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Determination of Optical Properties of Olive Oil Mixed with Black Seed Oil at Different Volume Using UV/VIS Spectrometer

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Abstract: Optical properties have many important industrial and scientific applications including heat transfer, contactless temperature measurement, laser technology, optics (mirrors, optical lenses and windows), energy, construction, photovoltaic industries, aerospace and many more. This paper aims to study the optical properties of olive oil when mixed with black seed oil at different quantities (0.5, 1, 1.5, and 2) ml, olive oil was obtained from the market and black seed oil was prepared by using a cold-pressing method. The optical properties were characterized using UV/VIS spectrometer, the result display that the increase in black seed oil volume has a small effect on absorption and absorption coefficient but the effect appears as a redshift in wavelength when compared to the reference sample. The reflection, refractive index, and optical conductivity have a constant value which was 0.2 a.u, 2.8, and 1.44×1010 sec-1 respectively. Finally, the optical power band gap of olive oil decreased from 3.33V to 2.60V when black seed oil volume increased. This work will open the door wide for the use of olive oil mixed with black seed oil in various fields of solar cells.

Keywords: Olive Oil, Black Seed Oil, UV/VIS Spectrometer, Optical Properties

1. Introduction

Olive oil (OL) is a liquid fat obtained by pressing whole olive kernels and extracting the oil, which is obtained from the olive kernels of the olive tree (fruit of Oleaeuropaea; family Oleaceae), this olive tree is abundantly found in the Mediterranean basin [1]. The main composition of olive oil is triglycerol (~99%) and secondary free fatty acids, mono- and di-glycerols, and a group of lipids such as hydrocarbons, sterols, aliphatic alcohols, tocopherols, and dyes [2, 3]. There are also a large number of phenolic and volatile compounds, which contribute to the unique character of the oil. Fatty acids such as palmitoleic (C16:0), palmitoleic (C16:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linoleic (C18:3) and myristic (C14:0) Hepta- and eicosaenoic acids are all found in olive oil [2]. Olive oil is commonly used in cooking, for frying foods, or as a salad dressing. It is also used as fuel for traditional oil lamps, cosmetics, pharmaceuticals, and soaps, and has additional uses in some religions [4]. Nigella sativa (Nigella sativa, black cumin, black seed, or kalonji) (BSO), black seed oil contains linoleic acid, oleic acid, palmitic acid, trans anethole, and other minor ingredients, such as nigericin, nigelone, nigelmine and nigelmine oxide. nitrogen.

It is an annual flowering plant in the family Ranunculaceae, native to Eastern Europe (Bulgaria, Cyprus and Romania) and Western Asia. Black seed essential oil also contains thymoquinone, thymoquinone, thymoquinone, b-cymine, carvacrol, alpha-thugene, thymol, alpha-pinene, beta-pinene, and anethole-trans. Several proteins and alkaloids are present in the seeds [2]. This paper aimed to evaluate the optical characteristics of olive oil mixed with black seed oil at a different concentration to enhance the optical properties.

2. Theoretical Background

Light can interact with matter in three ways: absorption, transmission, and reflection. Absorption is a measure of how much light a sample absorbs. Also known as optical density. Absorption is calculated based on the amount of light reflected or scattered by a sample or by the amount transmitted through the sample. The Beer-Lambert Law is used to calculate the absorbance A determined by the incident intensity I0 and the transmitted light intensity I by the light [5].

$$A = log_{10}(\frac{I_0}{I}) \quad (1)$$

The absorption coefficient α (λ) is the sum of the absorption cross-sections per unit volume of the material for an optical process. The absorption coefficient (α) of the samples can be calculated from the following relationship

$$\alpha = 2.303\frac{A}{t} \quad (2)$$

Where (A) is the absorbance and (t) is optical length on the sample [6].

Light reflection is the process by which electromagnetic radiation is returned either at the boundary between two media or within the medium.

$$\mathrm{R} = 1 - \mathrm{A} - \mathrm{T} \quad (3)$$

Where R is reflection and T is transmission [7].

Refractive index (n) depends on the type of material is the ratio between the speeds of light in a vacuum to the speed of light in a material that does not absorb this light. Its value can be calculated from equation [8]:

$$n = \left[\left(\frac{1+R}{1-R}\right)^2 - (1 + k^2)\right]^{\frac{1}{2}} + \left(\frac{1+R}{1-R}\right) \quad (4)$$

Band gaps are measured in electron volts and are the light energy that an electron acquires when moving from the valence band to the conduction band using a photon of a particular frequency. The energy gap of the material attached to it is the absorption coefficient and can be calculated by Tauc's equation which is

$$(\alpha h\upsilon)^n = C\left(h\upsilon - E_g\right) \quad (5)$$

Where Eg is the optical energy gap, (C) is constant, hυ is photon energy [9, 10].

Photoconductivity is a measure of the frequency response of a material when exposed to light which is determined using the following relationship [11],

$$\delta_{opt} = \frac{\alpha nc}{4\pi} \quad (6)$$

Where (c) is the light velocity.

3. Materials and Methods

Four samples of black seed oil were prepared by using a cold-pressing method, and then the emulsion was prepared by mixing different volumes (0.5, 1, 1.5, and 2) ml of black seed oil with 4 ml olive oil each time at room temperature, five samples were reference olive oil obtained from the market. The optical properties of samples were characterized by using UV/VIS spectrophotometer at wavelength range 200nm to 800nm, the obtained results were analyzed using Origin analysis software.

4. Results and Discussion

The optical properties of olive oil samples mixed with black seed oil in different volumes (0, 0.5, 1, 1.5 and 2) ml were obtained by UV/VIS spectrometry from Figure 1 to Figure 6.

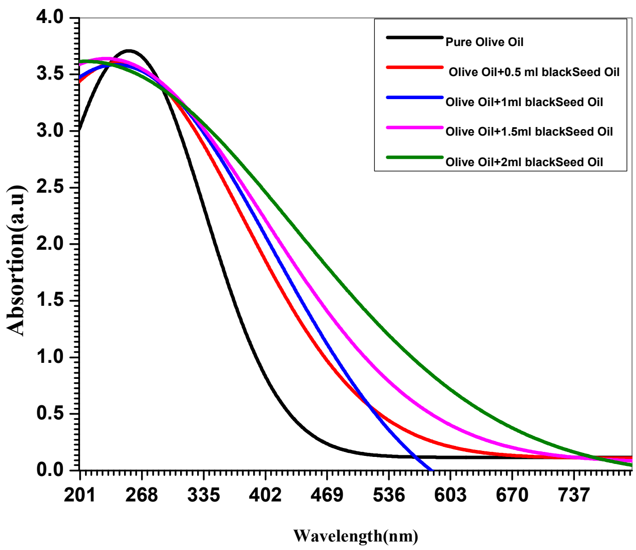

Figure 1. *Variation of absorption with (λ) for olive oil samples.*

From Figure 1 and Figure 2, it is clear that the peak absorption and absorption coefficients of olive oil mixed with black seed oil of different sizes (0, 0.5, 1, 1.5, and 2) ml are at 252.78 nm, 233.89 nm, 233.89 nm, 233.89 nm, 216.29 nm, respectively. It was also noted that the absorption and absorption coefficient values of the different samples have a low effect, but this effect appears in the form of a redshift in the wavelength when compared with the reference sample. This low effect of the absorption and absorption coefficient values can be attributed to the small amounts of black seed oil added, while the redshift in the wavelength is due to the presence of different chemical groups with an increase in the volume of black seed oil, which contains fatty acids which were found by Saima Amin and et al (2010) [12].

It was observed that all samples had the same value of reflection (0.2 au) and refractive index (2.8) at different wavelengths (444 nm, 554 nm, 536 nm, 614 nm, and 674 nm (blue shift) of olive oil mixed with black seed oil of different sizes (0), 0.5, 1, 1.5, 2) ml respectively as shown in Figure 3 and Figure 4. This constant in the reflectance value and refractive index is because the polarization is constant according to Brewster's law (Paniagua Domínguez, and et al, 2016) [13].

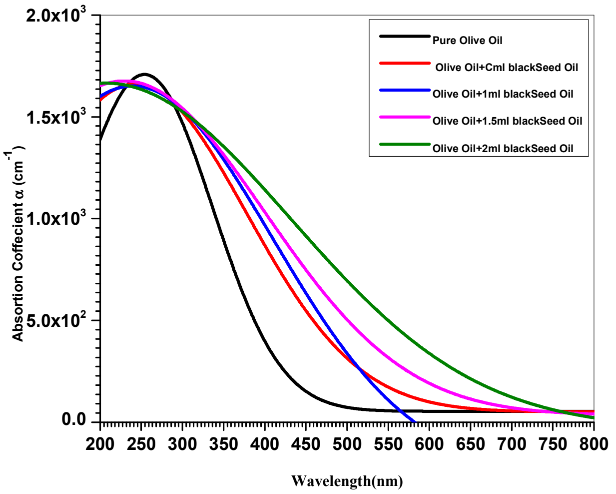

Figure 2. *Variation of absorption coefficient with (λ) for olive oil samples.*

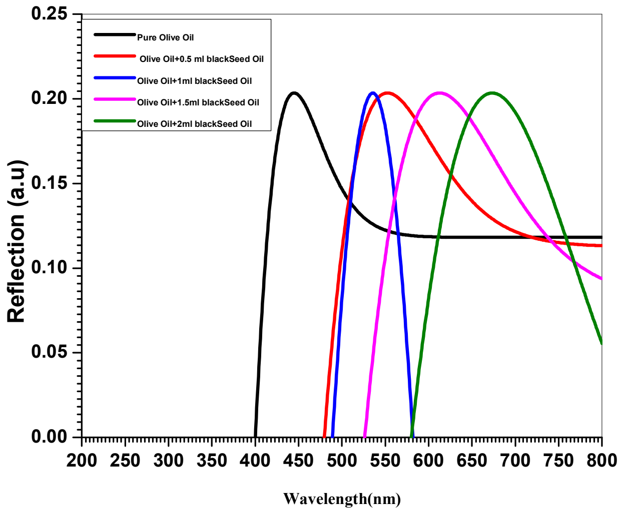

Figure 3. *Variation of reflection coefficient with (λ) for olive oil samples.*

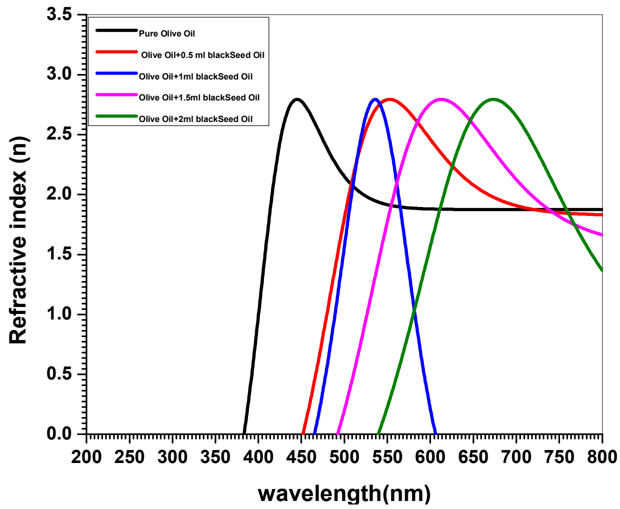

Figure 4. *Variation of refractive index with (λ) for olive oil samples.*

From Figure 5, it can be seen that the optical power gap of the olive oil mixed with black seed oil decreased when the volume of the mixed black seed oil increased from 3.33 to 2.60 eV. This means that increasing the volume of black seed oil reduces the energy gap and thus improves the electrical properties of olive oil mixed with black seed oil and can be used in various solar cell applications such as dye-sensitized solar cells (Sven Rühle, 2016 and Haining Tian, 2019) [14, 15].

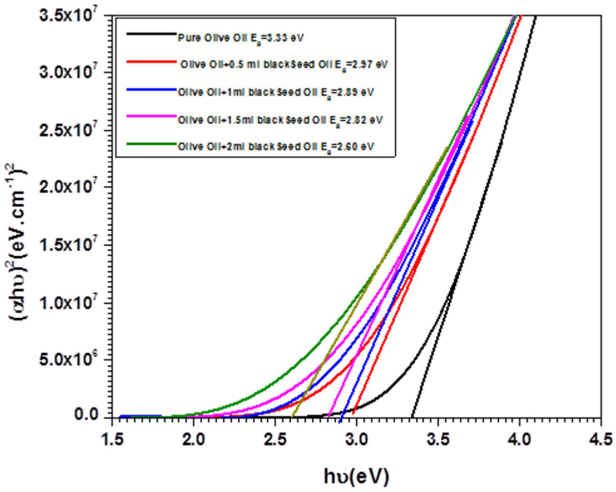

Figure 5. *Optical Energy Band Gap of olive oil sample.*

From Figure 6, it can be seen that the optical conductivity peaks of olive oil mixed with black seed oil of different sizes (0, 0.5, 1, 1.5, and 2) ml are 422 nm, 514 nm, 514 nm, 233.89 nm, 569.2 nm, respectively. It is also observed that the optical conductivity of olive oil mixed with black seed oil of different sizes is constant for all different wavelengths. From Figure 5, it is found that the refractive index is constant with the change of wavelengths, so the photoconductivity is constant according to Equation 5.

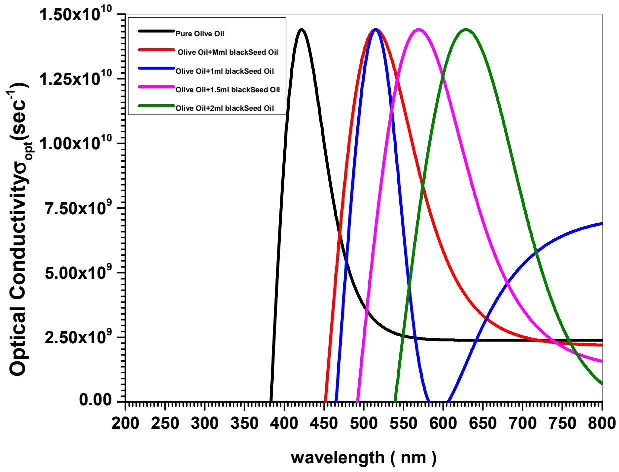

Figure 6. *Variation of optical conductivity with (λ) for olive oil samples.*

5. Conclusion

The optical properties of olive oil mixed with different volumes of black seed oil were characterized by used UV/VIS spectrometer, the obtained results show that there was a small effect on absorption and absorption coefficient but have a constant value of reflection, refractive index, and optical conductivity, and the optical energy band gap of olive oil decrease when the volume of black seed oil increase. According to the reduction of the optical energy band gap, the electrical properties of olive oil mixed with black seed oil can be improved and the mixture of olive oil with black seed oil can be used in various fields of solar cells.

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