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Studying the Effect of Water on Electrical Conductivity of Cu Powder Reinforced Epoxy Composite Material

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ABSTRACT

We study electrical conductivity behavior of Cu-powder reinforced epoxy composite material in different solutions (distilled water, tap water &3.5%NaCl) with a weight fraction (5, 15, 30 &45) was investigated for (7) weeks immersion time. The results exhibit that electrical conductivity increases as increasing immersion time due to the specimen was absorbed the solutions. The maximum values were reached with 3.5% NaCl solution because of Cl ions whereas electrical conductivity not apparent in distilled water was attributed to pure water containing no ions is an excellent insulator.

Keywords: electrical conductivity, epoxy & cupper.

دراسة تأثير الماء على التوصيلية الكهربائية للمواد المتراكبة المتكونة من الايبوكسي المدعم بمسحوق النحاس

الخلاصة

تم في هذا البحث دراسة سلوك التوصيلية الكهربائية للمواد المتراكبة من الايبوكسي المـــدعم ب (5, 15, 30 &45) % من مسحوق النحاس في محاليل مختلفة (ماء مقطر, مـــاء الحنفيـــة و3.5 % كلوريد الصوديوم) خلال 7 اسابيع فترة غمر. اظهرت النتائج ان التوصيلية الكهربائية تزداد بزيادة فترة الغمر وذلك بسبب امتصاص العينة للمحاليل. اعلى قيم سجلت للتوصيلية كانت عند الغمر بمحلول كلوريد الصوديوم بسبب ايون الكلور في حين لم تظهر قيم واضحة للتوصيلية الكهربائية عند الغمر بالماء المقطر لعدم احتوائه على الايونات حيث يعمل كعازل.

INTRODUCTION

The materials which conduct electricity when an electrical potential difference is applied across them are known as conducting materials. The most important property of a material is the electrical resistance, which characteristics the electrical properties more lucidly. The conductivity (σ) of a material depends on the presence of free electrons or conduction electrons, which move freely in the metal and do not correspond to any atom [1].

Composite materials, which are usually fabricated with emphasis on properties such as mechanical strength, have also been used in electronic applications. One such class of composite materials is particulate-filled conductive polymer matrix composites. These composites consist of a polymer matrix in which a second phase, it is usually either a metal or carbon based filler, is dispersed. Conductive polymer composites, which are light weight materials and combine the inherent

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process ability of polymers with the electrical conductivity of metals, have been used in a number of applications such as electromagnetic frequency interference (EMI) shields and antistatic devices [2].
Most polymer resins are intrinsically insulating, and their conductivity values are approximately $10^{-14} \sim 10^{-17}$ S/cm.

Epoxy Resin are materials may be formulated for strength and rigidity. The addition of metal or other powders will increase thermal and electrical conductivity. Epoxy resins can be formulated with a wide range of properties. These medium- to high-priced resins are noted for their adhesion, make excellent primers, and are used widely in the appliance and automotive industries. Their heat resistance permits them to be used for electrical insulation. They are used as electrical insulating because of their high electric strength at elevated temperatures [3]. Polymers are very good insulators because all the electrons are bound in covalent bounds and there is no free electron to conduct electricity [4].
P.V. studied the effect of water on electrical properties of polymer composite with cellulose fibres during 14 days; it was found that volume resistivity decreases with increasing immersion time [5].

EXPERIMENTAL SET UP

The materials studied were Cu-powder reinforced epoxy which consisted of its hardener in 3:1 ratio.

1. Weight amount of Cu-powder were mixed with measured epoxy at different of weight fraction (5, 15, 30& 45) %.
2. The mixture was mould and the samples of polymer composite were cutting with (2&0.5) cm dimensions.
3. The sample surface was Polishing to improve smoothing.
4. Make the electrodes by silver electroplating on the sample surface to improve the electrical properties.
5. The simplest capacitor structure disc form, consisting of a layer of dielectric material sandwiched between two silver layers.
6. The device precision LCR meter was accurately adjusted then used to measure the resistivity (R) values on the electronic screen. From these value can be fined an electrical conductivity by equation 1. These measurements test for (1 KHz.) at room temperature.
7. Whole Samples were immersed in distilled water, tap water &3.5%NaCl at room temperature for different periods of time (1, 2, 3, 4, 5, 6&7) weeks.
8. The samples were dried at room temperature for two hours after immersion test.

$$\sigma = \frac{d}{R.A} \qquad \text{...... (1)}$$

Where:
σ: electrical conductivity (Scm^{-1})
d: diameter of specimen, cm
R.: electrical resistivity, Ω/cm
A: cross- section area, cm^2

RESULTS AND DISCUSSION

Effect of Solutions

Electrical conductivity behavior of Cu-powder reinforced epoxy composite material in different solutions (distilled water, tap water &3.5%NaCl) with a weight fraction (5, 15, 30 &45) for 7 week immersion time as shown in figures (2-5), The results exhibit that electrical conductivity increases as increasing immersion time due to the specimen was absorbed the solutions then the values will be constant because of the specimen was saturated with solution and swelling.

The electrical conductivity values were different from solution to another according to ions in aqueous solution, therefore the maximum value was recorded at 3.5% NaCl solution, it reached ($3.03 *10^{-8}$ S/cm) with (45% Cu) for 7 week as shown in figure (1).

The conductivity of a solution of water is highly dependent on its concentration of dissolved salts, and other chemical species that ionize in the solution, Pure water containing no ions is an excellent insulator, but not even "de ionized" water is completely free of ions.

If water has even a tiny amount of such an impurity, then it can conduct electricity readily, as impurities such as salt separate into free ions in aqueous solution by which an electric current can flow. Any electrical conductivity observable in water is the result of ions of mineral salts dissolved in it.

Effect of Weight Fraction

The effect of weight fraction of copper reinforced epoxy composite materials was investigated in this work, it was (0, 5, 15, 30 &45) % in different solutions (distilled water, tap water &3.5%NaCl) for 7 weeks immersion time.

Since the copper has high conductivity ($59.6*10^{6}$ S/m), therefore epoxy reinforced with 45%copper was exhibited maximum values of electrical conductivity. The increase in electrical conductivity with increasing in weight fraction of copper was due to interfacial polarization, if materials are placed in an electric field, the charge particles interact with the field. If material is a conductor, the free electrons move to the nearest positive electrode. No field is, thus, left within the material.

If a material is non- conducting or an insulator or dielectric the electrons are only locally displacement, because they are bound to individual atoms. The local displacement polarizes the material.

CONCLUSIONS

1. As immersion time increases the electrical conductivity increasing.
2. Maximum value of electrical conductivity was recorded at (45%) Cu reinforced epoxy that is as weight fraction increases the electrical conductivity increasing.
3. The electrical conductivity was different from solution to another, it reached ($3.03 *10^{-8}$ S/cm) with (45% Cu) for 7 week in 3.5% NaCl solution.

4. Not apparent values of electrical conductivity with immersion in distilled water for same immersion time.

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Table (1) the variation of electrical conductivity (σ) with immersed in distilled water

Samples	$\sigma * 10^{-8}$							
	0 week	1 week	2 week	3 week	4 week	5 week	6 week	7 week
5%Cu-epoxy, (A)	0.187	0.238	0.306	0.517	0.654	0.654	0.654	0.654
15%Cu - epoxy, (B)	0.404	0.506	0.667	0.689	0.734	0.734	0.734	0.734
30%Cu-epoxy, (C)	0.596	0.642	0.741	0.795	0.795	0.795	0.795	0.795
45%Cu-epoxy, (D)	1.011	1.037	1.11	1.178	1.195	1.195	1.195	1.195

Table (2) the variation of electrical conductivity (σ) with immersed in tap water

Samples	$\sigma * 10^{-8}$							
	0 week	1 week	2 week	3 week	4 week	5 week	6 week	7 week
5%Cu-epoxy, (A	0.187	0.41	0.64	0.79	0.88	1.27	1.33	1.35
15%Cu - epoxy, (B	0.404	0.58	0.75	0.87	1.32	1.544	1.63	1.71
30%Cu-epoxy , C)	0.596	0.84	0.96	1.42	1.65	1.72	1.79	1.81
45%Cu-epoxy, D)	1.011	1.33	1.64	1.86	1.97	2.21	2.25	2.28

Table (3) the variation of electrical conductivity (σ) with immersed in (3.5% NaCl)

Samples	σ * 10^{-8}							
	0 week	1 week	2 week	3 week	4 week	5 week	6 week	7 week
5% Cu-epoxy, (A)	0.187	0.78	1.12	1.34	1.56	1.78	2.03	2.31
15% Cu - epoxy , B)	0.404	0.83	1.32	1.66	1.89	2.34	2.61	2.73
30% Cu-epoxy , C)	0.596	1.09	1.55	1.87	2.37	2.83	2.99	2.99
45% Cu-epoxy , D)	1.011	1.41	1.74	1.93	2.52	2.88	3.02	3.03

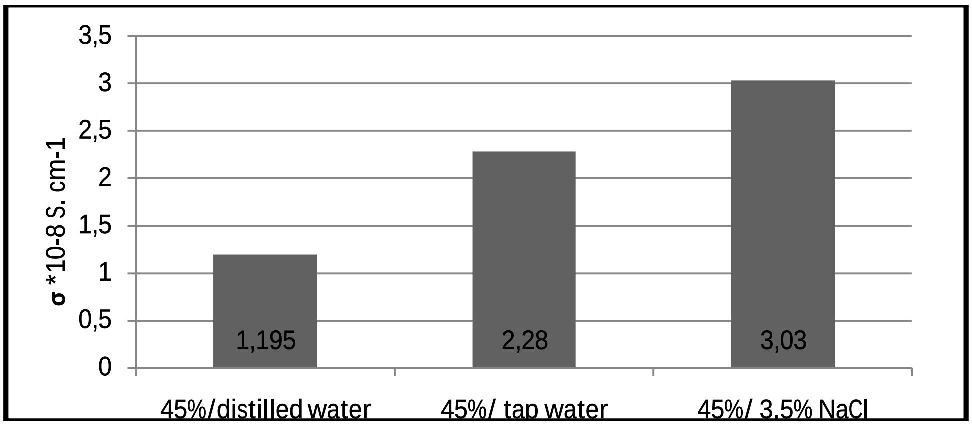

Figure (1): electrical conductivity with (45%) Cu reinforced epoxy for different solutions

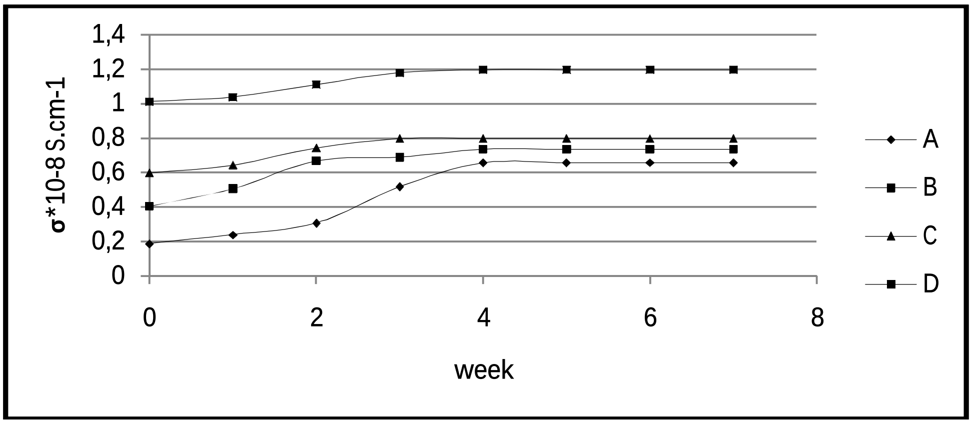

Figure (2) the variation of electrical conductivity (σ) with immersed

in distilled water

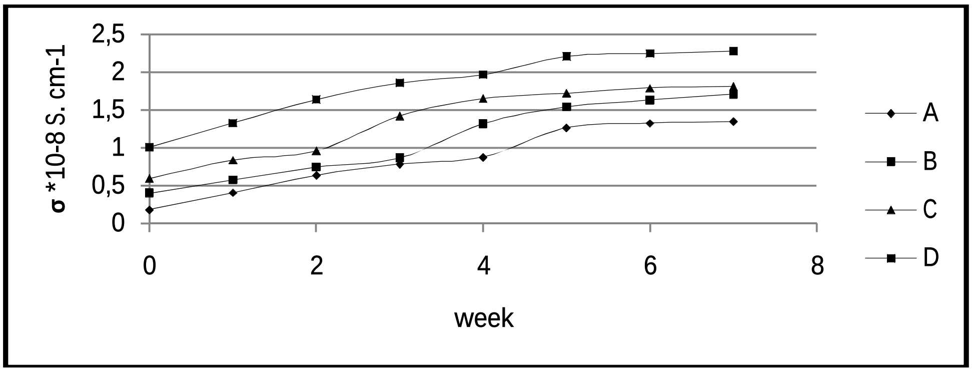

Figure (3) the variation of electrical conductivity (σ) with immersed in tap water

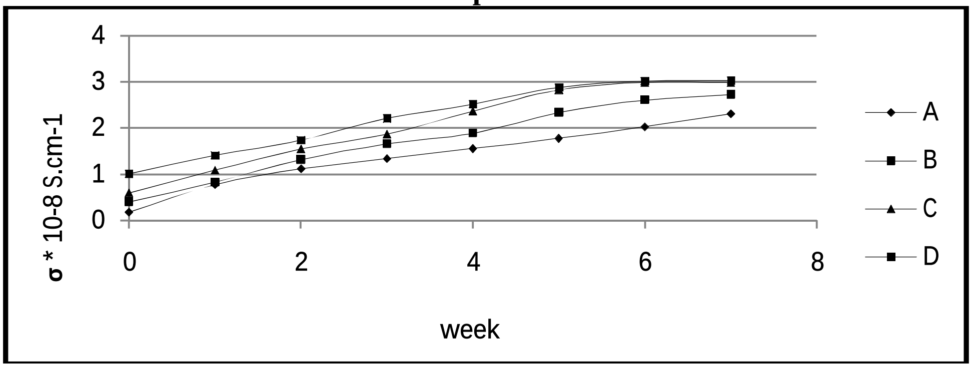

Figure (4) the variation of electrical conductivity (σ) with immersed in (3.5% NaCl)