

Investigation the Effect of Thermal Agent on Physical Properties of PVC-PVA Blended

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Abstract

In this study, the optical characteristics of polyvinyl chloride(PVC), polyvinyl alcohol (PVA) and binary PVA - PVC blend films at various concentrations PVA75% + PVC25%, PVA50% + PVC50%, and PVA25% + PVC 75% are examined in relation to temperature variations 25, 120 and 140 °C for 1 hour. The binary blend films of polyvinyl chloride and polyvinyl alcohol were produced using casting techniques. UV-visible spectroscopy used to determine the optical properties of the films in the wavelength range (200-900) nm, such as transmittance, absorbance, absorption coefficient and energy gap as well as the impact of temperature on these parameters, were measured and examined. The results of the experimental part demonstrated that the absorption and absorption coefficient of binary PVA - PVC blend films at various concentrations increased with increased concentration of polyvinyl alcohol (PVA) polymer. The energy gap of binary PVA-PVC blend films at various concentrations decreased with increased concentration of polyvinyl alcohol (PVA). The ratio of (PVA 75%+ PVC25%) binary blend has extremely suitable optical characteristics. The absorption and absorption coefficient of binary PVA-PVC blends increased with increased temperatures. While the transmission and energy gap of binary PVA-PVC blend films were decreased as the temperature was raised. The nature of electronic transitions of binary PVA - PVC blend films at various concentrations before and after exposure to temperatures is indirect. From the results obtained from the experimental part, it concludes that the absorption and absorption coefficient of binary PVA - PVC blend films are better than pure polyvinyl chloride and polyvinyl alcohol polymers. The optical characteristics of binary PVA - PVC blend films effect by exposure to temperatures.

Keywords: Binary blend films, Absorption peak, Transmission, Temperature effect, Energy gap.

Introduction

With new polymer development, composites, and blends it became necessary to modify thermal, mechanical, optical, and electrical characteristics to get the desired features¹. A polymer blend is a combination of two or more polymers created by physically combining the polymers in certain

quantities²⁻³. Polymer blends are frequently used in the new polymer sector because they have a wider range of properties than individual polymers⁴. The fundamental advantage of the blend system is how simple it is to prepare and how easily physical properties can be changed by changing

composition³. Poly (vinyl chloride) PVC is a rigid, hard substance at room temperature⁵. It is reasonably dense and has a low softening point. The chlorine atom boosts interchain attraction, resulting in an increase in the polymer's stiffness and hardness. In the realm of plastics, PVC's rigid shape, which may be extruded into pipe, conduit, or sheet, is important. It can be utilized in place of rubber in low-voltage cables and domestic wiring since it is flexible. With major applications ranging from high-volume construction-related products to straightforward electric wire insulation and coatings, this polymer could be called the most frequently used plastic substance⁶⁻⁷. Due to its numerous significant characteristics, polyvinyl alcohol (PVA) is a crucial polymer for the pharmaceutical and biomedical industries. It was applied to food, industrial, commercial, and medicinal products⁸⁻⁹. A linear polymer with a carbon-chain backbone and hydroxyl groups joined to methane carbonate is polyvinyl alcohol. The hydroxyl groups can act as hydrogen bond sources and facilitate the production of polymers. PVA is not a material that is found in nature. The main component utilized in the manufacturing of polyvinyl alcohol is vinyl acetate monomer¹⁰. The studies of ultraviolet and visible light spectroscopy to ascertain how substances absorb, transmit, and emit these wavelengths of light can be used to calculate the coefficient of absorption α from the absorbance (A)¹¹⁻¹³:

$$\alpha = \frac{2.303 \times A}{t} \dots \dots \dots 1$$

Where (t) the thickness of thin film. Many researchers studied the physical properties of blend and composite of PVC and PVA and they get good results. Due to its cheap production cost, PVA has

Materials and Methods

Polyvinyl alcohol (PVA) processed by the company Central Drug House (CDH)(India) with a molecular weight 14000 g/mole, polyvinyl chloride (PVC) processed by the company SABIC (Saudi) with a molecular weight 6000 g/mole and dimethylformamide (DMF) processed by Thomas Baker (India) used in this work. By using the casting method, PVC, PVA and binary blended with varying concentrations PVA75%+PVC25%,

recently been the subject of extensive study, which has led to a variety of industrial uses. As a result, this work attempts to employ a PVA-PVC polymer blending approach that can enhance the physical properties of the materials generated. Ghuzlan S. Ahmed¹⁴ has investigated how doping V₂O₅ on polymers such as poly vinyl alcohol (PVA) and poly vinyl pyrrolidone (PVP) affects the materials' optical and structural characteristics. With V₂O₅ doping and a raising in the ratio of doping, the (PVA/PVP) refractive index, extinction coefficient, absorption coefficient, real and imaginary dielectric constants rise. The optical characteristics of PVA and PVA/K₂CrO₄ composite were investigated by Itab F. H. Al-Sulaimawi¹⁵. In accordance with the findings, optical characteristics change as K₂CrO₄ concentration rises, and energy gap values for indirect transitions decrease as K₂CrO₄ concentration rises. Ghuzlan Sarhan Ahmed et al.¹⁶ have studied the optical properties of polyvinyl alcohol (PVA) and doped with CuO and Fe₂Cl₃ and they get good results. Zainab A. Al-Ramadhan and Itab Fadhil Hussein¹⁷ have studied the optical parameters of poly(vinyl chloride)(PVC) and PVC doped with Zn(etx)₂. The addition of the dopant was shown to have an impact on optical parameters including the absorption coefficient, refraction index (n), and extinction coefficient (K). The effect of temperatures on the optical properties of (PMMA-PVC- PS) blend was studied by Ali N. Sabbar, Karar M. Talib and Hassan T. Badh, they obtained that the energy gap was reduced by applied temperatures¹⁸. In this work the effect of different temperatures 25, 120 and 140 °C for 1 hour on the optical characteristics of binary blend films of PVC and PVA at various concentrations PVA75% + PVC25%, PVA50% + PVC50%, and PVA25% + PVC75% were examined.

PVA50%+PVC50%, and PVA25%+PVC75% were obtained¹⁹. PVC and PVA films are made by dissolving 0.4 grams of each polymer in dimethylformamide (DMF) solvent using a magnetic stirrer at 50 °C for 4 hours, casting the solution into a glass dish, and allowing it to dry for 2 days at room temperature. To make binary blended in various concentrations PVA75%+PVC25%, PVA50%+PVC50%, and

PVA25%+PVC75%, two polymers must first dissolve separately, then they must be thoroughly combined using a magnetic stirrer. UV-Visible spectroscopy type(UV Visible 1800 spectrophotometer) is used to determine the optical

Results and Discussion

The absorption spectra for PVA, PVC, and the binary PVA-PVC blends at different concentrations are shown in Fig. 1. PVA exhibits a small absorbance peak at 275 nm with an absorbance 0.2477. This absorption peak might be related to $\pi \rightarrow \pi^*$ electronic transition, this is agreed with reference ²⁰, which is followed by a significant increase in absorption at 250 nm. Whereas the pure PVC film's absorption spectrum exhibits a broad spectrum. The absorbance value at 240 nm abruptly rises in PVC. Binary PVA-PVC blends have a greater absorption compared to PVA and PVC pure polymers. The absorption spectra of binary PVA-PVC blends increased with increased the amount of PVA. The increase in absorbance in the blend due to overlap between chains of polymers leads to increased charge carriers ²¹. The increased absorption and the best ratio of the blend are evident with PVA 75%+ PVC25%.

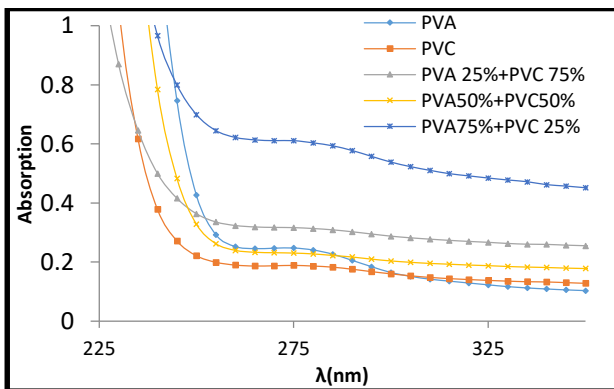


Figure 1. Spectrum of absorption for PVA, PVC and binary blend PVA-PVC.

The spectrum transmittance of PVA, PVC, and binary PVA-PVC blend films is shown in Fig. 2. The transmission in the binary mixture of PVA and PVC is lower than it is for PVA and PVC that are pure polymers. When the amount of the PVA in binary PVA-PVC blends increased, the transmission values decreased.

properties. Films of PVA, PVC and binary blended with varying concentrations PVA75%+PVC25%, PVA50%+PVC50%, and PVA25%+PVC75% were thermally treated at different temperatures 25, 120 and 140 °C.

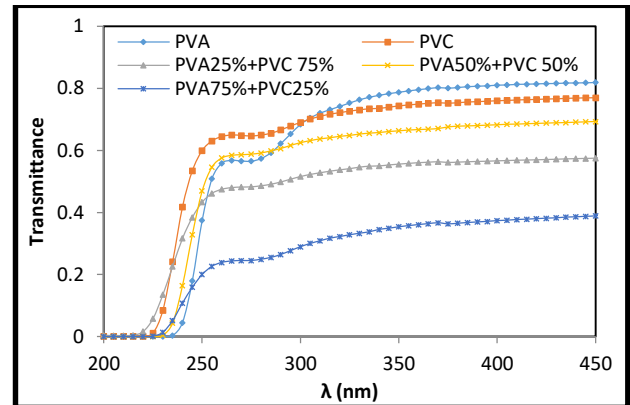


Figure2. Spectrum of transmittance for PVA, PVC and binary blend PVA-PVC.

Fig. 3 illustrates the temperature effect at 120,140 °C for 1 hour on the spectrum of absorption of PVA and PVC films. With a rise in temperature, the absorbance of the PVA's faint peak rose. PVC's absorbance changes slightly as the temperature rises.

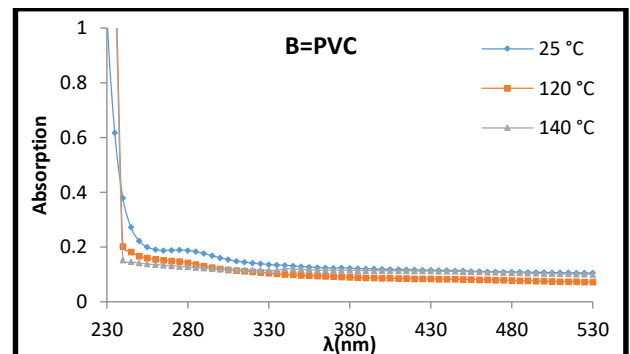
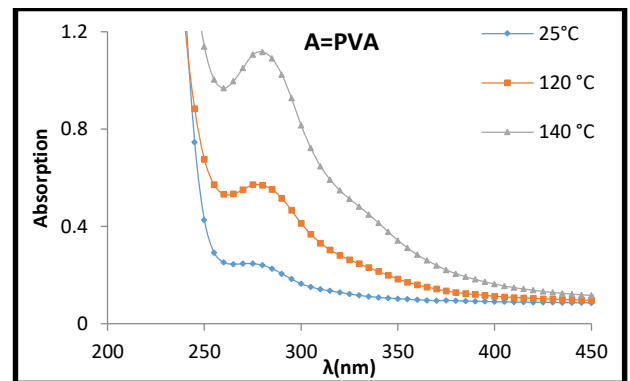


Figure 3. Spectrum of absorption at different temperatures for: A=PVA and B=PVC.

Fig. 4 shows the spectral transmittance of PVA and PVC after an hour at temperature 120, 140 °C. When temperature is applied, the transmission of PVA reduces whereas the transmission of PVC slightly changes.

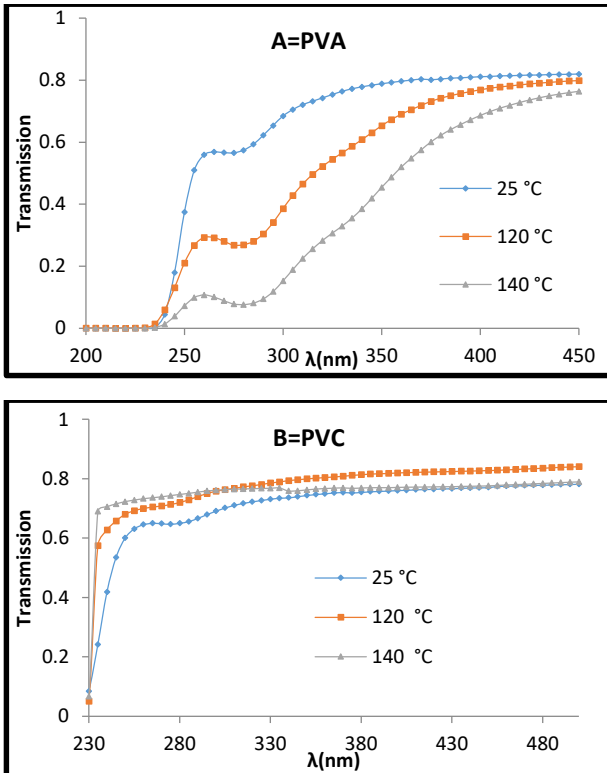


Figure 4. Spectrum of transmittance at different temperatures for: A=PVA and B=PVC.

Fig. 5 depicts the spectrum of absorption of a binary mix with various concentrations PVA75%+PVC25%, PVA50%+PVC50%, and PVA25%+PVC75% after one hour at 120,140 °C. With an increase in temperature, the weak PVA peaks in the binary blend became more absorbent. Increases in the absorbance in polymer blend with increased temperatures agree with reference¹⁸.

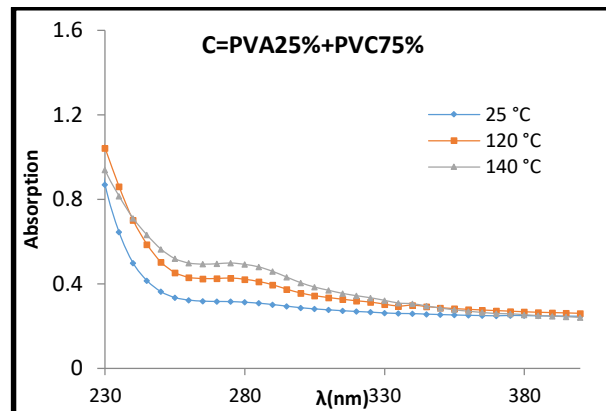
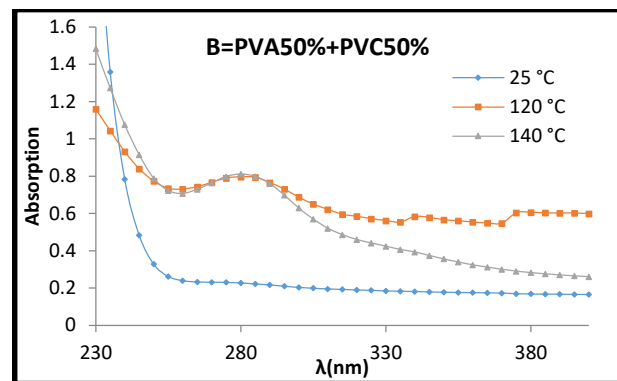
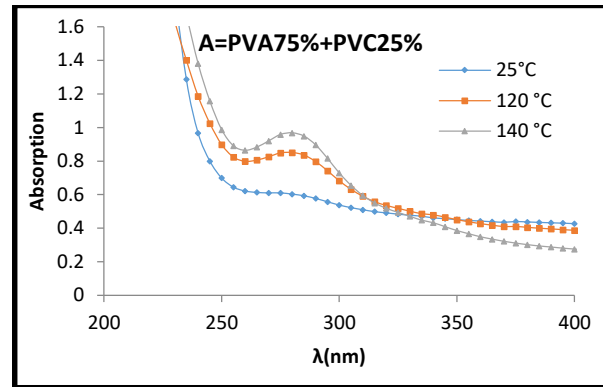


Figure5. Spectrum of absorption at different temperatures for: A=PVA75%+PVC25%, B=PVA50%+PVC50% and C=PVA25%+PVC75%.

Fig. 6 depicts the spectrum of transmittance for a binary blend with various concentrations PVA75%+PVC25%, PVA50%+PVC50%, and PVA25%+PVC75% as a function of temperature at 120,140 °C for 1 hour. As the temperature was raised, the binary blend's transmission dropped off.

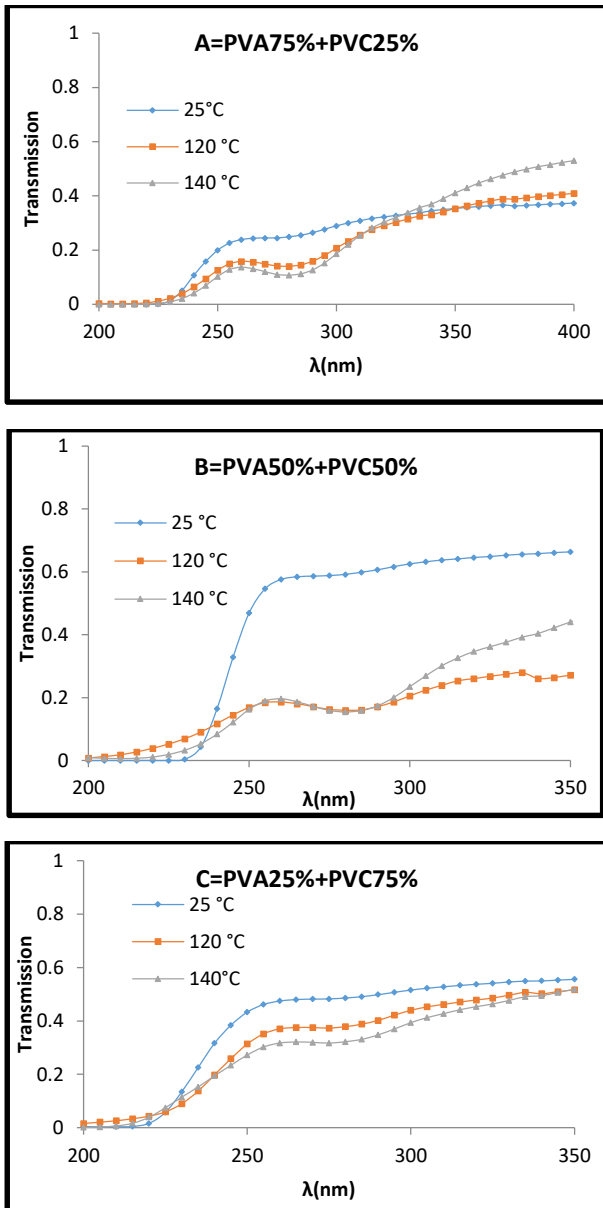


Figure 6. Spectrum of transmittance at different temperatures for: A=PVA75%+PVC25%, B = PVA 50%+PVC 50% and C = PVA 25%+PVC 75%.

The absorption coefficient can be obtained from Eq. 1. Fig. 7 illustrates the absorption coefficient for PVA, PVC, and a binary combination of both at various concentrations. The binary blend absorption coefficient is better than pure polymer because of increase in absorption due to the charge carried increased²¹. When the amount of the PVA in binary PVA-PVC blends increased, the absorption coefficient is increased. Electronic transitions are classified as direct transitions when the absorption

coefficient is greater than 10^4 cm^{-1} or as indirect transitions when it is less than 10^4 cm^{-1} ¹²⁻²². In this paper, the indirect nature of the electrical transitions is expected.

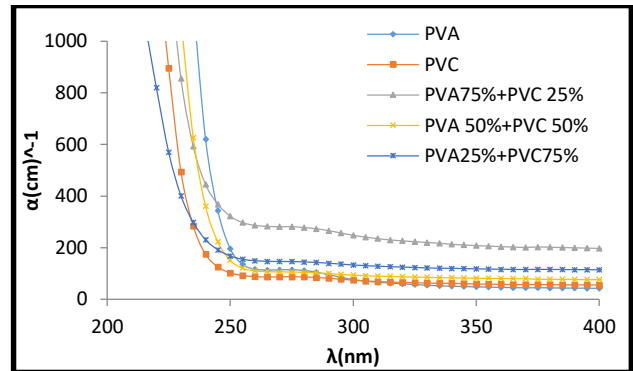


Figure 7. Absorption coefficient for PVA, PVC and binary blend PVA-PVC.

The absorption coefficient of PVA and PVC after undergo temperature at 120,140 °C for 1 hour is shown in the Fig. 8. In PVA, the absorption coefficient increase after applied temperature while the absorption coefficient of PVC slight changes after applied temperature.

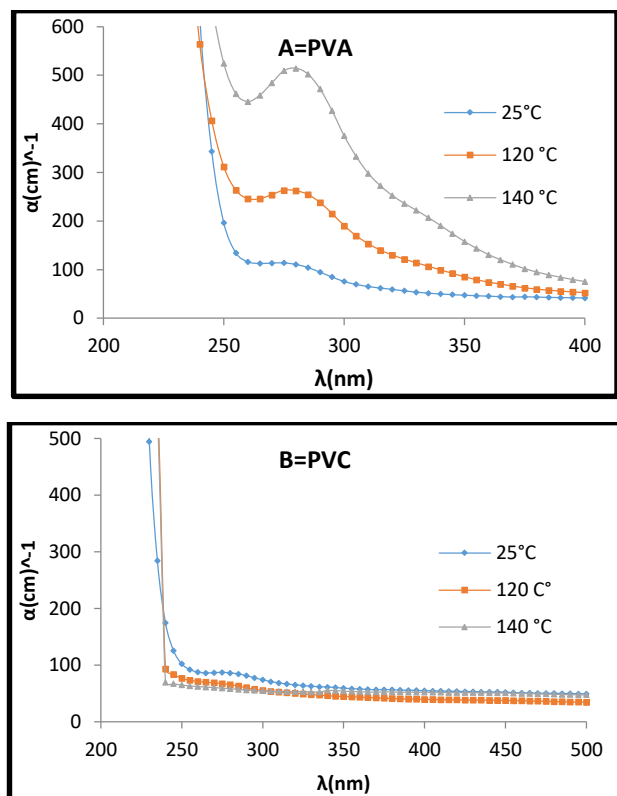


Figure 8. Absorption coefficient at different temperatures for: A=PVA and B=PVC.

Fig. 9 illustrates the absorption coefficient for a binary blend of PVA75%+PVC25%, PVA50%+PVC50%, and PVA25%+PVC75% at various temperatures. After applying temperatures, the binary blend's absorption coefficient rose, this is agreed with reference¹⁸. PVA, PVC, and binary mixed exhibit indirect electronic transitions both before and after applied temperatures.

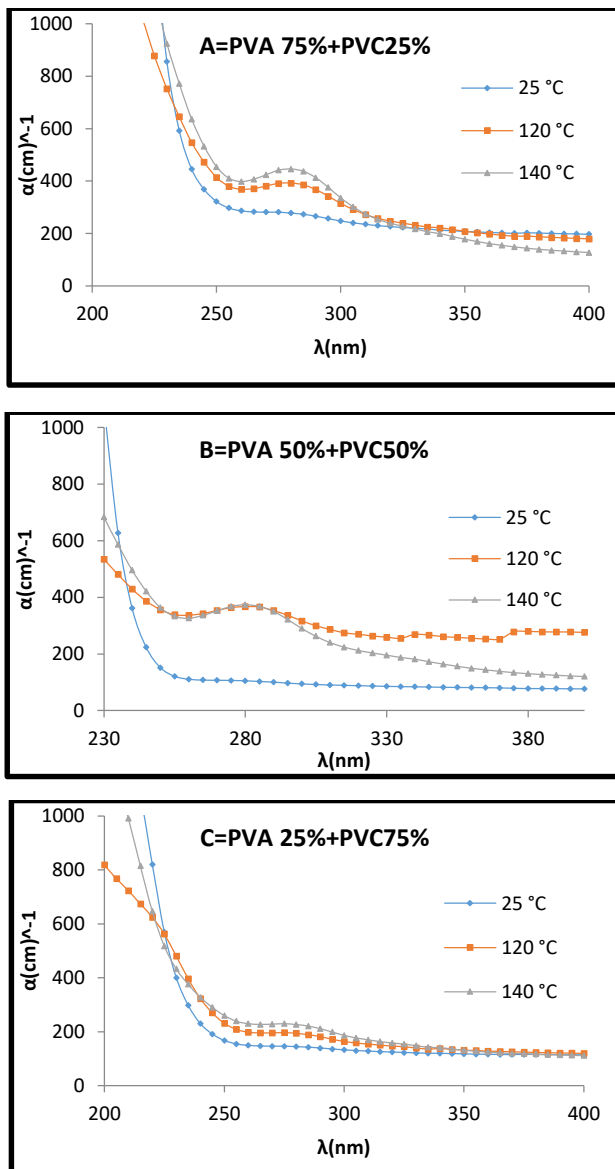


Figure 9. Absorption coefficient at different temperatures for: A=PVA75%+PVC25%, B=PVA50%+PVC50% and c=PVA25%+PVC75%.

The optical energy gap in indirect electronic transitions can be calculated via plot $(\alpha h \nu)^{1/2}$ to the $h \nu$ in high absorption ranges then extrapolating

the region of linear to $(\alpha h \nu) = 0$ ¹². Fig. 10 and Table 1 show the optical energy gap of PVA, PVC, and their binary blend with different concentrations. As the concentration of polyvinyl alcohol increased, the energy gap of binary PVA-PVC blend decreased.

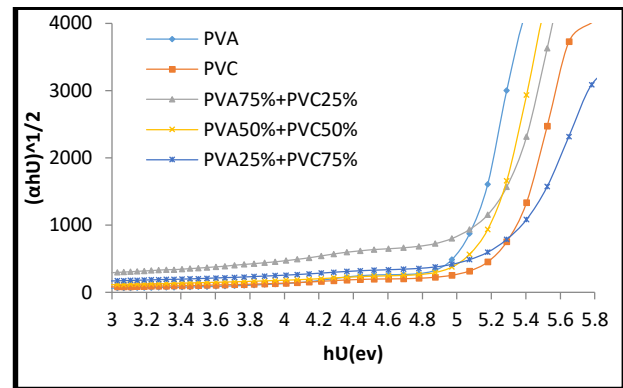
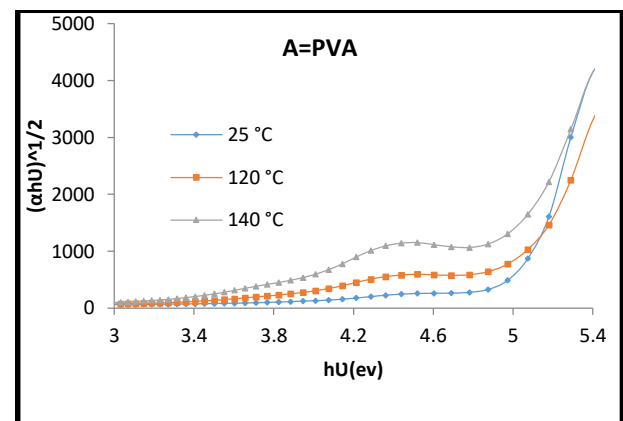


Figure 10. Energy gap for PVA, PVC and binary blend PVA-PVC.

Fig. 11 and Table 1 illustrate the impact of temperature at 120, 140 °C for 1 hour on the energy gap of PVA and PVC films. When the temperature was raised, in PVA the energy gap shrunk. The energy gap in PVC was slightly altered by the applied temperature.



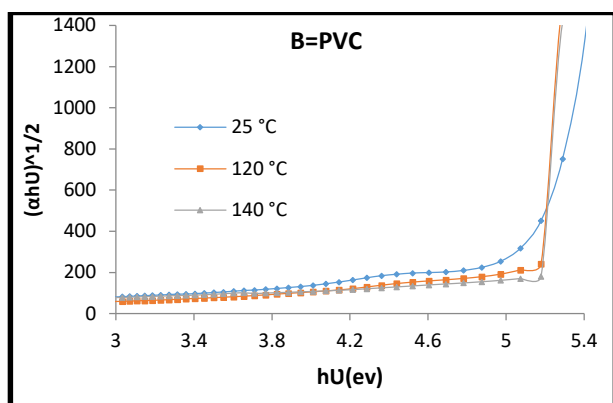


Figure 11. Energy gap at different temperatures for: A=PVA and B=PVC.

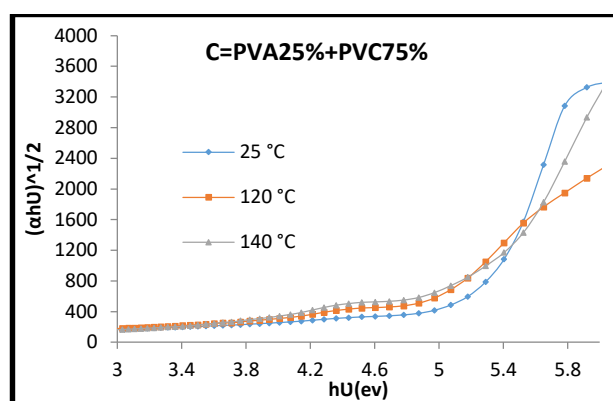
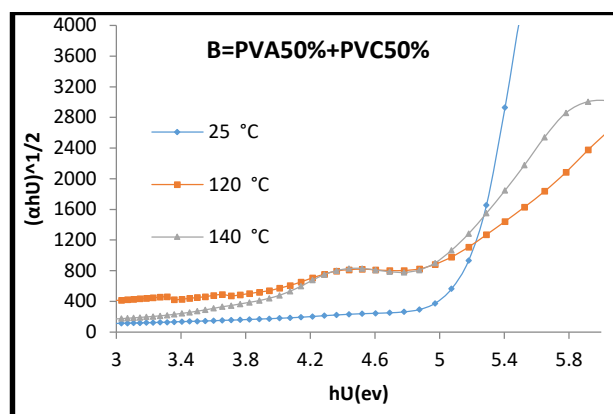


Figure 12. Energy gap at different temperatures for: A=PVA75%+PVC25%, B=PVA50%+PVC50% and C=PVA25%+PVC75%.

Fig. 12 and Table 1 display the energy gap for a binary mix with various concentrations (PVA75%+PVC25%, PVA50%+PVC50%, and PVA25%+PVC75%) at different temperature. The energy gap for the binary blend shrank as the temperature is raised¹⁸.

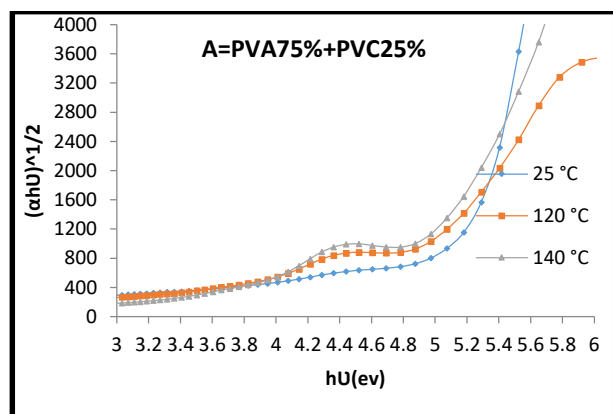


Table 1. The effect of temperature on energy gap for PVA, PVC and their binary blend

Temp.	PVA	PVC	PVA75%+PVC25%	PVA50%+PVC50%	PVA25%+PVC75%
25 °C	5	5.2	5.1	5.15	5.21
120 °C	4.95	5.19	4.7	4.55	4.78
140 °C	4.9	5.19	4.6	4.51	4.8

Conclusion

In our work, two polymeric composites made of PVA, PVC and binary mixtures of varying concentrations PVA75% + PVC25%, PVA50% + PVC50%, and PVA25% + PVC75% were formed in relation to temperature variations 25, 120, 140 °C. Films were produced using casting techniques. The impact of temperatures on the optical properties

of PVA, PVC and binary blends can be calculated by using UV-visible spectroscopy. At room temperature 25°C, increased the amount of PVA in binary PVA-PVC blend led to improve physical properties (absorption and absorption coefficient) and the best ratio of the blend is evident with PVA 75%+ PVC25%. We suggest a new field of binary

PVA-PVC blends with diverse uses (such as solar cells and optoelectronic devices). The results of temperature exposure 120°C and 140°C show that the optical properties of PVA and binary blends of

PVA and PVC at various concentrations PVA75% + PVC25%, PVA50% + PVC50%, and PVA25% + PVC 75% are characterized by certain changes, while those of PVC are slightly altered.

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Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for

- re-publication, which is attached to the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' Contribution Statement

This work was carried out in collaboration between all authors. K. A. J. designed the study and diagnosis the cases then collected the samples and doing the tests. Z. j. N., wrote and edited the

manuscript with revisions idea. Sh.H. M., performed the experiments part. All authors read and approved the final manuscript.

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تحقيق تأثير العامل الحراري على خصائص الفيزيائية لخلائط PVC-PVA

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قسم الفيزياء، كلية التربية للعلوم الصرفة (ابن الهيثم)، جامعة بغداد، بغداد، العراق.

الخلاصة

في هذه الدراسة، الخصائص البصرية لبولي فنيل كلورايد (PVC) و بولي فنيل الكحول (PVA) واغشية الخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية بتركيز مختلفة (PVA75% + PVC25%, PVA50% + PVC50%, and PVA25% + PVC75%) قد تم فحصها بالنسبة لدرجات الحرارة مختلفة (25, 120, 140) درجة سليزية لمدة ساعة واحدة. لقد تم تحضير اغشية الخلائط لبولي فنيل الكحول – بولي فنيل كلورايد الثنائية باستخدام طريقة الصب. مطيافية الاشعة المرئية-فوق البنفسجية سوف تستخدم لتعيين الخصائص البصرية لهذه الاغشية في مدى اطوال الموجية (200-900) نانومتر مثل النفاذية و امتصاصية ومعامل امتصاص و فجوة الطاقة وكذلك تأثير درجة الحرارة على هذه المعاملات. النتائج التي تم الحصول عليها من الجزء العملي تشير بان الامتصاصية ومعامل الامتصاص لخلائط بولي فنيل الكحول – بولي فنيل الكحول – بولي فنيل كلورايد الثنائية سوف تزداد مع زيادة تركيز بولي فنيل الكحول. فجوة الطاقة لخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية سوف تقل مع زيادة تركيز بولي فنيل الكحول. يتميز نسبة الخليط الثنائي PVA 75%+ PVC25% بخصائص بصرية مناسبة للغاية. امتصاصية و معامل امتصاص لخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية سوف تزداد مع زيادة درجة الحرارة في حين فجوة الطاقة والنفاذية لخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية سوف تقل مع زيادة درجة الحرارة. طبيعة الأنتقالات الالكترونية لخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية بتركيز مختلفة قبل و بعد تعرض للدرجات الحرارة هي غير مباشرة. من النتائج العلمية التي تم الحصول عليها يمكن الاستنتاج ان الامتصاصية و معامل الامتصاص لخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية هي أفضل من البوليمرات بولي فنيل الكحول وبولي فنيل كلورايد النقية. الخصائص البصرية لأغشية الخلائط بولي فنيل الكحول – بولي فنيل كلورايد الثنائية سوف تتأثر بتعرض الى درجات الحرارة.

الكلمات المفتاحية: اغشية الخلائط الثنائية، قة امتصاص، النفاذية، تأثير الحرارة، فجوة الطاقة.