Antibacterial activity and Electrical properties of Prepared Graphene Oxide GO Hybrid Cupper Phthalocyanine (CuPc)

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Abstract. GO samples were prepared by Hummer's method. The Electrical properties of polymer composite Go-CuPc (graphene oxide-cupper phthalocyanines) prepared by spin coating technique were studied. Three different ratio of the prepared graphene oxide added to the pure cupper phthalocyanines (10%, 15%, 20%). It was found that there was a clear increasing in the concentration of carriers and a decreasing in the values of mobility at room temperature with increasing of doping ratio, the electrical conductivity increased with the increase of the concentration of GO, the value of activation energy decreased for all (GO/CuPc) thin films with adding concentration of GO. The antimicrobial properties of Graphene Oxide Modified Cupper Phthalocyanine were evaluated against Staphylococcus aureus, Gram-positive bacterium and sydomonus, Gram-negative one. Bacteriological tests were performed in Muller Hinton solid agar plates with different concentrations of graphene oxide particles. The inhibition zones as a function of added graphene oxide where studied, the results show that as the concentration of graphene oxide increased the inhibition zone increased also against both types of bacteria. When the ratio of added graphene oxide was (15%) maximum inhibitionzone has been calculated.

1. Introduction
Graphene oxide, a 2D carbon material, has continued to take a high deal of interest [1], regardless the layered structure which has a considerable theoretical specification for surface area [2]. GO nanosheets have surface groups with abundant oxygen containing, such group are epoxide, hydroxyl, carboxyl and carbonyl groups [3]. The importance of such groups not only gives the GO sheets to be dispersible in water to product a colloidal suspension stability [4], but also provides remarkable application for the production of flexible GO based composite materials as nanoscale substrates. Such as the utilizing of GO in catalytic applications to support the anchor gold (Au) nanoparticles [5]. Newly, the GO used to prevent the growth of Escherichia coli (E. coli) [6]. The graphene and GO nanowalls are also important in biological application such as their ability to damage the cell tissue by direct contact with the bacteria [7]. Furthermore, graphene nanosheets can be used to increase photo-inactivation of graphene/TiO2 composite on E. coli bacteria [8]. Shen et al., [9] pointed out that Ag-chemically converted graphene presented antibacterial properties of free Ag nanoparticles.

In this work, the GO had been modified by surface depositing of Cupper Phthalocyanine (CuPc) nanoparticles on the GO nanosheets, that promised the following advantages: (a) to make CuPc nanoparticles more dispersible in aqueous solution with the GO support, and (b) to enhance its ability in the antibacterial activity by the synergistic effect of CuPc nanoparticles and GO. The experimental results displayed that the CuPc–GO nanosheets showed excellent antibacterial activity towards Pseudomonas and staphylococcus. An antibacterial mechanism was made to investigate the superior antibacterial activity of the CuPc–GO composite. A modified Hummers method had been used to
prepare the GO from natural graphite [10]. The obtained GO was modified with CuPc nanoparticles with three different weight ratio (10%, 15%, 20%) wt%.

2. Required materials
Graphite flakes (acid treated (99%)), Potassium permanganate (99.9%), Phosphoric acid (99.9%), Hydrogen peroxide (98.9%), Sulphuric acid (98%), Hydrochloric acid (35%), Cupper phthalococine (CuPc).

3. Result and discussion
The results of the measurements of the Hall effect that all films prepared is the p-type through the positive sign of the Hall coefficient, the results also showed that (CuPc) has a value of mobility (2.776×10^2 cm^2/V.s) at room temperature. There was a clear increasing in the concentration of carriers and a decreasing in the values of mobility at room temperature with increasing doping ratio of GO as in the table 1, this was due largely to the increasing in the concentration of carriers formed near the conductive band, which in turn lead to an increasing the number of donor atoms of electrons capable of ionization within the thermal energy does not exceed the value of topical levels (kBT), as for the decreasing in mobility shall be due to the increased concentration of carriers, this is agreement with [11].

Table 1. Hall parameters for (CuPc: GO) films at different ratio of GO

| Sample       | R_H (cm^-3/C) | n_H (1/cm^3) | P (Ω.Cm) | n_H (cm^2/V.s) | μ_H (cm^2/V.s) | μ_H (Ω.cm) | σ_D.C R. T (Ω.cm) | σ_D.C R. T (Ω.cm) |
|--------------|---------------|--------------|----------|----------------|----------------|------------|-------------------|-------------------|
| NiPc         | 1.132×10^-6   | 8.1×10^2     | 8.3×10^3 | 1.29×10^11     | 3.3×10^7       |            |                   |                   |
| NiPc: 10% GO | 1.066×10^-6   | 7.3×10^2     | 9.38×10^5| 1.6×10^11      | 1.10×10^7      |            |                   |                   |
| NiPc: 15% GO | 1.676×10^-6   | 3.7×10^2     | 5.96×10^5| 1.8×10^12      | 4.83×10^7      |            |                   |                   |
| NiPc: 20% GO | 1.919×10^-6   | 1.17×10^2    | 5.21×10^5| 5.6×10^11      | 3.84×10^7      |            |                   |                   |

3.1. D.C Electrical Properties of (GO/CuPc) and (GO/NiPc) Films
The relation of D.C surface electrical conductivity with the concentration of GO for (GO/CuPc) films is shown in figure 1, we notice that this conductivity has increased with the increase of the concentration of GO. The conductivity value of pure (CuPc) is (0.0367) (ohm.cm)^-1, the increase of the concentration of GO to (20%) leads to increase of the conductivity to become (0.1151) (ohm.cm)^-1[12].

![Figure 1. Relation of D. C electrical conductivity with the concentration of GO for (GO/CuPc) thin films](image-url)
Figure 2, shows the variation of electrical conductivity of (GO/CuPc) thin films with temperature, we notice that the bulk electrical conductivity increase with increasing in temperature, this mean that the resistance of these materials has a negative thermal coefficient; i.e. it have a decreasing resistance with the increase of temperature, and this because the (CuPc) and GO have ability to act as traps for moving the charge carriers by hopping process with increasing temperature the motion inside the polymer increase; as a result for the increase of the charge carriers and mobility of these charge carriers[12,13].

![Figure 2. Effect of Temperature on the electrical conductivity of (GO/CuPc) thin films](image)

Figure 3, shows the variation of conductivity with the inverse absolute value of temperature for (GO/CuPc) thin films. The activation energy was calculated, and from these calculation, it can be seen that the activation energy has high value existence in state of pure (CuPc), and by adding concentration of GO the value of activation energy are decreasing for all (GO/CuPc) thin films as show in figure 4, the addition of concentration creates a local energy level in the forbidden energy gap which acts as traps for charge carriers that move by hoping between these levels, by the increasing in the concentration of GO, the activation energy decreased as a result of the increase of the local level in the distance between conduction band and valence band as show in figure 4, thus the mechanism of conduction in the sample having low concentration is the hopping. The low value of activation energy for (GO/CuPc) thin films attributed to the formation of a continues network of GO that contain path inside the composite allow the charge carriers to pass through, resulting in the decrease of the activation energy as show in figure 4,[14].
3.2. Antimicrobial Investigations
The properties of antimicrobial activity had been evaluated against Staphylococcus aureus, Gram-positive bacterium and sydomonus, Gram-negative one. The kinetic of bacteria growth rate had been determined by a method called Disc count which is in detail On Muller Hinton agar media 0. 1 ml of bacterial culture was spread and then leave agar dish in wells at room temperature for 15 min for the purpose of absorbing the vaccine. four wells were made in the plate using 8 mm diameter, then filled with various 100 micro liter Volume of each weight ratio of GO (10%, 15%, 20%) In Muller Hinton ager at 37 for 24 hours, The zone of inhibition measured by mm after 24 hours of incubation. two types of bacteria used in this study Pseudomonas and staphylococcus as show in figure 5.
3.2.1. Antimicrobial Investigations against *staphylococcus aureus* bacteria. When the ratio of GO was zero there was no inhibition that mean the inhibition zone is zero. While at 10% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (16.75±0.75 and 9.50±1.32) respectively against staphylococcus aureus. And at 15% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (26.25±1.25 and 18.50±0.95) respectively against staphylococcus aureus. At 15% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (11.75±1.5 and 10.50±1.57) respectively against staphylococcus aureus

3.2.2. Antimicrobial Investigations against *Pseudomonas* bacteria. When the ratio of GO was zero there was no inhibition that mean the inhibition zone is zero. At 10% wt of GO (GO/CuPc), (GO/NiPc) The inhibition zone was (12.75±0.5 and 6.50±1.3) respectively against Pseudomonas bacteria. 3-At 15% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (21.25±1.3 and 13.50±0.75) respectively against Pseudomonas bacteria. 4-At 20% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (10.3±1 and 7.5±1.5) respectively against Pseudomonas bacteria. At 15% wt of GO (GO/CuPc), (GO/NiPc), The inhibition zone was (26.25±1.25 and 18.50±0.95) respectively against staphylococcus aureus.

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