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Study the optical properties of (PEG-cellulose derivatives) polymer blends and prepared new tire package

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ABSTRACT

In this research the optical properties of Polyethylene Glycol(PEG)with (0.1,0.2,…,0.8) concentrations mixed with some cellulose derivative polymers as CMC,MC and Xanthan gum added as (0.25 and 0.5) g everyone alone have been studied by spectrophotometer system. From (PEG-MC) blend prepared a film by using casting method and that use as tire package as compared with exported tires packages and taking a best results of absorbing UV-rays. The hardness of all films were measured by using (Shore D) tester. All materials were diagnosed with (FTIR) spectrum.
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KEYWORDS

Optical properties;
Tire packages;
PEG and CMC.

INTRODUCTION

Tire packaging, also called tire guards or tire protectors, slip over wheels to shield them from weather and harmful ultra-violet rays that can prematurely age rubber. Ungaraged vehicles, especially those that are driven less often, are at higher risk to develop cracked sidewalls from sitting in the sun. Tire covers can protect your investment by blocking UV and retarding the aging process. There is no greater enemy of rubber than UV and ozone. To combat these environmental effects, tires are made with a competitive absorber known as carbon black. This compound is what gives tires their color. The molecules in carbon black absorb UV rays converting them to heat that can dissipate off the tire. Over time, however, carbon black becomes depleted and the rubber turns gray and brittle. By shading tires with UV-blocking covers, method is effectively extending the life of tires[1].

PEG 6000 is a water-soluble and waxy solid that is used extensively in the several industries such as rubber, textile, paper, metal, wood, pharmaceutical, cosmetics and coating. PEG recognized by many characteristic such as, highly compatible to various kinds of organic compounds, high boiling point, easy control of the degree of condensation, controllable hygroscopic property, less toxicity and less skin irritation[2].

Sodium carboxymethyl cellulose (Na-CMC) or cellulose gum is a cellulose derivative with carboxymethyl groups (-CH2-COOH) bound to some of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone.CMC is

used as a lubricant in nonvolatile eye drops and artificial tears[3].

Methyl cellulose (or methylcellulose) is a chemical compound derived from natural cellulose. It is a hydrophilic white powder in pure form and dissolves in cold (but not in hot) water, forming a clear viscous solution or gel. It is sold under a variety of trade names and is used as a thickener and emulsifier in various foods and cosmetic products and as a treatment of constipation[4].

Xanthan cellulose gum is a polysaccharide secreted by the bacterium xanthomonascampestris, used as a food additive and rheology modifier, commonly used as a food thickening agent (in salad dressings, for example) and a stabilizer (in cosmetic products, for example, to prevent ingredients from separating). It is composed of pentasaccharide repeat units, comprising glucose, mannose[5].

Theoretical part

When light incidents on substance a number of reactions are triggered by of the interaction light beam with the material as it absorbs the photon, who works on the irritation of the molecules a lmutharh. The spectrum of ultraviolet and visible useful in the complexes characteral, as it gives a distinctive absorption in the ultraviolet - visible as is useful in the diagnosis of complexes containing antioxidants. Material cause absorption of the rays falling active electronically may lead to the dissociation of their molecules if the value of energy absorbed is greater than the value of the dissociation of one of the links or move to a higher energy level, since the probability of absorption increases with the concentration of the low energy level and increase the number of photons of light beam. The probability of photon absorption is directly proportional to the concentration of the absorbed molecules and the thickness of the model and on the following[6,7]:

2-3-1 Absorbance

Absorbance defined as the ratio between absorbed light intensity (I_A) by material and the incident intensity of light (I_o)[8].

$$A = I_A / I_o \quad (1)$$

The light absorbance coefficient (α_{op}), and films absorption coefficient are given by the equation[9]:

$$\alpha_{op} = 2.303A/d \quad (2)$$

Where (d) represent a thickness of film.

The ratio (I / I_o) called (Transmittance) (T_r), so can be defined as the ratio of the intensity of the transmitting rays (I) through the film to the intensity of the incident rays ($I_{o)}$ on it as follows, and connected by absorbance as[10]:

$$T_r = e^{-2.303A} \quad (3)$$

2-3-2 Nature life time (T_L)

In the near – UV regions, the following expression can be used for estimating the nature life time of the excited states[11,12]:

$$T_L = \frac{10^{-4}}{\alpha_{op}(\max)} \quad (4)$$

Where $\alpha_{op}(\max)$ is optical absorption coefficient of electromagnetic waves.

2-3-3 Refractive index (n)

The refractive index can be defined as a ratio between the speed of light in vacuum (c), to its speed of light in medium (v), and given by the relation[13]:

$$n = \frac{c}{v} \quad (5)$$

The value of refractive index was calculated by using equation depending on the reflectance and extinction coefficient (K) as in the following equation[13,14].

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

If extinction coefficient (K) equal to zero, then equation (2.26) will be:

$$R = \frac{(n-1)^2 + 0}{(n+1)^2 + 0} \quad (7)$$

$$\sqrt{R}\, n + \sqrt{R} = n - 1 \quad (8)$$

$$1 + \sqrt{R} = n\,(1 - \sqrt{R}) \quad (9)$$

Then refractive index will become:

$$n = \frac{1+\sqrt{R}}{1-\sqrt{R}} \quad (10)$$

2-3-4 Reflectance (R)

When light radiation passes from one medium into another having a different index of refraction, some of the light is scattered at the interface between the two media even if both are transparent. The reflectance can be represented depending on the value of refractive index by the relation[15]:

$$R = \left[\frac{n-1}{n+1}\right]^2 \quad (11)$$

Reflectance also can be obtained from absorption and transmission spectrum in accordance to the law of conservation of energy by the relation[16]:

$$R + T + A = 1 \quad (12)$$

Since the index of refraction of air is very nearly unity. Thus, the higher the index of refraction of the solid, the greater is the reflectivity. For typical silicate glasses, the reflectivity is approximately (0.05). Just as the index of refraction of a solid depends on the wavelength of the incident light, so also does the reflectivity vary with wavelength. Reflection losses for lenses and other optical instruments are minimized significantly by coating the reflecting surface with very thin layers of dielectric materials such as magnesium fluoride (MgF_2).

2-3-5 Molar Reflectance (R_m)

It's a relation between the density of material and molecular weight, and measured by (m^3 / mole) unit, and given by[17]:

$$R_m = \frac{n^2-1}{n^2+1}\frac{M_v}{\rho} \quad (13)$$

So can be defined as the multiplication relation between the specific reflectance and molecular weight.

2-3-6 Extinction coefficient (K)

It represents the imaginary part of complex refractive index (n^*):

The extinction coefficient represents the amount of attenuation of an electromagnetic wave that is traveling in a material, where it values depends on the density of free electrons in the material and also on the structure nature[18]:

$$n^* = n - i K \quad (14)$$

Where; n : the real part of refractive index; n*: complex refractive index which it depends on the material type, crystal structure (grain size), crystal defects, stress in crystal and extinction coefficient, so given by following equation[18] :

$$K = \alpha_{op}\,\lambda / 4\pi \quad (15)$$

Where λ is the wavelength of incident photon rays.

2-3-7 Coefficient of finesse (F)

It is a measure of the sharpness of the interference fringes, and defined as follows[19]:

$$F = \frac{4R}{(1-R)^2} \quad (16)$$

θ_c)2-3-8 Critical angle

The critical angle is defined as the angle of incidence which provides an angle of refraction of (90-degrees), and given by following equation[20]:

$$\theta_c = \mathrm{Sin}^{-1}(1/n) \quad (17)$$

θ_B) 2-3-9 Brewster angle

Brewster's angle (also known as the polarization angle) is an angle of incidence at which light with a particular polarization is perfectly transmitted through a transparent dielectric surface, with no reflection. When unpolarized light is incident at this angle, the light that is reflected from the surface is therefore perfectly polarized. This special angle of incidence is named after the Scottish physicist Sir David Brewster (1781–1868), and given by follow equation[21]:

$$\theta_B = \tan^{-1}(n) \quad (18)$$

EXPERIMENTAL PART

1- Optical measurements

The main purpose of studying the optical properties of the PEG after and before adding cellulose derivatives polymer as a blends is to identify the effect of adding these materials on the optical properties of PEG. The research covers the recording of the spectrum of absorbance and transmittance for the blend solutions at the room temperature and calculating the absorption coefficient, extinction coefficient and other optical constants.

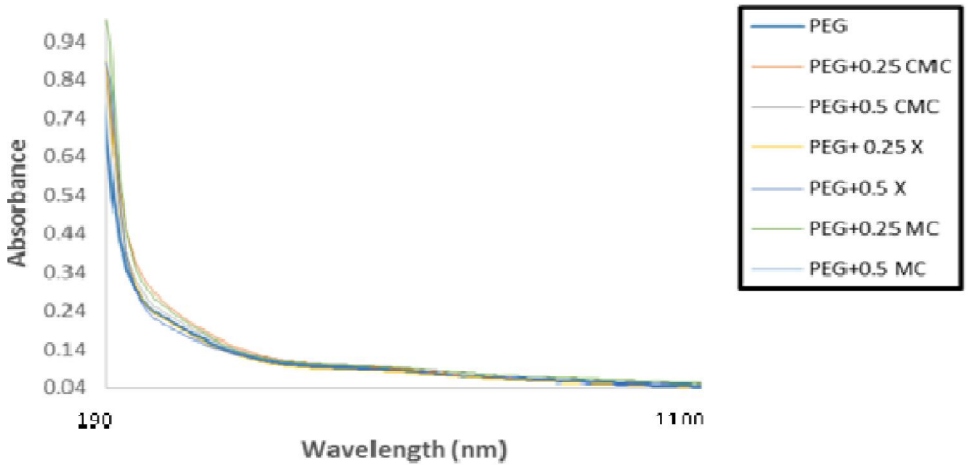

Figure 1 : Absorbance with different wavelengths

1-1 Absorbance spectrum

Absorbance measurements of PEGafter and before adding cellulose derivatives polymers and plotted against different wavelengths in the range between (190-1100) nm as shown in Figure (1). This Figure shows that absorption spectrum of PEG after and before adding cellulose derivatives polymers in solution blends method as a function of the wavelength of the incident light. It is shown that the adding of the additives to the basic polymer leads to increase the intensity of the peak. So, there is no shift in the position of the peak for all amounts of additives to the polymer. Chemically that means this addition do not change the structure of the (PEG-cellulose derivatives) blends.

Figure (1) also shows that cellulose derivatives polymers used in this work have a strong absorbance at a wavelength around (191 nm), but appear to be completely transparent at a longer wavelength, especially for MC when added to PEG, but for (PEG-CMC) and (PEG-X), polymers show good absorbance and bad transparent medium, and this is agreement with reference[22].

Figure (2),represent the relation between the absorbance of purity and its blends with cellulose derivatives polymers with various concentrations. We can note from this Figure, the increasing values of absorbance due to a steady increase of the concentration where it is directly proportional to the absorbance according to Lambert-Beer law. Furthermore we can be seen from absorbance, the increases proportion to additives especially in PEG mixed

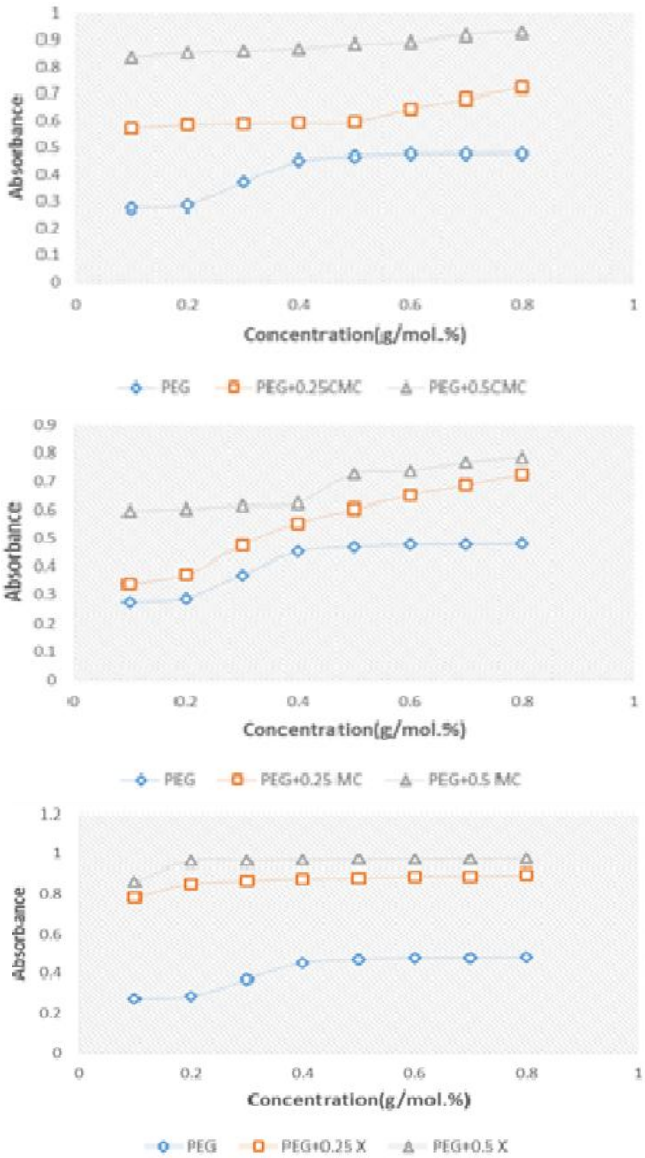

Figure 2 : Absorbance of PEG after and before adding cellulose derivatives polymers

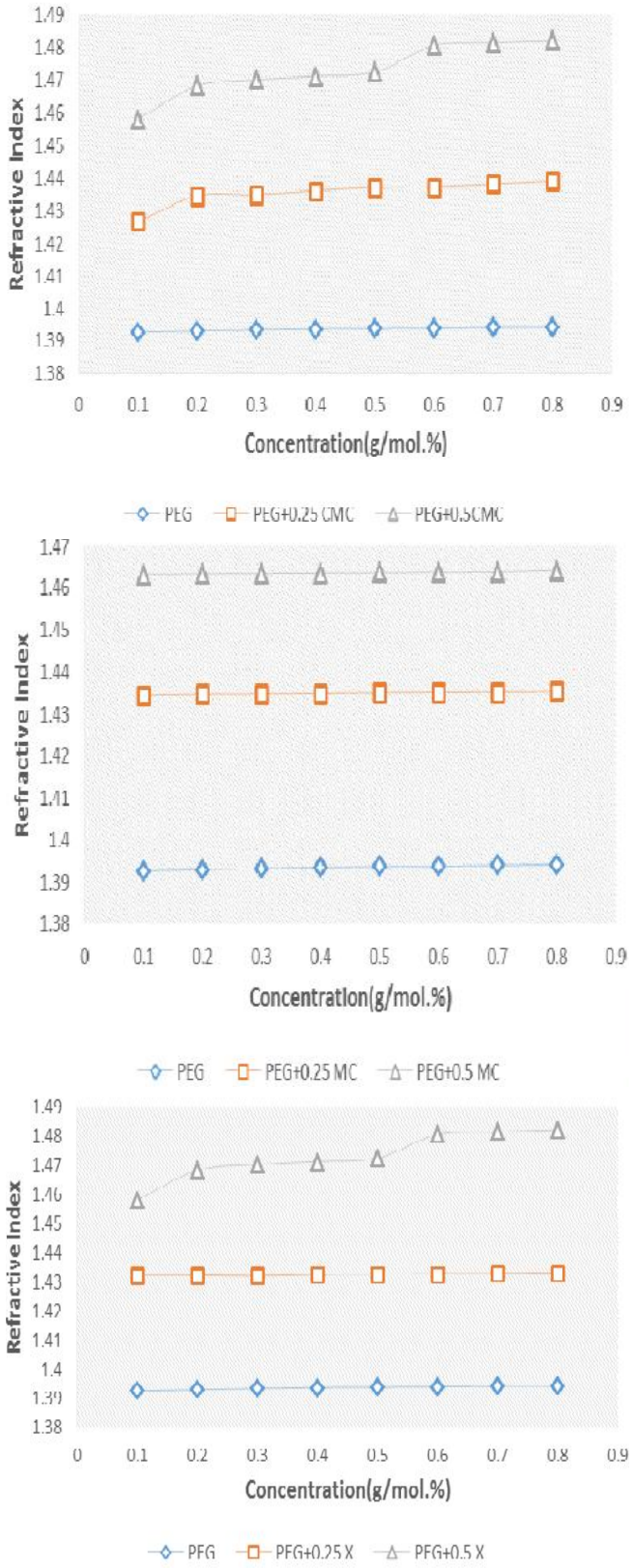

Figure 3 : Refractive index of PEG and its blends

with (0.5) additives from xanthan cellulose gum with, if comparing with (PEG-CMC) and (PEG-MC) and the reason for this is due to the increased focus within the same volume of the solution by adding cellulose derivatives polymers, so increasing the number of molecules that were to absorb the incident light and thus increasing the absorbance value and this applies to the law of Lambert-Beer.

1-2 Refractive index

The measured values of refractive index of PEG 6000 after and before adding cellulose derivative polymers are shown in Figure (3). This Figure shows that the refractive index values of pure polymer and its additives are increasing linearly with the increase of the concentrations of these polymers. This increment with concentrations are clearly satisfied, because refractive index is a function of density, since the density increase uniformly by increasing concentrations, the refractive index of these polymer blends also have uniformly increment. It's a clear that the best values of refractive index absent in (PEG-CMC) because this blend has greatest values of density comparing another blends as shown in Figure (3), and this result take the same behavior of reference[23].

2- Optical Calculations

From optical measurements, we can calculate other optical parameters as:

2-1 Absorption coefficient of electromagnetic waves

The values of the absorption coefficient of light are obtained by creating a slope of straight line between absorbance and molar concentration which refers to the values of the absorption coefficient as in Figure (2), and the TABLE (1) illustrates the change in the values of the absorption coefficient for solution polymer of PEG before and after the addition of cellulose derivative polymers at the focus wavelength (191nm). Noting that the increasing of absorption coefficient values under the influence of addition because of the increased density of the solutions as a result of the increased concentrations, that led to the increase of light absorbed because the interaction of the electromagnetic wave and the large molecules of the polymer increases with concentration, according to the law of Lambert- Bear and thus

TABLE 1 : Absorption coefficient of PEG and its additives

Type of polymer	Absorption coefficient (Lit./mol. cm)	
PEG 6000	**598.6 9**	
PEG + additives	0.25 CMC	904.82
	0.5 CMC	1162.5
	0.25 MC	907.09
	0.5 MC	983.48
	0.25 X	1117.8
	0.5 X	1218.4

TABLE 2 : Natural life-time of PEG and its additives

Type of polymer	Natural life-time (s)	
PEG 6000	**1.67×10^{-7}**	
PEG + additives	0.25 CMC	1.10×10^{-7}
	0.5 CMC	8.60×10^{-8}
	0.25 MC	1.16×10^{-7}
	0.5 MC	1.01×10^{-7}
	0.25 X	8.94×10^{-8}
	0.5 X	8.20×10^{-8}

increase the absorption coefficient.

TABLE (1) shows that (PEG-X) polymer blend has higher value of absorption coefficient and therefore (PEG-CMC) than (PEG-MC), because these two polymers have the higher values of molecular weight.

2-2 Natural life – time

In the near ultraviolet region the values of natural life time of PEG after and before adding cellulose derivative polymers, that causes excitation in the ultraviolet spectrum was obtained by using equation (4). Since the natural life time is inversely proportional to the absorption coefficient, for that note decrease life time under the influence of adding cellulose derivative polymers and this is illustrated in TABLE (2).

(PEG-CMC) polymer blend has higher values than all others, and (PEG-X) polymer blend has lower value than others, because the molar absorbance of (PEG-CMC) has the lowest value and for (PEG-X) the highest one.

2-3 The transmittance spectrum

The values of transmittance of all concentrations of PEG after and before adding cellulose derivative polymer were calculated theoretical by using equation (3). The results show that decreasing in the values of transmittance with all concentrations, this is because the values of absorbance are directly proportional to the concentration and there are logarithmic relation between absorbance and transmittance.

Figure (4) shows that the relationship between transmittance and concentrations after and before the addition, from Figure note that after adding the values of transmittance are decreasing and this return to the same case.

The Figure shows that transmittance decrease with the increase of the added concentration, this is caused by the added of cellulose derivative polymers contains electrons in it is outer orbits can be absorb the electromagnetic energy of the incident light and travel to higher energy levels, this process is not accompanied by emission of radiation because the traveled electron to higher levels have occupied vacant positions of energy bands, thus part of the incident light is absorbed by the substance and dose not penetrate through it.

2-4 The reflectance spectrum

Reflectance of all samples was computed by using equation (11). The results of reflectance were plotted in the Figure (5). It shows to have the same behavior of their refractive index, because reflec-

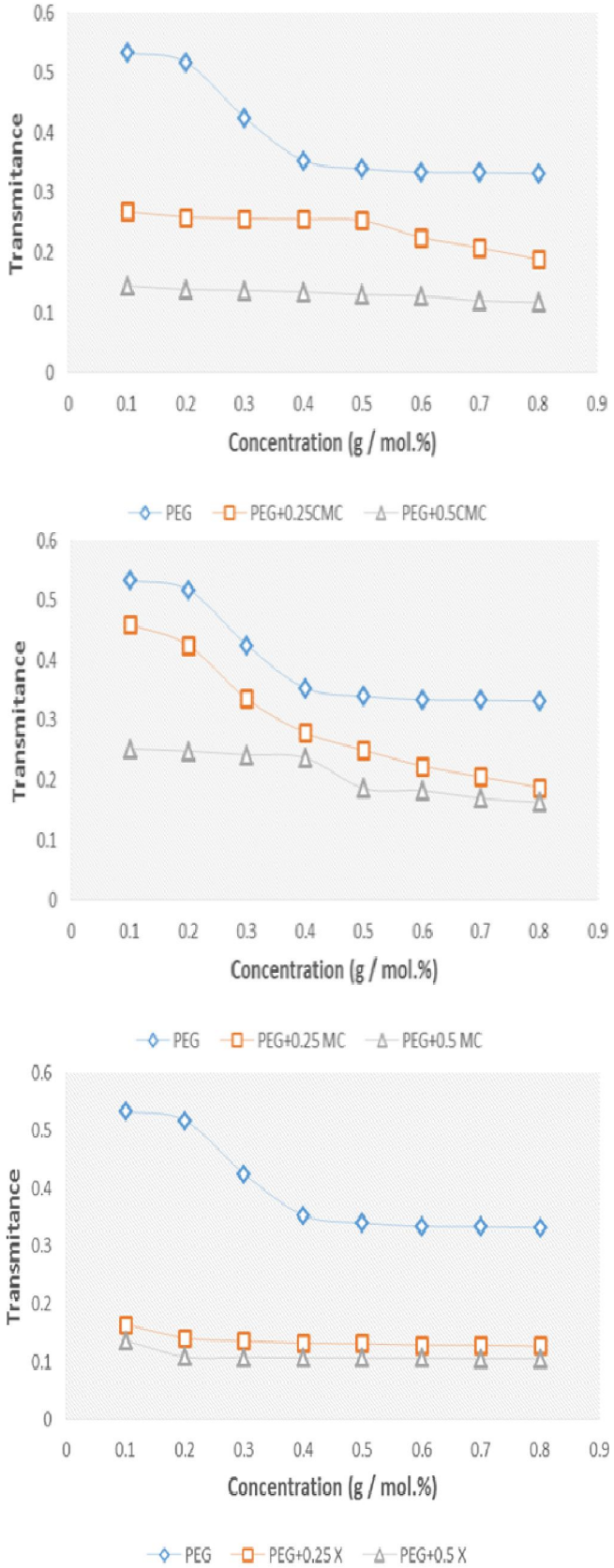

Figure 4 : The transmittance of PEG and its polymeric blends

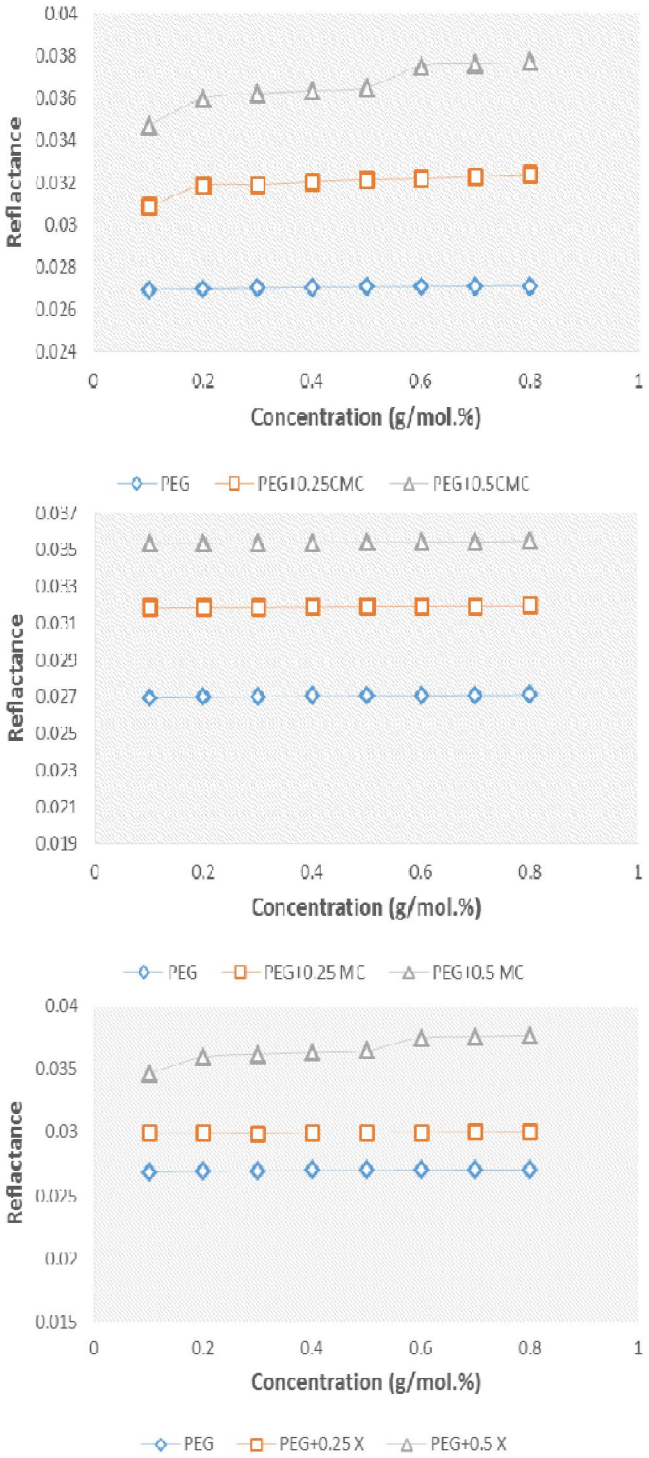

Figure 5 : The reflectance of PEG and its polymeric blends

tance equation has only one variable parameter, which is a refractive index. The uniformly increment of reflectance of PEG after and before adding cellulose derivatives polymers are similar to those given by reference[23]. It's a clear from Figure below the values of reflectance are increased with in-

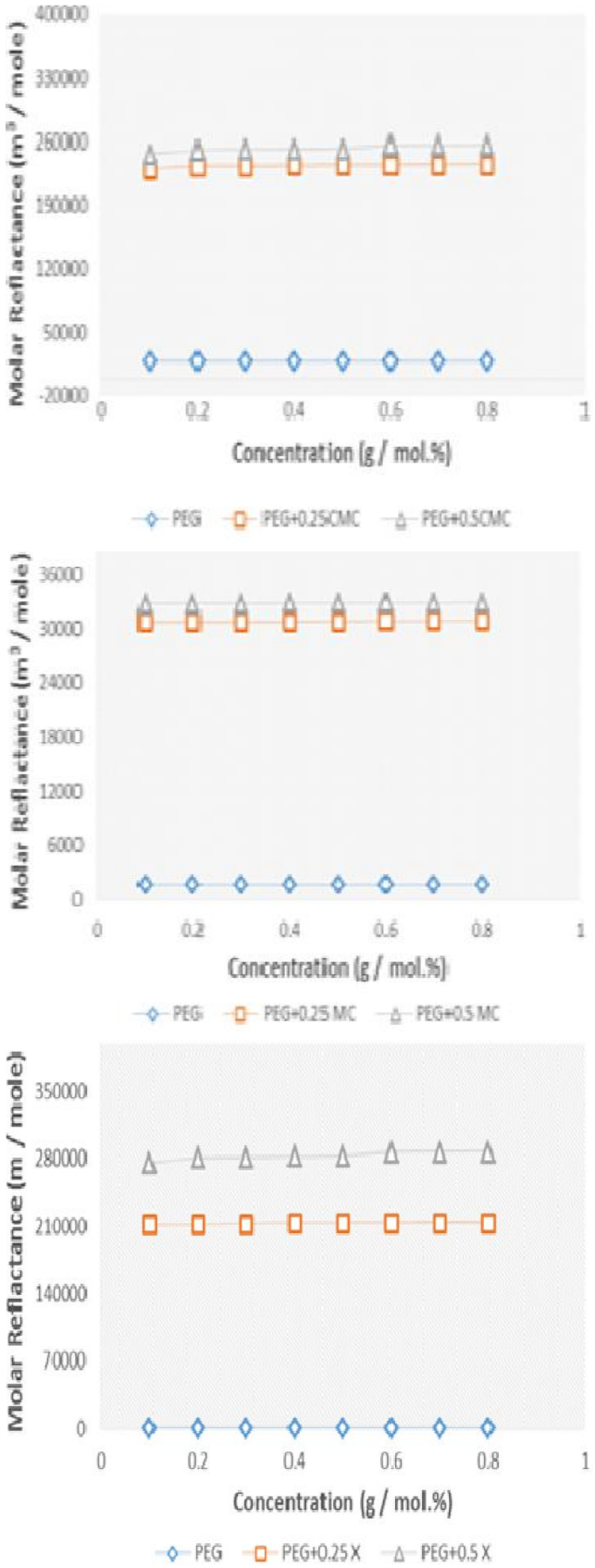

Figure 6 : The molar reflectance of PEG and its polymeric blends

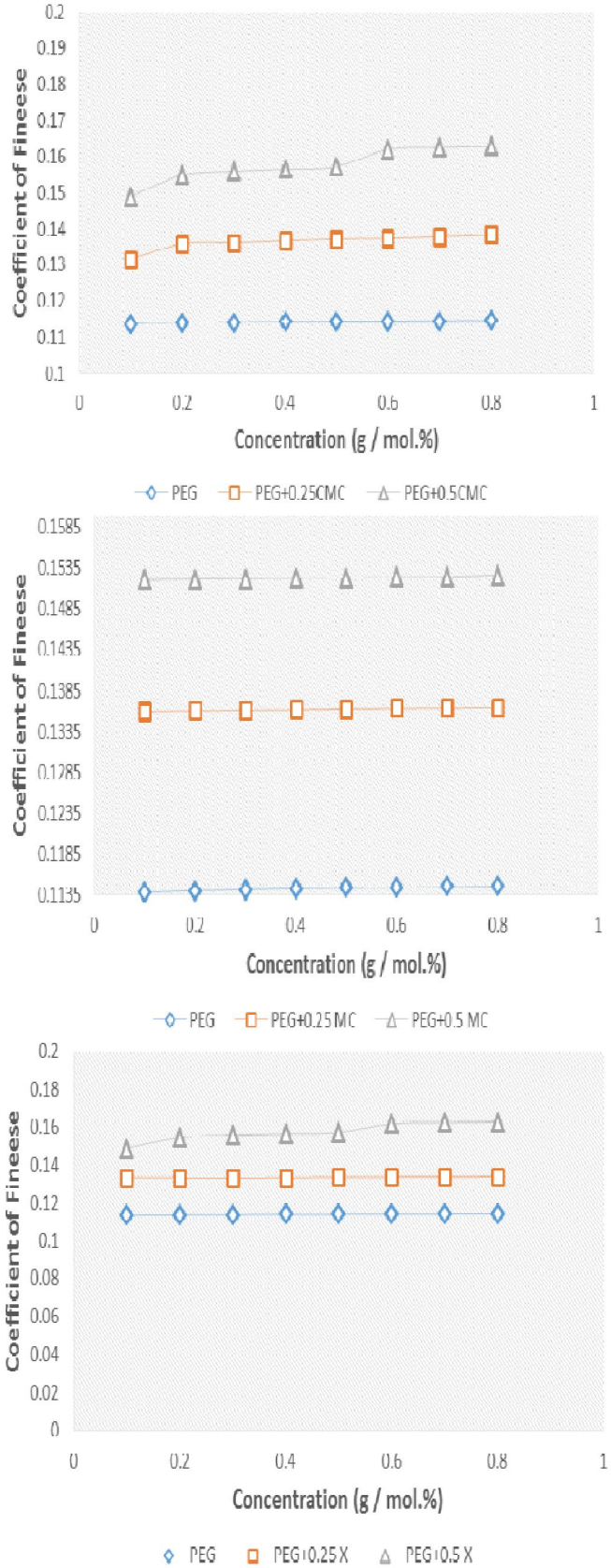

Figure 7 : The coefficient of finesse of PEG and its polymeric blends

creasing concentration before and after the addendum at the wavelength (191 nm), as illustrated, and the reason for this is due to the increased number of polymer molecules in solution and therefore increase the density of the solution as the reflectiveness is entirely dependent on the density[23].

2-5 The molar reflectance

Molar reflectance values were calculated by using equation (13), the results showed increased the values of molar reflectance after the addition of cellulose derivative polymers is due to an increase in the values of viscosity average molecular weight under the influence of added fact molar reflectance is directly proportional with molecular weight and this result is consistent with reference[23], when studying the polymers CMC, MC and X.

2-6 Coefficient of finesse

The coefficients of finesse of PEG after and before adding cellulose derivative polymers were calculated by using equation (16), as shown in Figure (7). This Figure shows that the coefficient of finesse of basic polymer and its blends has the same behavior to their reflectance, because this coefficient depends on reflectance, from another aspect the influences of addition lead to increase the values of finesse coefficient, this is because the increasing of reflected light as a result of increasing the density after addition, and this results agreement with reference[23].

2-7 Brewster and critical angles

The Brewster angle of PEG after and before adding cellulose derivative polymers were calculated by using equation (18). Figure (8) shows that Brewster angle values for different concentration. It's a clear from the equation above that Brewster angle shown to have the same behavior of refractive index.

The critical angle was calculated by using equation (17). Figure (9) shows that the critical angle values of PEG and its polymeric blends decrease linearly with the increase of the concentration, because it is inversely proportional to their refractive index, or it is a clear that as concentration increase, the density also increases, therefore the incident rays

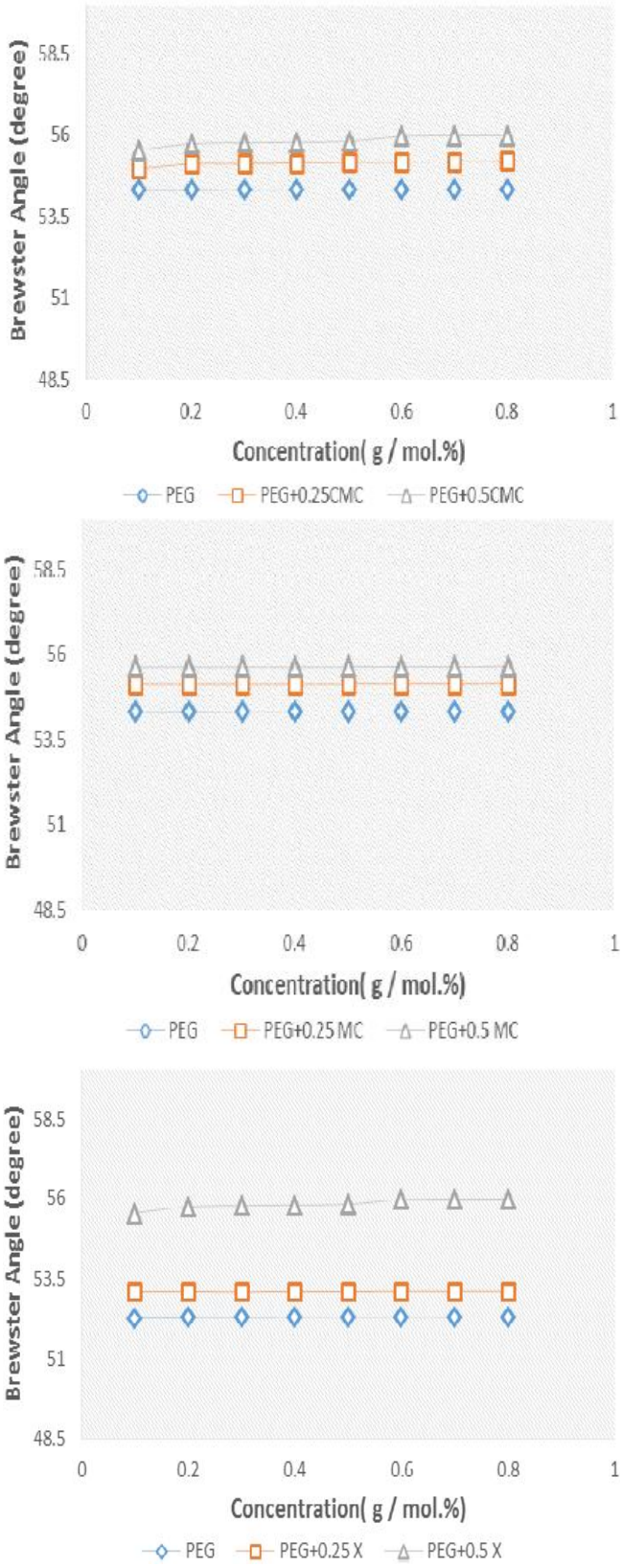

Figure (8): Brewster angle of PEG and its polymeric blends

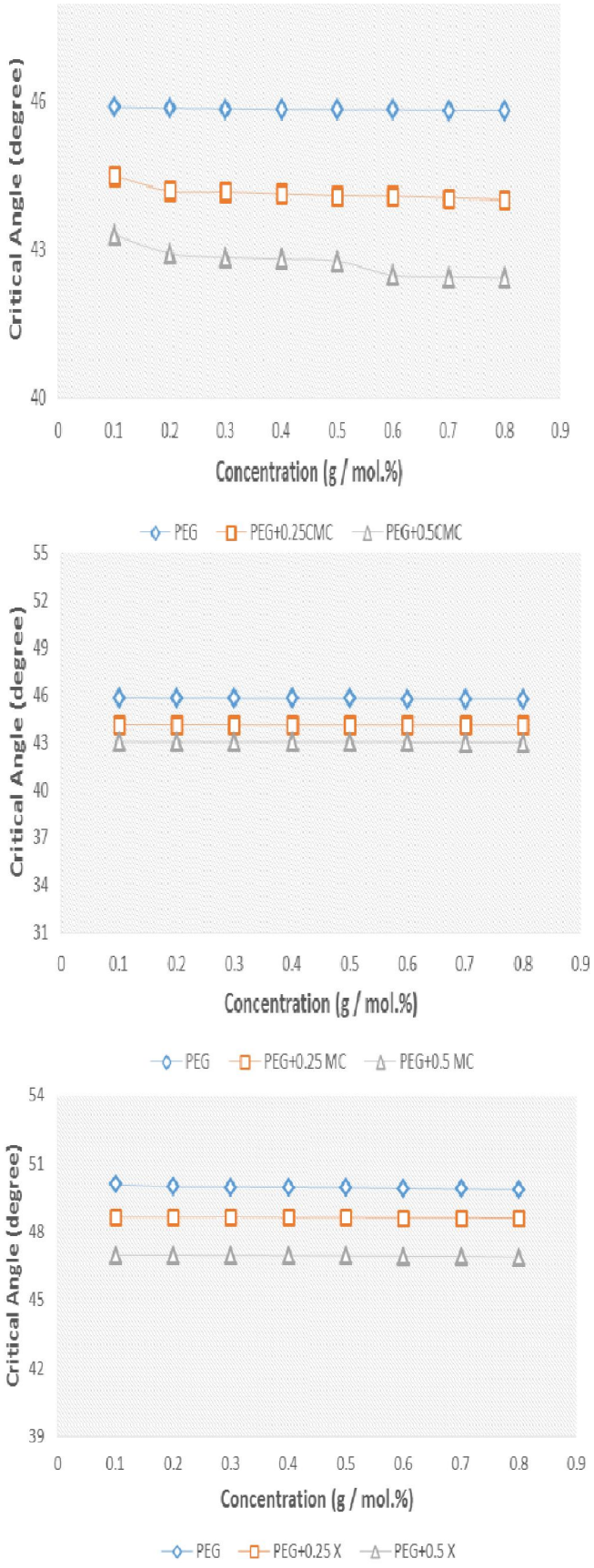

Figure 9 : Critical angle of PEG and its polymeric blends

will bend toward normal and causes critical angle to decrease and the result benefit with[23].

3- Fabrication of new tire packages

In this study design, new package usages in the saving of tires from ultraviolet rays were fabricated. We gave two types of tire packages, one of them fabricated by (Pro Circuit-Ogamasullitt) type (Beta),

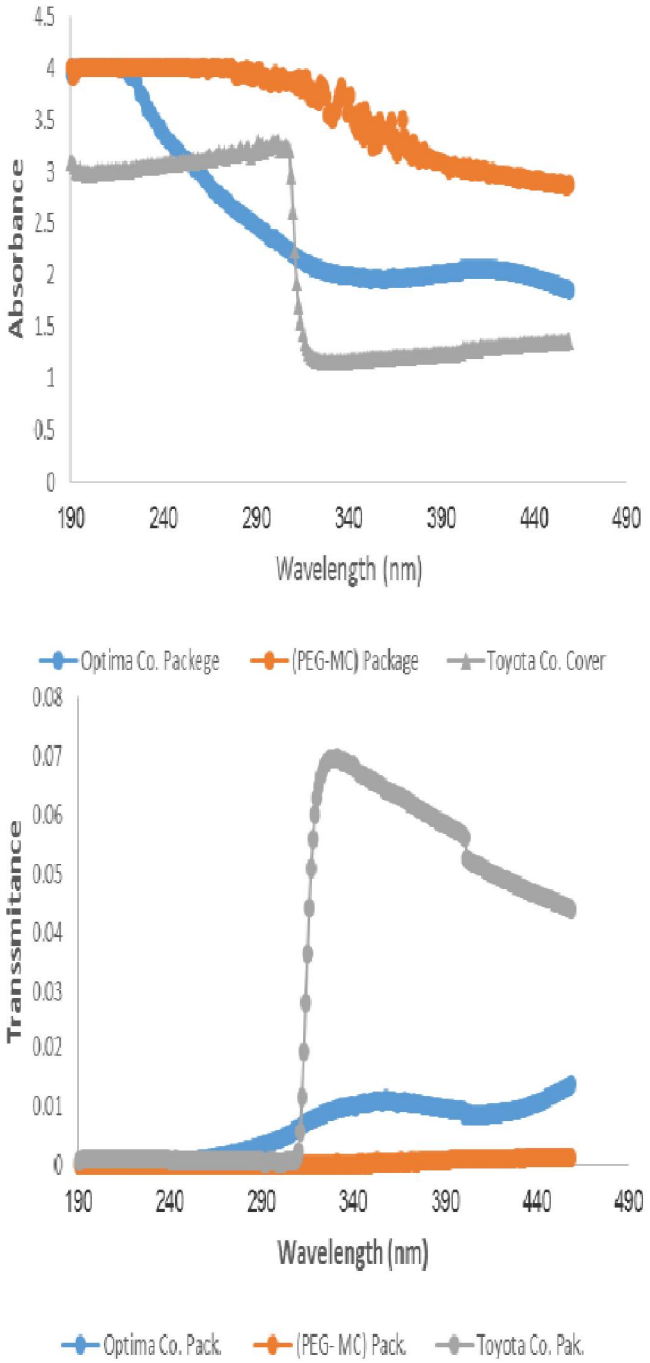

Figure 10 : The absorbance and transmittance of UV-spectrum of slandered packages and fabricated package

made in Chine, trade mark (Toyota), and other from (OPTIMA). The measurements were be done by using spectrophotometer to known the absorbance as shown in Figure (10), that represents the comparison between the original package and fabricated package. The new package was made by mixing (PEG-MC) and gave a good absorbance comparing with original packages, and this is because this blend has molecules that able to absorb ultraviolet rays and prevent it from transmittance to tires and this is increase the time of storage and absorb UV-spectrum from sun light. The hardness of all packages were measured by using (Shore D) device and the result shows that the hardness of (Toyota) package is (96.2) and (OPTIMA) is (96.5) but the fabricated package was (97.6). The new package was covered by nylon to save it from external weather conditions.

CONCLUSIONS

1- The higher absorption in (UV-region) makes the films good material for screening off (UV-portion) of electromagnetic spectrum, which is dangerous to human and animal health. These films can be used for eyeglass coating for protection from sunburn and in the saving of tires and any rubber types.
2- Adding cellulose derivative polymers to PEG lead to increase reflectivity in (UV region), therefore it can be used as a coating for different types of glass to protect the level of solar radiation and reduce it.
3- From fabricated (PEG-MC) film, we getting on a new tire package that best comparing with others.
4- The new tire package take a best hardness comparing with others.
5- From (FT-IR) spectra there are no chemical interaction happen between materials.

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