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AN EFFECT OF SUGAR CONCENTRATION LEVEL CHANGES FROM YELLOW TO GREEN LIGHT IN WATER

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ABSTRACT

Sugar is part of the carbohydrate chain. One group of these carbohydrates is disaccharides. The sugar used in this study is sucrose which is formed by glucose and fructose. Sucrose has the property of rotating polarized light to the right. Thus, the level of sugar content in water can affect the refractive index in the sugar solution. Therefore, more sugar content can cause the refractive index in the sugar solution to increase. For example, the addition of sugar at 37.5% level can increase the refractive index from 1.333 to 1.402. As the index of refraction increases in the sugar solution, more light is absorbed. Absorption of light in a sugar solution can change the color of light from yellow (589 nm) to green (560 nm). Yellow light can be used for healthy skin and green light can be used to reduce the intensity of migraine.

KEYWORDS: *sugar solution, refractive index, yellow light, and green light.*

1 INTRODUCTION

Sugar is part of the carbohydrate chain. These carbohydrates are in three groups: monosaccharides, disaccharides, and polysaccharides. Monosaccharides are simple carbohydrates because they consist of a simple sugar molecule and cannot be outlined by hydrolysis into other carbohydrates such as glucose, fructose, and galactose. The molecular formulas of the monosaccharides of them are the same $C_6H_{12}O_6$ (*David Buss et al., 1976*).

Disaccharides are chains of two monosaccharides, such as sucrose, maltose, and lactose. The molecular formulas of the disaccharides of them are the same $C_{12}H_{22}O_{11}$ (*David Buss et al., 1976*). Disaccharides are part of oligosaccharides (a series of several monosaccharides). The properties of monosaccharides and oligosaccharides are soluble in water easily. They are the solution tastes sweet. Because of their sweet taste, these two groups are called sugars.

Polysaccharides are polymers composed of sugar molecules strung together into long chains and can be branched, such as starch, cellulose, and glycogen. The molecular formula (general) of the polysaccharide of them are (C6H10O5)n (*David Buss et al., 1976*).

One of the polysaccharide's characteristics is difficulted to dissolve in water. Therefore, if the solution in water can be dissolved and tastes not sweet it means non-sugar.

In this research, the type of sugar used is sucrose. Sucrose is a sugar that we know every day. It is both from sugar cane and beets. Sucrose can find in other plants, such as pineapples and carrots. With hydrolysis, sucrose will be broken down and produce glucose and fructose. The sucrose molecule does not have a free aldehyde or ketone group or does not have a glycosidic –OH group. Sucrose has the property of rotating polarized light to the right (*George L. Teller, 1918*). Therefore, sugar in water can increase the calorie, so the energy used to absorb photons is greater than pure water.

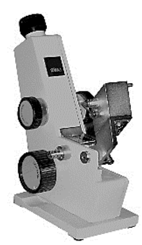
Based on the research conducted (*Alfred Zajac et.al., 2003*), the refractive index of pure water was measured based on the yellow light reference of sodium 589,29 nm. An increase in the sugar content in water can cause the energy to absorb photons to increase (*D. H. Sulaksono et al., 2019*). As energy increases, the wavelength of light passing through water decreases. It can cause yellow light that passes through water to turn green due to light refraction events. The refractive index and energy in the water increase so that the wavelength of light decreases (Born and Wolf, 1959).

2 MATERIALS AND METHODS

2.1 Materials

In this study, the materials used were water and sugar produced by the Watoetoelis sugar factory, Sidoarjo. The supporting tools are digital scales and an Abbe refractometer. A Digital scale has used to measure the sugar content that will dissolve in water. Then, an Abbe refractometer has used to measure the refractive index of the sugar solution. The Digital scale and Abbe refractometer can show in Figure 1.

(a)



(b)

Figure 1: Research tools: (a) Digital scale and (b) Abbe refractometer.

2.2 Methods

In this study, the refractive index of liquids can do by dissolving sugar in water solvents with different concentrations. The sugar solution consisted of 50 ml of water with the addition of sugar was measured with a digital scale in multiples of 2 g in each solution ranging from 2 g to 40 g. To determine the sugar concentration in the water, we can use the following calculations:

$$C = \frac{m_g}{m_a + m_g} \times 100\% \quad (1)$$

Where C is the concentration of the sugar solution, m_g is the mass of sugar, and m_a is the mass of water. Because water is 1 g/ml, the volume of water is equal to the mass of water.

Furthermore, each solution with a specific concentration was measured its refractive index using an Abbe refractometer. The refractive index can use to determine the wavelength of light that has refracted in the sugar solution. The relationship between the refractive index and wavelength can be written by following formulas 2 and 3 (*Eugene Hecht, 2002*).

$$n = \frac{c}{v} = \frac{c}{f\lambda} \quad (2)$$

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} \quad (3)$$

Where n is the refractive index of a sugar solution, c is the speed of light in a vacuum of 3 m/s, v is the speed of light in the medium, f is the frequency of light, λ is the wavelength of light, n_1 and n_2 are the refractive indexes in mediums 1 and 2, and λ_1 and λ_2 are the wavelengths of light in mediums 1 and 2.

Next, we can determine the wavelength change of light that passes through the sugar solution due to the sugar concentration change in the solution based on equation 3.

3 RESULTS AND DISCUSSION

First, we determine the value of the refractive index of pure water when irradiated with yellow sodium light, 589,29 nm. Based on the reference results, the refractive index of pure water is 1.333 (*Alfred Zajac et.al., 2003*). Consequently, we can measure the refractive index change of the water due to the influence of the level of sugar concentration in the water. Based on the research results, the refractive index of water increases when the sugar concentration in water increases, as shown in Figure 2.

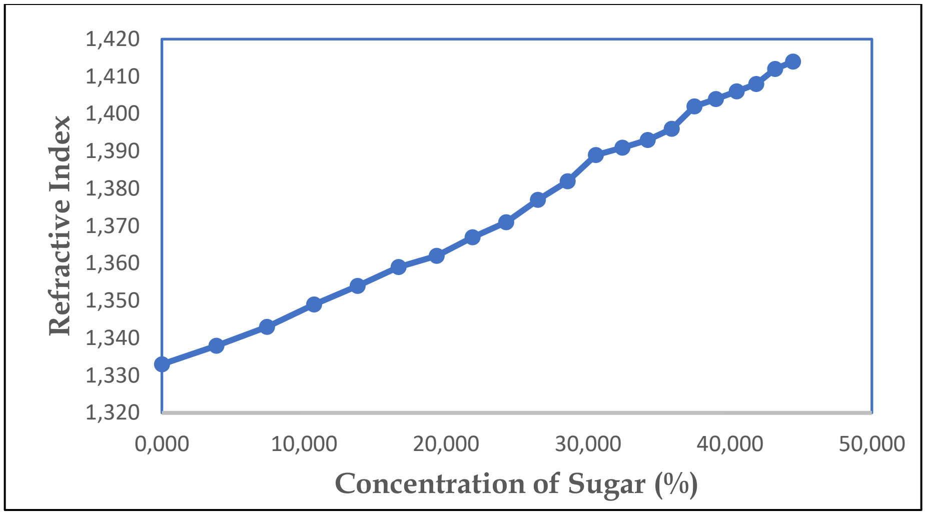


Figure 2: Graph of the relationship between concentration levels in sugar solution and refractive index.

Then, the change of refractive index results obtained can use to determine the wavelength of light that propagates in the water medium. Based on the research result, the increase of refractive index in a sugar solution can cause a decrease in the wavelength of light that propagates in the sugar solution, as shown in Figure 3.

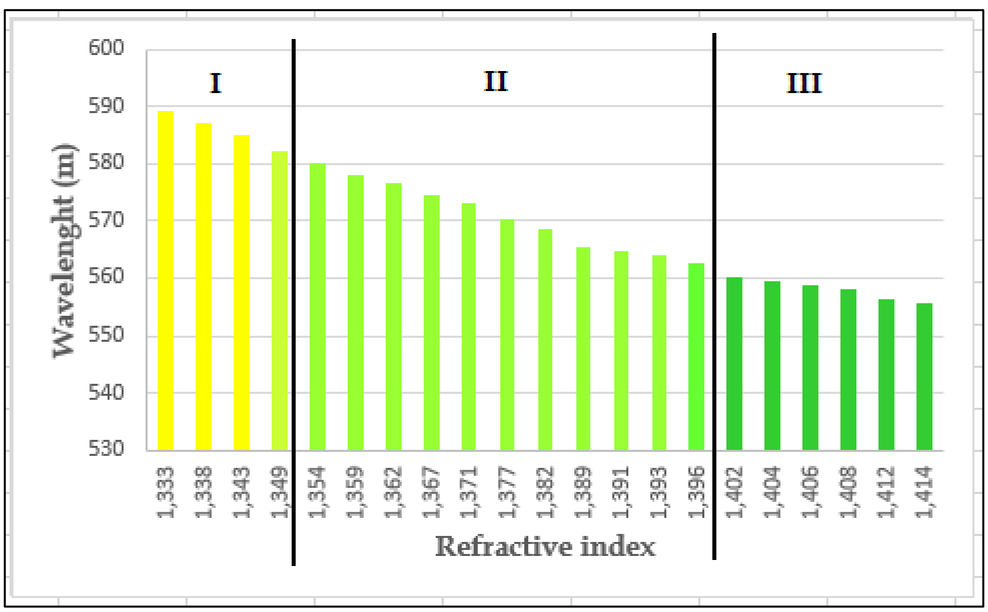


Figure 3: Graph of the relationship between the refractive index and the wavelength of light that propagates in a sugar solution.

The reference results (*Basset, 1994*) show that three wavelength regions are in the results of this study. Region I have a yellow light wavelength of 589.29 nm - 582.30 nm, region II has a yellow-green light wavelength of 580.15 nm - 562.70 nm, and region III has a yellow-green light wavelength of 560.29 nm - 555.53 nm.

4 CONCLUSION

Based on the research result, the refractive index of water increases when the sugar concentration in water increases. However, the increased refractive index in a sugar solution can cause a decrease in the wavelength of light that propagates in the sugar solution. It can produce three wavelength regions of light.

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