Physics AUC, vol. 29, 36-44 (2019) PHYSICS AUC

The Effect of Adding PAA on the Physical Properties of PEG

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Abstract

In this study, the physical properties of polymer (PEG) dissolved in distilled water with different concentrations ranged from (4%- 16%) g./ml before and after adding polymer (PAA) of different weights have been conducted. The effect of adding different concentrations of (PAA) polymer have been analyzed by using the optical microscope, Fourier Transform Infrared Spectrometer (FTIR). The optical properties such as absorbance and refractive index have been measured and the transmittance, reflectance, molar reflectance, absorption coefficient of electromagnetic waves. The Results showed that all properties have linear or exponential increment with the increase of PEG concentration.

Keywords: Polyacrylic acid, Polyethylene glycol, Physical Properties

1. Introduction

The polymer word came from the words of classical Greek *poly* which means "many" and *mers* meaning "parts", the polymer is a molecule with long chain that is consisted with large numbers of repeating units of identical structure [1]. A polymer may consist of hundreds, thousands, tens of thousands or more monomer molecules. Hence, its molecular weight is very large, giving it interesting and useful mechanical and chemical properties [2]. The science polymers science was started in the world laboratories of industry to understand and make new kinds of rubber, plastics, fibers, adhesives, and coating. The term monomer or monomer unit is often used to mean either the chemical repeat unit or the small molecule which polymerizes to give the polymer. These are not always the same in atomic composition [3]. M. J. K. Chee *et al.*, studied Huggins coefficients and intrinsic viscosities for (PCl /PHB) solution using viscometric, their experimental results showed Huggins coefficients displayed generally nonlinear dependencies on blend composition and intrinsic viscosities very linearly with blend composition [4]. Measurements of reflective index (nD) of (PVA/PVP), (PVP/PEG) at room temperature 298K by R. J. Sengwa *et al*. The results showed that the highest value of the refractive index appeared near the visible spectrum of all these mixtures, which it increases linearly with increasing concentration [5]. Three polymers concentrations and molecular weights of poly (acrylic acid sodium salt) (NaPA), polyacrylamide (PAA), and poly(ethylene glycol) (PEG) effects, on the electro kinetic and rheological properties of sepiolite suspensions were investigated by S. Tunc *et al*. [6]. The aim of the present work is to investigate the optical properties for (PEG) dissolved in distilled water with different concentrations ranged from (4%- 16%) g./ml before and after adding polymer (PAA) of different weights.

2. Experimental Work

Physical Properties of Polymer (PEG) dissolved in distilled water with different concentrations ranged from (4%-16%) g./ml before and after adding polymer (PAA) of different weights. (PAA) polymer as additive is prepared by using casting method with different concentrations and thickness. and mixed for 20 minutes to get more homogenous solution. The optical properties were measured in the wavelength range (220-820) 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.

The absorbance (A) is defined as the ratio between the intensity absorbed light (I_A) by the material and the light incident intensity (I_o).

$$A = \frac{I_A}{I_0} \qquad (1)$$

The transmittance (T) is defined by the ration of the intensity of the rays transmitting from the film (I) to the incident ray intensity (I_o) ($T=I/I_o$) and can be determined from

$$T = \exp(-2.303A) \qquad (2)$$

The reflectance (R) can be determined from absorption and transmission spectra in accordance with the law of conservation of energy by the relation

$$\mathrm{R} + \mathrm{T} + \mathrm{A} = 1 \qquad (3)$$

Absorption coefficient α of adding (PAA) polymer to (PEG) polymer is defined by following equation:

$$\alpha = 2.303\, {}^{A}\!/_{t} \qquad (4)$$

where A: is the absorbance and t: is the thickness of the sample t.

The indirect transition for amorphous materials is

$$\alpha h\nu = B\left(h\nu - E_g\right)^r \qquad (5)$$

where B is a constant, $h\nu$ is the energy of the photon, E_g 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 for adding (PAA) nanoparticles to (PEG) polymer is defined by following equation:

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

The dielectric constants (ε) is divided into two parts real (ε1) and imaginary (ε2) are calculated by using equations:

$$\varepsilon_1 = n^2 - k^2 \qquad (7)$$

$$\varepsilon_2 = 2nk \qquad (8)$$

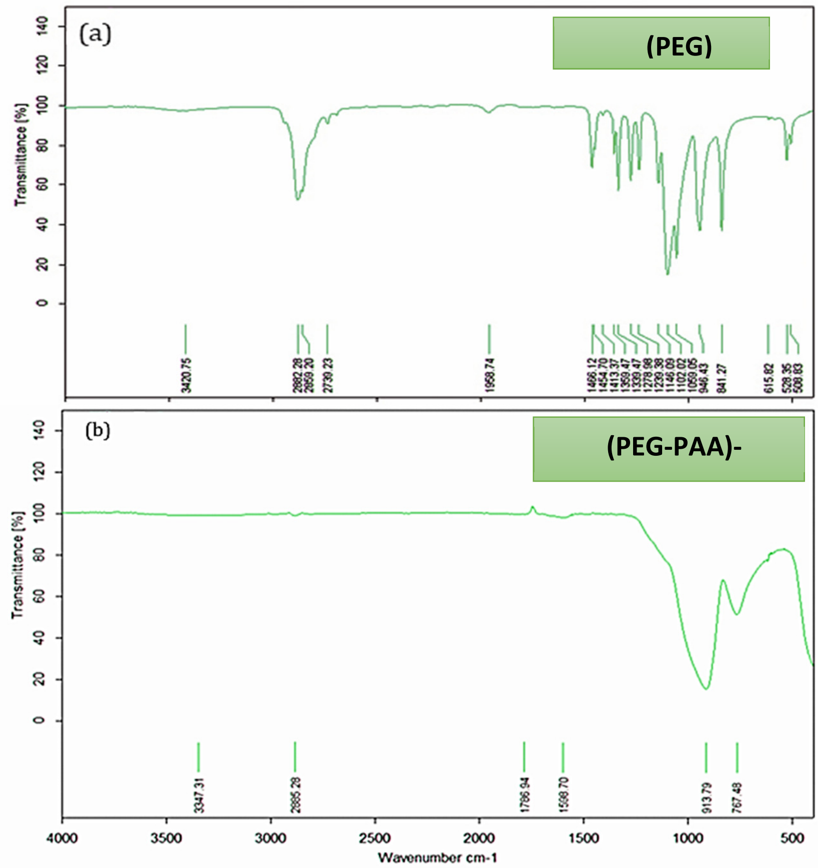
Optical conductivity (σ_{op}) can be determines as:

$$\sigma_{op} = \frac{\alpha_{nc}}{4\pi} \qquad (9)$$

3. Results and Discussion

3.1 Fourier Transforms Infrared Spectroscopy analysis (FT-IR)

FTIR spectroscopy has been used to analyze the interactions among atoms or ions in (PEG) polymer, these interactions can include changes in the vibrational modes of the nanocomposites. The (FTIR) transmittance spectra of (PEG) polymer with the different ratio of (PAA) polymers are shown in figure 1 are recorded at room temperature in the region (500-4000) cm^{-1}. From the spectra, The FTIR spectrum of (PEG) Polymer shows broadband about 3420 cm^{-1} is assigned to the stretching vibration of hydroxyl group (OH) [6-7], which may be due to the intermolecular or intramolecular type of hydrogen bonding of the polymer and the nanoparticles. The band corresponding to C-H asymmetric stretching vibration occurs at about (2850-2950) cm^{-1}. The peaks at (1466,1454,1359,1339,1278,1239,1146) cm^{-1} have been attributed to the C−O, C−C stretching mode, and thus shows all the bonds present in the chemical structure of (PEG) [8,9]. In the case of additive (PAA) with concentrates (4 wt %, 8 wt %, 12 wt %, 16 wt %), shown in Fig. 2 (a, b, c, d), in addition to the three existing bonds Three other bonds, are shown, depending on the chemical composition of PAA. C-H is found in the PEG and NH2 structures within wavelengths (3697, 3683, 3637, 3043) cm^{-1} that in the range of (3500-3200) cm^{-1}, within the strong bonds and C-H region appear within the area of medium-strength bonds which were mentioned previously in Figure 1, while C = O is in the region of weak links Within the range of wavelength (1692,1659,1585) cm^{-1}, which in the range of (1630-1680) cm^{-1} [10]. Thus, no new bonds were shown when mixing polymers and there was no chemical reaction between them, that is, it is just a good physical mix.



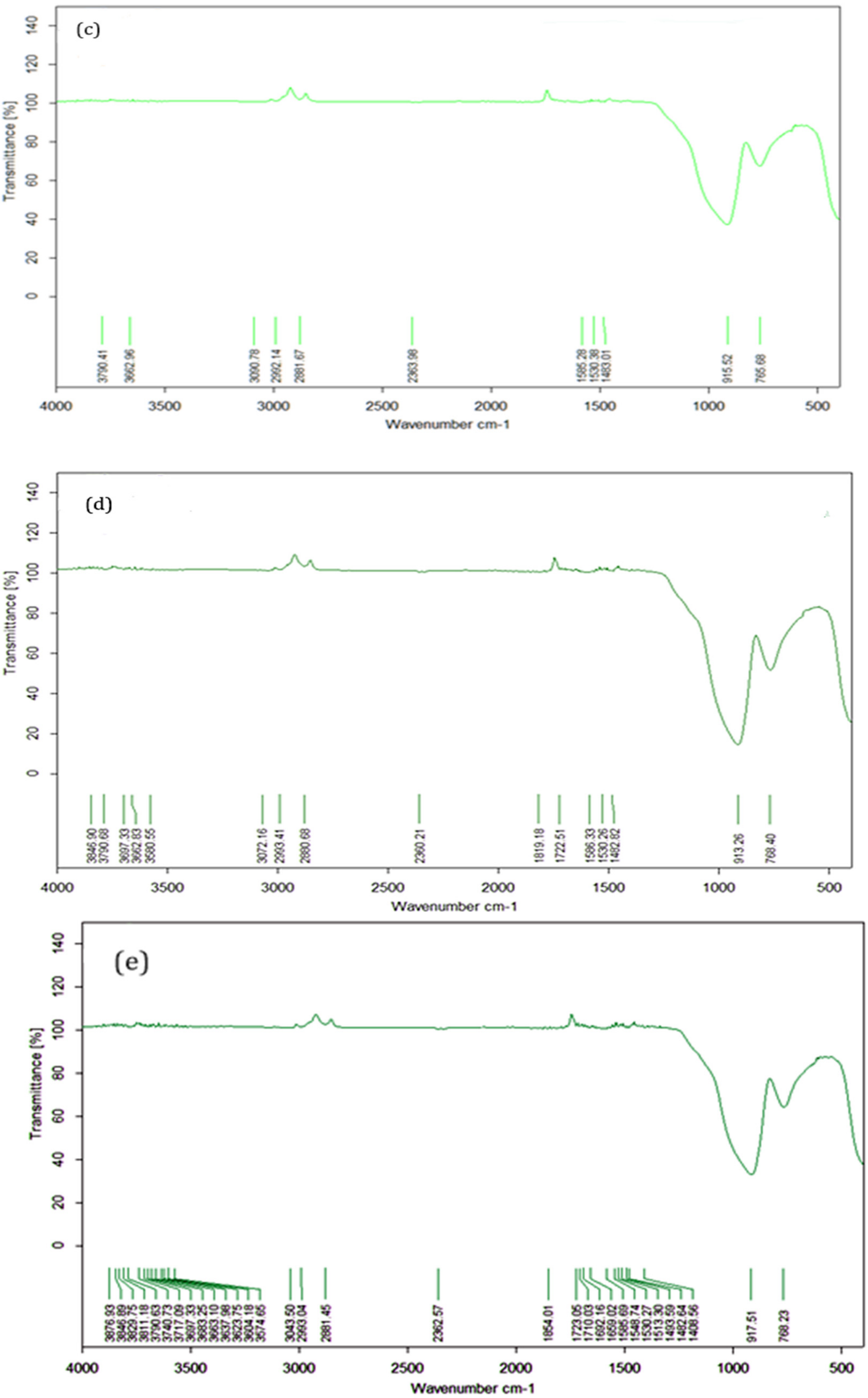


Figure 1: FTIR spectra for (PEG-PAA) flims : (a) PEG pure, (b) PEG-PAA 4wt.%, (c) PEG-PAA 8wt.%, (D) PEG-PAA 12wt, (e) PEG-PAA 16wt.%.

3.2

The Optical Properties

3.2.1 The Absorbance (A)

Figure 2 illustrate the absorption spectrum of (PEG-PAA) films as a function of wavelength of the incident light. It can be noticed from the figure that the high value of absorbance obtained at the wavelength between (190-240 nm) and reaches its maximum at the wavelength (210nm). The polymer become transmitted for light at the higher wavelength because the increasing of the incident light due to decreasing the energy of the light, thus the absorbance decreasing according to the Planck's law. Since the additive (PAA) lead to increasing the absorbance for the ultraviolet region at the wavelength (210nm) because the increase the concertation. The results showed also the absorbance increase by the increase of the weight percentages of (PAA). This results because that absorbance proportional with the number of molecules of substances in absorption the radiation in wavelength certain and for existences more the one type in the same solution, therefore the absorbance increase [11].

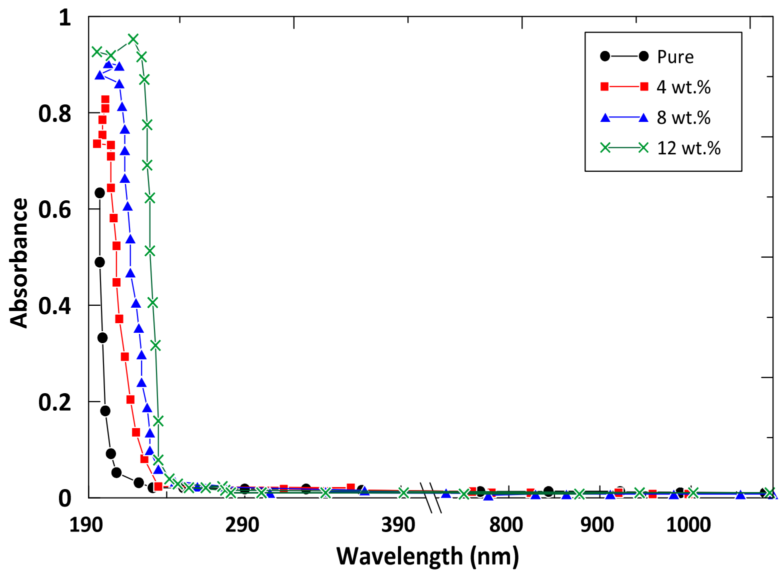


Figure 2: Absorbance as a function of wavelength for adding (PAA) polymer to (PEG)

3.2.2 Refractive Index

The refractive index (n) is calculated from equation 6. Figure 3 shows the refractive index for adding (PAA) polymer to (PEG) as a function of concentration. It is obvious from the figure that the refractive index increase with increasing weight percentages of the concentration of (PAA) to (PEG) because of increasing in density. Also we noticed the values of the refractive index increase after additive (PAA) because the increasing of density after additive [12].

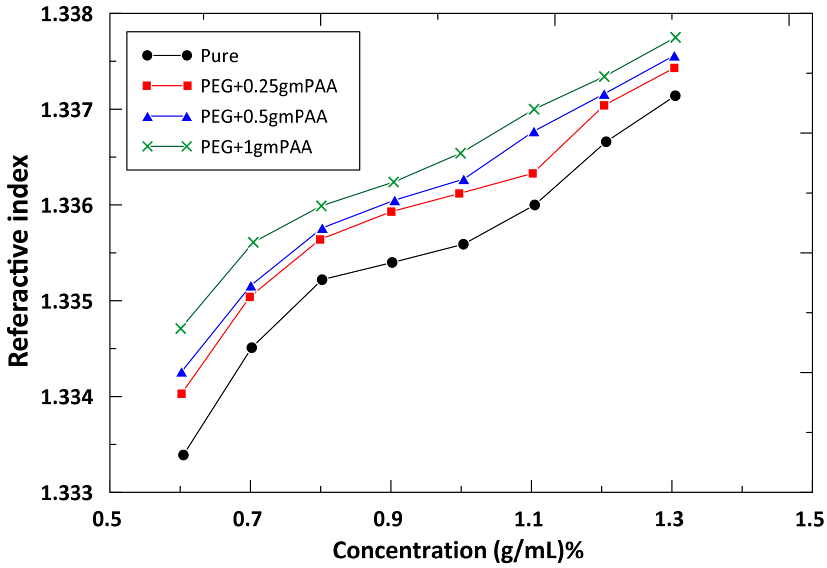


Figure 3: Refractive index as a function of concentration for adding (PAA) polymer to (PEG)

3.2.3 Reflectance

The values of reflectance measured for different concentration of (PEG) polymer. Figure 4 shows the values of reflectance proportional with concentration, that is increase with increasing concentration because increase the number of polymer molecules in solution, thus increasing the density of solution whereas the reflectance dependence on the density. We notice from the figure the values of reflectance increase after additive PAA, because the bonding process between the molecules which lead to the amount of the reflective rays by the polymer molecules that dissolved in solution. Therefore, the reflectance has behavior similar to the refractive index [12].

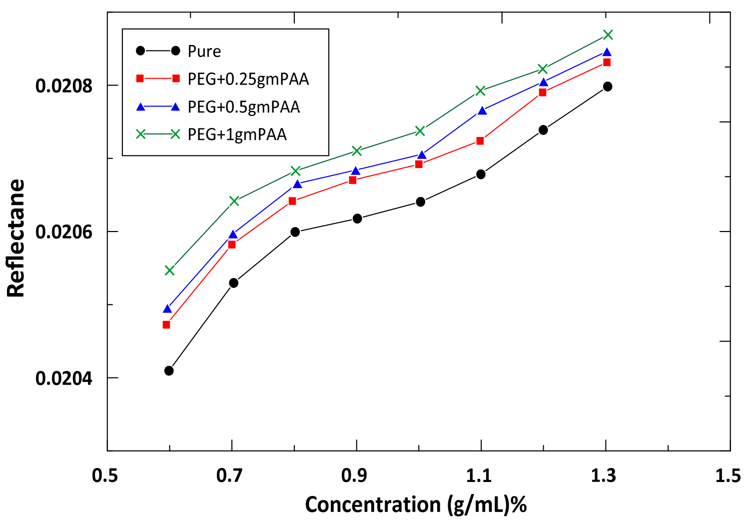


Figure 4: Reflectance as a function of concentration for adding (PAA) polymer to (PEG)

3.2.4 Transmittance

The transmittance values were calculated from the relationship (2) for all PEG concentrations before PAA was added. The results showed that the transmittance decreased with the wavelength of all concentrations due to the increase of absorption with the wavelength because the transmittance relationship with the absorbance is logarithmic, so increasing absorption leads to decreased transmittance. After the addition of PAA, it resulted in a decrease in the values of the effect due to increasing absorption with wavelength. Figure (5) shows the relationship of permeability with wavelength before and after addition. these results are similar to the results that reported by the previous researcher [13].

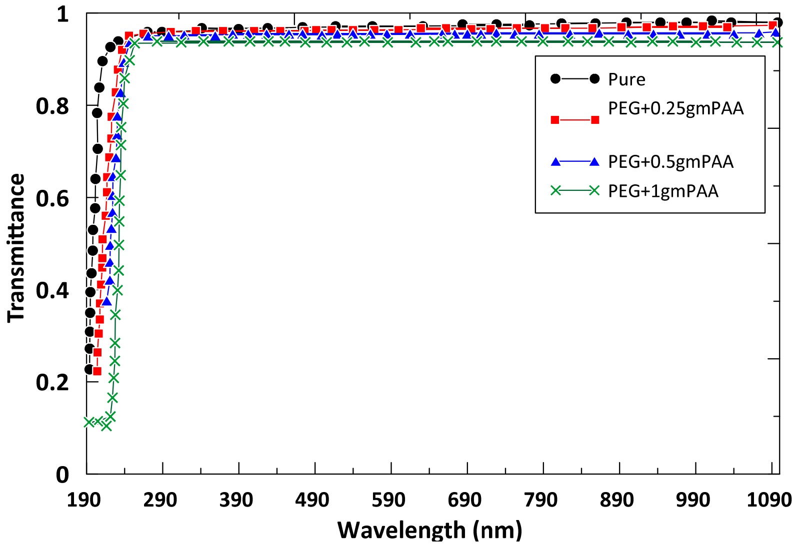


Figure 5: Transmittance as a function of concentration for adding (PAA) polymer to (PEG)

3.2.5 Critical Angle

When an optical beam falls from the medium of the highest density (the solution) to a less dense medium (the air), the overall internal reflection will occur, provided that the angle of fall is greater than the critical angle, so any increase in mean density leads to an increase of the refractive index. Their relationship is inverse with refractive index. From the figure we observe that the addition has increased the values of the refractive index, which in turn causes a decrease in critical angle values. Figure 6 shows the change in critical angle values with emphasis before and after addition.

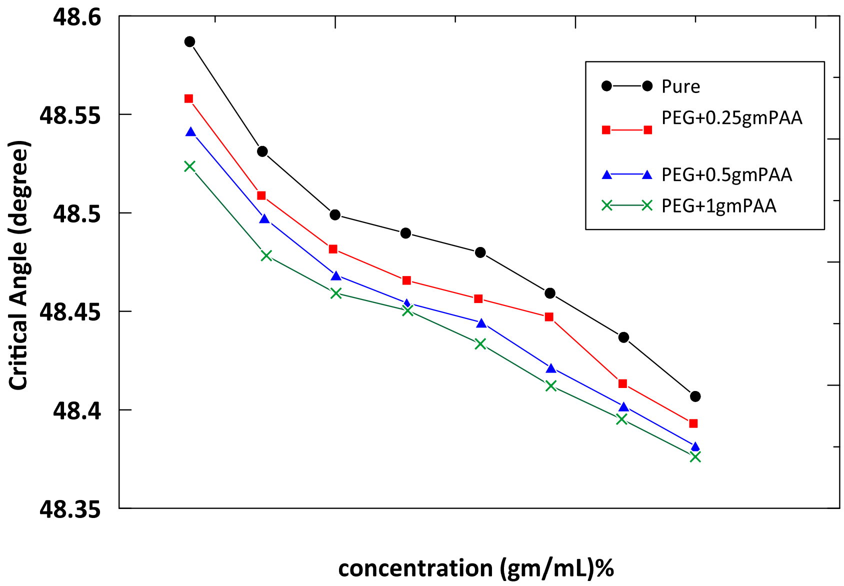


Figure 6: Change critical angle with concentration before and after adding

3.2.6 Brewster Angle

The Brewster angle values are based mainly on the refractive index, where they are positively correlated with the refractive index and the figure shows that the Brewster angle increases after the addition, due to the increase of the refractive index as a result of addition. Figure (7) shows an increase in Brewster angle values with increased concentration before and after addition.

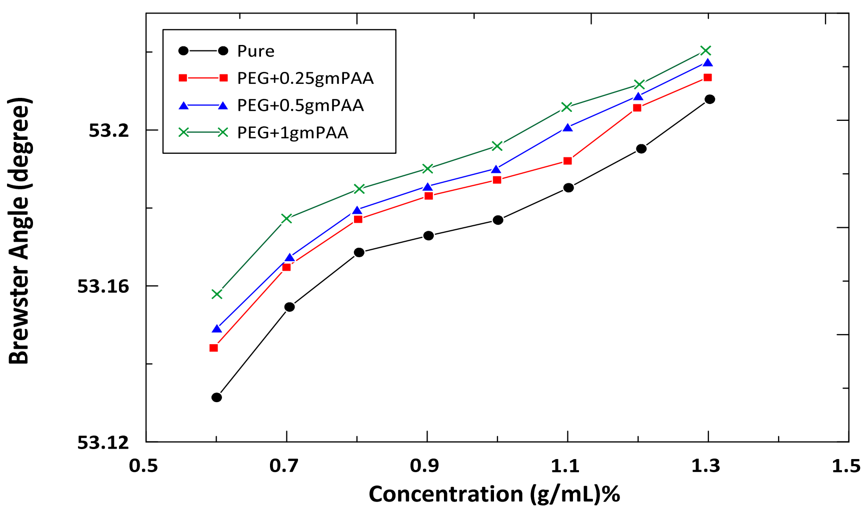


Figure 7: Change Brewster Angle with concentration before and after adding

4. Conclusion

The physical properties of (PEG) polymer dissolved in distilled water with different concentrations ranged from (4%- 16%) g/ml before and after adding polymer (PAA) of different weights were studied. The (FTIR) analysis shows good mixture after adding different (PAA) percentages. The optical Properties had been measured which included measuring absorbance and refractive index and from these two properties, other properties were calculated such as: transmittance, reflectance, molar Reflectance, absorption coefficient of electromagnetic waves, critical angle and Brewster angle, Through the results of these characteristics can be used polymer mixture for the purposes of protection or protective cover from the sun so it is used for the storage of medicines and coating tires to prevent the arrival of ultraviolet rays to it. The Results showed that all properties have linear or exponential increment with the increase of PEG concentration.

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