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# Synthesis of (PVA-PEG-VLO) Bio composites and their applications for Humidity Sensors

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**ABSTRACT**

This paper is aimed to the benefit from natural remains in advances industrials. The effect of addition the vegetarian lotion of orange (VLO) on optical properties of PVA –PEG blend has been studied for sensors applications. The vegetarian lotion of orange was added with different weight percentages by using casting method. The absorption spectra have been recorded at the wavelength range (200-800) nm. The results show that the (absorption coefficient, extinction coefficient, refractive index and real and imaginary dielectric constants) of (PVA-PEG-Vegetarian lotion of orange) bio composites are increasing with the increase of the vegetarian lotion of orange concentrations. The energy band gap of (PVA-PEG-Vegetarian lotion of orange) bio composites decreases with the increase of the vegetarian lotion of orange concentrations. The humidity sensor application of bio composite was investigated by measuring the capacitance for different humidity range (40-90) %. The results examined the bio composites have higher sensitivity for humidity at high values of relative humidity.

**KEY WORDS**: biocomposites, vegetarian lotion of orange, relative humidity, capacitance.

## 1. INTRODUCTION

Bio composites are materials incorporation one or more phase(s) derived from a biological or vegetarian origin. A wide range of applications exist for bio composites as antibacterial and humidity sensor. The interest in bio composites is rapidly growing in terms of industrial applications (antibacterial, storage energy and packaging) and fundamental research, due to its great properties as renewable, biodegradable, cheap, light in weight and recyclable. Bio composites use to improve health and safety in their production. Polymer matrix composites exhibit distinct properties and have found ever-increasing applications as engineering components and structures in land transportation, aviation, aerospace, military, marine, sports and recreational industries. The development of polymer system with high ionic conductivity is one of the main objectives in polymer research which resulted in blending of polymers, cross linking, insertion of ceramic fillers, plasticization etc. The lightweight composite materials can offer the impressive mechanical properties such as a high specific strength, stiffness and the relatively good energy absorbing characteristics. PVA is a semi crystalline polymer and has various interesting physical properties which are used for different applications.

## 2. EXPERIMENTAL PART

PVA and PEG solution were prepared by dissolving it in water by using magnetic stirrer in mixing process to get homogeneous. Bio composites of (PVA-PEG-Vegetarian lotion of orange) films are prepared by using casting method. The vegetarian lotion of orange is added to poly vinyl alcohol and poly ethylene glycol with different concentrations are (0, 4, 8 and 12) wt.% and mixed for 20 minutes to get more homogenous solution. The optical properties of (PVA-PEG-Vegetarian lotion of orange) bio composites are measured by using UV/1800/ Shimadzu spectrophotometer in range of wavelength (200-800) nm. The optical constants are very important because they describe the optical behavior of the materials. The absorption coefficient of the material is very strong function of photon energy and band gap energy.

Absorptance (A) is defined as the ratio between absorbed light intensity ($I_A$) by material and the incident intensity of light (Io).

$$A = I_A / Io \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Transmittance (T) is given by reference to the intensity of the rays transmitting from the film (I) to the intensity of the incident rays on it (Io) (T=I/ Io), and can be calculated by:

$$T = \exp(-2.303A) \quad \ldots\ldots\ldots\ldots (2)$$

And Reflectance (R) can be obtained from absorption and transmission spectra in accordance with the law of conservation of energy by the relation:

$$R + T + A = 1 \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Absorption coefficient (α) of (PVA-PEG-Vegetarian lotion of orange) bio composites is defined by following equation:

$$\alpha = 2.303A/t \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where A: is the absorbance and t: is the sample thickness.

The indirect transition for amorphous materials is:

$$\alpha h\nu = B(h\nu - Eg)^r \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Where B is a constant, hυ is the photon energy, Eg is the optical energy band gap, r=2 for allowed indirect transition and r=3 for forbidden indirect transition.

The Refractive index (n) is given by following equation for (PVA-PEG-Vegetarian lotion of orange) bio composites:

$$n= (1+R^{1/2})/(1-R^{1/2}) \ldots\ldots\ldots\ldots\ldots (6)$$

R is the reflectance.

The extinction coefficient (k) is calculated by the following equation:

$$K=\alpha\lambda/4\pi \ldots\ldots\ldots\ldots\ldots (7)$$

The dielectric constants (ε) is divided into two parts real ($\varepsilon_1$) and imaginary ($\varepsilon_2$) are calculated by using equations:

$$\varepsilon_1=n^2-k^2 \ldots\ldots\ldots\ldots\ldots (8)$$

$$\varepsilon_2=2nk \ldots\ldots\ldots\ldots\ldots (9)$$

Optical conductivity ($\sigma_{op}$) can be determines as:

$$\sigma_{op} = \frac{\alpha nc}{4\pi} \ldots\ldots\ldots\ldots\ldots (10)$$

**Fabrication of humidity sensors:** The application of humidity sensor for (PVA-PEG-Vegetarian lotion of orange) bio composites were prepared by precipitated the solution of these bio composites on glass slides dimensions (2x2)cm$^2$ by using spin coating method after cleaning by ethanol and distilled water and left to dry mix for two days. Aluminum electrodes were deposition on the surface of the samples of (PVA-PEG-Vegetarian lotion of orange) bio composites by using the vacuum evaporation system (Edwars Coating System -C) type. To examine the sample place in box and the water vapor was used as a source of humidity. The control network monitored and controlled variations in humidity. The capacitance for different humidity range (40-90) % was measured by using LCR meter type (HIOKI 3532-50 LCR HI TESTER) system locally manufactured.

## 3. RESULTS AND DISCUSSION

The variation of absorbance of (PVA-PEG-Vegetarian lotion of orange) bio composites with wavelength of different concentrations of additive nanoparticles is shown in figure.1. The figure shows that the absorbance of polymer blend is increased with the increase the concentrations of vegetarian lotion of orange, this is due to the vegetarian lotion of orange absorb the incident light.

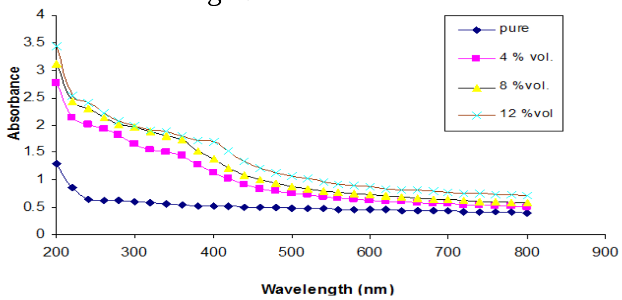


**Figure.1. Variation of the absorbance of (PVA-PEG- vegetarian lotion of orange) bio composites with the wavelength**

Figure.2, shows the optical transmittance spectra as function of incident wavelength for (PVA-PEG-Vegetarian lotion of orange) bio composites. From the figure, the transmittance decreases with increasing of concentration of vegetarian lotion of orange.

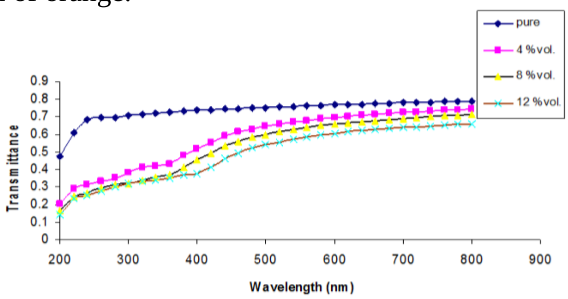


**Figure.2. Variation of the transmittance of (PVA-PEG- vegetarian lotion of orange) bio composites with the wavelength**

The relationship between the absorption coefficient of (PVA-PEG-Vegetarian lotion of orange) bio composites and photon energy with different weight percentages of vegetarian lotion of orange is shown in figure (3). From the figure, the absorption coefficient of (PVA-PEG-Vegetarian lotion of orange) bio composites increases with the increase of the vegetarian lotion of orange concentrations which related to the increase the number of carries charges in bio composites.

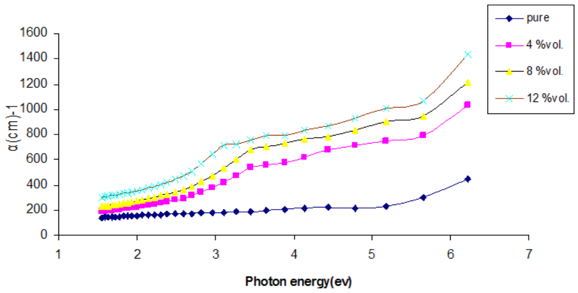


**Figure.3. Variation of the absorption coefficient of (PVA-PEG- vegetarian lotion of orange) bio composites with photon energy**

The values of absorption coefficient of (PVA-PEG-Vegetarian lotion of orange) bio composites are less than $10^4$ $cm^{-1}$, so, the bio composites have indirect energy gap as shown in figure.4 and figure.5, for allowed indirect and forbidden indirect transition of (PVA-PEG-Vegetarian lotion of orange) bio composites respectively. The energy band gap of (PVA-PEG-Vegetarian lotion of orange) bio composites decreases with the increase of the concentrations for vegetarian lotion of orange, this behavior attributed to the increase of the localized level in energy band gap.

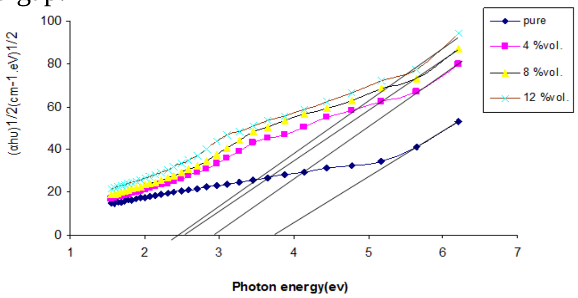


**Figure.4. Relationship between $(\alpha h\upsilon)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of (PVA-PEG- vegetarian lotion of orange)**

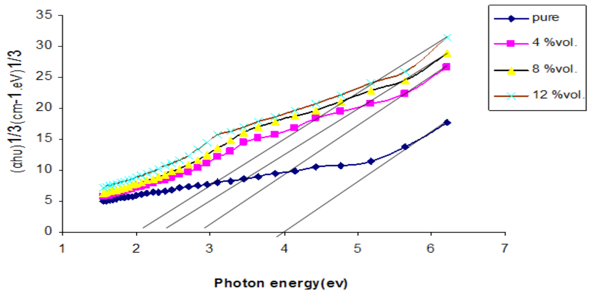


**Figure.5. Relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of (PVA-PEG- vegetarian lotion of orange) bio composites**

Figure.6, shows the variation of the extinction coefficient of (PVA-PEG-Vegetarian lotion of orange) bio composites with photon energy for different concentration of vegetarian lotion of orange. The extinction coefficient is increased with the increase of vegetarian lotion of orange concentrations which attributed to the increase of absorb part of the incident light, and loss of energy because the reaction between the light and the molecules of the medium.

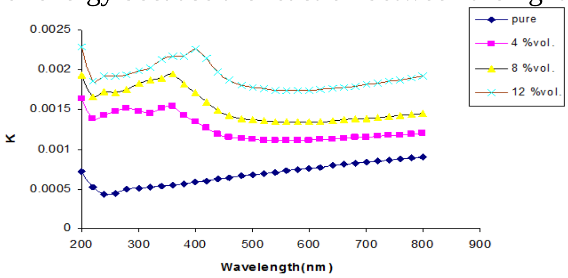


**Figure.6. Variation of extinction coefficient of (PVA-PEG- vegetarian lotion of orange) bio composites with the wavelength**

The relationship between the refractive index of (PVA-PEG-Vegetarian lotion of orange) bio composites and wavelength is shown in figure.7. The figure shows that the refractive index increases with the increase of the concentration of filler which is due to the increase the scattering of the light; so it increase, because the increase of the density of bio composites.

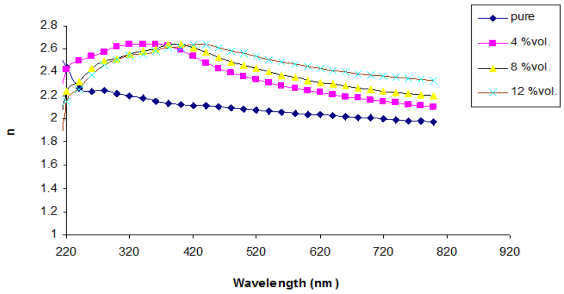


**Figure.7. Relationship between the refractive index of (PVA-PEG- vegetarian lotion of orange) bio composites and wavelength**

Figure.8 and figure.9, show the variation of real and imaginary parts of dielectric constant of (PVA-PEG-Vegetarian lotion of orange) bio composites with wavelength for different vegetarian lotion of orange concentrations respectively. From the figures, the real and imaginary parts of dielectric constant for (PVA-PEG- vegetarian lotion of orange) bio composites increase with the increase of vegetarian lotion of orange concentrations. The increase of real and imaginary parts of dielectric constant attributed to increase the absorption of incident light and the density of (PVA-PEG- vegetarian lotion of orange) bio composites with the increase of vegetarian lotion of orange concentrations.

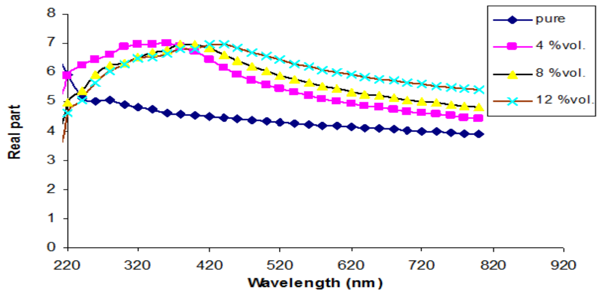


**Figure.8. Variation of real part of dielectric constant of (PVA-PEG- vegetarian lotion of orange) bio composites with wavelength**

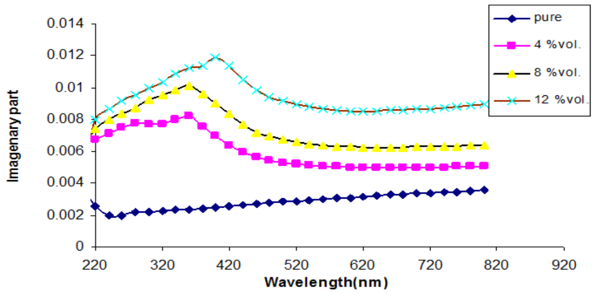


**Figure.9. Variation of imaginary part of dielectric constant of (PVA-PEG- vegetarian lotion of orange) bio composites with wavelength**

Figure.10, shows the plot of optical conductivity vs. wavelength for (PVA-PEG-Vegetarian lotion of orange) bio composites. The behavior for (PVA-PEG) blend is different from the (PVA-PEG-Vegetarian lotion of orange) bio composites. The optical conductivity increases in higher photon energies and then at lower photon energies it decreases, in furthermore the additive of vegetarian lotion of orange increase the optical conductivity of the (PVA-PEG-Vegetarian lotion of orange) bio composites.

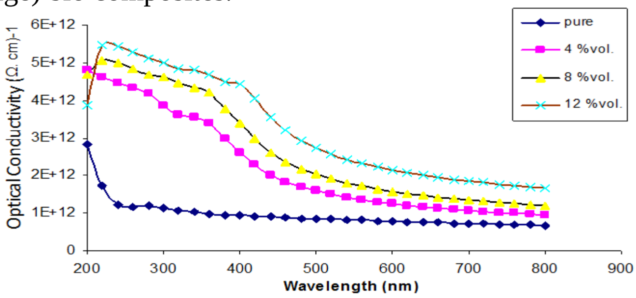


**Figure.10. Variation of optical conductivity for (PVA-PEG- vegetarian lotion of orange) bio composites with wavelength**

Figure.11, shows the plot of variation of capacitance for (PVA-PEG-Vegetarian lotion of orange) bio composites vs. the relative humidity (%RH). The capacitance increase with increase humidity, This is can be attributed to the mobility of the Vegetarian lotion of orange which is binding force between it and polymer blend chains are weak in general; van der Walls forces of attraction.

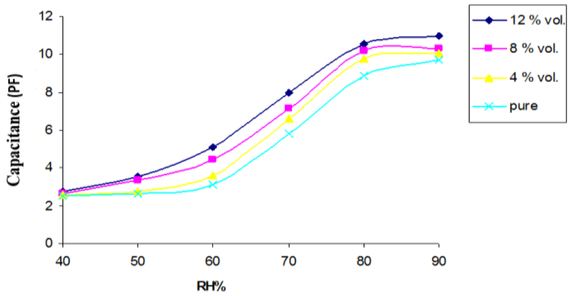


**Figure.11. Variation of capacitance of (PVA-PEG- vegetarian lotion of orange) Bio composites with Relative humidity (RH%)**

## 4. CONCLUSIONS

The absorbance of (PVA-PEG-Vegetarian lotion of orange) bio composites increases with the increase of the concentrations of vegetarian lotion of orange and the transmittance decreases with increasing of the concentrations of the vegetarian lotion of orange.

The optical constants (absorption coefficient, extinction coefficient, refractive index and real and imaginary dielectric constants) of (PVA-PEG-Vegetarian lotion of orange) bio composites are increasing with the increase of the concentrations of the vegetarian lotion of orange.

The energy band gap of (PVA-PEG-Vegetarian lotion of orange) bio composites decreases with the increase of the concentrations of the vegetarian lotion of orange.

The capacitance of (PVA-PEG-Vegetarian lotion of orange) bio composites increases with increase of humidity.

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