Research Article **Open Access**

Thermal and Electrical Properties of (PVA_CuCl) Composite

Zainab F. Nazzal[1], Samah M. Hussen[2], Ali J. Mohammed[1]
[1]College of Science, Al-Karkh University of Science, IRAQ
[2]Department of Applied Science, University of Technology, IRAQ
*Correspondent Author Email: gerges.ahmed@gmail.com

Article Info

Received
25/06/2018

Accepted
22/10/2018

Published
15/08/2019

Abstract

In this study, the properties of thermal and dielectric Constant and electrophoresis of polyvinyl alcohol (PVA) membranes with different concentrations (0, 3, 5, 7 and 10 wt%) of CuCl powder were investigated. A mixture was prepared using ultrasound technique for the distribution and homogeneity of the powder in the comparator polymer. The thermal conductivity (W/ m K) of the casting membrane was examined. The thermal conductivity of this polymeric system was increased by increasing the concentration of copper chloride. At 5% concentration, high thermal conductivity was observed, followed by a decrease in the values that followed. The electrical insulation and the electric permittivity were measured as a function of the percentage of the material. The results showed a gradual improvement in the durability of the electrical insulation by increasing the copper chloride material.

Keyword: Insulation, Electrophoresis, Copper Chloride, PVA, Durability of Electrical Insulation.

الخلاصة

تم في هذا البحث دراسة الخصائص الحرارية والثابت العزل الكهربائي والسماحية الكهربائية لأغشية بولي فنايل الكحول (PVA) المشوبة بتراكيز مختلفة(0, 3, 5, 7 and 10 wt%) من مسحوق ملح كلوريدالنحاس (CuCl). تم تحضيرا لمزيج باستخدام تقنية الموجات فوق الصوتية لغرض توزيع المسحوق وتجانسه في البوليمر المستخدم كأساس للمقارنة .قيست التوصيلية الحرارية (W/ m K) للأغشية المرسبة بطريقة الصب. أظهرت النتائج إن التوصيلية الحرارية لهذا النظام البوليميري قد زادت بزيادة تركيز كلوريد النحاس وعند تركيز ٥% تم ملاحظة صعود عالي للتوصيلية الحرارية ثم هبوط بالقيم التي تليها . وتم قياس ثابت العزل الكهربائي والسماحية الكهربائية كدالة للنسبة المئوية لمادة التدعيم , أوضحت النتائج تحسن تدريجي في متانة العزل الكهربائي بزيادة مادة كلوريد النحاس .

Introduction

Conductive polymers are organic compounds that conduct electricity. Such compounds may be true metallic conductors or semiconductors .It is generally accepted that metals conduct electricity well and that organic compounds are insulating, but this class of materials combines the properties of both. The biggest advantage of conductive polymers is their process suability. Conductive polymers are also plastics (which are organic polymers) and therefore can combine the mechanical properties (flexibility, toughness, malleability, elasticity, etc.) of plastic swath high electrical conductivity their properties can be fine-tuned using the exquisite methods of organic synthesis [1]. Different additives are usually added to polymer in order to modify and improve its properties. Inorganic additives such as transition metal salts have considerable effect on the thermal and electrical properties of PVA (polyvinyl alcohol) polymer [2]. Polyvinyl polymer, namely polyvinyl alcohol (PVA) has several interesting physical properties, which are very useful in material science and technical applications. (PVA) as semi crystalline water-soluble material exhibits certain physical properties resulting from crystal-amorphous interfacial effects [4]. Conducting polymers are conjugated chain of organic compounds that display high electrical conductivity similar to metals because of the present of large carrier concentrations of extended π-electrons, known as polarons, which allow charge mobility along the backbone of the polymer chain. Their electrical conductivities are comparable with metals but polymers have many advantages, such as being light-weight, resistance to corrosion, flexibility, and low cost.

Conducting polymers are finding numerous applications in television sets, cellular telephones, displays, light emitting diodes, solar cells, batteries, actuators, sensors, electromagnetic shielding, and microelectronic devices [5].

Thermal conductivity test Lee's disc instruments used to calculate thermal conductivity of the samples under test. The heat (e) ($W/m^2.K$) that flows through across section area of the sample per unit time is calculated from the following equation [8]:

$$K\left[\frac{T_B - T_A}{d_S}\right] = e\left[T_A + \frac{2}{r}\left(d_A + \frac{1}{4}d_S\right)T_A + \frac{1}{2r}d_S T_B\right] \quad (1)$$

Where:

I: is the current value through the electrical circuit. V is the supplied voltage.

r: is the radius of disc (2cm).

T_A, T_B and T_C are the temperature of the brass discs A, B and C, respectively. d_A, d_B and d_C are the thickness of the brass discs A ,B and C, respectively.

d_S is the thickness of the sample.

The values of thermal conductivity K (W/m. K) are calculated by applying the equation:

$$IV = \pi r^2 e(T_A + T_B) + 2\pi r e\left[d_A T_A + d_S \frac{1}{2}(T_A + T_B) d_S T_S + d_C T_C\right] \quad (2)$$

Materials and Methodology

Poly (vinyl alcohol) (PVA) (MW = 85,000 g/mol) supplied by Sigma Aldrich (St. Louis, MO, USA), aniline monomer (MW = 93.13 g/mol) by Fulka Chemie (Buchs, Switzerland). The materials used in this work were as powder of commercial polyvinyl alcohol (PVA) doped by Cupper Chloride (CuCl) salt with weight percent (0, 3, 5, 7 and 10 wt%). It was dissolved in glass beaker (10 ml) of distilled water using magnetic stirrer for about (1hr) and placed in Petri dish (5 cm diameter) using casting technique to prepare the films. The thickness of the dried samples is (0.045) cm by using micrometer. The Thermal conductivity by use test Lee's disc instrument is used to calculate thermal conductivity of the samples. The dielectric strength measurement was carried out using a breakdown test cell BAUR (0-60) KV designed with the appropriate electrodes and the breakdown tests were carried out in a medium of transformer oil.

Results and discussion

The use of copper chloride in this work in order to prepare and increase the transport carriers and increase the thermal conductivity because it is responsible for the transfer of thermal energy in the conductive materials and because the polymer used in this work is a heat insulation material and electricity so it was supported by different percentages of copper chloride.

Figure 1 shows a significant improvement in the thermal conductivity values of the supported models (CuCl) compared to the base material (PVA). The preferred value of the model supported by 5% is due to the regular distribution in the polymer matrix. The thermal conductivity of the base material reached 5% (0.43 W/m K) compared with the base material which was the value of the thermal conductivity (0.0001).

Figure 1 shows the behavior of the thermal conductivity of the supported and non-supported models. The value is at 5% as shown in Figure1.

Table 1: The Value of The Temperature degree.

(PVA_Cucl)	d_S mm	T_A ºC	T_B ºC	T_C ºC
0%	0.34	39.5	40	42
3%	0.37	38	39	38
5%	0.45	41	41.5	40
7%	0.63	39	41	40
10%	0.65	39.5	40.5	41

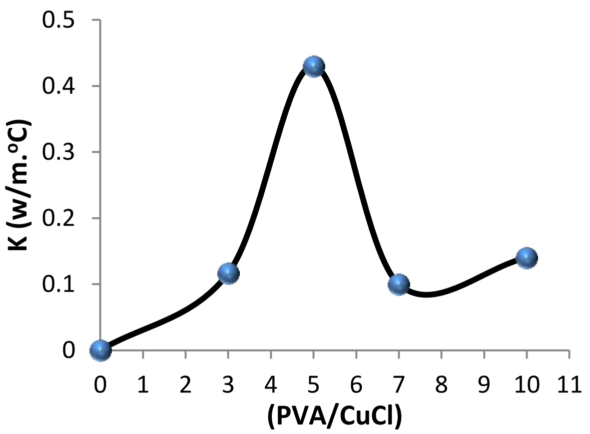

Figure 1: Thermal conductivity of (PVA-CuCl) at frequency 100(Hz).

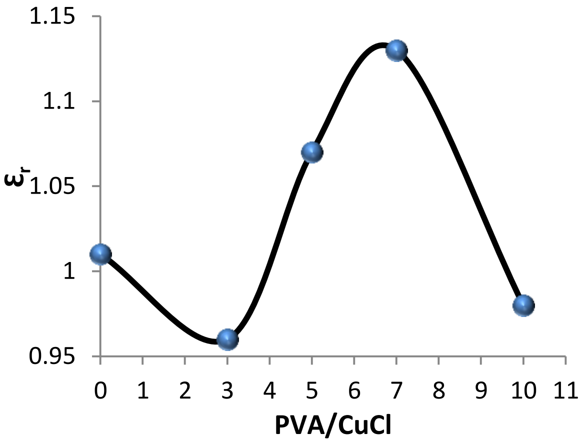

Figure 2: Dielectric Constant of (PVA -CuCl) at frequency 100(Hz).

Table 2: Experiment of Thermal Conductivity.

PVA_CuCl	Thermal conductivity (w/m.°C)
Pure PVA	0.0001
3%	0.117
5%	0.43
7%	0.1
10%	0.14

Table 3: Experiment of Dielectric Constant.

PVA_CuCl	Dielectric constant
Pure PVA	1. 01
3%	0.96
5%	1.07
7%	1.13
10%	0.98

Dielectric Constant

The relative static permittivity, εr, can be measured for static fields as follows: first the capacitance of a test capacitor, C_o, is measured with vacuum between its plates. Then, using the same capacitor and distance between its plates, the capacitance C with a dielectric between the plates is measured [9]. The relative permittivity can be then calculated by equation:

$$\varepsilon_r = C/C_o \quad (3)$$

Figure 2 and Table 2 shows the results of the test of the electrical Dielectric constant of the prepared models. The figure shows the fluctuation of the values of the insulation constant between the values (0.98-1.13). We observe the increase and increase the value of the insulation constant at 7% compared to other ratios. The behavior of the reinforcement material at the different frequencies and the composite is a conductive material that led to a decrease in the insulation constant at the higher value of the subsidized ratio compared to the base material (PVA) .

Dielectric strength

The dielectric strength measurement was carried out using a breakdown test cell BAUR (0-60) KV designed with the appropriate electrodes and the breakdown tests were carried out in medium of transformer oil. The dielectric break down voltage was measured at several points for testing samples. The test was carried out at room temperature (25°C).The dielectric strength was obtained from the following equation [10]:

$$E = V/t \quad (4)$$

Where E is the Dielectric strength, V and t are breakdown voltage (KV) and sample thickness (mm), respectively.

Figure 3 and Table 4 show the results of the test for the durability of the dielectric strength, where in the form shows a significant improvement in the durability of the dielectric strength when adding the supporting material (CuCl) and the best value at the percentage of 5% due to the regular distribution of powder under the matrix of the base material (PVA) and this led to Increasing the resistance of the collapse The number of frequencies used In Figure 3 we notice a decrease in the values of durability at high ratio due to the direction of the material to the conductivity and loss of insulation strength compared to the base material (PVA) and is expected because the material used is a high-conductivity materials.

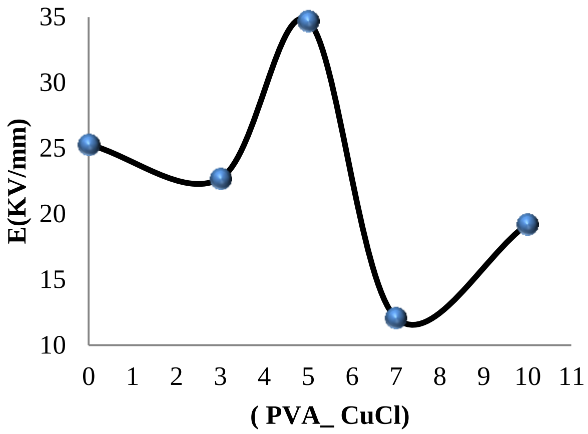

Figure 3: Dielectric strength of (PVA-CuCl) at frequency 100(Hz).

Table 4: Experiment of Dielectric Constant.

PVA_CuCl	Dielectric strength (KV/mm)
Pure PVA	25.3
3%	22.7
5%	34.7
7%	12.1
10%	19.23

SEM Test

Surface morphology was conducted for selected samples with the copper chloride powder used for reinforcement to illustrate the results of the tests performed. Figure 4 shows images of the scanning electron microscopy of sample 5% and sample 7% in addition to the copper chloride powder. In the figure we observe the homogeneous distribution of the models prepared in an effective mixing method to obtain the best results at 5% and 7% consolidation.

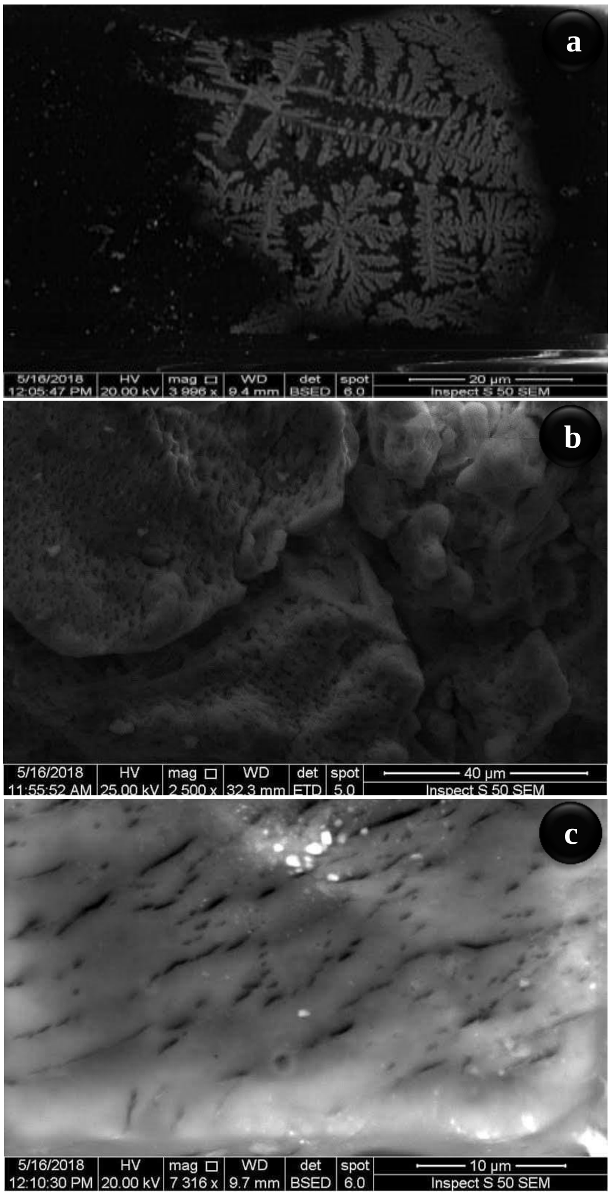

Figure 4: SEM Image (a) CuCl Powder, (b) 5% PVA/ CuCl, (c) 7% PVA_CuCl.

Conclusions

Through this work, we can conclude the following:

1- PVA_CuCl prepared with different ratios and weights have significantly improved the thermal conductivity properties and durability of the insulation due to the efficiency of the material and its suitability for such application.

2- Through the results these composites can be classified as semi-conductive substances

3- This type of composites can be used as sensors for heat and humidity.

References

[1] N. Herbert; "Polymers, Electrically Conducting ,Ullmann's Encyclopedia of Industrial Chemistry";Wiley-VCH, Weinheim; (2002).

[2] R.I. Mohamed and A. M.Gadou; "AC-Conductivity and Dielectric Properties of Y-Irradiated PVA Films Doped with Mn2+ Ions";EgyptJ.Sol.23(1), (2000), 277.

[3] M. Abdul-Aziz;" Cerium (III)doping ffects on optical and thermal properties of PVA films"; Physics B: CondensedMatter.406(6-7),(2011), 1300.

[4] K.G. Vijaya andR.Chandramani;"Study of the Semiconducting Behavior of La(No3)3 DopedPolyVinylAlcoholFilmswithandWithoutGamma(Y)-Irradiation";Journalof Applied Science Research.4(11), (2008), 1603.

[5] Ali, M.A.; Saion, E.; Yahya, N.; Kassim, A.; Dahlan, K.M.; Hashim, S. Synthesis of conducting poly aniline nano composites by radiation doping. J. Eng. Sci. Technol. 2007, 2, 111–118.

[6] Reda , S.M.; Al- Ghannam, S.M. Synthesis and electrical properties of poly aniline composite with silver nanoparticles. Adv. Mater. Phys. Chem. 2012, 2, 75–81.

[7] Chuang, F.-Y.; Yang, S.-M. Cerium dioxide/poly aniline core–shell nano composites. J. Colloid Interface Sci. 2008, 320, 194–201.

[8] Tolf G. and Clarin P.," Fiber Composite Hybrid Materials", Applied Science Publisher LTD, London, (1981).

[9] Jump up^ Costa ,F.;Amabile ,C.; Monorchio ,A.; Prati, E. (2011)."Waveguide Dielectric Permittivity Measurement Technique Based on Resonant FSS Filters".
Letters. 21 (5):273. doi:10.1109/LMWC.2011.2122303.

[10] Hazizan MdAkil, Leong Wei Cheng ,Z.A. MohdIshak , A.Abu Bakar ,and M.A. Abd Rahman, Water absorption study on pultrud edjute fibre reinforced unsaturated polyestercomposites, Composite Science Technology,Vol.69.