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Effect of neutron-irradiation on the optical properties of PVA/K_2CrO_4 composites

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Abstract
In the work, poly (vinyl alcohol) doped with potassium chromate with concentration (1, 3, 5, and 7) %. These samples are prepared by casting method and irradiation by fast neutron with flux (10^5 n.cm^{-2}.s^{-1}) at room temperature, and then optical properties of (PVA/K_2CrO_4) are investigated by UV-visible spectroscopy in the wave length (350-1100) nm. These result show that the optical properties change with increase the concentration of K_2CrO_4, and after irradiation especially energy gap.

Keywords: PVA polymer, K_2CrO_4, optical properties, neutron-irradiation

1. Introduction

Traditionally, polymer matrix composites have been thought as insulating materials and have been used in applications like power tools handles, cables, jackets, capacitor films and electronic packaging materials [1]. Especially the electrical and optical properties of polymers have been extensively investigated due to their applications in optical devices recently. Polymeric materials have unique properties such as low density, light weight, and high flexibility and are widely used in various industrial sectors [2]. In recent years the great progress in understanding polymer surface phenomena and developments in their theoretical description have been done. Forces occurring on polymer surfaces depend on interactions between macromolecules, which are different inside the material and on the phase boundary. Several reactions occur at the polymer surface during modification such as oxidation, crosslinking, degradation and isomerisation (rotation of functional groups) [3]. The determination of the optical constants of polymers such as refractive index and extinction coefficient is also important for optical applications. Furthermore, the refractive index and optical band gap are the fundamental parameters of an optical material, because these are closely related to the electronic properties of the material [4].

Polymer materials are of interest in scientific and technological research [5] optical communications in clouding polymer optical fiber, optical waveguides and their ease of processing [6] optical properties of polymer are particular importance; as these materials are intended for particular application in various field [7]. The PAV is semi crystalline, synthetic, water soluble polymer and has very important application [8]. The additional like K_2CrO_4 in organic salt in to polymer matrix can improve its physicsl properties [9].

When the neutron source interacts with polymer material, these polymers absorbs it is energy and produce various chemical reaction [10, 11].

The absorbance (A) is defined as logarithmic relation between absorbed light intensity (I) if material and incident intensity of light (I_0) of samples [12]:-

$$A = -\log T = \log\left(\frac{I_0}{I}\right)$$

The absorption coefficient (α) can be obtain by this relation [13]

$$\alpha = \frac{2.303}{d}\log\frac{I_0}{I} = \frac{2.303\,A}{d}$$

Where (d) is thickness of sample.

The optical behavior of material has been utilized to determine it is extinction coefficient (k); which calculated using this equation [14].

$$k = \frac{\alpha\lambda}{4\pi}$$

The absorption coefficient dependence on the energy [15]

$$\alpha = \alpha_\circ(hv - Eg \pm Ep)^r/hv$$

Where

Eg energy gap, Ep phonon energy, hv is photon energy.

The aim of this work is study the influenced of the concentration of K_2CrO_4, before and after irradiation by neutron on UV-visible spectra on PVA/ K_2CrO_4 composite .

2. Experimental

PVA polymer was dissolved in distilled water by magnetic stirrer, K_2CrO_4 additive was added to PAV polymer with different concentration 1, 3, 5, 7% and mixed for two hours at room temperature. Then the solution cast in petri dish with diameter 3cm and leaved to evaporate the solvent for 24 hr. The absorption spectrum was recorded using UV-vis spectraphotometer at wave length 300-1100 nm, before and after irradiation the samples by using (Am^{241}-Be^9) neutron source with flux (10^5 n.cm^{-2},s^{-1}) for three days.

3. Result & Discussion

The study of optical properties in UV-Vis region is useful as analytical technique for two reasons; firstly, it can be used to identify optical enery gap, and secondly it can be used to help to under studying of the optical martial constants [16].

Figure (1) show the absorbance spectra of PVA/K_2CrO_4 samples as a function of wave length, from this plot, the values of absorption increase with increase the concentration of additive, after irradiation it is noticed that the values of absorption have same behavior but less than the values before irradiation this which may be due to some sort of interaction between the color centers created by interaction of radiation with PVA & K_2CrO_4 [17].

Figure (2) show the relation between absorption coefficient (α) as a function of wave length, (a) before (b) after irradiation . It is can be note for the unirradiation samples of PVA/K_2CrO_4 that the absorption coefficient values increase by increase the concentration of K_2CrO_4 . Also the pure sample has low absorption coefficient that can be interpreted as lower crystalinity. After irradiation, these values of absorption coefficient (α) decrease with increasing the wavelength this may be due to the variation in internal fields associated with structure disorder in system [18].

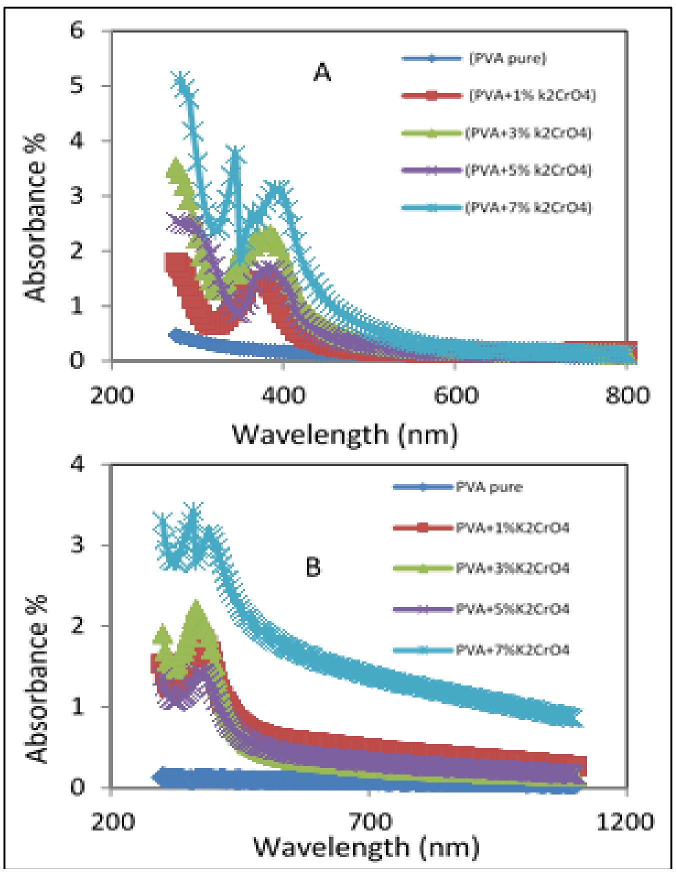

Fig 1: Optical absorbance as a function of Wavelength (A) Before irradiation (B)After irradiation

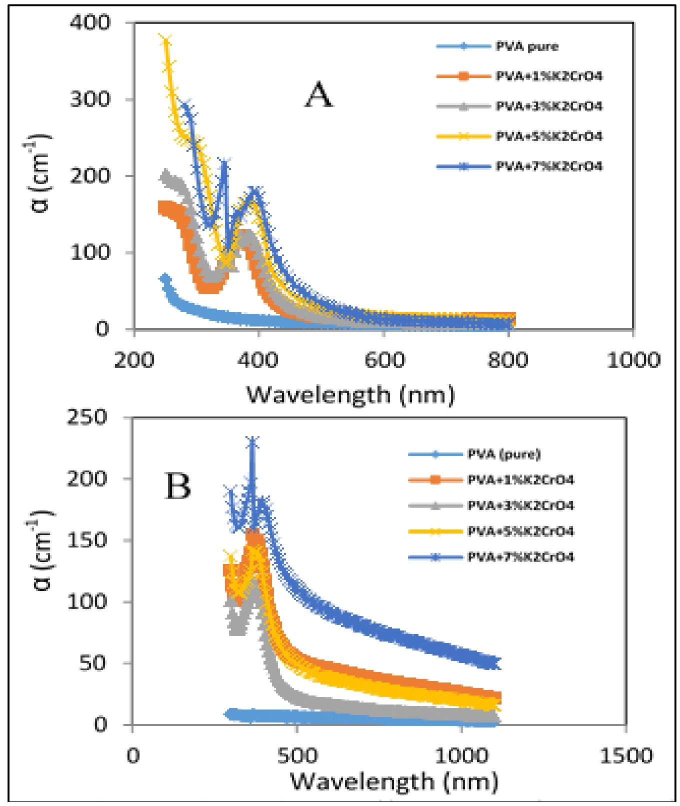

Fig 2: Absorption coefficient as a function of wavelength (A) before irradiation (B) after irradiation

Figure (3) represent the variation of extinction coefficient k with wavelength (a) before (b) after irradiation, from this plote, these values of extinction coefficient increase by increase the concentration of K_2CrO_4, the similar behavior noticed after irradiation but the values of k less than before irradiation while the decrease in wavelength show that the fraction of light lost due to scattering

Figure (4) show the relation between indirect forbidden transition $(\propto h\nu)^{\frac{1}{2}}$ as a function of photon energy before, it is clear when the concentration of K_2CrO_4 increase the values of energy gap decrease. while after irradiation by fast neutron the type of optical transition is chnage from indirect forbidden transition before irradiation to allowed direct transition aftere irradiation. And also the values of band gap were decreased with respect to band gap of unirradiated samples, this can be explaining by the structure defects and the change in degree of discover [19] and the interaction of the salt with polar group of polymer, which gives a complex for- motion. The evidence of polar formation made the reaction in band – to band transition due to shifting of the band density of state toward the energy gap [20], See Table (1).

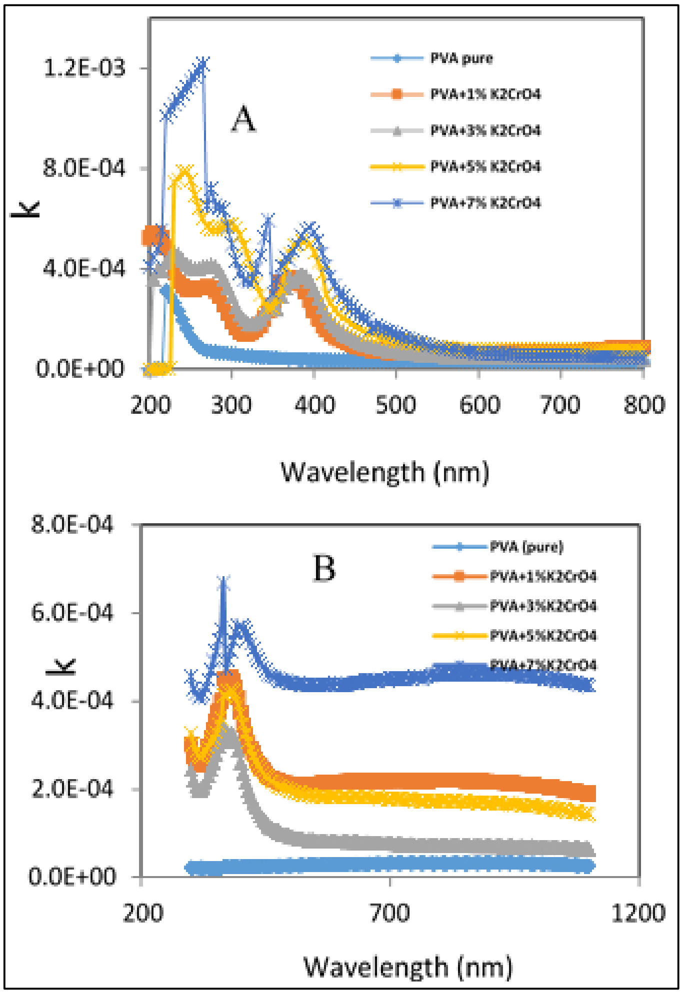

Fig 3: Extinction coefficient as a function of wavelength (A)before irradiation (B)after irradiation

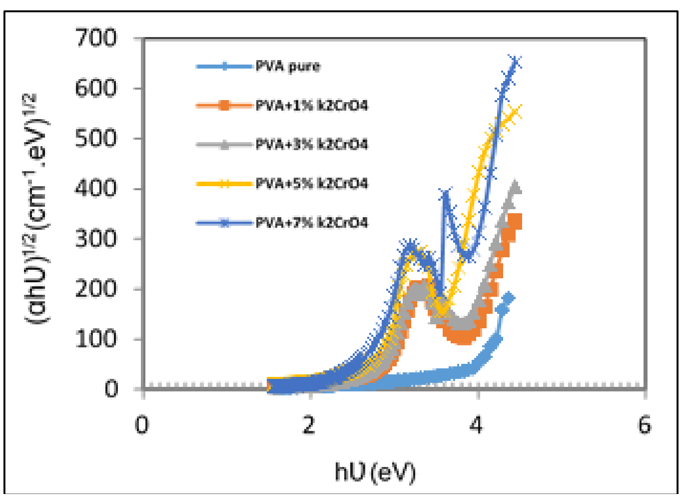

Fig 4: indirect forbidden transition $(\propto h\nu)^{\frac{1}{2}}$ as a function of photon energy (a) before (b) after irradiation

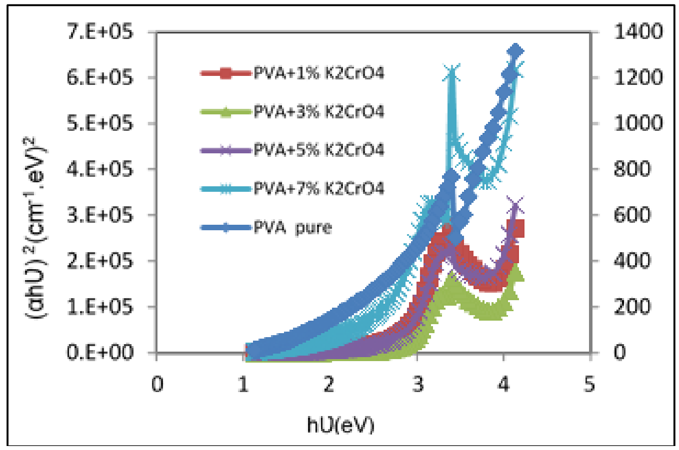

Fig 5: indirect forbidden transition $(\propto h\nu)^2$ as a function of photon energy (a) before (b) after irradiation

Table 1: The values of Eg of K_2CrO_4 composite.

Dopping Concentration	Eg eV before irradiation	Eg eV after irradiation
PVA Pure	3.8	2.31
PVA+1% K_2CrO_4	3	2.95
PVA+3% K_2CrO_4	2.8	2.75
PVA+5% K_2CrO_4	2.7	2.6
PVA+7% K_2CrO_4	2.6	2.4

4. Conclusions

The optical properties measurement were carried out in the uv-vis rang (350-1100) nm for samples of pure PVA and PVA doped by different concentration of K_2CrO_4, the values of optical properties increase by increase the concentration of K_2CrO_4, and irradiation by fast neutrons effects to the absorption and reduce the energy gap . These result important for improvement the optical characterization of PAV.

5. References

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