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Optical properties of Transparent Liquid: Water, Oils, and Honey

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Abstract

The purpose of this work is to investigate the transmittance and absorbance of drinking water, organic honey solution, sunflower oil, mustard oil, and a mixture of all of these. This investigate is necessary because all considered experimental sample is eidable (used in daily life of human population) with huge amount and no such type of research is conducted in optical field of transmittance eidable material. The Theremino spectrometer v2.7 instrument for visible photon wavelength was used for the observation and experiment, study. The separately conducted experiment shows that transmittance decrease with increasing the wavelength of photon increases and absorbance increase with increasing the wavelength of photon. When the transmittance of all samples is compared, the transmittance of water is higher while the mixture is lower, while the absorbance of the mixture sample is higher while the transmittance of water is lower. The absorbance and transmittance of cooking oil change with change in wavelength of the photon (Sunflower and Mustard Oil). All the experienmt is conducted at hot and cold temrpeature at normal pressure with same experienmal environment with visible wavelght photon. Since transmittance and absorbance also determine the quality of materials and its interaction with composition. Therefore, this technique of measurement may be the one of the best, cost effective and chemical free method to test the purities as well as interaction of compsotion with photon.

1. Introduction

1.1 Optical properties of water

Understanding the optical properties of various materials allows for the interpretation of material properties such as concentration, dissolved particle size, transmittance, absorbance, and attenuation. Photon absorbance is lower in the 300-550nm wavelength range, while it is higher above this range for transmittance materials [1]. The photon's transmission through a transparent material provides valuable information such as composition, chemical properties, dissolved particle dimension, and so on. Furthermore, the dissolved matter contains near-infrared photons in amounts ranging from 10 to 50 percent when measured using scattering phenomena [2-5]. Different instruments and technology are used to provide everyone with safe drinking water, but there is no specific indicator or measurement that specifies water quality.

1.2 Optical properties of oil

A study of nine different edible oil samples found absorbance peaks at different wavelengths of 900, 1210, 1400, 1750, 2150, and 2300 nm at 80 degrees Celsius **[6].** Acid concentration, specific gravity, pH value, iodine concentration, refractive index, peroxide concentration, saponification value, free fatty acid concentration, kinematic viscosity, and other factors are used to classify mustard oil. According to a WHO report, the N3/N6 ratio for edible oil is 4:5, which is closer to mustard oil **[7].**

1.3 Optical properties of Organic Honey

Honey quality is also determined by refractive index, electrical properties, optical spin, and other factors. The concentrations of -carotene and potassium in honey samples aid in determining the purity of the honey. The transition temperature and optical spin of honey determine its adulteration with glucose [8]. More than 180 constituents are found in natural honey bee. The presence of fructose determines the honey bee's hygroscopic nature, whereas the presence of glucose determines the rate of crystallization. Spectroscopic techniques with mid-infrared and near-infrared photons are used to study the chemical properties and characteristics of honey bees **[9-15].**

1.4 pH value

The pH value, defined as the log of hydrogen ion concentration and given as pH = -log (H+), is used to identify the acidic and basic properties of a solution. The point of separation value of pH for acid and base separation is 7, which is neutral. If the pH of the solution is less than 7, it is acidic, which means the solution is concentrated with more hydrogen ion but less hydroxyl ion. If the pH value is greater than 7, the solution is basic, which means it contains less hydrogen ion but more hydroxyl ion. The Environmental Protection Agency (EPA) recommends that drinking water have a pH value between 6.5 and 8.5, which is slightly acidic and slightly basic **[16].**

2. Literature Review

2.1 *Optical properties of water by different experiment and observation*

Optical water quality measurements in the NRWQN have been well described in a number of publications **[17-18]**, including reports on optical aspects **[19-20]**, so only a brief overview is provided here. The black disc technique is used in the field to measure visual water clarity **[21-22]**. With a precision of about 5%, a viewer equipped with a 45°mirror is used to observe the visual target (black disc) in the horizontal direction beneath the water surface. Water samples collected during field visits are transported chilled via overnight air freight to the NIWA Hamilton Laboratory for next-day water quality analyses such as turbidity and CDOM. Turbidity is routinely measured in the NRWQN using a Hach 2100A nephelometer, which is still considered the de facto standard in water quality work.. CDOM is measured using a spectrophotometer on membrane filtrates at 340, 440, and 740 nm, using protocols that were originally proposed by Kirk in 1976 for more detail in **[23].** The spectrometer and other photometry-based equipment were used to measure this optical property.

The authors noted the plateau of low intensity difference from the control and concluded that decreased intensity and increased turbidity do not result in lower signal quality. The use of a spectrometer to study absorbance and transmittance properties is a non-destructive method similar to chemical and other methods. Furthermore, this provides numerical data for numerical analysis, which provides specific knowledge at a specific point. This instrument is also linked to a computer for data analysis and visualization, providing some additional information over other methods **[24].** Spectrophotometric analysis is widely used in various research fields because it is a nondestructive method, such as using visible wavelength to study the faces and backs of leaves for several plant species **[25].**

Table 1: Transmittance of Pure Water by Jerlov in 1968 **[26]**

S.N.	Wavelength (nm)	Transmittance
1	400	95.8
2	450	98.1
3	500	96.5
4	550	93.3
5	600	83.3
6	650	75.0
7	700	60.7
8	750	9.0

UV photons are scattered by water molecules and particles with smaller dimensions than UVs, and thus image formation with this wavelength provides less information than image formation with longer wavelengths (blue and green) of visible wavelength **[27]**. A variety of technologies are being developed to study the various properties of transparent materials, such as bacterium in water, on-chip opt-fluidic immersion refractometer, which determines the constituent properties and the nature of the material (size, shape, and refractive index) **[28]**. Most drinking water contains bacteria, and the most well-known bacteria in drinking water are E. coli, Shigella flexneri, Vibrio cholera, Salmonella enterica, and others **[29-30]**. These cause a variety of diseases such as typhoid, diarrhea, fever, kidney infection, and so on.

*2.2 **Optical properties of Vegetable oil by different experiment and observation***

Nuts, legumes, flesh fruits, and other plant materials are used to make vegetable oils. They are mostly plant products known as oilseeds. These seeds are pressed using machinery to extract oil from their raw material and refine for purity in order to satisfy the customer. These vegetable oils are used in a variety of cooking methods in our kitchens. According to 2008 **[31],** there are four types of vegetable oil in the market: palm oil, soybean oil, rapeseed oil, and sunflower seed oil.

Specific gravity is one of the most important parameters for measuring the quality of edible oil, and the Indian Standard edible oil example mustard oil is 0.907–0.910. For oil, specific gravity is defined as the ratio of the material's density to the density of water. It lacks a SI unit. If the specific gravity of edible oil is less than one, the oil quality is considered good, and the oil is insoluble on water, which means it floats on water. Mustard oil has been used for centuries in India for a variety of purposes in the kitchen. The scientific name for mustard is Brassica nigra, and this oil contains a variety of constituents, the most important of which is protein, which accounts for approximately 30% of the oil. Edible oils contain calcium, phytins, phenolics, erucie, eicosenoic, linoenic acids, natural anti-oxidants, and other compounds **[32].** Nasirullah et al. described the method for identifying the different type of oil from the products like rice bran cake is made and oils are detected by Coloimetric test **[33].**

2.3 Honey organic and its composition

Natural honey contains several hundred compounds from various chemical groups. These different compounds are dextrose, acids, minerals, vitamins, and so on. Because of these rich ingredient compounds, honey is important and used for a variety of purposes ranging from eating to medicine.

The optical properties of honey are affected by the concentration of water, and the refractive index decreases as the concentration of water increases; thus, this technique is used to determine the purity of honey. Proline is an acid that is abundant in honey. There are approximately 600 different types of honey that have been identified so far.

Some of the major commercial honey bee stations in the districts of Dang, Chitwan, Nawalparasi, Sarlahi, Makwanpur, and Rautahat. This station's honey production is based on four different floral sources, including Chiuri, Rudhilo, Mustard, and Buckwheat, and the honey also contains bioactive components, as detailed in [34]. The pH value of honey solution, according to the International Honey Commission, also helps to determine the quality of honey. According to a report, the ash content in honey ranges from 0.198 to 0.271 percent, the pH value ranges from 4.26 to 4.44, indicating that the nature is acidic, and the moisture content of honey ranges from 14.9 to 16.4 percent. Honey contains 83.6 to 85.7 percent total soluble solids and 81.6 to 83.4 percent soluble sugar [35]. Because photon, electron, and atom sizes are disturbed with incidence energy, the cross-section area of a photon can be used to study the optical interaction of photons and constituent interactions present in the sample in greater detail in [36-38]. The cross-section area is proportional to the square of the photon's wavelength and the refractive index of the medium. The relationship derived from this work is useful in photonic technology, medical fields, studying the interaction of stuff with a photon, and so on [39]. Sundarijal River provides drinking water in Kathmandu, Nepal, and a study found that when 0.5g, 0.6g, and 0.8g dosages of hydroxylamine hydrochloride were tested with 10mg/L, 50mg/L, and 100mg/L river water, no reduction in nitrate was observed. These tested samples demonstrate the feasibility of removing nitrates from river water, according to Sundarijal [40].

The optical properties of two water supply samples from Kathmandu Upatyaka Khanepani Limited (KUKL) and Kathmandu Valley Water Supply Improvement Project (KVWSIP) in the Kupondole Area, Lalitpur, Nepal show that the KVWSIP sample water has a higher light transmittance than the KUKL sample water. Although much work has been done to test the chemical purity of KUKL and KVWSIP water supplies, their optical properties have not been studied. When comparing the optical properties, the authors advised the public to drink KVWSIP water rather than KUKL if they had the choice. This is due to the fact that KUKL is more contaminated and contains more total dissolved solids (TDS) particles, whereas KVWSIP contains fewer TDS particles. As a result, consuming KVWSIP water on a daily basis provides relief from a variety of water-related diseases [41].

The current study was carried out to test the performance of filtration media systems on water purification quality and to evaluate optical properties such as reflection, transmission, and absorption intensities for filtered water using a spectrophotometer operating in the 350–400 nm range. The head losses through the filtration system in the experiments were 20, 40, and 60 kPa. Both the total suspended solids content and turbidity in optical property intensities for filtrated water increased as the filtration process progressed and the different head loss (from 20 to 60 kPa) increased, as did the water cloudiness. It has been demonstrated that the intensity of optical properties can be used to determine the need for filtration system backwashing [42].

The relationships between the spectral absorbance and fluorescence properties of water and human-associated and fecal indicator bacteria were developed to aid in the development of field sensor applications for estimating wastewater contamination in waterways. Receiving waters are frequently contaminated by leaking wastewater conveyance infrastructure. Methods for quantifying such contamination can be time-consuming, costly, and frequently nonspecific [43].

The optical properties of liquid water influence radiation transfer through liquid clouds. Despite the fact that these optical properties are temperature dependent, radiative transfer simulations typically use properties based on measurements taken at 298 K, even for supercooled liquid clouds at temperatures as low as 240 K. Temperature-dependent complex refractive indices (CRIs) of liquid water from 1 to 15,000 cm^{-1} (0.7 to 10,000 μm) at 240, 253, 263, and 273 K. The imaginary parts of the CRI (k) are calculated using values reported in the literature for temperatures ranging from 238 to 298 K, and the real parts are calculated using the Kramers-Kronig transformation. Ignoring the temperature dependence of complex liquid water refractive indices results in biased-high supercooled liquid-cloud fluxes ranging from 250 to 580 cm^{-1} and biased-low fluxes ranging from 710 to 940 cm^{-1} [44].

3. Material and Method

Intensity is defined as the quantity of photon incidence per unit time per unit solid angle. The unit of intensity is the lumen and the human eye is highly sensitive to 555nm. Different optical properties of the material are determined based on the intensity of light. Moreover on the principle of intensity different equipment are developed to measure the optical properties of material like spectrometer, colorimeters etc.

*3.1 **Beer-Lambert law for Transmittance and Absorbance***

When light passes through a transmitting solvent, the amount of light absorbed is directly proportional to the concentration and path length, according to Beer-Lambert law. A scientific instrument spectrophotometer is based on this principle, and it studies the optical properties of the material. Let It is the intensity of light when it passes through the transparent substance, and I0 is the intensity of light after it has passed through the substance; thus, transmittance is defined as:

$Transmittance\ = \frac{I_t}{I_0}$ and in percentage, it is defined as :

$T(\%) = \frac{I_t}{I_0} \times 100\%$. Also, Absorbance (A) is the quantity of light absorbed by a solution and calculated from Transmittance percentage as:

$A\ =\ 2\ - \log_{10}(T(\%))$. It is also known as optical density. For example, 10% of transmittance is equal to 1Au (Absorbance unit) and 1% of transmittance is equal to 2Au.

For our work, we used an experimental method to investigate the transmittance of a sample, which we define as, Sample 1 (Drinking water (Jar Water)=DW), Sample 2 (Sunflower Oil=SO), Sample 3 (Mustard Oil=MO), Sample 4 (Drinking water +Organic Honey =DWOH), and Sample 5 (Drinking water +Organic Honey + Sunflower Oil + Mustard Oil =DWOHSMO).

3.2 Preparation of Sample

3.2.1 Sample preparation information

Samples 1, 2, and 3 are taken directly from the manufacturer's package. The transmittance was measured with a spectrometer (DIY: Spectrometer + Theremino Software), while the other sample was prepared with a magnetic stirrer. Instead of samples 1, 2, and 3, a magnetic stirrer is used to create a homogeneous mixture for another sample..

3.2.2 Preparation of Sample 4

Sample 4 is prepared by dissolving 1gm of organic honey in 25ml of drinking water (Jar Water) at 24^{o}C using a magnetic starrier (rps 100, for 10minuts).

3.2.3 Preparation of Sample 5

Sample 6 is prepared to take 2.5ml of Mustard oil (cooking), 2.5ml of sunflower oil (cooking oil), and 2.5ml of honey solution at 24^oC with the help of magnetic starrier (rps 100, for 30minuts). The show the nature of the solution (semi-homogenous solution) is basic. The solution was filtered and then transmittance is absorbed.

Table 2: Sample preparation time, temperature are tabulated below

S.N.	Sample	Type of Sample Preparation	Temperature (^{0}C)
1	DW	Industrial Sample	24 ± 1^oC
2	DWOH	Prepared in Lab	24 ± 1^oC
3	MO	Industrial Sample	24 ± 1^oC
4	SO	Industrial Sample	24 ± 1^oC
5	DWOIHAMO	Prepared in Lab	24 ± 1^oC

3.3 Phenomena of Measuring Transmittance

The figure below depicts a sketch of how to measure transmittance. When a visible photon passes through a sampled prepared, the sample absorbs and transmits the photon. In our case, we're using a visible photon because we're looking for a sample that emits a visible photon.

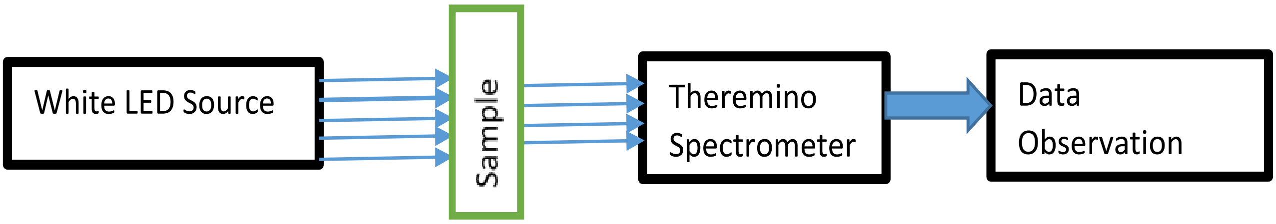

Figure 1: Block Diagram of the experiment to study the Transmittance and Absorbance of Sample

3.3.1 Phenomena of Photon

When visible photons are passed through a sample, some of the photons absorb in the sample while others transmit through the sample. The same material sample is used at different temperatures in our study to investigate the transmittance of a photon through the sample. There are two samples hot and cold that is hot sample is at $34^0C \pm 1^0C$ and cold sample is at $24^0C \pm 1^0C$ for our study. Moreover, the visible photon is used to study the transmittance of the samples.

4. Result and discussion

4.1. *Absorbance and Transmittance of Drinking Water*

The drinking water sample is not prepared, which means it is taken from the market or manufactured production (Jar water) and tested with a spectrometer. The obtained observation is depicted in Figure 2 below. The graph is smooth, indicating that the chemical composition or particle size is less than mustard and sunflower oil. The transmittance is maximum at 422 to 424nm, which means that the transmittance is approximately 100% at this wavelength range, while the absorbance is minimal. In comparison to the transmittance, the transmittance is observed to be shifted towards a high wavelength.

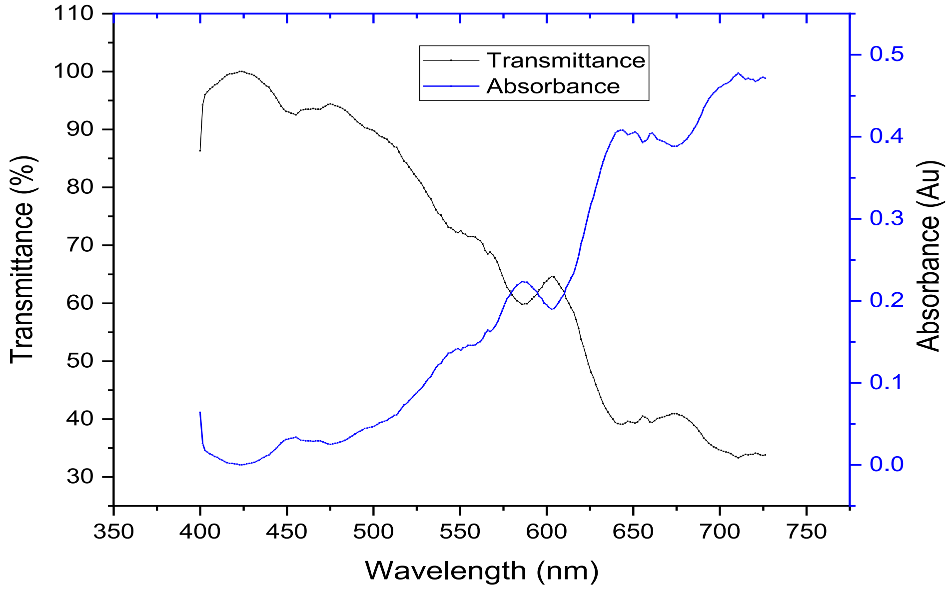

Figure 2: Absorbance and Transmittance of Drinking water

4.1 Absorbance and Transmittance of Honey

The results of testing a prepared sample of honey solution with a spectrometer are shown in Figure 3 below. The observation shows that transmittance decreases as the wavelength of the visible photon increases. For this study, we only looked at visible photon behavior; the behavior at about 600nm fluctuates, and in general, the absorbance coefficient increases as the wavelength of visible photons increases. At 600nm, a similar fluctuation to that seen in transmittance is observed.

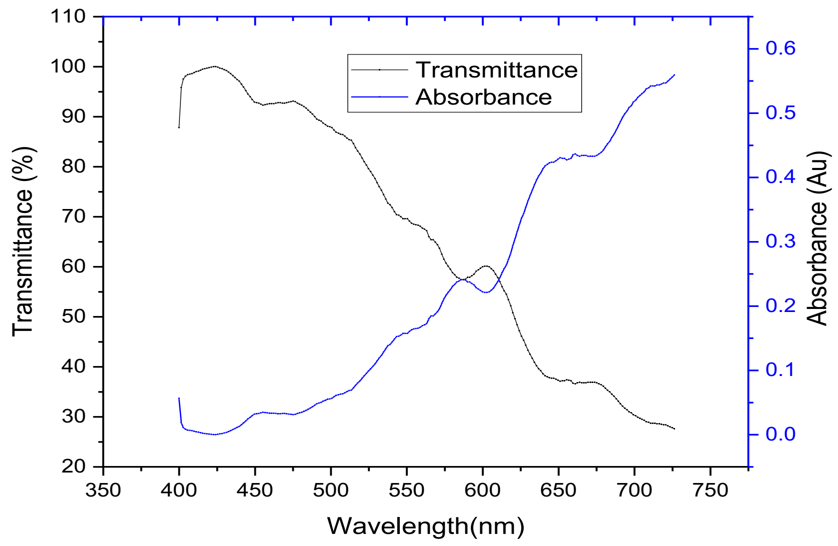

Figure 3: Absorbance and Transmittance of Honey Solution

The transmittance is maximum at 422 to 424nm, which means that the transmittance is approximately 100% at this wavelength range, while the absorbance is minimal. When compared to the transmittance of honey solution and water, the transmittance is nearly the same at the same wavelength. This indicated that the solution is homogeneous and that the particle size of the hone solution is comparable to the particle size of drinking water.

4.2 Absorbance and Transmittance of Mustard oil

The mustard oil sample is not prepared, which means it is taken from the market or manufactured production and tested with a spectrometer; the results are shown in figure 4 below. Similar to the honey solution, the observation shows that transmittance decreases as the wavelength of the visible photon increases. We only considered visible photon behavior in this study because the behavior at about 550nm is not uniform, and both absorbance and transmittance oscillate. This could be due to the composition of the mustard oil content, which is sensitive at this wavelength, and in general, absorbance increases as the wavelength of photons in the visible ranges increases. The steepness of the graph differs significantly from the honey solution and water results shown in Figures 3 and Figure 2, respectively.

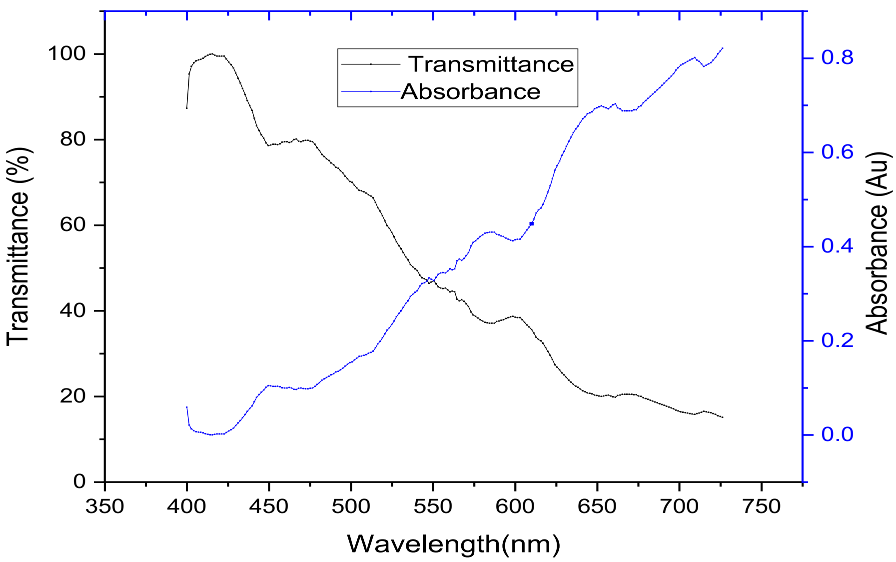

Figure 4: Absorbance and Transmittance of Mustard Oil

The transmittance is maximum at 414 to 415nm that is at this range the transmittance is about 99.8% while the absorbance is minimum at this range.

4.3 Absorbance and Transmittance of Sunflower Oil

The mustard oil sample is not prepared, which means it is taken from the market or manufactured production and tested with a spectrometer; the results are shown in figure 5 below. Similar to the honey solution, the observation shows that transmittance decreases as the wavelength of the visible photon increases. We only considered visible photon behavior in this study because the behavior at about 550nm is not uniform, and both absorbance and transmittance oscillate. This could be due to the composition of the mustard oil content, which is sensitive at this wavelength, and in general, absorbance increases as the wavelength of photons in the visible ranges increases. The steepness of the graph differs significantly from the honey solution and water results shown in Figures 3 and Figure 2, respectively.

The transmittance is greatest between 415 and 418nm, which corresponds to a transmittance of approximately 99.5 percent, while the absorbance is lowest. In comparison to mustard and sunflower transmittance, it is observed that the transmittance is shifted towards a high wavelength.

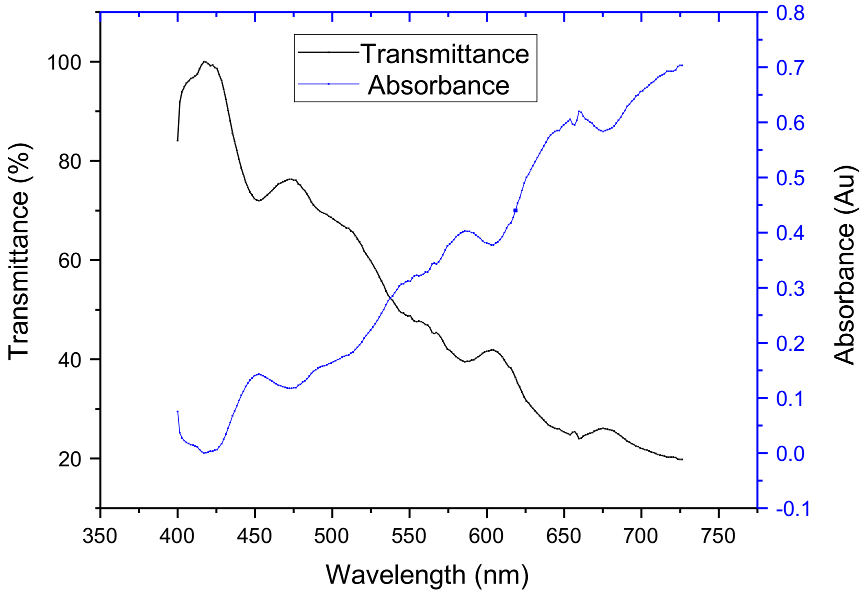

Figure 5: Absorbance and Transmittance of Sunflower Oil

4.4 Absorbance and Transmittance of Mixture of all sample

Figure 6 depicts the transmittance and absorbance of a prepared solution sample containing honey, water, mustard, and sunflower oil. The same ideal conditions as described above apply to the observation. The observation shows that as the wavelength increases, the transmittance decreases while the absorbance increases.

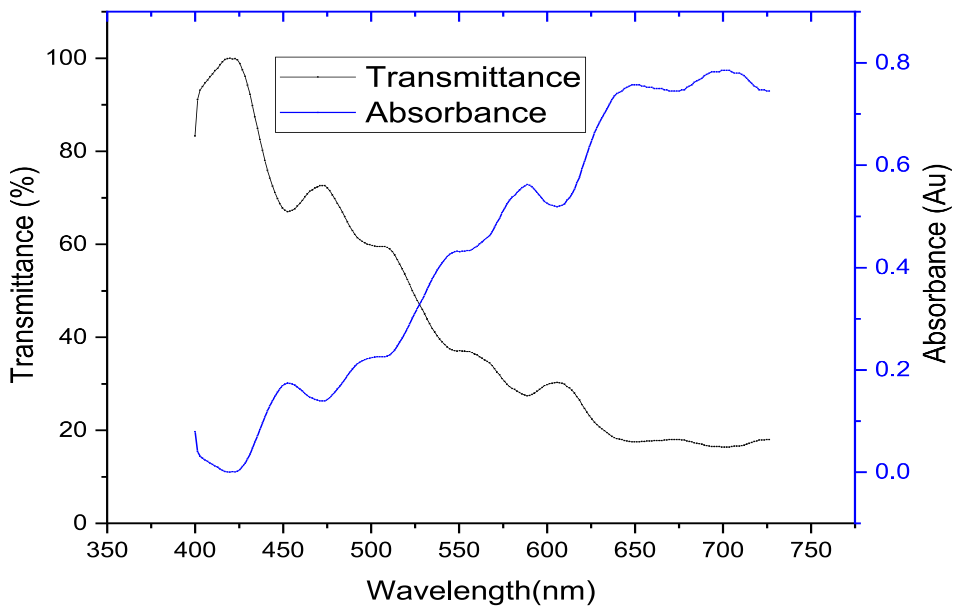

Figure 6: Absorbance and Transmittance of the Mixture sample

For this experiment, we ignored visible reflection and calculated absorbance using the equation Total Light = Transmittance Photon + Absorbance Photon. The nature of the mixture solution is quite different from all individual samples in the study above, which could be attributed to the sample filter. The graph's smoothness differs from another sample with steepness in nature. The transmittance is maximum at 422nm to 424nm, which means that the transmittance is close to 100% at this wavelength range, while the absorbance coefficient is lowest. In comparison, the transmittance of this sample is comparable to that of honey and water, but it differs from that of mustard and sunflower.

4.5 Comparative study of Transmittance of All Sample

All samples and experiments are performed under the same conditions, i.e. at the same temperature and photon wavelength. Figure 7 depicts the nature of the transmittance of the various samples with the visible photon. The nature of the honey and water samples is the same, but the transmittance of honey is less than that of water for the same photon wavelength. The nature of mustard and sunflower oil is also observed, and the observation shows that the transmittance of sunflower is lower than that of mustard oil at short wavelengths (425nm to 500nm), but higher at longer wavelengths (above 500nm). The mixture's transmittance is less than the sum of all individual sample transmittances, but its smoothness is greater. The steepness of the mixture sample, mustard oil, and sunflower oil differs from one another, whereas water and honey do not.

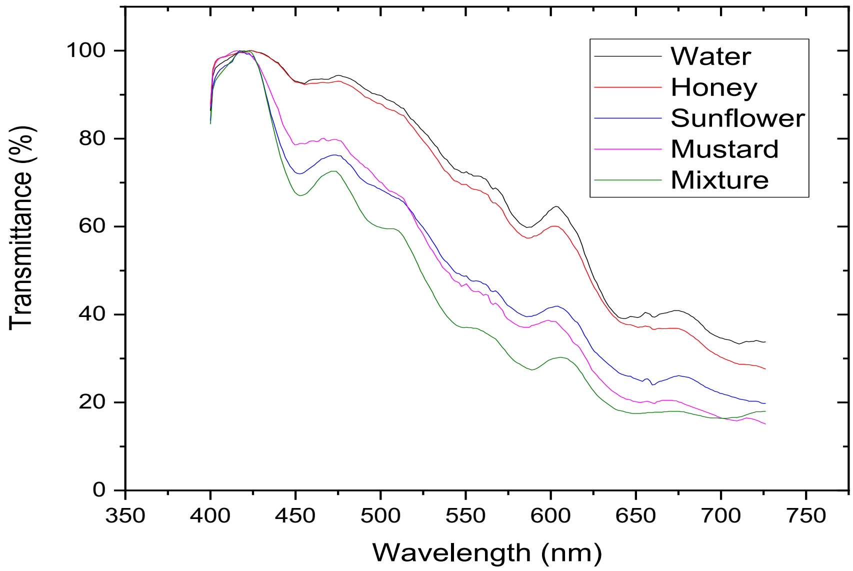

Figure 7: Comparison of Transmittance of all Samples

The transmittance of all samples is high at lower wavelengths and decreases as the wavelength increases. The peak appears at approximately 600nm for water and honey, while sunflower is higher than mustard oil and mixtures have the least of all samples.

4.6 Comparative study of Transmittance of All Sample

Figure 8 depicts the absorbance of samples; the observation shows that the absorbance increases as the wavelength of the photon increases. The absorbance of the water and honey samples is lower than that of the other samples, whereas the absorbance of the sunflower is higher at a lower wavelength and higher at a higher wavelength. The absorbance of the mixture sample is greater than that of all individual samples.

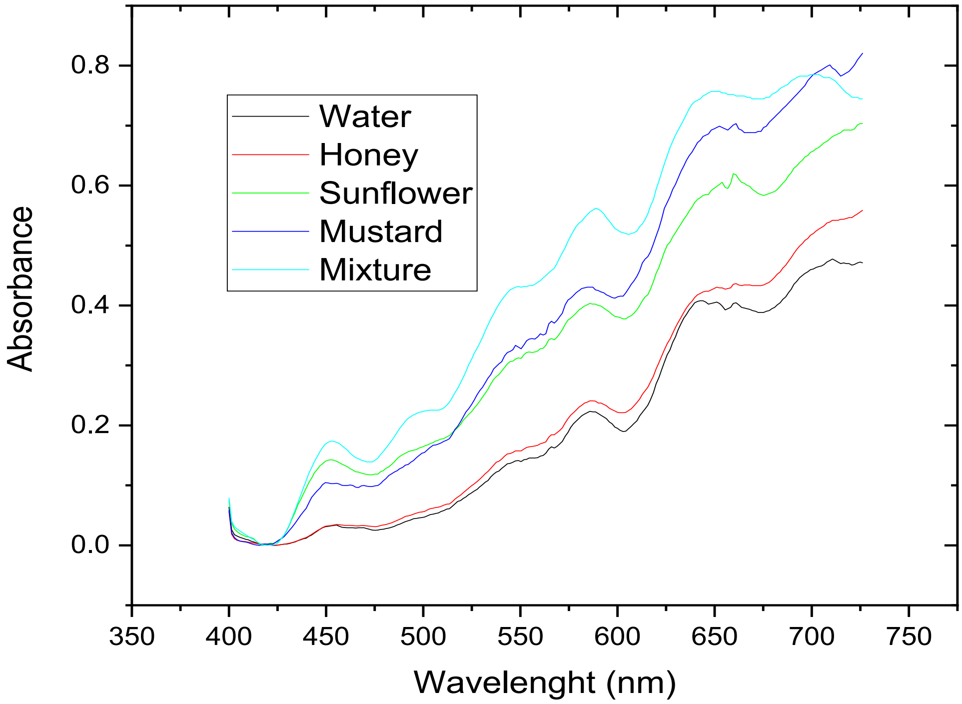

Figure 8: Comparison of Absorbance of all Samples

Conclusion

We consider five samples for our study: drinking water, organic honey, mustard, sunflower oil (cooking oil), and a mixture of all samples. Absorbance and transmittance were studied separately and then combined. The observations for individuals are depicted in Figures 2, Figures 3, Figures 4, and Figures 5. All observations show that transmittance is higher at lower wavelengths and lower at higher wavelengths, and absorbance is reversed, that is, lower at shorter wavelengths and higher at longer wavelengths. When we compare the transmittance of the whole sample, we find that water has a higher transmittance and the mixture has a lower transmittance. Similarly, for the same wavelength, the absorbance of the mixture sample is higher and that of water is lower.

If we compare increasing order of transmittance the arrangement is like Mixture Sample < Sunflower at low Wavelength < Mustard oil at high Wavelength < Honey Solution < Drinking Water and for Absorbance coefficient the reverse relation is valid that is Mixture Sample > Mustard oil at high Wavelength > Sunflower at low Wavelength > Honey Solution > Drinking Water.

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Authors Contribution: All authors are equally contributed to this work

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