

A STUDY OF THE PHYSICAL AND OPTICAL PROPERTIES OF PINK GLASSES MADE FROM SUGARCANE LEAVES IN NAKHON PATHOM PROVINCE

Pornnapha Mangthong^{1,2}, Pattraporn Saengka^{1,2}, and Nattapon Srisittipokakun^{1,2*}

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Abstract

This research aims to study of the physical and optical properties of pink glasses made from sugarcane leaves in Nakhon Pathom Province. Sugarcane leaves were subjected to baking at temperatures of 1000°C. It was observed that as the SiO₂ content increased, the color of the glass changed. The glass formula was designed according to the ratio of (40-x) SiO₂: 20B₂O₃: 25Na₂O: 15CaO: xEr₂O₃ mol%, where x represents the concentration of Er₂O₃ in the glass. The ground mixture was melted in a porcelain crucible at a temperature of 1,200°C in an electric furnace for 3 hours under normal atmospheric conditions. Subsequently, the homogeneous melts were formed and quenched into a preheated graphite mold, followed by immediate annealing at 500°C. The glass was then slowly cooled to room temperature. Afterward, the colored glass samples were analyzed, revealing that the density and refractive index of the glass samples ranged from 2.6060 to 2.7548 g/cm³ and 1.5465 to 1.5664, respectively. All glass samples exhibited a hardness value of 5.5 on the Mohs scale.

Keywords: Nakhon Pathom Province; Optical Properties; Physical Properties; Pink Glasses; Sugarcane Leaves

Introduction

Nowadays, when talking about sugarcane leaves, Growers or farmers often see it as a symbol of wealth. Sugarcane is a worldwide crop cultivated in 105 countries. From its very origin in earlier times to its present-day production sugarcane has played its role in improving the socio-economic conditions

of human society and the abundance of land sources allows farmers to have a lot of income. Sugarcane leaves are an important part that has a variety of uses in daily life and various industries (Plangklang *et al.*, 2012; Malik, 2016). From food to living to use in the production of alternative materials and

¹ Physics Program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, 7300, Thailand. E-mail: Pmangthong@hotmail.com; pattraporn02542@gmail.com; Nattapon@webmail.npru.ac.th*

² Center of Excellence in Glass Technology and Materials Science (CEGM), Nakhon Pathom Rajabhat University, Nakhon Pathom 73000, Thailand.

* Corresponding author

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plastics and to use in industries related to agriculture and beverages but sugarcane leaves are not only a symbol of wealth. Assemble rice baking or even the life and culture of the villagers who live near the sugar cane fields. The uses of sugarcane leaves are diverse and can add value in many industries, such as the food and beverage industry. It's possible the sentence was a misunderstanding, or perhaps referred to some experimental process that isn't widely used. In general, sugarcane juice comes from the stalks, and the leaves are used for other purposes, such as animal fodder or biofuel production. Sugarcane leaves are also used as an ingredient in other foods and beverages, such as sugarcane syrup. To add flavor to various beverages, cosmetics, and health care industries, sugarcane leaf extracts are used in the production of cosmetics or facial and body care products such as lotions, creams, or skin care products containing leaf extracts. Sugarcane leaves are also used in other industries. Related to agriculture, such as being used in the production of animal feed or as an ingredient in animal feed to increase nutritional value, the use of sugarcane leaves is diverse and can create added value in many different industries. This allows the use of agricultural materials to grow and increase value in production and various industries efficiently. As in the research that is being done, there is talk of adding value. It can be developed into materials or products that reflect local identity. It will help resolve the environmental problems mentioned above. It also helps increase careers and income for people in the community with scientific and technological knowledge (Amaral *et al.*, 2013; Khempila *et al.*, 2022).

The color of the glass can be changed by adding different transition metal oxides during the melting process. These oxides react with the silica in the glass to produce a variety of colors. For instance, adding iron oxide (Fe_2O_3) can result in a green or brown color, while chromium oxide (Cr_2O_3) can produce a green color. Manganese dioxide (MnO_2) can create a purple color, and titanium dioxide (TiO_2) can result in a white color. Cobalt oxide (CoO) can produce a deep blue color, and copper oxide (CuO) can result in a blue, green, or red color depending on the other elements present. The amount and type of oxide added will determine the final color of the glass. This technique is commonly used in the production of decorative items like gems and jewelry due to its cost-effectiveness and the relative ease of the process (Terczynska-Madej *et al.*, 2010).

This research involves using leftover sugarcane leaves used in Nakhon Pathom Province to develop colored glass. This will bring sugarcane leaves of known quality and quantity to study the

process of preparing them as glass material. The glass formula will be designed. Find suitable conditions for preparation and study related scientific properties, including density, refractive index, light absorption, color values in the CIE $L^*a^*b^*$ system, and light emissivity (Gaafar and Marzouk, 2007). Once the appropriate formula for preparing glass from sugarcane leaves is obtained, it will be developed into various colored glasses whose quality can be controlled. All glasses are prepared from raw materials, which are sugarcane leaves leftover from the agricultural sector in Nakhon Pathom Province. To increase the value of sugarcane leaf waste, create income, and help reduce the environmental impact of diffusing into the air.

Experimental

This paper used sugarcane leaves are the primary component, used sugarcane leaves in Nakhon Pathom to have the exact composition depending on the desired properties of the glass shown in Figure 1. and preparation the sugarcane leaves need to be thoroughly dried to remove moisture. The sugarcane leaves are burned in a controlled environment at high temperatures (around 400, 600, 800, and $1,000^\circ\text{C}$). This process combusts the organic material in the sugarcane leaves, leaving behind ash rich in silica burned in Figure 2. Glass samples were melted quenching, and glass samples with the formula as seen in Figure 3. $(40-x) \text{SiO}_2$ (use sugarcane leaves as SiO_2): $20\text{B}_2\text{O}_3$: $25\text{Na}_2\text{O}$: 15CaO : $x\text{Er}_2\text{O}_3$ (when $x = 0.0, 0.5, 1.0, 1.5, 2.0$, and $2.5 \text{ mol\%}$). The process that involves heating a substance at very high temperatures to bring about thermal decomposition of the mixture at $1,200$ degrees Celsius in a furnace could be a step to prepare the raw materials for melting and forming glass. Melting the calcined mixture in a porcelain crucible for 3 hours further helps to homogenize the materials and allow them to melt and combine thoroughly (Yalcin *et al.*, 2019). Pouring into a heated graphite mold, the homogenized melt was then poured into a mold made of heated graphite. Graphite molds are often used in high-temperature applications due to their resistance to heat and their ability to withstand molten materials without reacting chemically. Annealing at 500 degrees Celsius for 3 hours. The glass samples were cut to size of $1.0 \times 1.5 \times 0.3$ cubic centimeter. Density Measurement using Archimedes' Principle (A&D HR-200): Archimedes' principle involves measuring the density of an object by determining the buoyant force acting on it when submerged in a fluid. Refractive Index Measurement using an Abbe

Refractometer: The refractive index of the glass samples is determined using an Abbe refractometer (Atago), this measurement is conducted at a specific wavelength (589.3 nm). 1-bromonaphthalin (C₁₀H₇Br) is used as a contact liquid to ensure proper contact and accurate refractive index measurements. **Optical Absorption Spectra Analysis:** The optical absorption spectra of the glasses are recorded using a UV-VIS-NIR spectrophotometer (Shimadzu UV-3600). This analysis helps in understanding how the glass interacts with light over a range of wavelengths from 200 to 1000 nm, providing information about its transparency and absorbance characteristics. **Photoluminescence and Decay Time Measurements in NIR Region:** Measurements in the Near-Infrared (NIR) region is conducted using a PTI Quantum Master-300 instrument. This analysis involves studying the photoluminescence (light emitted after absorption of photons) and decay time of the emitted light in the NIR region, providing insights into the material's luminescent properties. **Color Coordinate Measurement** using CIE L*a*b* is a color space defined by the International Commission on Illumination (CIE) (Cary-Eclipse). Measurements in this space provide information about the perceived color characteristics of the glass samples, including attributes like lightness (L*), red - green (a*), and yellow - blue (b*) components.



Figure 1. Sugarcane leaves in Nakhon Pathom



Figure 2. Sugarcane leaves (burned)



Figure 3. Er₂O₃ doped glasses

Results

The researcher studied the effect of temperature on the state change of sugarcane leaves to find the appropriate temperature for preparing sugarcane leaves before using them in glass development. It will be Annealing at temperatures of 400, 600, 800, and 1,000 degrees Celsius for 10 hours, the same temperature for every temperature. Then it was analyzed for chemical composition. The results of the analysis are shown in Table 1 from the study of the effect of temperature on sugarcane leaves state change. It was found that when sugarcane leaves were burned at a higher temperature, the silicon ratio increased. This is due to the loss of carbon components during the annealing process. Firing at a temperature of 1,000 degrees Celsius will increase the ratio of silicon compared to before firing. It can be concluded that the firing temperature affects the compositional properties. Therefore, the researcher will select samples of sugarcane leaves that have been annealing at a temperature of 1,000 degrees Celsius, focusing mainly on silicon. Let's continue research to develop the glass formula.

Table 1. Composition of sugarcane leaves annealed at 400, 600, 800, and 1,000°C

Compound	Raw	400°C	600°C	800°C	1000°C
MgO	2.00	2.13	2.28	2.30	2.36
SiO ₂	69.60	69.74	69.82	69.89	69.93
P ₂ O ₅	2.15	2.08	2.03	2.20	2.31
SO ₃	2.64	2.52	3.13	3.54	2.44
K ₂ O	4.43	4.38	4.40	3.20	1.72
CaO	17.06	17.15	16.42	16.38	18.57
TiO ₂	0.07	0.06	0.06	0.11	0.09
MnO	0.08	0.08	0.08	0.09	0.10
Fe ₂ O ₃	0.54	0.48	0.44	0.54	0.73
CuO	0.02	0.02	0.02	0.03	0.04
ZnO	0.01	0.01	0.01	0.02	0.02
Al ₂ O ₃	1.40	1.35	1.33	1.70	1.70
Total	100.00	100.00	100.00	100.00	100.00

The analysis of the physical property (density, molar volume value, and refractive index) of glass obtained from sugarcane leaves doped with Er₂O₃ at concentrations of 0.0, 0.5, 1.0, 1.5, 2.0, and 2.5 mol%. It was found that the density, molar volume, and refractive index tend to increase as the concentration of Er₂O₃ increases (Effendy *et al.*, 2017). As shown in Figure 4, this is because the oxide of Er₂O₃ (151.99 grams/mol), which has a

higher molecular mass, replaces the oxide of sugarcane leaves (69.93 grams/mol). The molar volume value tends to increase as the concentration of Er_2O_3 increases (Punj and Singh, 2019). A glass modifier produces many oxygens that are not bridging (NBO), to oxygen atoms within the glass structure that are not part of the bridging network between different network-forming atoms. These non-bridging oxygens (NBOs) occur when an oxygen atom is bonded to only one network-forming atom instead of being shared between two, creating structural defects or variations in the glass network (Jiang, 2002; Gaafar and Marzouk, 2007). As a result, the molar volume of the glass sample increases. From the results of the analysis, it was found that the refractive index increases as the concentration of Er_2O_3 increases. It has the same characteristics as the density-value relationship. Generally, materials with higher densities tend to have higher refractive indices. This relationship arises due to the higher number of atoms or molecules present in a denser material, leading to stronger interactions with light. When the polarity of an atom changes, it results in a change in the refractive index. In general, atoms with higher polarity increase their refractive index. On the other hand, atoms with low polarity have a lower refractive index (Pradeesh *et al.*, 2008).

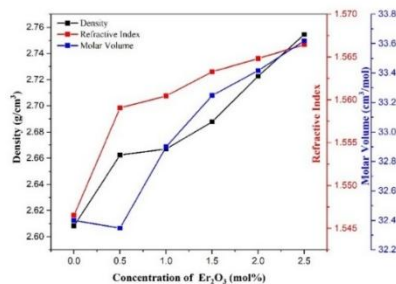


Figure 4. The physical property of glass from sugarcane leaves doped with Er_2O_3 at concentrations

The absorbance value in the wavelength range (200 - 2000 nm), showing the absorbance spectrum at room temperature. It was found that the intensity of the absorption peak increased with increasing amounts of Er_2O_3 . It shows an absorption peak at a wavelength of approximately 379, 407, 451, 489, 521, 546, 652, 806, 980, and 1542 nm, corresponding to $^4\text{I}_{15/2} \rightarrow ^4\text{G}_{11/2}$, $^2\text{G}_{9/2}$, $^4\text{F}_{3/2, 5/2}$, $^2\text{H}_{11/2}$, $^4\text{S}_{3/2}$, $^4\text{F}_{9/2}$, and $^4\text{I}_{9/2, 11/2, 13/2}$ transitions of Er^{3+} ions, respectively. As shown in Figure 5. The emission spectra in the Near-Infrared (NIR) region, specifically between 1450 and 1650 nm, were observed under an excitation wavelength of 521 nm. Additionally, it's noted that the intensity of

the glass sample exhibited a higher emission intensity in this region. ($^4\text{I}_{13/2} \rightarrow ^4\text{I}_{15/2}$) (Nikonorov *et al.*, 1999) (Figure 6).

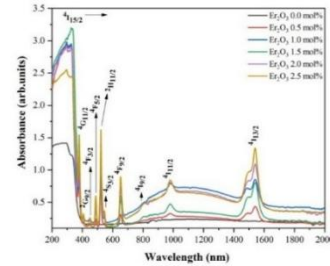


Figure 5. Absorption spectra of glass from sugarcane leaves doped with concentrations of Er_2O_3

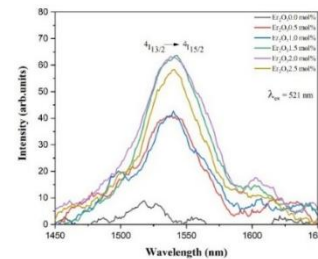


Figure 6. The NIR spectra glass from sugarcane leaves doped with concentrations of Er_2O_3

Color Coordinate Measurement using CIE $L^*a^*b^*$ is a color space defined by the International Commission on Illumination (CIE). Measurements in this space provide information about the perceived color characteristics of the glass samples, including attributes like lightness (L^*), red - green (a^*), and yellow - blue (b^*) components. The glass sample's luminance ranges from 20.87 to 92.61, with lightness among the glass samples. The a^* and $-a^*$ values represent the position on the red-green axis. Positive a^* values indicate the presence of red hues, while negative values represent greenish hues. glass samples show a^* values ranging from 19.10 to -1.39, implying a tendency towards red (positive values) and green (negative values) colors. b^* and $-b^*$ (yellow-blue axis), Similarly, the $+b$ and $-b$ values indicate the position on the yellow-blue axis. Positive b^* values represent yellows, while negative values suggest blue tones. Your glass samples exhibit $-b^*$ values ranging from -3.02 to 3.27, indicating the presence of blue tones in the color. The information suggests that with an increase in the concentration of Erbium ions (Er^{3+}) in the glass, there is a trend toward a color shift towards pink. Er_2O_3 absorbs specific wavelengths of light, particularly in the blue and ultraviolet (UV) regions. The extent of this absorption depends on the concentration of Er_2O_3 present in the glass. With increasing Er_2O_3 content,

bluer and UV light is absorbed. This translates to a decrease in the intensity of transmitted light in these wavelengths. This change is indicated by alterations in the a^* and b^* values, which move towards values associated with pink hues higher positive a^* (indicative of red) and potentially lower negative b^* (reducing blue tones), as shown in Figure 7 (Ohno, 2000; Khan *et al.*, 2009).

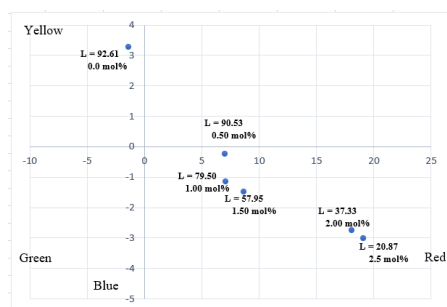


Figure 7. CIE L*a*b* of Er₂O₃ glasses

Conclusions

This research conducted experiments to study the effect of erbium glass dye obtained from sugarcane leaves in Nakhon Pathom Province. It will be developed into colored glass that can control quality and be applied to the jewelry industry. It was found that it increased with the concentration of Er₂O₃ from density analysis. Molar volume and the refractive index tend to increase as the amount of Er₂O₃ increases. Light absorption value of glass in the wavelength range of 200 to 2000 nm, absorption transitions, especially the $^4I_{15/2} \rightarrow ^2H_{11/2}$ (521 nm) transition, were found to exhibit the strongest intensity. The NIR transition $^4I_{13/2} \rightarrow ^4I_{15/2}$ of Er³⁺ ion is the most effective in increasing laser emission efficiency at various concentrations. Color analysis in the CIE L*a*b* system found that the color trend of the resulting glass ranges from light yellow and increases along the a^* axis in the direction of pink.

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