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SPECTROPHOTOMETRIC ANALYSIS OF COCONUT OIL IN THE UV REGION

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Abstract

In this research we investigate the optical properties of coconut oil within the UV and NIR region at different temperatures. The coconut oil was heated from 40°C to 80°C and their response within the UV and NIR region was studied using the spectrophotometer. The coconut oil was found to have a very high reflectance at 50°C and this opens up the possibilities of using the coconut oil in some high reflectance applications.

1.0 INTRODUCTION

There has been an increase in research properties and applications of coconut oil. One of such potential applications is in biodiesel production [1,2]. Studies are being conducted to increase its thermal stability so that it can be applied more widely as industrial lubricants [3-6]. Other potential health effects of coconut oil have also been explored [7,8]. In this research, we have explored the optical properties of coconut oil in the UV region with a view of opening up further studies on the possible applications of the coconut oil.

2.0 THEORY

In general, absorbance is a process of EM interacting with matter. When light incidence on matter, its takes some of the light and that is what absorbance is about. The light that is absorbed is not lost; rather it is transformed to heat or chemical energy as the absorbing molecule gets excited. Traditionally, absorbance measurements were performed in a cuvette. A solution with an analyte of known absorbance characteristics is placed into a cuvette. An absorbance reader then determines the absorbance by sending light with known intensity through the sample and detecting the intensity transmitted. Light that did not make it through to the detector was either absorbed or scattered. The scattered part is determined separately by measuring appropriate blanks and is subtracted from this value to obtain pure absorbance of the substance of interest. This is same in measuring for transmittance and reflectance. The portion of light that is able to pass the sample is also called transmission and is mainly given as a percentage. The more the analyte is found in solution, the more light is absorbed by it and the lower is the transmission. The absorbance, however, is the part of the light that was taken up by the analyte. It is the absolute value of the logarithm (to the power of 10) of the transmission [9]. Mathematically, the absorbance of a material, denoted by A, is given by

$$A = \log_{10}\frac{I}{I_o} = -\log_{10} T \qquad (1)$$

Where I_o is the light transmitted by that material, I is the light received by that material, T is the transmittance of that material. The optical depth is the measure of the extinction coefficient or absorptivity up to a specific depth. It describes how much absorption occurs when light travels through an absorbing medium. Optical depth is denoted by β and can be expressed mathematically as

$$\beta = A\ln 10 \qquad (2)$$

The Beer-Lambert law describes the relation of absorbance, path length and concentration of an absorbing substance as follows[10]:

$$A = cd\varepsilon \qquad (3)$$

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where c is concentration, d is the path length and ε is the extinction coefficient.
The absorbance is linear to the product of the concentration, the path length and the extinction coefficient. The path length refers to the length of sample the light passes through. In a cuvette, the path is standardized to 1.00cm. The extinction coefficient is a constant specific for an absorbing substance and at a specific wavelength, typically the absorbance maximum of the substance. It provides information on how strongly a particular substance absorbs light at a specific wavelength. Using the Beer-Lambert allows quantification of absorbing substances without the need to add any other reagents during the measurements with the spectrophotometer [10]. However, there are some limitations as the Beer-Lambert law can only be used if the analyte absorbs light at a specific wavelength, the path length is known and the extinction coefficient for the analyte is known. The absorbance of buffer reagents does not overlap with absorbance of the analyte.

3.0 RESULTS
The coconut oil was heated to 40^oC in a cuvette and the absorbance was obtained over the wavelength range from 1.00nm to 1100nm using the spectrophotometer. Likewise, similar measurements were made for temperatures of 50 ^oC, 60 ^oC, 70 ^oC, and 80^oC respectively. Results of the measurements are presented in figure 1 below.

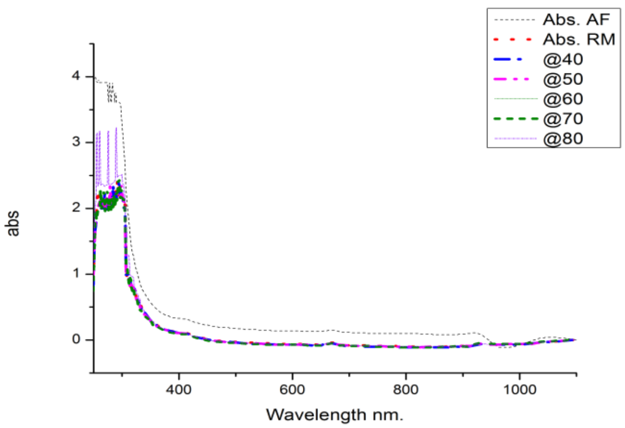

Figure 1: Absorbance for the coconut oil at different temperatures of 40^oC, 50^oC, 60^oC, 70^oC and 80^oC respectively.
From the results of figure 1 above, as the temperature increases the absorbance of the coconut oil was observed to decreases. A high absorbance after heating the oil and allowing it to fall back to room temperature was also observed.
The transmittance measurements for the temperatures of 40^oC, 50^oC, 60^oC, 70^oC, and 80^oC respectively are shown in Figure 2, showing an increase in transmittance as temperature increases. Also, at room temperature of 26^oC, the coconut oil almost appears to be transparent over the UV wavelength range (black dotted lines in Figure 2), although at a temperature of 40^oC and above it shows a high transmittance. The coconut oil appears to be transparent around the ultraviolent region.

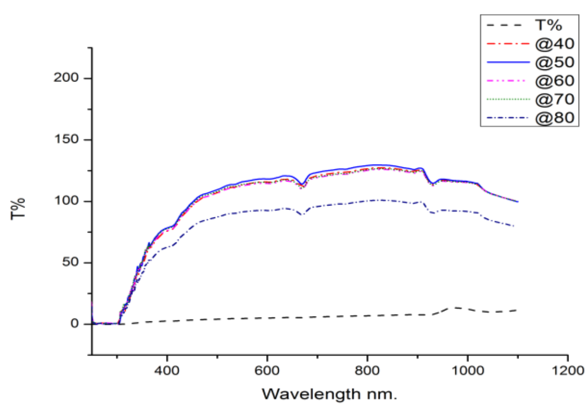

Figure 2: Transmittance for the coconut oil at different temperatures of 40^oC, 50^oC, 60^oC, 70^oC and 80^oC respectively.

Reflection measurements were carried out for the coconut oil for temperatures of 40ºC, 50ºC, 60ºC, 70ºC and 80ºC respectively as shown in Figure 3. There was an observed increase in reflection with temperature. However, at room temperature of 26ºC there was a low reflectance from the coconut oil (solid black line as shown in Figure 3).

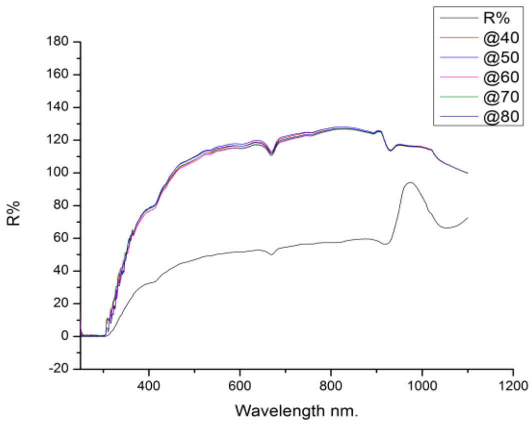

Figure 3: Reflectance of coconut oil at different temperatures of 40ºC, 50ºC, 60ºC, 70ºC and 80ºC respectively.

4.0 DISCUSSION

The absorbance, transmittance and reflectance of the coconut oil were taken at room temperature of 26 ºC and the different temperatures of 40ºC, 50ºC, 60ºC, 70ºC and 80ºC respectively. From the absorbance measurements, there was a general decreased in the absorbance for the coconut oil at different temperature, which can be attributed to the weakening of the molecular bond of the coconut oil, thereby allowing light more to pass through. After heating to 80ºC and allowing the oil to cool back to room temperature 26ºC, a higher value of absorbance was obtained for the coconut oil in the UV region and while in the NIR the oil appear to be transparent. The reason for this high absorbance was that the boiling point of the oils was not reached and as such the molecular bonds of the oils were not broken by heat. The increase of temperature caused a change in the molecular bonds of both coconut oil, seen as a gradual decrease of intensity amplitudes[11]. The absorption peaks of the coconut oil are attributed to the characteristic of overtones and combinations of C─H stretching vibration of various chemical groups (─CH2, ─CH3, ─CH CH─) and the composition of fatty acids in the spectral range 300–2500nm[12]. From the transmittance, as temperature increases the transmittance of coconut oil increases but a higher value was obtained at 50ºC. The oil was observed to be transparent across all the wavelength range when the sample was at room temperature and with a low transmittance.

5.0 CONCLUSION

At room temperature the coconut oil displayed a poor reflectance within the UV region, but as the temperature is increased the reflectance of the coconut oil increases. The high reflectance of coconut oil with the UV region opens up the possibility of many applications. One of such possible applications is the "energy saving paint", where the high reflectance of the coconut oil can be exploited in making a room appear brighter and only very few electric bulbs will be need. Also, the possibility of using the coconut oil as additives to paints can be explored as well.

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