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Study electrical properties of pure PVA doped with multiwall carbon nanotubes films

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Abstract
Electrical properties include the study of the Hall effect as well as the electrical conductivity of a combination of PVA compound solution with multiple nanotubes. Hall coefficient, electrical conductivity and some other constants, as well as the type of charge carriers were measured. These samples were attended by different concentrations of the various carbon nanotubes added to PVA (0.0025, 0.0050 and 0.0075 g). The values of electrical conductivity are increased and the Hall coefficient of pure and graded polymer films decreases with increasing rates of vaccination with multiple carbon nanotubes. The results showed low resistance values with all concentrations of multiple nanotubes of carbon nanotubes. The values of mobility decreased with increased concentrations after vaccination. The results also showed that the activation energy decreases with the increase in vaccination rate.

Keywords: PVA, electrical, nanoscale film, MWCNT

1. Introduction

Nanoscience is a developing modern scientific phenomenon that has been successful even as an antibacterial agent as much research is conducted to deal with this new concept. The idea has led to a qualitative turn and brought original solutions to realms related to materials science, biomedicine, micro-electronics, and optic. Nanoscience can be termed as the measurement and study of materials in the nanoscale this science gets its significance because, together with nanotechnology, it can precisely control the movements of atoms and molecules in order to produce ultra-fine materials, compounds, and devices. This technology gives scientists the possibility to create new systems of different properties unattainable by traditional approaches and allows opening wide perspectives of development in the range of different sciences and their application.

The conclusion by the scientists is that small size, small particles and thin films materials may have different properties as the same materials at large size. I can use silver as an example, which can be regarded as nontoxic, but when it is converted to nanoparticles, it is considered as killing viruses when it comes into contact with it. Besides; describes similar to color, electrical conductivity and strength that different when material turns into nanomaterial. An example is metal when it transforms to the nanoscale level that it becomes an insulator or a semiconductor [1].

Enlightenment of these various the infinite that are promised in terms of better structures, devices and materials.

Nanomaterial can be applied due to various reasons as little size, light weight and strong. The significant key aspects in nanotechnology are:

1. Sub-microscopic size typically less than or equal to 100 of nanometers.
2. It gets unique characterizations because of its small size.
3. They can be controlled in their structure and composition at (nm) scale therefore be able to control the properties [2, 3].

2-Carbon nanotube

Wherein the atoms are united in a three-way curved foils the vicious variety cylinder is acquired carbon arc in the conversion of energy in order to be continued into the formation of a continuous movement as opposed to AC and, consequently, acquired the tubular structures in a sediment on the pole [5].

These are pipes comprising of pure carbon and has been labeled nanotubes, since it is of a few nanometers in diameter. Formation of carbon nanotubes has numerous methods

a) When evaluation of the metallic actions is conducted under an electrical analysis by means of electrodes in Table Ravit in molten salts,
b) Hydrocarbon analysis thermal catalyst.
c) Laser evaporation of graphite.

Also, the working techniques of the nanotubes vary and so they have various electronics resulting in some being metal and others being semiconductor. It was revealed that these nanotubes had exceptional strength, surpassing that of steel by hundreds of times, and what in some part because of this geometric hexagon shape, which can transmit forces and deflections because of the might of the common wealth of carbon - carbon, as well as, the properties of electronic peculiarities [6].

Carbon nanotubes have found commercial applications in many areas both industrially and technically where they have been used in automotive fuel tanks, tennis rackets, golf clubs, ski equipments and in coating military materials so as to limit their detection through radar. It is the possibility to use carbon nanotubes in such a wide range due to their unusual properties, including a great hardness, a light weight and good electrical conductivity. Recent example of nanotechnology use is creating a new kind of ink consisting of Carbon nanocomponents developed by researcher Lee Jin-woong at the Korea Electro-Technology Research Institute. This is quite the advanced technology in that it involves the covering of the plastic surfaces with a thin layer of nano-ink, which makes it conduct electricity. This technology is a revolution in the electronics industry because it can be applied in production of touch screens, foldable screens, and other activities that need some flexing inative like warmth as well as electricity [5].

Experimental Part 3

The materials used in the research

a) Conductive polymer (PVA)
b) Distilled water
c) Carbon nano-tubes
d) Slides of glass

Preparation of polymer 3

To make the films, vestiges amount of carbon nano-tubes are added in the solution obtaining the two percentages by weight (1, 2, 3) and the ratio of carbon nano-tubes is added (0.0025,0.0050 and 0.0075 g) respectively.

Preparation of thin films 3.

Material was deposited onto the pieces of glass in order to prepare thin films following the clean samples and be a sedimentation process, through the use of spin coating method.

Electrical measurements

In this section, the author speak about the electrical characteristics of the polyvinyl alcohol (PVA) nanofilms of pure and multi-walled carbon nanotubes (MWCNTs) reinforced ones. These properties encompass not only the straight-line (σ_{dc}) electrically conductivity (sigmadc) but also the Hall effect. The analysis of these properties was done to determine how the electrical property of their electrical transport mechanism was in these films and also how adding nanotubes would help in enhancing the electrical performance of the polymeric material.

Theoretical Part

D.C. Electrical Conductivity

The electrical conductivity of transmission of electrons between atoms linked. These are known as valence electrons and these electrons depend highly on the circumnavigation conditions such as, illumination, press, and electrical field put. Electrical conductivity atoms depend on temperature and resistance in semiconductor reduces as we increase temperature. The current density (J) can calculate it as in the relation [7]:

$$J = \sigma \times E \qquad (1)$$

Where:

$(J = I / A)$ and $E = V / \ell$

σ: conductivity

A: is the cross-sectional area.

I: is the measured current.

V: is the bias voltage.

ℓ: is the electrode spacing distance (conductor length)

w: is the width of the thin film

The correlation between current density and electric field in semiconductors is articulated by:

$$J = \left(n\, e\, \mu_e + p\, e\, \mu_p\right) \qquad (2)$$

Where n and p are the concentrations of electrons and holes respectively, μ_e and μ_p The mobilities of the electron and hole respectively. Based on this, correlation of conductivity and electron-hole concentration is then determined. [8]:

$$\sigma = \left(n\, e\, \mu_e + p\, e\, \mu_p\right) \qquad (3)$$

The preparation method and the conditions of deposition play a major role in the electrical properties. At high temperature range, the conductivity is caused by thermo ionic emission as shown in the relation below [9]:

$$\sigma = \sigma_o \exp\left(\frac{-E_a}{k_B T}\right) \qquad (4)$$

σ_o: Is relation constant (conductivity at 0 ^oC).

T: Is the absolute temperature

k_B: Boltzmann constant.

E_a: Activation energy is equivalent to (Eg/2) for intrinsic conduction, pertains to the distance between the donor level and the conduction band edge for n-type extrinsic conduction, or corresponds to the distance between the acceptor level and the valence band edge for p-type extrinsic conduction [10].

Hall Effect

Hall effect The disparity in the current flow inside the semiconductive or conductive component is attributed to the magnetic field [11]. That produce a magnetic field on a conductive body where there is an electric current direction which is perpendicular to the towards of the current flow produces an electric driving power on the side of the resist-free anti-magnetic field causing electric charge less side on the sides hence the creation of electric driving power across the connector in which the direction is perpendicular to that of the current and of the magnetic field.

The measurements of the Hall effect in semiconductors are represented by the following equation [12]:

$$R_H = -(\frac{1}{ne}) = \frac{V_H . t}{I_x . B_z} \quad (5)$$

Where:
R_H: Hall coefficient, n: the concentration of carriers.
e: Electron charge. Bz: the intensity of the magnetic field.
I_x: Current flowing in the films, t: the thickness of the films.

The concentration of the majority carriers is determined from this connection, utilizing the following equation for the Hall mobility of these carriers [13].

$$\mu_H = |R_H| \sigma \quad (6)$$

Where:
μ_H: Hall mobility, σ: Electrical conductivity

Results and Discussion

The D.C Conductivity and Activation Energy

The result of measurements indicated that the electrical conductivity of PVA at room temperature is (1.41×10-9 (Ω.cm)-1). It was also noted that the electrical conductivity rose with elevation in temperature which was similar to semiconductor behavior which was thermally activated. Moreover, the ready films were found to be characterized by the interrelated electrical conductivity raising with the rising multi-walled carbon nanotube (MWCNT) doping fraction. The estimation of the activation energy showed one unique activation energy thus meaning that there was a thermally activated shift in the limit of granular mechanical phenomena. With the rise of the doping ratio, the values of the activation energy have decreased, as it can be seen in Table (1). This is explicable to the fact that, by upsurge of the percentage of impurities, the Fermi level became more near the conduction band.

Table 1: Direct current conductivity characteristics for (PVA: MWCNTs) films at different ratios

Sample	Activation energy E_a (eV)	Electrical conductivity $\sigma_{D.C}$ $(\Omega.cm)^{-1}$
Pure PVA	0.49753	7.41×10^{-12}
PVA:MWCNTs 1%	0.4745	1.18×10^{-11}
PVA:MWCNTs 2%	0.4494	3.30×10^{-11}
PVA:MWCNTs 3%	0.3377	6.36×10^{-11}

Hall Effect Measurements

Measurements of Hall effect have been revealed that all prepared films belong to p-type category, with the positive value of Hall coefficient. The findings also indicated that at the room temperature, PVA electrolyte moves with a value of (2.013×10^{-8} $cm^2/V.s$). With the aid of an analysis of the various movies, it became evident that as the ratio of doping to multi-walled carbon nanotubes increases, the degree of charge carrier concentration also increases which correspondingly balances out with ample reduction in the degree of mobility values at room temperature as shown in Table (2). This conductivity is largely explained by a subsequent high concentration of the charge carriers close to the conduction band. In this increase, the electron-donating centers increase such that they can be ionized by the thermal energy but do not surpass a high level of thermal energy (k_BT). As a result, higher number of carriers causes a drop in their mobility rate because of higher possibility of collision and dispersion of the carriers within the polymer structure.

Table 2: Hall parameters for (PVA: MWCNTs) films at different ratios of doping.

Sample	R_H (cm^{-3}/C)	n_H $(1/cm^3)$	ρ (Ω.cm)	μ_H $(cm^2/V.s)$
PVA	5.3×10^4	1.51×10^{10}	4.13×10^6	2.01×10^{-8}
PVA:MWCNTs 1%	1.629×10^4	3.36×10^{10}	3.37×10^6	1.79×10^{-8}
PVA:MWCNTs 2%	5.017×10^3	5.12×10^{10}	2.18×10^6	0.85×10^{-8}
PVA:MWCNTs 3%	4.35×10^3	7.47×10^{10}	1.28×10^6	0.38×10^{-8}

Conclusions

1. Conductivity increases at a higher doping ratio.
2. PVA possesses a singular activation energy, which diminishes as the doping ratio increases.
3. The Hall effect demonstrated that PVA is p-type.
4. With rising doping ratio, there was a clear increment in the concentration of carrier and a reduction in the value of the mobility at room temperature.

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