increasing of temperature and (CrCl<sub>2</sub>) concentration, and the value of D.C electrical conductivity was reached to  $9.19 \times 10^{-7} (\Omega \cdot \text{cm})^{-1}$  at 50 °C for (PVA-PVP-CrCl<sub>2</sub>) composite.
2. Activation energy for all composites decreased with increasing of concentration.
3. Dielectric constant and dielectric loss decreased with increasing of frequency but A.C electrical conductivity  $\sigma_{ac}$  increased with increasing of frequency for all samples
4. Dielectric constant, dielectric loss and A.C electrical conductivity increase with increasing of concentration.

## References

- [1] S. Rahe, "Study of Effect X-ray on the physical properties of a polyvinyl pyrrolidone (PVPD)", M.Sc. Thesis, University of Mustansiriah, collage of science, (2004).
- [2] W. Bolton, "Engineering Materials Technology", 3<sup>rd</sup> ed., amember of reed EL Sevier Group Butter worth–Heinemann, (1998).
- [3] Rzayev Z M O, Denizli B K and Denizli H, J Appl. Polym. Sci., (2008).
- [4] S. Patachia: Blends based on poly(vinyl alcohol) and the products based on this polymer. in: "Handbook of polymer blends and composites", (eds.: Vasile C., Kulshreshtha A. K.) Rapra Technology, Shawbury, (2003).
- [5] S.N. Ushakov, "Polyvinyl alcohol and derivatives thereof", Moscow Leningrad, Publishing House of Academy of Sciences, Vol.2, pp.781-790, (1960).
- [6] H.D. Wu, I.D. Wu, and F.C. change, "Polymer", (2001).
- [7] R.B. Seymour, "Polymer composites", 1<sup>st</sup> ed., Utrecht, The Nether Lands, (1990).
- [8] N. F. Mott and E.A. Davis, "Electronic Processes in Non Crystalline Materials", Calderon Press Oxford, 1979.
- [9] A. Muheisin, "Study of electrical conductivity for amorphous and semi crystalline polymers filled with Lithium Fluoride Additive", M.Sc. Thesis, University of Mustansiriah, college of Science, (2009).
- [10] H. Ibrahim and A. Hashim, "The D.C Eelectrical properties of PVA-LiF composite", Proceedings of International Conference on Chemical Innovation, (2011).
- [11] J. Wiley, "Effect of Metal concentration on the Electrical conductivity and some mechanical properties of poly methyl methacrylate-Copper composites", J. of Appl. Poly., Vol.20, (1976).
- [12] R. Khleel, "Electrical and optical properties Modification of poly vinyl chloride by Zinc, Copper and Nical EthylXanthate Chelate Complexes", M.Sc. Thesis, University of Mustansiriah, collage of Science, (2004).
- [13] E.A. Stefanescu, X. Tan, Z. Lin, N. Bowler and M.R. Kessler "Multifunctional fiberglass-reinforced PMMA-BaTiO<sub>3</sub> structural /dielectric Composites", Polymer 52 pp.2016-2024, (2011).
- [14] S.H.Kwan , F.G. Shin and W.L . Tsul , J. of materials science, pp. 4093- 4098, (1984).

- [15] M. Hamza, E. Soion, A. Kassim, and E. Mahmed, "Dielectric properties of polyvinyl alcohol/polypyrrole Composite polymer Films", Pakistan, Vol.1, No .1, pp.9-14, (2009).
- [16] S. Satapathy, P. Gupta, K. Varma, P. Tiwari and V. Ganeshan, "Study on dielectric behavior of lithium tantalite (LT) nano particle filled poly(vinyl fluoride) (PVDF) nano composites", Institute of science, India, (2008).
- [17] M. Alvarez, V. Poblete, M. Pilleux, and V. Fuenzalida, "Submicron copper-low-density polyethylene conducting composites: structural, electrical and percolation threshold", Comision chilena de energia nuclear, Chile, (2008).
- [18] B.G. Streetman, and S. Bonerjee, "Solid state electronic devices", 5<sup>th</sup> ed., Engle Wood cliffs, Nj Prentice ilall, (2000).



This academic article was published by The International Institute for Science, Technology and Education (IISTE). The IISTE is a pioneer in the Open Access Publishing service based in the U.S. and Europe. The aim of the institute is Accelerating Global Knowledge Sharing.

More information about the publisher can be found in the IISTE's homepage:

<http://www.iiste.org>

## CALL FOR PAPERS

The IISTE is currently hosting more than 30 peer-reviewed academic journals and collaborating with academic institutions around the world. There's no deadline for submission. **Prospective authors of IISTE journals can find the submission instruction on the following page:** <http://www.iiste.org/Journals/>

The IISTE editorial team promises to review and publish all the qualified submissions in a **fast** manner. All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Printed version of the journals is also available upon request of readers and authors.

## IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digital Library, NewJour, Google Scholar

