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THE EFFECT OF PAINT VISCOSITY ON THE WETTING PROPERTIES OF RAJUMAS WOOD (*Duabanga moluccana* Blume)

The Effect of Paint Viscosity on the Wettabillity of Rajumas Wood (Duabanga moluccana Blume)

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ABSTRACT

Rajumas wood is one of the local wood forest products from West Nusa Tenggara and has low strength and durability. Finishing treatment is needed for the service life of wood. One of the indicators of finishing quality is the ability of paint liquid wetting on the wood surface (wettability). This research aims to analyze the effect of paint viscosity on the wettability of rajumas wood. The samples used were radial and tangential sections in air-dry condition, and the wood surfaces were sanded with abrasive paper of 150 grit. The value of viscosities was 2.44, 2.41, and 2.32 poise from each percentage of paint and water ratio of 90%:10%, 80%:20%, and 70%:30%. Wettability was determined based on the rate of change equilibrium contact angle using the S/G equation. The research results show that the low viscosity value of Aqua Politur produces the lowest equilibrium value and highest wettability value (K-Value) in both radial and tangential sections. A high K-value indicates that Aqua Politur's ability to wet the wood surface is better, as shown by the paint percentage ratio of 70%:30%.

Keywords: Contact angle; paint viscosity; rajumas wood; sessile drop; wettability

A. INTRODUCTION

Rajumas wood (*Duabanga moluccana* Blume) is one of the local wood forest products originating from West Nusa Tenggara Province and is included in *the fast-growing tree species.* The advantages of using local wood are certainly good based on ecological, economic, and social aspects (Rofaida *et al.,* 2014). Apart from that, there is a trend in using raw materials for wood products that come from fast-growing tree species that have great potential to be cultivated in nature because of their fast growth rate, abundant availability, high productivity, and use for various needs (Alamsyah *et al.*, 2007). People in West Nusa Tenggara Province generally cultivate rajumas wood because this wood is one of the primary sources in the sawmill and woodworking industry, which can be used to make furniture, wood, building construction materials, and household equipment (Lestari, 2020).

However, rajumas wood is included in the class IV-V category for each class of strength and durability of wood (Bonita, 2015). It means that rajumas wood is classified as wood with low strength and durability against attacks by fungi, termites, and dry wood powder (Oey, 1990 *cit.* Muslich, 2016). Therefore, one effort to increase the strength and durability of wood is to provide finishing treatment on the wood to provide protection and appearance (Darmawan *et al.,* 2017).

Wood that has been given a final coating will have durability and quality that can increase the wood's aesthetic value and service life (Safitri, 2016). The things that must be considered in choosing finishing materials include appearance, protection, and properties affecting wooden surfaces in the application and performance of the finishing materials (Williams, 2010). Finishing properties can be influenced by three main factors: the surface of the wood, wood products, and the weather after applying the finishing materials used (Williams, 2010). One use of finishing materials is wood paint, which is a liquid for coating the surface of a material to beautify, protect, and increase the dimensional stabilization of the material (Darmawan *et al.*, 2011). Paint solvents are divided into two types, namely oil soluble and water soluble. However, water-soluble paint is quite popular because it is environmentally friendly. Additionally, Volatile Organic compounds (VOC) produced by water-soluble paint are small. So, when the drying process takes place, it won't pollute the air in the environment (Fawzi, 2016).

One indicator of getting good finishing quality is the ease with which a liquid wets its surface (wettability) (Gray, 1962). Wetability is the ability of a fluid to spread and penetrate a material surface. The wettability of wood can be obtained by measuring the angle contact between fluid and wood surface. If the contact angle is smaller than 90 ^{o,} it means good wettability, whereas if the contact angle is more significant than 90 ^{o,} it means the wettability is not good. It is because the liquid does not wet the surface well (Yuan and Lee, 2013). Wettability is influenced by several factors, such as adhesive (surface tension, temperature,

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viscosity), wood (density, porosity, extractive substances), cleanliness of the wood surface, and machine condition (Tsoumis, 1991).

Many fluid and wood factors influence wettability when using water and adhesive, but very limited If using paint. Based on Lestari (2020), the value of the contact angle in the radial section is higher than in the tangential section. However, the two wood cross-sections showed no significant differences between the wood cross-section patterns. Safitri Research (2016) informs that the lower the viscosity of the coating material, the better the wettability of the wood surface. It indicates that the paint material's viscosity is expected to influence wettability. Therefore, research needs to be done on the effect of paint viscosity on the wettability of rajumas wood.

B. METHODS

The test samples used commercial rajumas wood from Masbagik, East Lombok (-9 º 22' 1.55", 116 º 29' 5.92"). The types of boards used are radial and tangential, then cut using 54 circular saws with dimensions of 20 cm x 12 cm x 2 cm. Test samples were dried in an open space for 14 days and continued with kiln drying using an oven at 103 ± 2 ºC for 24 hours. The test samples were sanded using wood sandpaper number 150. The paint used was water-soluble, namely Propane Aqua Politur AQP-630, with a ratio of 90 %: 10 % (V1), 80 % diluted paint and water, respectively. :20 % (V2), and 70 % :30 % (V3). So, each viscosity value is 2. 44 poises, 2. 41 poises, and 2. 32 poises.

Determination of wettability is carried out using the sessile drop method to measure the contact angle between the paint and the wood surface, which is placed on a flat table (Figure 1). Next, the paint is dripped by a syringe onto the wooden surface with a drop volume of Aqua Polish as much as 0. 2 ml. Then, the drops were carried out three times on each test sample. The drip results were recorded for 3 minutes using a digital camera parallel to the wooden surface via the *MaxSee application.* Next, the video recording was cut every 10 seconds using GOM *Player,* and then the contact angle formed in each image was measured using Motic Image Plus (MIP) version 2.0 (Figure 1).

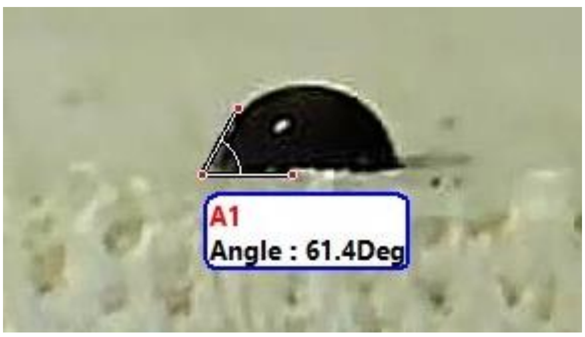

Figure 1. Measurement of the contact angle when liquid penetrates the wood surface

The constant contact angle value is obtained based on segmented-regression to determine the contact angle value formed between time (x) and contact angle (y) by looking at the change in contact angle during the wetting process, as shown in the two functions (Figure 2).

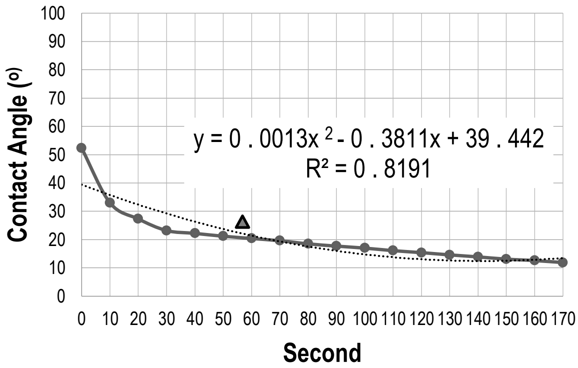

Figure 2. Determination of static contact angle values based on changes in time in the radial plane of rajumas wood

The first function is the steep slope (quadratic) of the curve since the first second of the spread and penetration of a liquid. Then, the second function is a constant slope (plateau) of the curve so that it can be seen that the contact angle is constant. So, the form of the regression model used for these two functions, namely a quadratic model with a plateau and the transition point between the two functions, can be obtained using the non-linear least squares model in the PROC NLIN program from SAS (Darmawan *et al.*, 2018).

According to Lestari (2020), the segmented regression formula equation is:

$$Y = a + bX + cX2 + E \quad (1)$$

Where X is time, Y is the contact angle, E is the error, and a, b, c are constants.

After the static contact angle value (θ_e) is obtained, then determine the K parameter using the XLSTAT 2007 program to obtain the wettability value using the S/G model equation (Shi and Gardner, 2001) :

$$\theta = \frac{\theta_i . \theta_e}{\theta_i + (\theta_i - \theta_e) \exp\left[K\left(\frac{\theta_e}{\theta_i - \theta_e}\right)t\right]} \quad (2)$$

Where θ is the contact angle at a particular time, θ_i is the initial contact angle, θ_e is the *equilibrium* contact angle, K is the constant rate of change of the contact angle, and t is time.

The data obtained were then processed and analyzed based on a two-way analysis of variance and Duncan's advanced test at a significance level of 0.05.

C. RESULTS AND DISCUSSION

Wettability describes the ability of a liquid to spread and penetrate the wood surface, as seen through the K value. The wettability properties of wood influence the strength of the adhesive bond between the surface of the wood and the finishing material (Qin *et al.*, 2014). The method used to determine wettability, namely the sessile drop method by measuring the contact angle formed based on the thermodynamic properties between the liquid finishing material and the wood surface (Shi and Gardner, 2001). Then, the value obtained from the contact angle is used to determine the value of the parameter K, which shows the relationship between the wettability properties of the finishing material and the wood surface.

Contact Angle Measurement

Graph of changes in material contact angles *finishing Aqua Politur* at a percentage ratio of paint and water of 90%:10%, 80%:20%, and 70%:30% are presented sequentially in Figure 3-5. The results show that as time increases, the contact angle experiences changes in acceleration at the beginning of the drop. Then, the liquid will penetrate and spread until it reaches a constant contact angle at a specific time.

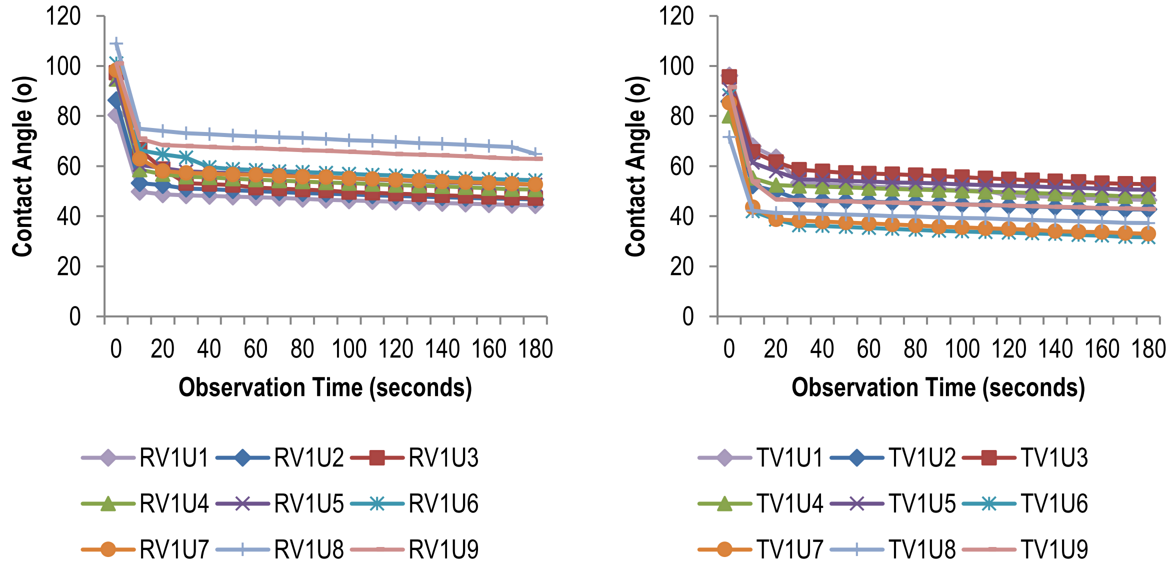

Figure 3. Changes in contact angle based on changes in time for the finishing material Aqua Politur at a percentage ratio of paint and water of 90%:10%

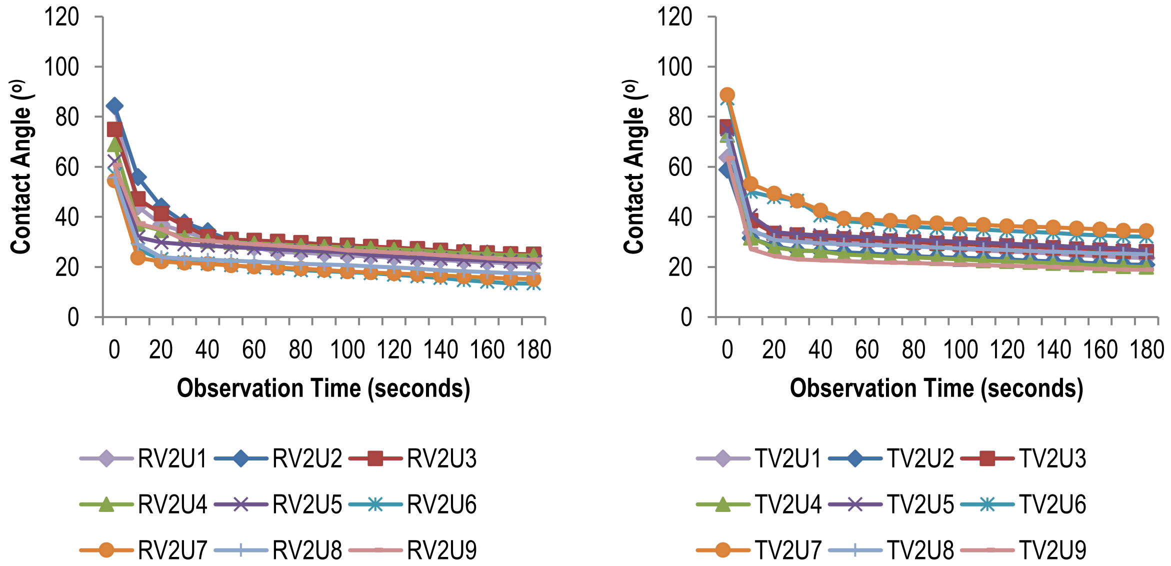

Figure 4. Changes in contact angle based on differences in time for Aqua Politur finishing material at a percentage ratio of paint and water of 80%:20%

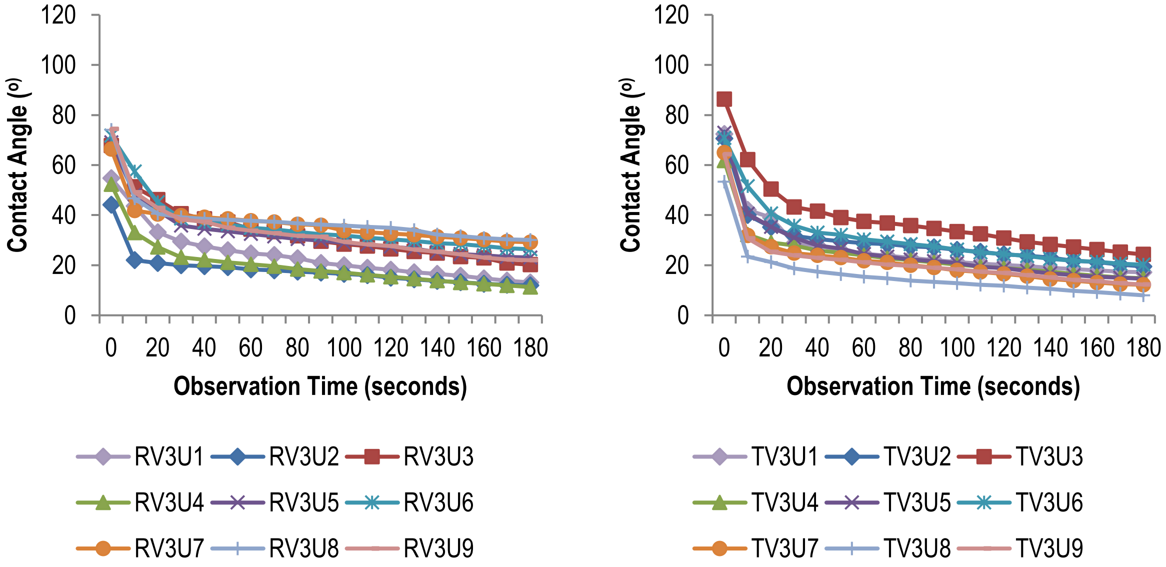

Figure 5. Changes in contact angle based on changes in time for the finishing material Aqua Politur at a percentage ratio of paint and water of 70%:30%

The results in Figure 3 show that the contact angle was higher (>90 °). It indicates that the viscosity value of the finishing material influences the wettability properties of wood, where a high viscosity value will also produce a high contact angle value so that the wettability properties of the wood will be lower. It follows what Ayrilmis et al. (2010) stated: the high value of the contact angle formed on the surface of the wood will be difficult to wet and have low hydrophilic properties. Gavrilovic-Grmusa et al. (2012) added that high viscosity values of finishing materials will result in common wettability values.

The results in Figure 6 show that the constant contact angle value for the Aqua Politur finishing material at a percentage ratio of paint and water of 90%:10% has a higher average constant contact angle value of 50. 71. It is suspected that the amount of water solvent added will reduce the viscosity value of the finishing material. Safitri (2016) states that finishing materials with a high viscosity value will produce a high constant contact angle value because the time required is slower to reach a constant contact angle when the layer of finishing material spreads and penetrates the wood. Apart from that, density is also thought to influence the absorption of paint solution on wood. Panshin and de Zeeuw (1970) stated that high wood density causes low absorption levels because wood with a high density has fewer water reservoirs. The average density value is 0. 279 g/cm $^{3.}$ According to Anoop and Pasha (2017), the classification of wood density in air-dry conditions is grouped into three classes, namely light wood (< 0.55 g /cm ^{3}), medium wood (0. 55-0. 75 g/cm 3), medium wood (0. 55-0. 75 g/cm ^{3}), and heavy wood (> 0. 75 g/cm ^{3}).

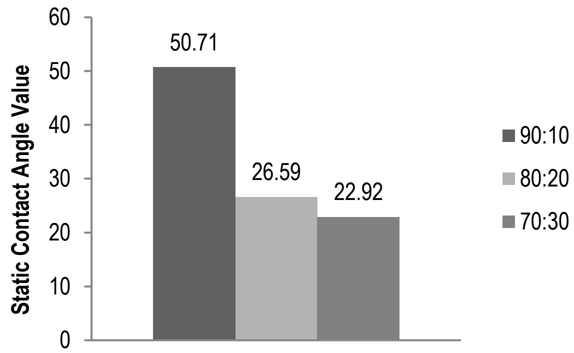

Figure 6. Average constant contact angle values in radial and tangential sections

Table 1. ANOVA test results on wettability values

EFFECT	SS	DF	M.S	F	ProbF	Sign.	CV (%)
Wooden Cross Section	0. 0007481	1	0. 0007481	2. 439047	0. 124918		
Viscosity	0. 0263324	2	0. 0131662	42. 922378	2. 05E-11	**	
Wood Cross Section x Viscosity	0. 0016067	2	0. 0008033	2. 6190742	0. 083261		
Residual	0. 0147237	48	0. 0003067				20. 03
Total	0. 0434112	53					

Determination of Wettability

The average wettability value (K-Value) of various percentages of paint and water ratios in radial and tangential sections is presented in Figure 7.

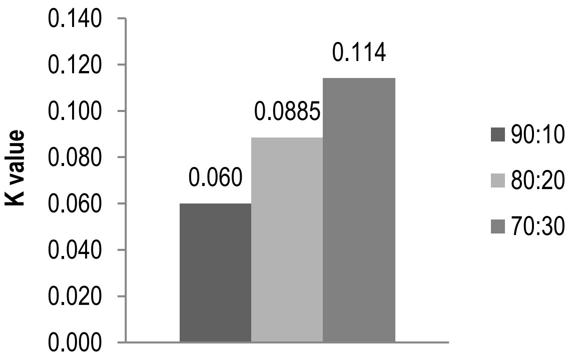

Figure 7. Average wettability value (*K-Value)* on radial and tangential sections

The results in Figure 7 show that the Aqua Politur *finishing material* with a percentage ratio of paint and water of 70 %: 30 % obtained the highest average K value of 0. 114. It indicates that finishing materials' wettability properties improve with increasing K values (Yuningsih, 2017) and decreasing viscosity values (Monni *et al.*, 2007). The wettability properties of wood are influenced by the viscosity, type of liquid, and surface tension of a liquid (Qin *et al.*, 2014). Apart from that, the wettability properties of wood are also influenced by the macroscopic characteristics of the wood (porosity, surface roughness, wood surface polarity, pH value, water content, fiber direction, and extractive substances), wood surface quality, and processing temperature (Unsal, 2011). Therefore, to determine the effect of paint viscosity on the wettability properties of wood, both in tangential and radial sections, it is presented in Table 1.

The ANOVA test results show that the wood cross-section treatment factor has no significant effect on the wettability properties, meaning that there is no significant difference between radial and tangential cross-sections to the value of the contact angle formed. It aligns with research conducted by Amorim *et al.* (2013) that the resulting contact angle values tend to be the same in radial and tangential sections. Then, the paint viscosity treatment factor significantly affects the wettability properties or K value at a significance level of 0. 05, so Duncan's further test analysis of paint viscosity is needed, as presented in Table 2.

Based on Duncan's further test results, it can be seen that the V 3 treatment is significantly different from the V 2 and V 1 treatments, where the V 3 treatment has a better average of 0. 113889 compared to treatment V 2 (0. 088556) and V 1 (0. 059833) are expressed by different notations. Thus, this research shows that the lower viscosity value of the *finishing material* produces the highest K value, so its wettability properties are better.

Table 2. Duncan's further test results for viscosity values against wettability values

Treatment	*Grand Total*	Notation	*Critical Range*
V3	0. 113889	a	0,000
V 2	0. 088556	b	0. 012
V1	0. 059833	c	0. 012

D. CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the viscosity of paint very significantly influences the wettability properties of rajumas wood, which can be seen from the ANOVA results at the 0.05 level, which produces a significant value of 2.05E -1 1. However, the radial and tangential sections did not show significant differences with the ANOVA results at the 0.05 level, which produced a significant value of 0.08.

A paint percentage of 70%:30% has the best wettability properties compared to other treatments. The low viscosity value indicates this at a paint percentage ratio of 70%:30%, producing the lowest average constant contact angle value and the highest average wettability value (*K-Value)* in both radial and tangential sections.

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