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THE EFFECT OF IMPREGNATION TREATMENT WITH MEG AND PEG ON THE COLOR OF SOLOMON TEAK WOOD

Pengaruh Perlakuan Impregnasi dengan MEG dan PEG Terhadap Warna Kayu Jati Solomon

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ABSTRACT

The color of wood is an important indicator that can be used for assessing the quality of wood, particularly for decorative product applications. This research aims to analyze the results of color changes in Solomon teak wood with impregnation modification (0.5 bar of vacuum for 60 minutes and 2.5 bar pressure for 120 minutes) using the impregnants monoethylene glycol (MEG) and polyethylene glycol (PEG). The Solomon teak wood used measures 2 cm x 5 cm x 10 cm, with a total of five repeated samples. The research results indicate that the treatment with PEG resulted in greater changes in brightness and color compared to aquades and MEG. The effect of impregnation with PEG and MEG on color change falls into the large category, while the category for wood impregnated with aquades is moderate.

Keywords: Impregnation; MEG; PEG; solomon teak wood*;* wood color

ABSTRAK

Warna kayu merupakan salah satu indikator penting yang dapat digunakan dalam menilai kualitas kayu, khususnya untuk pemakaian produk secara dekoratif. Penelitian ini bertujuan untuk menganalisis hasil perubahan warna kayu Jati Solomon dengan modifikasi impregnasi (vakum 0.5 bar selama 60 menit dan tekan 2.5 bar selama 120 menit) menggunakan impregnan Monoethylene glycol (MEG) dan Polyethylene glycol (PEG). Kayu jati Solomon yang digunakan berukuran 2 cm x 5 cm x 10 cm sebanyak lima sampel ulangan. Hasil penelitian menunjukkan bahwa perlakuan PEG mengakibatkan perubahan kecerahan dan perubahan warna yang lebih besar dari pada aquades dan MEG. Pengaruh impregnasi dengan PEG dan MEG terhadap perubahan warna termasuk kategori besar, sedangkan kategori sedang pada kayu impregnasi dengan aquades.

Kata kunci: Impregnasi; jati solomon; MEG; PEG; warna kayu

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A. INTRODUCTION

Solomon teak is a fast-growing teak wood widely developed in the Solomon Islands, east of Papua New Guinea. Its leaf's characteristics are not too broad but thick and robust. It grows straight up. The leaf pairs are matched, bluish-green. The stem is upright, prominent, round, disease resistant, overgrows, and has little branching. The top of the stem is strong and rarely broken by storms or pests so that the plant can grow ideally (Maskuro 2012). Solomon teak sapwood is yellowish white, and the heartwood is non-dark brown, making it very easy to distinguish. Wood color is one of the essential indicators that can be used in assessing wood quality, especially for decorative product use. The function of wood color can be improved by modifying the wood.

Wood modification is a treatment to change wood to overcome or improve one or more wood deficiencies (Hill 2006). Wood modification aims to improve resistance to changes in environmental moisture content, wood decay organisms, weather, wood color, etc. Some methods to modify wood properties include impregnation, furfurylation, acetylation, and polymerization. Impregnation is filling wood cell cavities with chemicals (impregnants). Impregnation can increase the density and hardness and change the color of wood. One way of impregnation is the vacuum press method. The vacuum press method can cause penetration in wood because the pressure causes the air in the lumen to be replaced by chemical liquids (Archer & Lebow 2006). Based on the literature study that has been conducted, there is very little information on impregnation using Monoethylene Glycol (MEG) and Polyethylene Glycol (PEG) as impregnant materials in the impregnation method, which specifically aims to determine the color change of Solomon teak wood.

PEG is a polymer often used in various industries (food, cosmetics, pharmaceuticals etc.). PEG is a group of synthetic polymers that are readily soluble in water and have the main properties of being stable, evenly distributed, volatile, able to bind pigments, etc. (Gao 1993). PEG has wax-like characteristics that resemble paraffin, is solid at room temperature and can melt at 104^0 F, has an average molecular weight of 1000, is easily soluble in warm water, non-toxic, non-corrosive, odorless, colorless, and has a very high melting point (580^oF). The properties of PEG in wood are said to be a barrier (bulking agent) against the entry and exit of water in wood (Meints 2018). PEG is commonly used as a drug solvent, glass or metal coating, as a mixture of paints and inks, for cosmetics, toiletries, rubber, leather, and textile materials, and in the paper and home furnishing industries.

The characteristics of MEG are entirely soluble in water, colorless, liquid with a sweet taste but odorless, molecular weight of 62.07 g/mol, and low volatility (Eisenreich *et al.* 1981; ATSDR 1997). In addition, MEG is hygroscopic and absorbs twice its weight in water at 100% relative humidity (Budavari, 1989). Based on its perfectly soluble characteristics in water and at a relatively cheap price, MEG and PEG can be chosen as impregnants. Therefore, this research focuses on analyzing the color change of Solomon teak wood by using MEG and PEG solutions in impregnation technology. The expected impact of this research is providing helpful information for the wood processing industry and craftsmen, as well as general readers interested in innovations in utilizing natural resources. By understanding the effects of MEG and PEG solutions, this research is expected to encourage the development of more efficient and environmentally friendly impregnation techniques. In addition, the results of this study can also be a reference for further research in the field of wood materials, especially in improving the visual appeal and resistance of wood to environmental factors.

B. METHODS

Materials and Tools

The materials used in this study were Solomon teak wood from Bogor, West Java, aged 13 years, with a tree diameter of 25 cm, distilled water, MEG, and PEG. The tools used in this research are an impregnation tube, oven, aluminum foil, CanoScan 4400 F, and desiccator.

Procedures

1. Wood Preparation

The Solomon teak wood used was taken from the heartwood section. Cutting Solomon teak wood samples using parts cut down from a height of 2 m from the base of the trunk. The size of the Solomon teak wood test sample used is 2 cm x 5 cm x 10 cm for wood color testing. A total of 5 replications were made for each treatment.

2. Impregnants Preparation

The composition of the mixture of MEG and PEG solution as treatment refers to the research of Dirna *et al.* (2020), which can be seen in Table 1.

Table 1. Composition of MEG and PEG solution mixture as treatment

Treatment	MEG (mL)	PEG (mL)	Water (mL)
Control	0	0	1400
MEG	700	0	700
PEG	0	700	700

3. Preparation of Impregnation Solution

The impregnation process with MEG and PEG solutions was carried out in stages, as shown in Figure 1. The stages of this process were adapted from Dirna *et al.* (2020), which impregnated jabon wood using MEG and nano SiO_2.

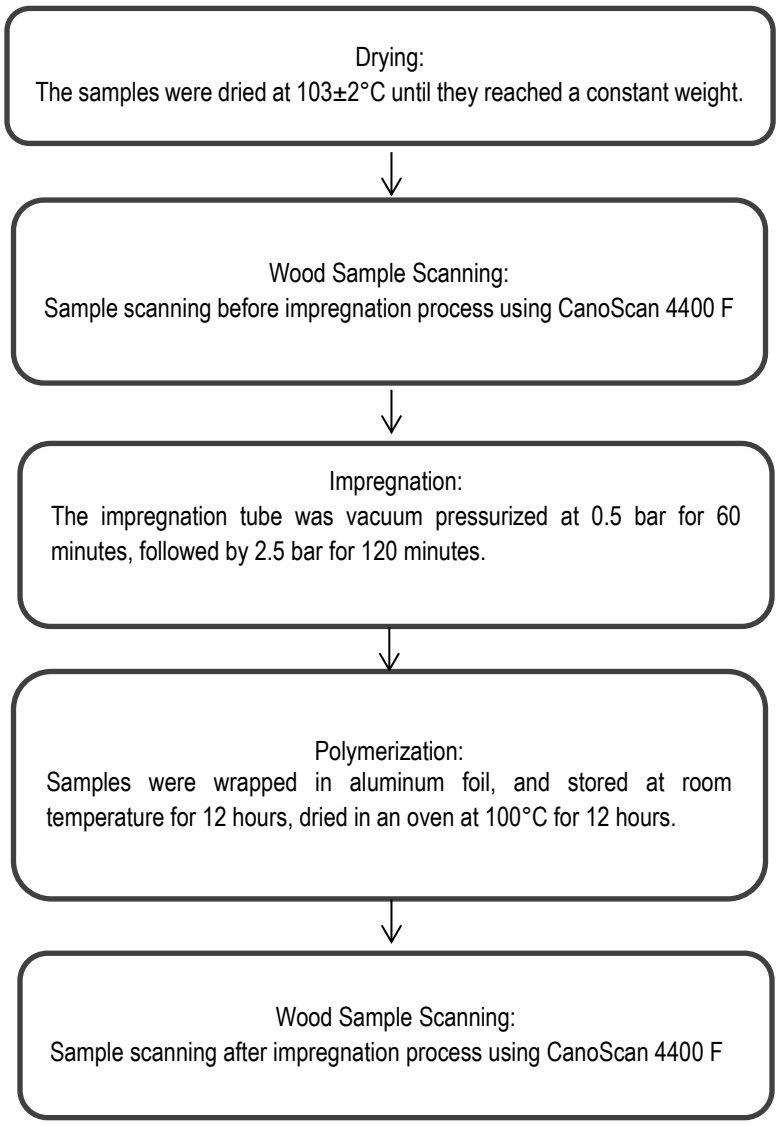

Figure 1. Impregnation process using MEG and PEG

4. Observation and Data Collection

The wood color differences were measured and analyzed by determining L*, a*, and b* using CanoScan 4400 F, an image processing scanner connected to a laptop as data storage and processed with Image J software. The wood test samples were scanned first with a scanner. Each sample image was taken from 5 marked points to obtain the L*, a*, and b* values. L*, a*, and b* values were taken at the same point before and after impregnation treatment. The color difference (ΔE) as shown in Table 2 was calculated according to the CIELab method (Christie 2007) with the following formula.

$$AE = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Where, ΔE = Color difference, ΔL* = Brightness difference = (L* before impregnation - L* after impregnation), Δa* = Red or green difference = (a* before impregnation - a* after impregnation), and Δb* = Yellow or blue difference = (b* before impregnation - b* after impregnation)

Table 2. Effect of different values of ΔE (Christie 2007)

Color difference (ΔE)	Influence
< 0.2	Not visible
0.2 - 1.0	Very small
1.0 - 3.0	Small
3.0 - 6.0	Medium
> 6.0	Great

Data Analysis

Data analysis was evaluated using ANNOVA, then followed by Duncan's test at a confidence level of 5%. Tests were conducted using the IBM SPSS Statistics calculation program version 23.0. The equation model used is as follows:

$$Yij = \mu + \tau i + \varepsilon ij$$

Where, Yij was the response or observation value of the i-th impregnation treatment (control, MEG, PEG) and j-th replication, μ was the generalized mean value, τi was the effect of i-th treatment (control, MEG, PEG), and εij was the effect of experimental error of the i-th treatment (control, MEG, PEG).

C. RESULTS AND DISCUSSION

Color is one of the essential parameters, especially in assessing the quality of wood for the use of decorative-based products. Impregnation treatment with various materials resulted in color changes in Solomon Teak wood. Color changes were identified using the CIELab method by Christie (2007). Based on Figure 2, it shows a decrease in the level of brightness (L*) of wood due to treatment. Changes in the L* value indicate changes in the brightness of the wood color. The L* value of Solomon teak wood decreased along with the change of materials used successively from control, MEG, and PEG. The higher the L* value, the higher the brightness. Otherwise, the lower the L* value, the darker the color. The changes in the color components of Solomon teak wood after impregnation with various materials can be seen in Figure 2.

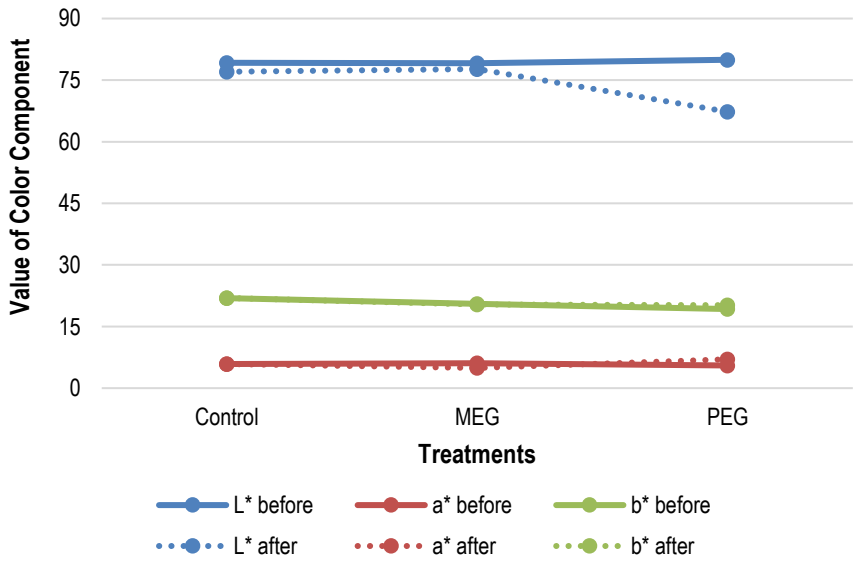

Figure 2. Changes in color components (L*, a*, and b*) of Solomon Teak wood after impregnation with various materials

In addition to L* values, the measured color component change values are a* and b*. Table 3 shows that the a* value reaches the maximum value in PEG-impregnated wood, and the b* value reaches the maximum value in control-impregnated wood. This explains that the wood color has an additional red or green color due to using a PEG solution. The more significant the change in L*, a*, and b* values, the darker the color of the wood. The changes in each color component value of Solomon teak wood after impregnation can be seen in Table 3.

Table 3. Color component value of Solomon Teak wood after impregnation with various materials

Color Components	Control		MEG		PEG	
	Before	After	Before	After	Before	After
L*	79.19	77.06	79.12	77.70	79.96	67.30
a*	5.87	5.89	6.07	4.91	5.52	7.03
b*	21.91	21.95	20.55	20.36	19.26	20.20
ΔE		3.76^{a}		6.24^{b}		14.65^{c}

Notes: Superscripted letters in the table indicate a significant difference ($\alpha = 0.05$)

Table 3 shows that the change in wood color occurs significantly due to impregnation treatment with PEG material. This can be seen from the total value of color change (ΔE). The analysis of variance showed that impregnation treatment with PEG had a significant effect ($P<0.05$) on the total value of discoloration of Solomon teak wood. The value of ΔE increases along with the addition of MEG and PEG as impregnant when the impregnation process is carried out. The color of Solomon teak wood became darker due to the use of PEG. The results showed that the color change of Solomon teak wood was in the large category in impregnation using PEG and MEG, while the control was in the medium category.

Figure 3 shows that the color of Solomon teak wood becomes darker after impregnation with PEG. This is caused by the impregnation process, which causes the impregnants (PEG and MEG) to enter the cavities and microvoids in the wood tissue. The impregnants are thought to be chemically bonded and at the same time react with the chemical components of the wood. This follows the results of research by Hill (2006) who said that impregnating wood with polymers can cause the polymer to penetrate and enter the cavities and microvoids in the wood. The chemical component of Solomon teak wood is tannin. Tannins can react with polymers to affect the final appearance color of the wood.

Figure 3. Color appearance of Solomon Teak wood after impregnation with aquades (top), PEG (middle), and MEG (bottom)

In this study, the results of impregnation with PEG were 3 times darker than those of MEG impregnation. This result is thought to be because PEG has a better attachment to the chemical components of Solomon teak wood. This follows Xie (2021), who explained that PEG has a high affinity for tannins, which can affect the color of the wood due to the impregnation process. Furthermore, Jones (1965) also proved that tannins and PEG can bind well in situ. So, the characteristics of PEG as an impregnant in this study significantly affect the final result of the appearance of Solomon teak wood color due to the impregnation process.

D. CONCLUSION

Based on the results of the color change of Solomon teak wood due to MEG and PEG impregnation treatment through the vacuum press method that has been given, the following conclusions can be drawn.

1. Solomon's teak wood impregnated with PEG resulted in greater changes in brightness and color than distilled water and MEG.
2. Impregnation with PEG resulted in Solomon's Teak being 3 times and 2 times darker than impregnation with distilled water and MEG.
3. The effect of impregnation with PEG and MEG on color change is in the large category, while the medium category is in impregnated wood with distilled water.

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