Study the Optical Properties of a Combination of Polymer (PVA+PbPc) Films Preparation by Spin Coating Method.

a Ahmed Shaker Hussein, b Mohammed Hadi Shinen, c Mohammed Sami Abdi

aDepartment of Basic Science, College of Dentistry, University of Babylon, Iraq. 
bDepartment of General Science, College of Basic Education, University of Babylon, Iraq.
cDepartment of Environmental, College of Science, University of Al-Qadisyah, Iraq.

ahmed.aldulami67@gmail.com, b mohammed.shinen@yahoo.com, c mohammed.sami68@yahoo.com.

Abstract. In this research, study the optical properties for Poly(vinyl alcohol) PVA and lead phthalocyanine (PbPc), where the films prepared by spin coating method. The some of optical properties of poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) have studied, which includes (energy gap, absorbance spectrum, transmittance spectrum, reflectance, extinction coefficient, refractive index, absorption coefficient, imaginary and real dielectric constant). This study shows that having different properties and note that the value of the energy gap is as high as possible and reaches to (3.7 eV) after mixing between (PVA+PbPc) in the rate of 50% also enhancement of the optical properties of (PVA) after adding (PbPc).

Keywords: PVA+PbPc, Thin films, Optical properties.

1. Introduction

Polymer materials have been broadly used because of their easy processing, relatively low cost and mass production compared to silica based optical materials [1]. A polymer blend or polymer mixture is a member of a class of materials analogous to metal alloys, in which at least two polymers are blended together to construct a new material with different physical properties [2]. Poly (vinyl alcohol) (PVA) is a polymer that has been studied intensively due to its several interesting physical properties, which are useful in technical applications including biochemical and medical. and is of relatively low cost in manufacture [3]. Polymer blend can be more useful because of its easier preparation method and its ease to control the properties of polymer electrolytes by changing the composition of the blended polymer. These polymer blends have gained an ever-increasing importance as an excellent way to develop [4]. In this work showed enhancement of the optical properties of (PVA) after adding (PbPc).

practical part

2. Preparation of films

2.1 Spin coating method
Spin coating is a multipurpose and active practice to polymers films. It is an attractive technique to make a extensive variety of powders and thin film materials for different manufacturing uses. Polymers films have been deposited by this method. Spin coating opens up the probability to control the membrance morphology. The properties and quality of the membrane depend heavily on the process parameters. A spin coating system, (model V T C-100). The system consists of several parts which have been arranged so as to make use of them in the preparation of various films on various substrates. In this system the thickness of the prepared films can be controlled by increasing or decreasing the rotation speed of the system, where the increasing of the speed rotation of the system the thickness of the films are decreasing and vice versa. Also the homogeneity of the prepared films depends on the speed of rotation and on the balance and stability of the system, the spin speed is 2000 and the time is 10 sec, where the mixing is 50 % for (PVA+PbPc).

### 2.2 Optical measurements

The study of the optical measurements enables the identification of the practical application that can be used to identify film material. The optical properties of the (PVA+PbPc) thin films deposited on a glass substrate by spin coating technique have been investigated by the transmission spectra at room temperature which were measured in the range from (300 to 1100) nm.

### 3. Result and discussion

#### 3.1 Absorbance spectrum

From the figure (1) shown that the absorbance measurements of poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film, were plotted against wavelength in the range of (300-800) nm. From this figure it is noticed that the absorption value of a polymer PbPc is almost nearly 0.26 and the absorption value of a polymer pva almost nearly 0.017 but when mixed with 50% we observe that the absorbance reaches a value almost nearly 0.17 at wavelength 300 nm. Note from the figure that the absorption spectrum begins to decrease by increasing the wavelength and then observe after the wavelength (573) nm begins to increase. This is consistent with the researcher [5,6].

![Absorbance spectrum](image)

**Figure 1.** variation of absorption spectrum of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film with wavelength.
3.2 Transmittance spectrum

The transmittance spectrum of poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film are shown in the fig. (2), were plotted against wavelength in the range of (295-800) nm. From this figure it is noticed that transmittance value of a polymer PbPc is almost nearly 0.55 and the transmittance value of a polymer PVA almost nearly 0.96 but when mixed with 50% we observe that the transmittance reaches a value almost nearly 0.67 at wavelength 295 nm, the transmittance spectrum behaves as an opposite behavior of the absorbance spectrum according to the following exponential relationship:

\[ A = \log \left( \frac{1}{T} \right) \]  

The behavior of transmittance consistent with the researcher [5].

![Transmittance Spectrum](image)

Figure 2. variation of transmittance spectrum of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film with wavelength.

3.3 Optical energy gap

Optical energy gap for poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film, is determined by using equation \( \alpha h\nu = B (h\nu - E_{opt})^\gamma \) .... (2). The plot of \( (\alpha h\nu)^2 \) with energy \( h\nu \) shows that (PVA+PbPc) films are direct transition type semiconductors for the thin films. Figure (3) and Figure (4) shows the relation of \( (\alpha h\nu)^2 \) against photon energy, from straight line obtained at high photon energy the direct allowed energy gap could be determined, the energy gap value of a polymer PbPc is almost nearly (3.6 eV) and the energy gap value of a polymer PVA almost nearly (3.2 eV) but when mixed with 50% we observe that the energy gap reaches a value almost nearly (3.7 eV), the value of energy gap related in common on crystal structure of films, the arrangement and distribution for atoms in the crystal lattice, as well it is affected by crystal regularity. In this research, the direct band gap results are in good agreement with research [7,8].
3.4 Reflectance spectrum

From figures (5) it is noticed that variation of reflectance vs. with photon energy(hv), for poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film. Note that the reflectivity decreases first and then increases by increasing the energy at (2.16) eV, it can be attributed to the basis of reflectance that depend on the refractive index as the relationship

\[ R = \frac{(n - 1)^2 + k^2}{(n + 1)^2 + k^2} \]  

(3) therefore the reflectance behave is similar to the refractive index. and this is consistent with the researcher [8,9].
3.5 Refractive index

Figures (6) show that the variation of refractive index, as a function of photon energy ($h\nu$) for poly(vinyl alcohol) PVA, lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film, it can be attributed to the basis of refractive index that depend on the reflectance as the relationship:

$$n = \left[ \left( \frac{1+R}{1-R} \right)^2 - (k_0^2 + 1) \right]^{1/2} + \left( \frac{1+R}{1-R} \right)$$  \hspace{1cm} (4),

this is consistent with the researcher's findings [9,10].

Figure 5. Variation of reflectance vs. with photon energy ($h\nu$), for of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film.

Figure 6. Display the variation of refractive index, as a function of photon energy ($h\nu$) for of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film.
3.6 Extinction coefficient

Figure (7) shows the variation of extinction coefficient as a function of photon energy (\(h\nu\)) for poly(vinyl alcohol) (PVA), lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film, [11].

![Extinction Coefficient Graph](image)

Figure 7 display the variation of extinction coefficient as a function of photon energy (\(h\nu\)) for PVA, PbPc and a combination of polymer (PVA+PbPc) thin film.

3.7 Absorption Coefficient

Figures (8) illustrates the change in the values of the variation of absorption coefficient, as a function of photon energy (\(h\nu\)) for poly(vinyl alcohol) (PVA), lead phthalocyanine (PbPc) and a combination of polymer (PVA+PbPc) thin film, [12]. Note that behavior of absorption coefficient is almost similar to behavior of extinction coefficient and so depending on the relationship:

\[
K_\omega = \frac{\alpha \lambda}{4\pi}
\]

\[\text{...}(5)\]

![Absorption Coefficient Graph](image)

Figure 8. display the variation of absorption coefficient, as a function of photon energy (\(h\nu\)) for PVA, PbPc and a combination of polymer (PVA+PbPc) thin film.
3.8 real and imaginary dielectric constant

The "real (\(\varepsilon_r\)) and imaginary (\(\varepsilon_i\)) dielectric constant" for (PVA+PbPc) thin films system is linked to the relationship (6), (7) respectively. The variation of "real (\(\varepsilon_r\)) and imaginary (\(\varepsilon_i\))" parts of values for dielectric constant versus of photon energy(\(h\nu\)) is shown in the figures. From figures((9), (10)), it is found that the behavior of \(\varepsilon_r\) is analogous to that of the refractive index because of the value of \(k^2\) is smaller compared with value of \(n^2\), while \(\varepsilon_i\) is mostly linked on the \(k\) values according to equation (7). This behavior is in line with his findings [12]. From following relationship can be calculated real and imaginary dielectric constant

\[
\varepsilon_r = n^2 - k^2 \quad \text{...............(6)}
\]

\[
\varepsilon_i = 2nk \quad \text{...............(7)}
\]

figure 9. display the variation of real dielectric constant, as a function of photon energy(\(h\nu\)) for of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film.

figure 10. display the variation of imaginary dielectric constant, as a function of photon energy(\(h\nu\)) for of (PVA, PbPc) and a combination of polymer (PVA+PbPc) thin film.
4. Conclusions

1- *Note that* the value of absorption, reflectance, extinction coefficient, refractive index, absorption coefficient, imaginary and real dielectric constant behave the same behavior, where their values of (PbPc) films are reduced and their values of (PVA) films increase after mixing.

2- *Note that* the value of the transmittance after mixing is more valuable for (PVA) membrane and less valuable for (PbPc) membrane.

3- Improved properties after blending the materials after by mixing ratio 50% and obtain value of the energy gap is as high as possible and reaches to (3.7 eV) after mixing.

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