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Research Article

COLOUR MEASUREMENTBY UV ABSORPTION TECHNIQUE

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ABSTRACT

The aim of this research work was to acquire and classify different colour scales resulted by serial dilutions of a specific colour. Through the serial dilutions, different colour scales were obtained and analyzed for a dialysis purpose. Visible (VIS) light spectrometer was proposed to measure the colour absorption through the integration with Spectrasuite software which respects to absorption. Spectrasuite is able to display spectral patterns corresponding to the absorption. Each colour scale indicates a different concentration. Thus, spectrometer was proved to distinguish different colour scales and it must even overcome cross-sensitivity issue. The application was validated through a correlation with the use of International Commission on Illumination (CIE) spectral measurement system. Every colour scale was successfully classified by a standard colour code. Thus, the spectrometer is applicable for the colour measurement analysis by absorption method besides contributing benefits to various applications.

INTRODUCTION

Colour is a basic element of object appearance which is supported by the existence of spectral light. White light itself is a combination or reaction of spectral colours including red,blue and green as the main ones to contribute the variety of colours [Yokono et al., 2009]. Each type of colour has a different emissive energy within electromagnetic radiation or spectrum. Figure 1 illustrates an electromagnetic spectrum where UV, Visible (VIS) and Infrared (IR) light are specifically located within their wavelength range. VIS is only the small part of it which is located from 400nm till 700nm [Timma, 1952]. Transmittance and absorbance are two invertible values of light interaction when the light shining over a material or object. The less transmittance values, the more amount of light is being absorbed by the material and vice-versa. The light transmittance occurs by a radiant energy which is also called emission. The colour of the object is unequal one of the transmittance because of its effect towards the absorption. Therefore, the object appears with own specific colour that only absorbs thecolour spectrum from the light source distribution. This is the way on how the object gets coloured [Pohl et al., 2004]. At the same time, the unabsorbed light will only transmit as a proportional variable due to the light absorption by the object.

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They principally work based on Snell's Lambert Law and how they can be related to Beer's Lambert Law as shown in Figure 2. In this study, the colour measurement is based on VIS light absorption by different colour scales as experimental samples. Their working principal had to be correlated with CIE application to validate that each colour scale successfully traced at a different absorbance wavelength. Besides that, it can advantageously validate that VIS light is also usable for colour detection and classification. Colour scale as the main exposure in this research work since both colour measurement techniques were used to categorize the colour scales based on the absorption and emission potential [Le Moan et al., 2011]. Colour scales could be formed from every specific type of colour through a serial dilution technique [Color and chemical constitution, 1962; Sandroni, 2014]. Each colour scale of a selected colour was chromatically encoded by a standard colour code to be a complete colour scheme since they can be marked out by using CIE application. Absorption measurement system was proposed to reveal its expertise for such working principal. Different refractive index or vibrations of different frequencies can be also evaluated for the spectral determinations [Wiens et al., 2012; Popp et al., 1997]. Since every colour scale was recognized well by the absorption technique and CIE application, they were specifically coded. Table 1 shows all the colour scales with their standard colour code.

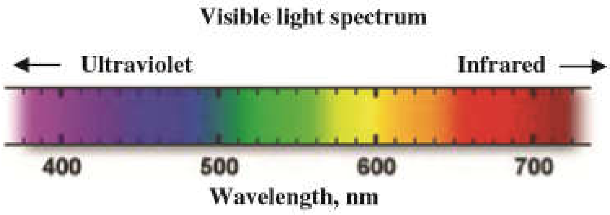

Figure 1. Electromagnetic Radiation

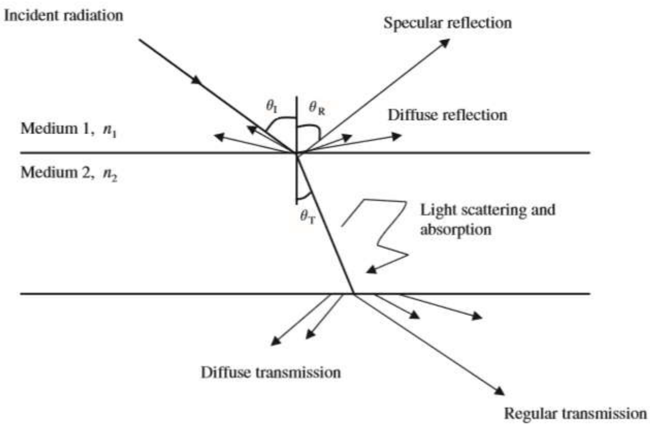

Figure 2. Relation of Snell's Law with Beer's Lambert Law

Table 1. Standard Colour Code of Colour Scale

Colour Scale	Standard Colour Code
Bluish Purple	#8A2BE2
Yellowish Green	#9ACD32
Orange	#FFA500
Reddish Orange	#FF4500
Purplish Blue	#483D8B
Yellow	#FFFF00
Yellowish Orange	#FF00FF
Magenta	#FF00FF

MATERIALS AND METHODS

In this research, two techniques were proposed to detect and categorize each colour scale based on their concentration. Colour absorption was used as the main technique to be compared and correlated with the performance of CIE application. CIE application is used as the second technique. It is able to perform the colour measurement by respecting to emission as invertible variable of absorption. This means that the both techniques still afford a same function.

Colour Absorption Technique

Colour absorption technique can be performed by using spectrometer.VIS light were used to inspect the colour of the food product or material [Utzinger et al., 2003]. Colour absorption is based on the sample concentration and colour spectrum. Every colour scale has a different concentration produced by a serial dilution. Amount of light that may transmit through the material is counted as an indicative value of the absorption. Absorption colour can be inversely presented by emission of the colour as its emissive energy in the electromagnetic radiation or spectrum. This emissive energy also gives an effect towards the absorption potential [Bin Omar, 2009].

International Commission on Illumination (CIE) System

International Commission on Illumination (CIE) system is supposed to mark out the colour of the material by deriving three primary colours; red at 700nm, green at 546.1nm and blue at 435.8 nm. The various combination of these three colours called tristimulus (X,Y and Z). New Percent Reflection Processing was set up and it should be based on the emissive energy of the colour spectrum. Therefore, it could be correlated with the absorption technique since emission is invertible with absorption. The performance of colour observation was also affected by the light source and its working temperature which also had to be set up on Spectrasuite. Therefore, LS-1 light source at 2800 Kelvin was selected which corresponds to the illumination attributes. Using CIE measurement, the light reflecting off the experimental material was filtered by red, green and blue glass to acquire a specific spectral illumination. A photodetector plays a role for the passing light detection in order to acquire and display X,Y and Z variables. CIE system has been also common in food manufacturing industries. Figure 5 and 6 illustrate a chromatic diagram and map with wavelengths in nanometer (nm).

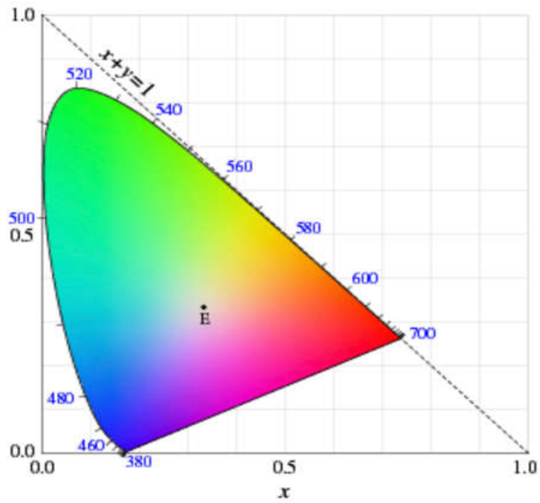

Figure 5. Chromatic Diagram of CIE Application

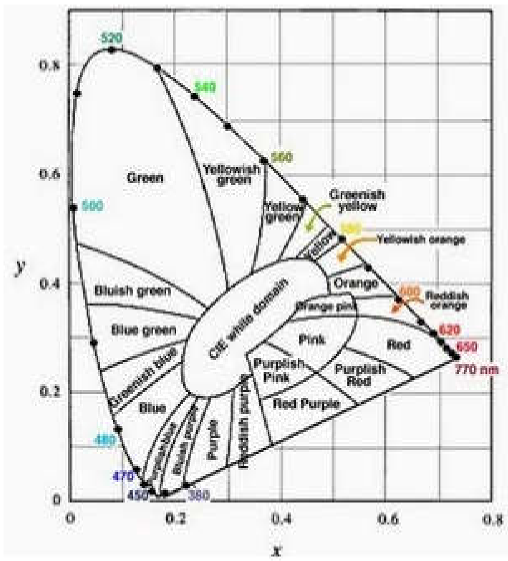

Figure 6. Chromatic CIE Map

CIE application is used as a reference to correlate the results by using absorbance technique. It used to validate that the absorption technique is also able to mark out every colour scale correctly by absorbance variables. In other words, every colour scale has its a specific absorbance value that VIS light is absorbed at a certain wavelength range. This even contributes for colour classification based the absorption potential of the colour scales. Thefeatures of the sample was firstly specified in order to ensure that an appropriate experimental setup could be suited well with the application. All the samples came in liquid form. Thus, a cuvette and its holder were absolutely required to place the sample for the investigation purpose. Four different colours; blue, green, yellow and magenta were selected to examine their absorption potential. Each colour came from a same base or material.

Therefore, the measurement was done by having all the samples at a same standard. This is very important to get accurate comparison of the absorbance measurement by all the colours. Any dissimilarity of the material may cause at least some differences towards the reading measurement. Serial dilution technique was proposed for the dilution of each colour to afford five different colour scales. Starting with 1ml of a selected colour stock, it was diluted with 9ml of distilled water to make it to 10 ml of a complete colour scale as the first working sample. Afterward, 1ml of this first working sample was diluted again with 9ml of distilled water. Entirely, each colour was serially diluted till five colour scales were produced. Figure 6 to Figure 9 show five different colour scales for each type of colour.

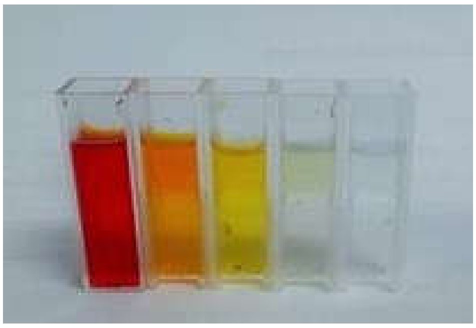

Figure 7. Samples of Yellow Scales

Figure 8. Samples of Green Scales

The first sample of each type of colour couldnot be used since they showed too high absorption. Due to this condition, they could be classified as a blank colour which are very concentrated and creates shadows among the molecules. The fourth and fifth colourscale of each type of colour also were not used since they almost showed no absorption.

Figure 9. Samples of Magenta Scales

Figure 10. Samples of Blue Scales

They were produced as too bright colour scales through the serial dilution. Only the second and third colour scale could work well since they were absorbed well in the VIS wavelength range. A same absorption method was repeatedly used for all the samples and all the results were analyzed for a comparison purpose. Repeatability is necessary to find out the best optimal wavelength to indicate the concentration of each colour scale. In the experimental setup, a cuvette was used as a cell to place the sample where the VIS light was able to penetrate through it. Integration time had to be set up till Spectrasuite was able display observable and optimal wavelength pattern. During the experiment, the cuvette containing the sample had to be firstly taken out of the cuvette holder and placed it into the cuvette holder every time before getting the capturing process done by using Spectrasuite. This repeatability is good to afford reading accuracy. Figure 11 illustrate a complete experimental setup for this experiment. The optical cables, cuvette holder and the spectrometer were arranged in a line as shown in Figure 11 to prevent from any cabling loss that might possibly occur especially during the system operation.

RESULTS

A comparison of VIS absorption by each colour shows different curve patterns to indicate their absorption level. Figure 15 to Figure 18 show the absorbance curve against wavelength range in nanometer unit (nm) of each colour scale by the second serial dilution. From the absorption wavelength pattern, it shows that the VIS light was absorbed at 400nm till 460nm. This wavelength is reasonable because the absorption value should be at least below 2.0 abs. It also indicates that the blue colour scale absorbs very well within this range. This even fulfills the criteria that the blue colour should absorb the VIS light within this wavelength range.

Figure 11. Experimental Setup of Colour Measurement

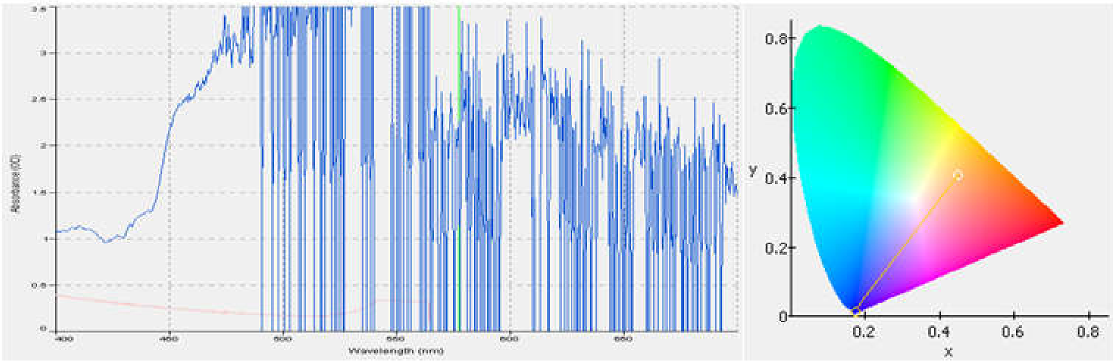

Figure 15. Curve Pattern and Chromatic coordinate of Bluish Purple Colour Scale

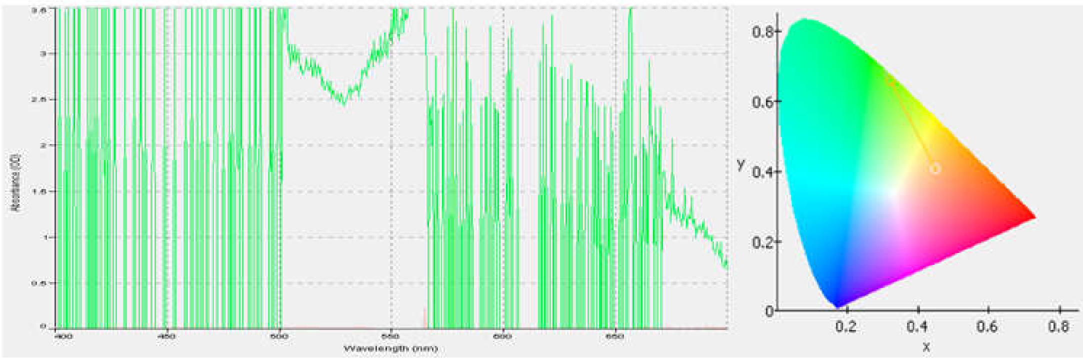

Figure 16. Curve Pattern and Chromatic Coordinate of Yellowish Green Colour Scale

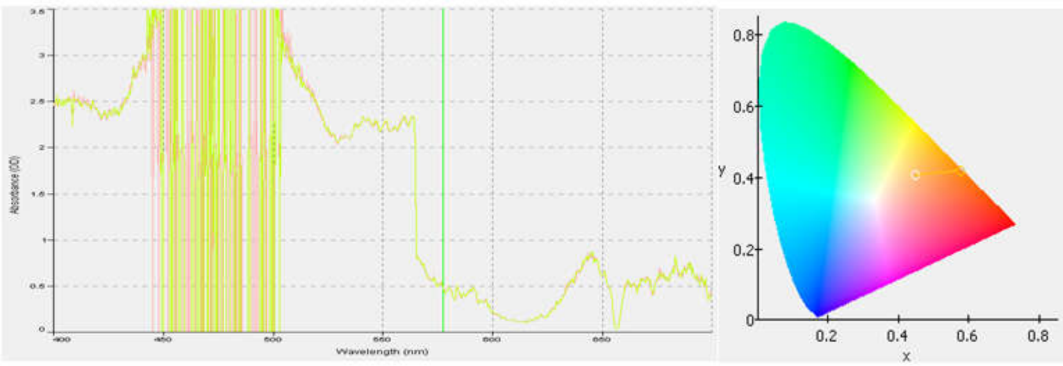

Figure 17. Curve Pattern and Chromatic Coordinate of Yellowish Orange Colour Scale

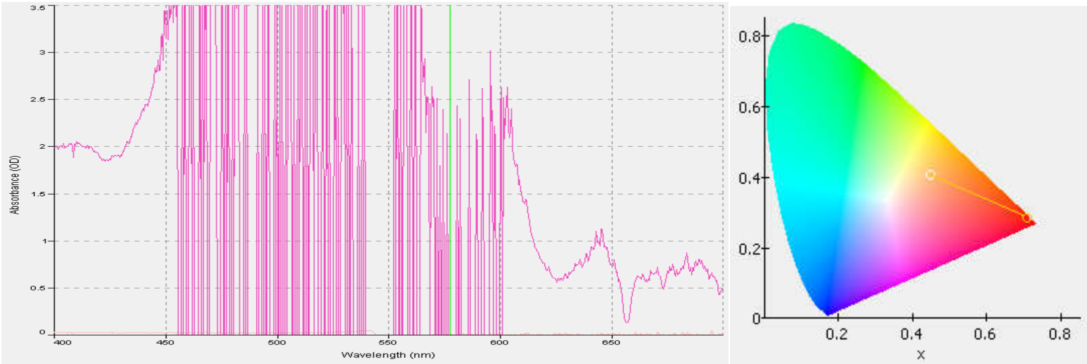

Figure 18. Curve Pattern and Chromatic Coordinate of Magenta or Reddish Orange Colour Scale

The rest only indicates noise due to a very high absorption. CIE application used to prove that the range of absorption wavelength should belong to the blue colour scale (Brilliant Blue by second dilution) as shown in the chromatic diagram. The absorption wavelength pattern shows that VIS light was absorbed at 500 nm till 550 nm and 675.5 nm till 700 nm. These two wavelength ranges were taken since the green colour scale absorbed well there. Normally, the green colour only absorbs VIS light in 500nm till 550nm. The second wavelength here might be caused by other colourcompounds which is also used to produce green colour itself such as Tartrazine and Carmoisine. The rest only indicates noise that the colour cannot absorb well in the wavelength ranges. The chromatic diagram marked out the area of yellowish green colour in order to indicate the absorption wavelength pattern should belong to the colour. Yellow or yellowish orange colour absorbed VIS light within the wavelength range from 575 nm till 700 nm. In this case, the absorption reading was taken below 1.0 abs as the best absorption value resulted by the colour. VIS light was absorbed at 625 nm till 700 nm by magenta or reddish orange colour that also can be observably seen on the chromatic diagram. The figure shows that magenta colour scale exactly absorbed VIS light in the most right wavelength range, 600-700 nm of VIS light spectrum.

DISCUSSION

From the results, it can be seen that the second dilution of the sample shows a better absorption. Absorbance measurement should be taken below 2.0 abs or 1.0 abs. However, there is an absorbance value above 2.0 abs in a certain wavelength range. It can be considered since the other wavelength ranges only show noise. Noise is theoretically formed when the sample is too concentrated above 3.0 abs. The light transmission here is only about 1% due to the existence of shadows formed by the molecule chromospheres of the solution. 100% light transmission will only happen at 0 abs that absorption does not occur at all which means the sample might be a reference spectrum. Thus, a considerable absorbance is below 2.0 abs or 1.0 abs that the light transmission is counted in a reasonable range without shadow creation. For the experiment by the second serial dilution, the reading measurement was an attempt to be taken below 3.0 abs even molecule chromospheres might create shadows. In this specific case, any signal which was considered as noise above 3.0 abs should be ignored.

The second dilution successfully worked since CIE application was able to exactly indicate the colour belongs to the tested sample which was being placed in the cuvette. It was used a reference to the wavelength absorption. For the green colour, CIE application marked out yellow colour on the chromatic diagram. This was caused by the existence of Tartrazine in the sample which is normally mixed with Brilliant Blue and Carmoisine to produce a green food colour. It has good light stability besides having maximum absorption potential. When the green colour was diluted at the second time, the colour became brighter and Tartrazine was well traced due to its light stability or conductivity. Thus, this kind of green colour was already close to yellow as a part of green colour. Brilliant Blue and Carmosine used as darker overlapping colours towards the green colour itself. Tartrazine is the brightest colourconsitituent among them besides having the best conductivity. For the yellow colour, it is close to yellowish orange or orange colour. Thus, CIE application successfully marked out the yellowish orange and orange colour either in the first and second stage. The first, fourth and fifth dilution were not able to give any appropriate results. The first dilution consists of the darkest colour which can work as a dark spectrum which only produced high noise if we use absorption technique. CIE application also cannot trace them very well that it only marked out the point which is close to the center of the chromatic diagram (white light source). While the fourth and fifth dilution consisted of very bright colour scales with very low absorption. There are common errors which may cause effects during the reading process. Cabling loss is a common instrumental error which can directly affect the measurement by causing a reading error. However, these two kinds of error are considerable since they can be analyzed and deducted by using Spectrasuite. Analysis was carried out for each colour to inspect its absorption potential. Each colour absorbs VIS at a different wavelength due to its own emissive energy in electromagnetic radiation which reacts as emission or transition. Emission and absorption are invertible to each other which has a same function and are readable on the Spectrasuite display. Thus, absorption variable of each colour can be potentially observed through absorbance versus wavelength curve. CIE colourimetric analysis was also done to prove that absorption has a very good potential to mark out each colour scale that they optimally absorb the VIS at a different wavelength. An optimal wavelength for each colour is very important to validate their absorption potential. However, the compounds or constituents of the sample have to be also considered and that is why, all the samples were selected from a same base. The dissimilarity is only caused by any different compounds in order to produce different colour although they still come from a same base material.

Conclusion

This research used to optically investigate the absorption wavelength by different colours based on their most indicative colour scale. VIS spectrometer successfully detected all the colours at the second colour scale in VIS light region by respecting to absorption. . In addition, the data were analyzed by assuming every second colour scale of the dye products as a different colour. They were analyzed to differentiate each other by inspecting their standard location of wavelength region in electromagnetic spectrum Therefore, the cross-sensitivity issue was solved by this analysis. Absorbance analysis proved that every colour has a different absorption potential that VIS light wavelength is absorbed at a different absorption peak. This absorption technique was successfully correlated with the use of CIE application. Furthermore, every second colour scale was encoded with a standard colour code. This application can be carried out for further research works by relating the optical method to the colour scale measurement either in the food dye or paint colour industries. For further research, pH of the solutions has to be maintained along the serial dilution process to avoid any changes towards the chemical bonding or water solubility. Therefore, the creation of every colour scale of every dye product can be used as an indicative shade to form a complete colour scheme. In other words, every dye product will have their own complete colour scheme by the classification of different colour scales.

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