Optical Properties of PVA/K_2CrO_4 Composite

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Abstract

The change in the optical properties for samples of pure PVA and PVA /K_2CrO_4composite have been studied .The samples were prepared with different percentage (1,3,5,and 7)%wt of K_2CrO_4 by casting method technique .In this work ,we are study the absorption ,reflectance spectra ,absorption coefficient, energy gap ,extinction coefficient ,and transmittance spectra as a function of wavelength range (200-800)nm ,Also real and imaginary part of dielectric constant have been studied in the range of wave length .The results exhibit the optical properties change by the increase of K_2CrO_4 concentration, and the values of energy gap for indirect transitions decrease by the increase of the concentration of K_2CrO_4.

Keyword : poly (vinyl alcohole),K_2CrO_4,optical properties

Introduction

In the precent years, optical polymers have attracted considerable attention because of their significant manufacturing application such as solar cells,filters of light , diodes….etc. [1] in this paper, we used polyvinyle alcohol(PVA) as a semi crystalline polymer which has various features like gloss nature ,adhesive, easy film forming, compactable for wide application [2,3]. Different additives are usually used for the refinement of the properties of polymeric membranes for example potassium chromate (K_2CrO_4) [4,5,6]. K_2CrO_4 is a yellow-colored compound that is in form of crystalline solid and it is very stable [7].In the present work, we studied the effect of various concentrations of potassium chromate on the optical properties of PVA polymer .

Optical properties

The measurements of optical absorbance were taken for pure PVA and PVA/K_2CrO_4 samples. Absorbance (A) is defined as the ratio between absorbed light intensity (I) and the incident intensity of light (I_0) [8]

$A= -\log T = \log(I/I_0)$ -----(1)

while the absorption coefficient is defined as the ability of sample to absorb the light and its calculated by using this equation [9,10]

$I=I_0\exp(-ad)$ -------------(2)

$I=(2.303/d)\log I/I_0$ -----------(3)

Where d :is the thickness of the sample

and extinction coefficient (k) can be back according to high absorption coefficient and its calculation by this relation:

$k = \alpha\lambda/4\pi$ ------------(4)

The optical energy gap (Eg) is calculated from this relation

$\alpha = B\frac{(h\upsilon-Eg)r}{h\upsilon}$ ---------(5)

Where $h\upsilon$ is the energy of phonon, and B is constant, r is power factor depending to the electronic transition, and taken the value (1/2,2) respectively for allowed direct, indirect transition and (3/2,3) respectively for forbidden transition.

The reflective index (n) is a basic optical property of material and it’s the ratio of velocity of light in vacuum to the velocity in the sample, and it's calculation by this equation:

$n = [(\frac{1+R}{1-R})^2 - (K^2+1)]^{1/2} + \frac{1+R}{1-R}$ ------------(6)

Dielectric constant (real part (ε_r)and imaginary part ($\mathcal{E}_i$) are defined as response of material in a direction of incident electromagnetic field, real and imaginary part can be calculated by this equation[10]

$\mathcal{E}_{r=n^2-k^2}$ -------------(7)

$\mathcal{E}_{i=2nk}$ ---------------(8)

So the complex dielectric constant

$\mathcal{E} = \mathcal{E}_{r-i}\, \mathcal{E}_i$ ----------------(9)

Experimental work

The polymer PVA was dissolved in distilled water by using magnetic stirrer in blending process to obtain homogenous solution. Potassium chromate K_2CrO_4 with various concentration (1, 3, 5 and 7) %wt was added to PVA polymer and mixed for 2hr to obtain homogenous solution . Then the solution molding in petri-dish with diameter 3cm,and left to vaporate for (24hr) at room temperature .The dried samples are set aside by tweezers clamp .The optical properties measurements were made using shimadzu-UV-Vis in the wavelength (200-800)nm

Result and Discussion

From figure (1). the intensity of absorption peak has increased by the increase of the concentration of K_2CrO_4, the absorbance dependence of the incident intensity and it records high value in the range (350-450) nm of wavelength and became constant in the wave length range larger than 500nm, this expiation of the absorbance result is matched with many researchers such Tagreed K.Hameed2015 [11]. If the destination to get a diaphanous composite, the doped need to be diaphanous and scattering at the attach between the doped and matrix requirement to be as small as possible to decrease the absorbed [12]. Figure (2) shows the relation between the absorption coefficient with wavelength, the composite has a high absorption coefficient at small wavelength while the pure PVA sample has low absorption coefficient, this may be as outcome of low crystallinity and the local state of density which decrease the absorption coefficient value[13,14]. Figure (3) shows the relation of transmission spectra as a function of wavelength for samples of PVA and PVA/K_2CrO_4. It is noticed that the low value of transmission in the range between (300-400) nm of wavelength but the optical transmission increase rapidly within the range larger than 450nm, in general it is clear that transmission spectra of composite sample decrease with the increase of the concentration of potassium chromate, this result is in agreement with the work of many researchers such as Bakhtyar K.Azize 2013 [15]. The relation between reflectance and wavelength is shown in Figure (4) from this figure, within the range of (200-500) nm of wavelength, reflectance exhibited a clear change, while remained constant at wavelength larger than 500nm for all samples. Figure (5) showed the variations of extinction coefficient (k) with wavelength .it is observed that the extinction coefficient increase by the increase of the concentration of K_2CrO_4. This result referred that the rate of doping atoms of K_2CrO_4 will change the structure of host polymer [10].

The values of indirect energy gap (Eg) are tabulated in table (1).And these values of optical energy gap (Eg) which allowed indirect transition are plotted in figure (6), from this figure the relation between $(\alpha h\upsilon)^{1/2}$of pure PVA and PVA is doped by K_2CrO_4 plots as a function of photon energy, it is observed that when the concentration of K_2CrO_4 increases the values of energy gap decrease. While the value of energy gap reliance is on the crystal structure and allocation way of atoms in crystal lattice, and the decrease in the band gap energy of polymer can refer to the interaction of host polymer matrix which prepared additional charge in the matrix diminishing of optical energy gap [8,14] Figure(7) represents the relation of refractive index as function to wave length , it's clear the values of refractive index increase by the increase of the concentration of K_2CrO_4, this variation can be indicated of the increase in the peak density as a result to the change in the molecular structure of PVA[14].Figures(8&9) show the relation between real, imaginary parts of dielectric constants and the wavelength for different samples composite .it is clear that the magnitude of real part is greater than imaginary part. This result can retrain to the effect of free carriers and lattice vibration modes of dispersion [12]

Conclusion

In this work, samples of pure PVA and PVA/K_2CrO_4 composite prepared using casting methods, transmission spectra measurement exhibit high value and the optical properties increase by the increase the concentration of K_2CrO_4,while the energy gap values decrease by the increase of the concentration of K_2CrO_4 .According to these results of optical properties, this material may be suitable as a solar cell.

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Table No. (1) :optical energy gap for PVA /K_2CrO_4 samples

Sample type	PVA Pure	PVA+1%K2CrO4	PVA+3%K2CrO4	PVA+5%K2CrO4	PVA+7%K2CrO4
Eg	3.9	2.9	2.8	2.75	2.62

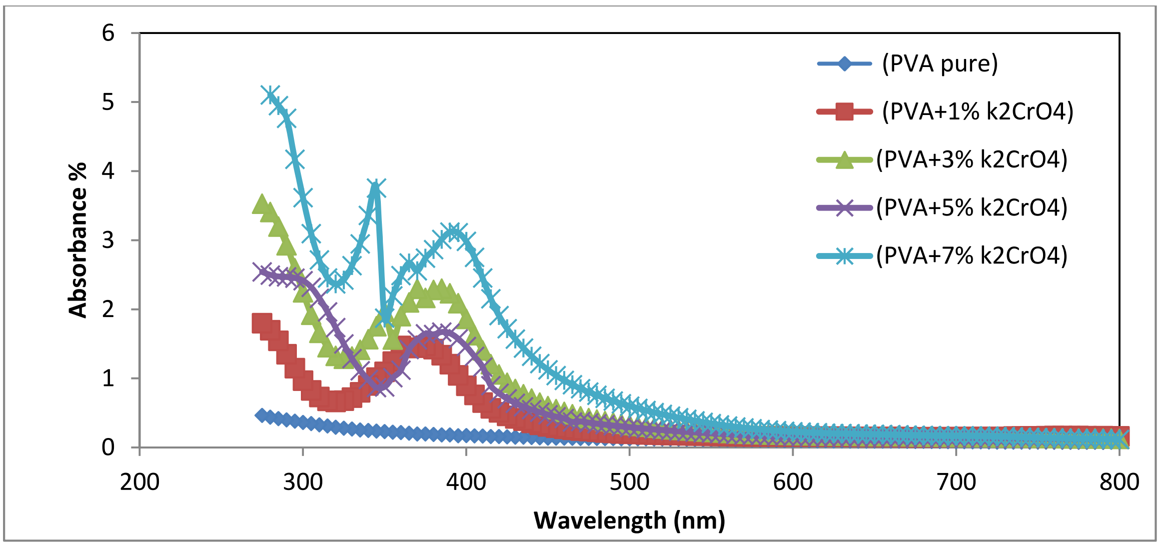

Figure No.(1). Absorbance as a function of Wavelength for(PVA/K_2CrO_4)samples

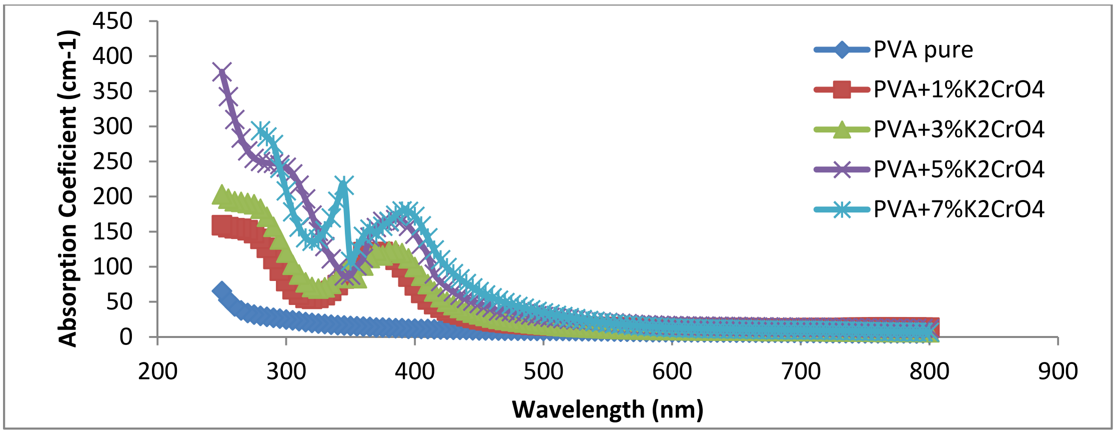

Fig. No. (2): Absorption coefficient as a function of Wavelength for(PVA/K_2CrO_4)samples

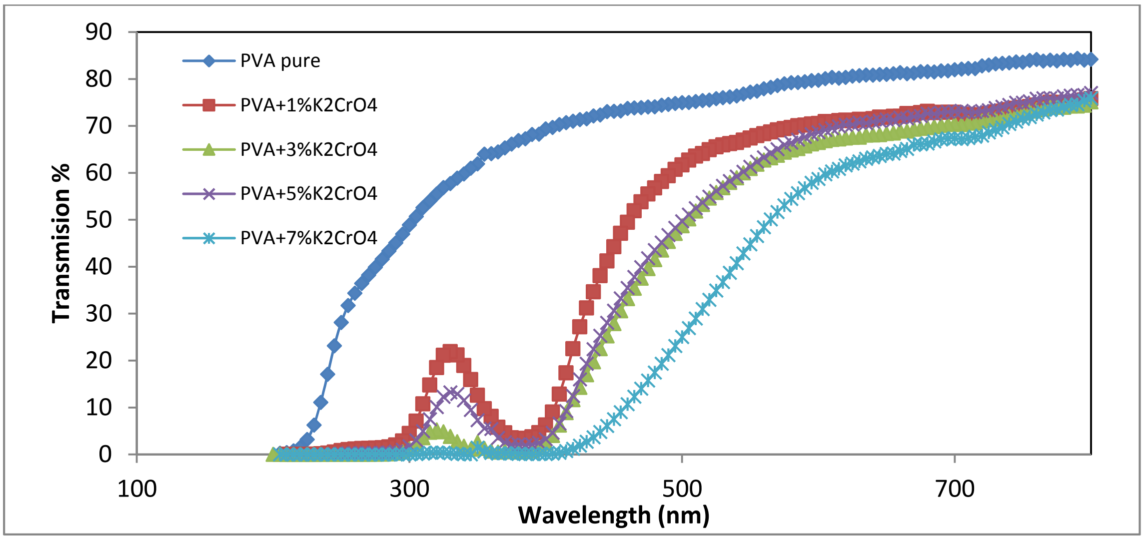

Fig. No. (3): Transmission spectra as a function of Wavelength for (PVA/K_2CrO_4)samples

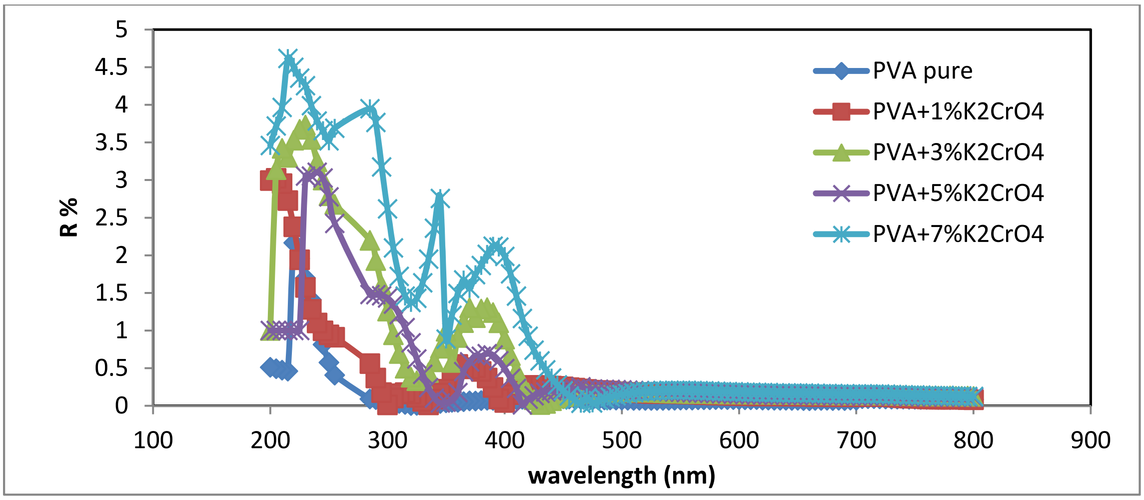

Fig. No. (4): Reflectance as a function of Wavelength for(PVA/K_2CrO_4)samples

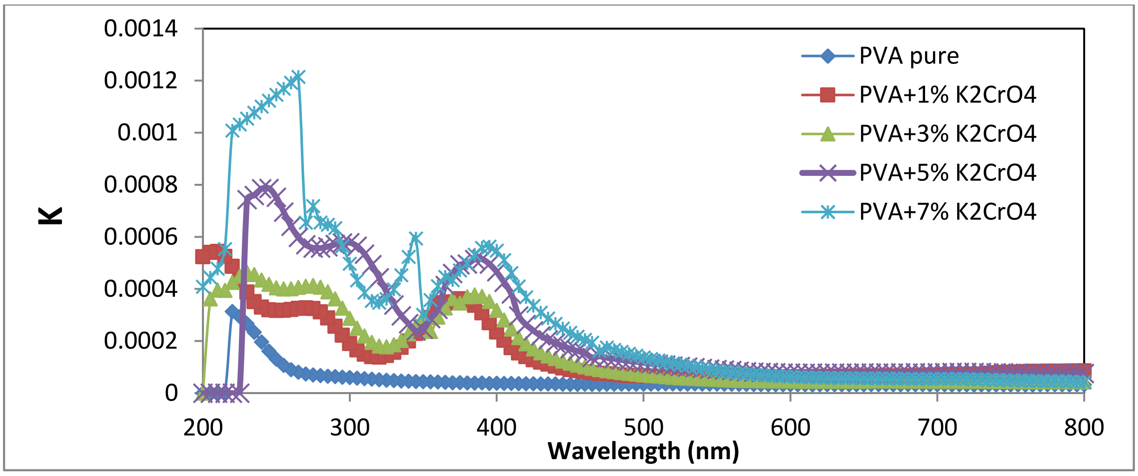

Fig. No. (5): Extinction Coefficient as a function of Wavelength for(PVA/K_2CrO_4)samples

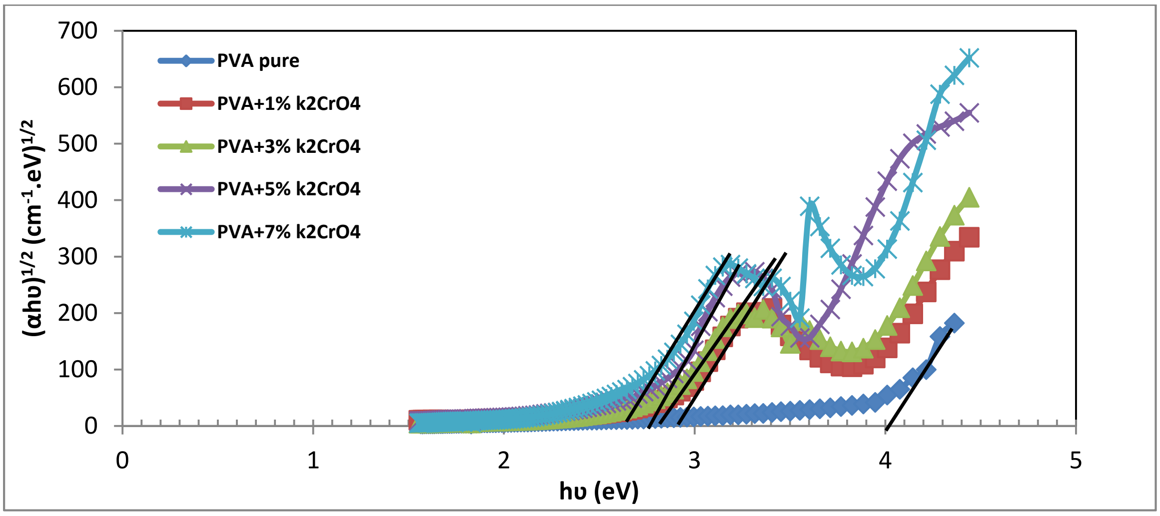

Fig. No. (6): Indirect transition as a function of photon energy for (PVA/K_2CrO_4)samples

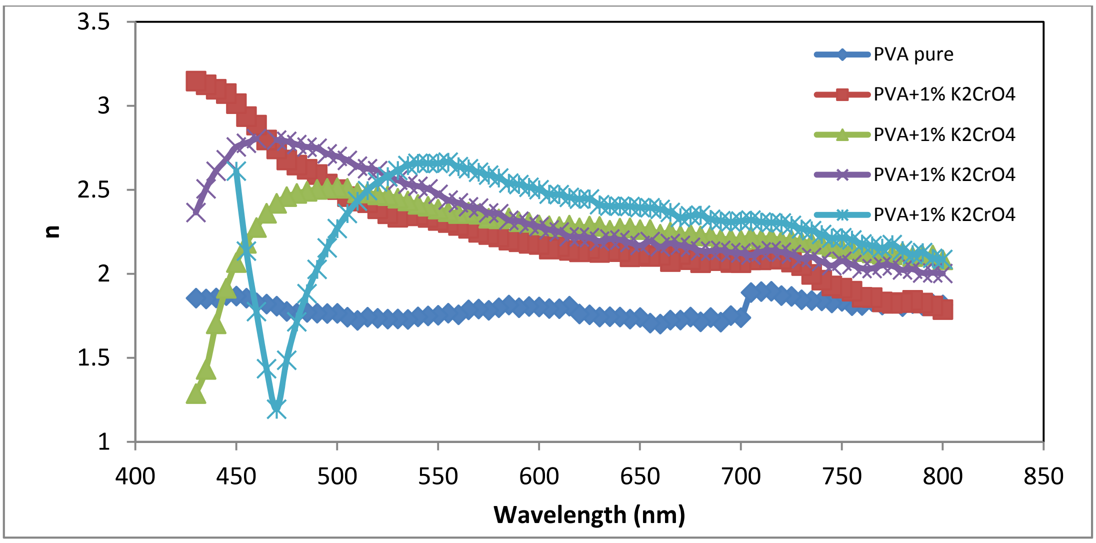

Fig No. (٧) Refractive index as a function of Wavelength for(PVA/K_2CrO_4)samples .

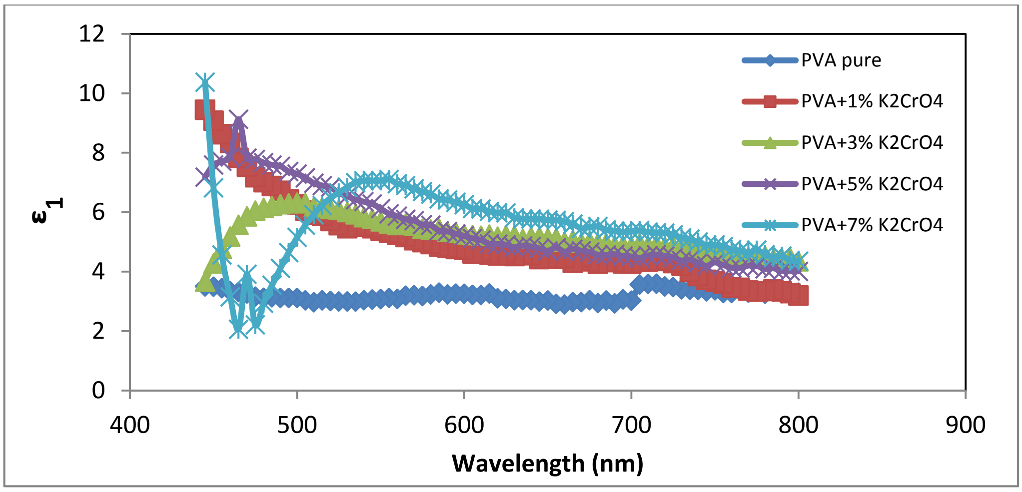

Fig. No. (٨): Real parts of dielectric constants as a function of Wavelength for(PVA/K_2CrO_4)samples.

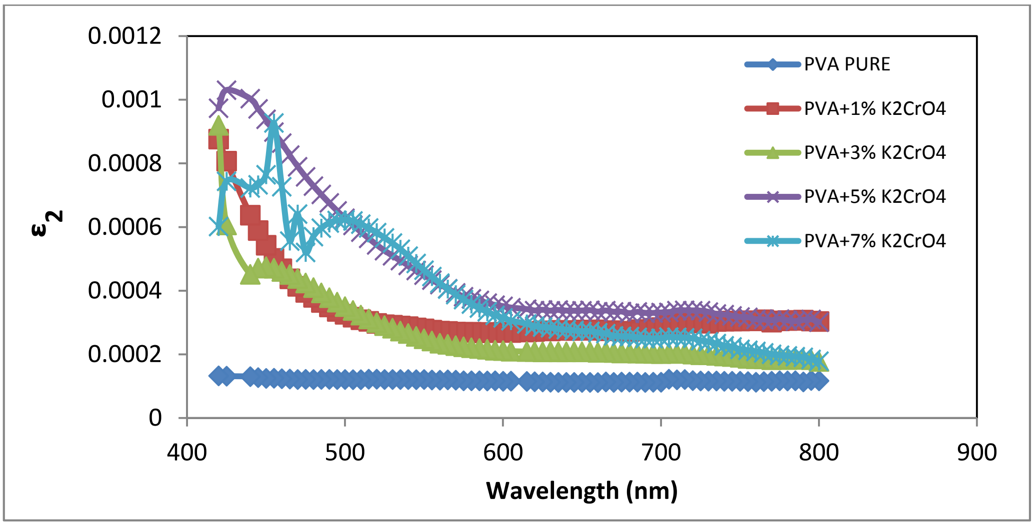

Fig No. (٩): Imaginary parts of dielectric constants as a function of Wavelength for (PVA/K_2CrO_4)samples

الخصائص البصرية لمتراكبات PVA/K_2CrO_4

عتاب فاضل حسين السليماوي
قسم الفيزياء/ كلية العلوم /الجامعة المستنصرية

استلم في:٢ نيسان ٢٠١٥،قبل في : ٧حزيران ٢٠١٥

الخلاصة

تم دراسة التغير في الخصائص البصرية لنماذج من البولي فانيل الكحول (PVA) النقي ومتراكبات من البولي فانيل الكحول وكرومات البوتاسيوم (PVA/K_2CrO_4) . حضرت العينات باضافة نسب مختلفة من كرومات البوتاسيوم (١،٣، ٥، ٧) % باستعمال طريقة الصب . تم في هذا البحث دراسة طيف الامتصاصية، الانعكاسية، معامل الامتصاص،معامل الخمود ومعامل الانكسار وطيف النفاذية و،وفجوة الطاقة والجزء الحقيقي والخيالي لثابت العزل كدالة للطول الموجي ضمن المدى (٢٠٠-٨٠٠) نانومتر. بينت النتائج ان الخصائص البصرية تتغير بزيادة كرومات البوتاسيوم،وان قيم فجوة الطاقة للانتقال غير المباشر تقل بزيادة تركيزكرومات البوتاسيوم .

الكلمات المفتاحية : بولي (فانيل الكحول) ، كرومات البوتاسيوم ، الخصائص البصرية.