

THE ADHESION PROPERTIES OF WOOD PRESERVED WITH NATURAL PRESERVATIVES

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ABSTRACT

Wood preservation technology has been using synthetic preservatives for a long time. However, some disadvantages have been recorded such as quality degradation of environment, killing more non target wood destroying organism. Since environment quality requirement has been up lifted, then general wood processing and wood preservation paradigm has to change from utilization of synthetic to natural wood preservatives. The new natural wood preservatives have their own properties and influence differently on wood adhesion. Wood adhesive based products such as plywood, lamination, particleboard and fiberboard use wood waste consisting of all kind of processes wood such as naturally preserved wood. The objective of this research is to know the effect of naturally wood preservatives on wood adhesion properties.

This research was conducted by wood adhesion block method. The fast growing teak plantation wood was chosen since this type of teak wood was claimed as low grade of wood quality. This type of wood has high portion of sapwood which is susceptible to wood destroying organism. The source of natural, local wood preservatives are gadung tubers, pulai bark and kumis kucing leaves. The wood adhesive used was bio-industrial PVAc in the form of glue paste. Extraction procedure of natural wood preservatives followed ASTM D1110-1984. The procured naturally extracts was processed to obtain extract concentration 1.00 gram per liter concentration. Wood preservative application used padding method on the wood surface by 0; 1; 2 and 3 application times. Each padding layer processed was applied after the former one was air dried. Wood adhesion test followed block type with 40#/MSGL glue spread and cold press system. Compression shear test of block samples followed British Standard (1957). This adhesion test method was chosen since the method has proven as efficient and effective adhesion test in the laboratory.

The research results showed that interaction factor of natural wood preservative and padding application did not affect to the adhesion strength. This adhesion strength was affected by single factor of natural wood preservative and padding application. The highest adhesion strength of 94.29 kg.cm⁻² was resulted by pulai bark followed by gadung tubers (80.61 kg.cm⁻²) and kumis kucing leaves (55.31 kg.cm⁻²). Padding application exerted a negative correlation to adhesion

strength. Higher padding application number of natural preservative on the wood surface, lower adhesion strength. The reduction of adhesion strength of 1; 2 and 3 padding application resulted 20; 42 and 66 % for gadung tubers. Pulai bark extract reduced 24; 30 and 57 % while kumis kucing leaves lowered 22; 37 and 75 % consecutively.

KEYWORDS: Natural wood preservatives, adhesion properties, gadung tubers, pulai bark, kumis kucing leaves.

INTRODUCTION

Background

Wood preservation technology has been using synthetic wood preservatives for long time. Synthetic wood preservatives have some advantages and disadvantages. The significant disadvantages observed were quality degradation of the environment, side effect in terms of killing organism other than wood destroying organism and therefore reducing the diversity of organism. Parallel to this trend is in human therapy that is changing from synthetic chemical to herbal curing system. One advantage of using synthetic chemical is fast response, efficient and effective curing system. Based on this situation and condition of wood preservation then the wood technologist are changing from using synthetic chemical to herbal or natural wood preservatives. Wood preservation history shows that wood preservatives have been banned due to the significant disadvantages such as PCP (Penta Chloro Phenol), CCA (Chrome Copper Arsenic), creosote and others.

The most important of wood preservation objectives is to make service life of wood products longer (Martawijaya et al. 2005). The wood products are exposed to many destroying factors in the end utilization. Furniture can face interior condition as chairs, bed, wall-panel. On the other hand, garden furniture is exposed to exterior condition. Similarly, construction wood such as beam to support roof (subject to interior condition) or as fence (subject to exterior condition). Only a small number of wood species can withstand to the exterior condition. Most commercially wood can be used only for interior condition. For that reason wood preservation is a must to improve wood capability to face exterior condition. Similar technology employed to improve the wood based product span life when they are exposed to destroying insects and other organism. When wood products can serve longer therefore fresh wood demand will decrease significantly (Anonym 2012).

Wood based products need adhesives for their production of glued wood products. Plywood, lamination, particleboard, fiberboard and other wood composite used adhesive to joint them. The ideal condition of wood gluing is the availability of high attachment capacity of wood surface. Unfortunately this ideal condition is difficult to obtain due to many factors such as dirt, wood extractives, wood preservatives and other foreign materials that are deposited on wood surface (Haygreen and Bowyer 1996). This results in a reduction of adhesion strength of the wood. For that reason, a research on this adhesion reduction problems is needed.

The objective of the research is to know the effect combination of natural preservatives and padding application on wood adhesion properties.

The research results would be very useful for wood processing mill and other wood composite producers. They would be provided data of adhesion strength reduction when the wood is processed for glued wood products. They would have many scientific reasons for making a right decision in wood gluing and preservation.

MATERIAL AND METHODS

Material

Fast growing teakwood used as raw material for glued wood products testing. They were supplied by Perhutani, a State owned Forest Corporation. Wood adhesive used was commercial bio-industry PVAc which was a new type of PVAc adhesive family. This adhesive in the form of glue paste. The natural wood preservatives were obtained by cold water extraction of three different type plant sources namely, gadung tubers (*Dioscorea* spp.), pulai bark (*Alstonia* spp.) and kumis kucing leaves (*Orthosiphon* spp.).

The research was conducted in the Laboratory of sawmill and composite products, Faculty of Forestry, UGM. Yogyakarta Indonesia The adhesion test was conducted in Engineering Laboratory of Faculty of Engineering.

Methods

The research entitled adhesion properties of naturally preserved wood was executed by following several standards. First standard used was ASTM D1110-84 for extracting the three kinds of natural biochemical sources, namely gadung tubers, pulai bark and kumis kucing leaves. Second standard used was adhesion block testing followed British standard (1957). This method has been using in the laboratory due to its efficient and effective in wood bonding test. The procedure for completing the research was described below:

1. Procuring the fast growing teak trees from Perhutani, State owned Forest Corporation and brought to Sawmill laboratory of Faculty of Forestry. The teak logs were sawn into radial sawn timbers and then air dried to reach air dry moisture content of the lumber. The lumber were the re-sawn and cut to produce the adhesion block sample following British standard 2 x 2 x 15 cm. The teakwood strips were then sanded in such a way to produce completely pair assembly for adhesion test.
2. Collecting the natural biochemical sources namely gadung tubers, pulai bark and kumis kucing leaves from the rural herbal plantation in Kulon Progo Yogyakarta and Temanggung, Indonesia. The natural preservatives material sources were grinded to produce powder passing 40 mesh sieve.
3. Cold water extraction was chosen. The ratio herbal to cold water was 1:10 w/w to produce natural cold water extracts following the standard ASTM D 1110-84. The collected extracts were then evaporated to produce 1:1 ratio.
4. The extract was then applied to wood surface by padding system. The number of application of 1, 2, 3 in order to know the effect of number application on the adhesion capability of the wood samples. The new padding application was conducted after the wood surface was air dried after the first padding.
5. The air dried wood strips after natural preservatives treated was then spread with the glue amount to 40 pond /MSGL. The type of wood adhesive used was bio-industry PVAc which was claimed to be much better than the white one.
6. The glued wood strips were then assembled to become adhesion block test following British standard (1957). The adhesion blocks dimension were 40 thick, 20 wide and 150 mm long. The adhesion blocks were pressed together in a screw flat press for 24 hours for adhesive curing at room temperature (ambient condition). The adhesion block tests were then conditioned for a week. The adhesion sample tests measuring 40 thick by 20 wide and 20 mm long were cut from the adhesion block. The adhesion sample for compression adhesion tests were subjected to test machine.

7. The adhesion strength and wood failure data were analyzed by SPSS employing CRD ANOVA test following Steel and Torrie (1981).

RESULTS AND DISCUSSION

Adhesion strength and wood failure data of teak wood glued by PVAc bio-industry were presented in Tab. 1.

Tab. 1: Average of adhesion strength and wood failure percentage of teakwood block test.

Natural Preservative	Padding application	Adhesion strength (kg.cm ⁻²)				Wood failure percentage (%)			
		Replicate				Replicate			
		1	2	3	Average	1	2	3	Average
Extract Gadung (EG)	0	94.00	98.70	161.03	117.91	63.16	55.56	55.02	57.92
	1	66.92	89.89	124.44	93.75	80.20	80.20	84.21	81.54
	2	54.52	76.60	75.44	68.85	70.00	82.01	82.71	78.24
	3	55.79	55.70	14.34	41.94	84.66	74.07	53.03	70.59
	Average	67.81	80.22	93.81	80.61	74.50	72.96	72.96	73.47
Extract Pulai Bark (EKP)	0	108.14	115.63	167.78	130.52	72.86	80.95	80.95	78.25
	1	60.08	107.05	131.27	99.47	63.49	61.90	85.71	70.37
	2	59.18	105.29	109.37	91.28	66.67	75.00	82.27	74.65
	3	53.41	59.40	54.93	55.91	72.86	77.73	68.57	73.05
	Average	70.20	96.84	115.84	94.29	68.97	73.90	79.38	74.08
Extract Kumis Kucing (EKK)	0	123.88	68.17	56.44	82.83	90.91	92.86	71.05	84.94
	1	108.11	55.78	30.86	64.92	60.53	61.58	92.50	71.54
	2	87.05	42.89	27.38	52.44	75.63	85.00	45.11	68.58
	3	30.46	19.60	13.10	21.05	34.45	55.14	80.20	56.60
	Average	87.38	46.61	31.95	55.31	65.38	73.64	72.22	70.41

The CRD ANOVA of adhesion strength was presented in Tab. 2. The CRD-ANOVA analysis showed that interaction factors of natural preservation and padding application did not affect the adhesion strength. On the other hand single factor of natural preservatives and padding system exerted its effect on adhesion strength. This meant that both factors effect was individual factor.

Tab. 2: ANOVA of adhesion strength.

Variation source	DF	Sum of squares	Mean of squares	F	Prob.
Natural Preservative(NP)	2	9,388,834.00	4,694,417.00	5.63	0.01
Padding Application (PA)	3	23,688,883.00	7,898,294.33	9.47	0.00
NP x PA	6	460,134.00	76,689.00	0.09	0.99
Error	24	20,009,273.00	833,719.71		
Total	35	53,547,123.00			

HSD Tukey test for natural preservative showed that pulai bark extract influenced weakly to the surface of the wood. This was detected by the highest adhesion strength resulted by wood samples treated with pulai bark extracts. The gadung extract exerted a moderate effect, while the kumis kucing showed the strongest one. For that reason the highest adhesion strength was pulai bark treated, followed by gadung and the lowest was kumis kucing treated samples (Fig. 1).

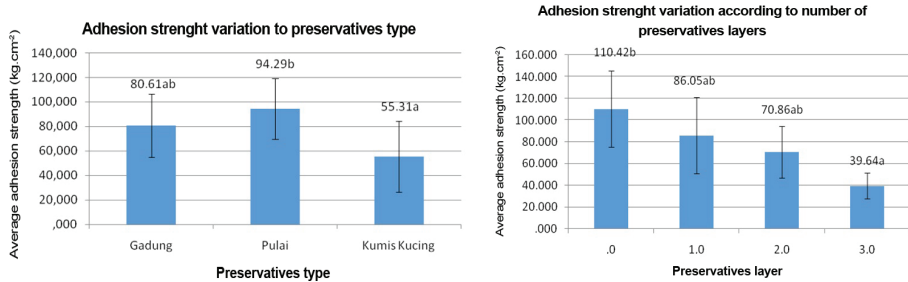


Fig. 1: The effect of natural preservative on adhesion strength. Fig. 2: Adhesion strength reduction due to padding application.

Several references mentioned that gadung tubers containing cyanide which is powerful toxic to the wood destroying organism and in this research did not reduce the adhesion strength significantly. On the other hand pulai bark containing alkaloid and kumis kucing containing flavonoid were also high potency for wood preservatives (Ngasifudin and Sukosrono 2006). Gadung extract had been tested for wood preservatives (Wulandari 2012) and also applied as bamboo preservatives (Hirmawan et al. 2010). The kumis kucing leaves extract exerted a strong influence to the adhesion strength due to hydrophobic type chemicals. In this research the adhesion strength of 55.31 kg.cm⁻² was produced by teak wood treated with kumis kucing leaves extracts. The adhesion strength of gadung and pulai bark treated showed adhesion strength of 80.61 and 94.29 kg.cm⁻² consecutively.

The padding application number gave more layers of natural extract preservative to the wood surface. The more layer of natural preservative on the wood surface, the more organic materials attached to cellulose molecules. This condition would produce less attachment site for adhesive molecules. For that reason lower adhesion strength would be the result.

The adhesion strength reduction due to the natural preservatives padding application number 1; 2 and 3 were shown in Tab. 1. Adhesion strength reduction due to gadung tubers extract application were 20; 42 and 66 % consecutively. Pulai bark extracts produced adhesion reduction of 24; 30 and 57 %, while kumis kucing leaves extract application resulted in 22; 37 and 75 % adhesion strength reduction. These results showed that higher number of natural preservatives application then higher adhesion strength reduction percentage. Fig. 2 showed HSD Tukey test with significant reduction of adhesion strength of teakwood after application of natural preservatives before gluing the wood. The average adhesion strength of control wood (without natural preservative application) was 110.42 kg.cm⁻², reduced to 86.05; 70.86 and 39.64 kg.cm⁻² with application number of 1; 2 and 3 times.

Gadung tubers extract contains cyanide compound such as hydrogen cyanide. Hydrogen cyanide is a poison form and capable to conduct a strong reaction with or without catalyst. This chemicals can react to keton and aldehyde to form cyanohydrin (Fig. 3)

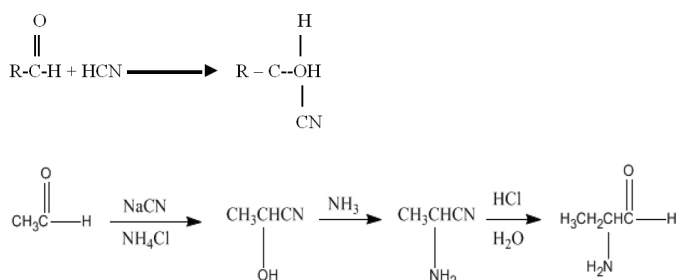


Fig. 3: Addition reaction of hydrogen cyanide to aldehyde and keton (Nikita 2012).

Pulai bark extract contains alkaloid compound. They are ditamin ($\text{C}_{16}\text{H}_{19}\text{NO}_2$), echitamin ($\text{C}_{22}\text{H}_{29}\text{N}_2\text{O}_4$) dan echitenin ($\text{C}_{20}\text{H}_{27}\text{NO}_4$). Other alkaloid compound detected by Yamauchi et al. (1990) is 17-0-Acetylechytamin. Wood preservation research employing pulai bark extract was conducted by Khanifatun (2003), Fadhli et al. (2012) and showed a good result. It was reported that pulai bark extract contained saponin and flavonoid. The research focus in finding the effect of natural preservatives on adhesion strength has not been conducted yet. This research result has shown that natural preservatives applied on the wood surface reduced the adhesion strength. As stated above that the number of attachment site of the wood surface could be reduced significantly by natural preservatives or other chemicals. For that reason the number attachment site available for adhesives is reduced and resulting lower adhesion strength. Wood cellulose could react to alkaloid compound. Alkaloid compound shows base behavior (alkali-oid) and this contain nitrogen compound (Fig. 4.). The reaction of alkaloid to cellulose was likely hydrogen reaction and electron substitution.

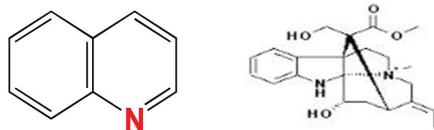


Fig. 4: Typical alkaloid and echitamin.

On the other hand, kumis kucing extract contains flavonoid (tannin), oil (essential) and saponin (Anonym 2008). Tannin has monomer of flavonoid and used for drug, while essential oil could give a specific smell to repel the wood destroying organism. Flavonoid has back bone of C6-C3-C6 atom carbon as shown in Fig. 5. When tannin reacts to the wood cellulose, possible attachment are hydrogen and methyl linkage.

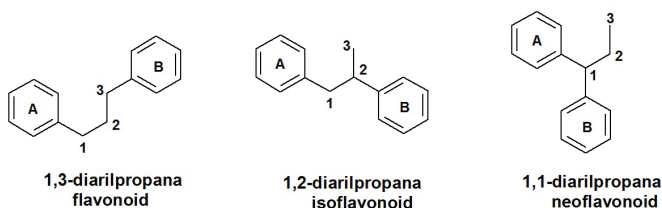


Fig. 5: Typical flavonoid.

Essential oil is a very complex chemical compound and very easy to evaporate. This oil contains lower than 10 carbon atom skeleton with variety of bonding types. This chemical might be grouped to hydrophobic compound which inhibit adhesion between wood and adhesives.

Research on kumis kucing extracts as wood preservatives had been conducted by Sutjipto et al. (2009), Azis (2011) and Mariana et al. (2013) with good result as well. The adhesion strength affected by kumis kucing extract significantly. For that reason an advanced research on kumis kucing is needed to find out the cause of significant reduction of adhesion strength.

CONCLUSIONS

This research entitled the adhesion properties of wood preserved by natural preservatives has several conclusions as followed:

1. Interaction factor natural preservative and padding application number did not affect significantly to adhesion strength of teakwood block test
2. Natural preservative factor affect significantly the adhesion strength. The highest adhesion strength produced by teakwood preserved with pulai bark extracts, followed by treatment with gadung tubers and the lowest one was produced by wood treated by kumis kucing leaves extracts. The average of adhesion strength of the adhesion block treated with natural preservatives were 94.29; 80.61 and 55.31 kg.cm⁻² consecutively.
3. Padding application number on the teakwood surface affect significantly the adhesion strength. Higher number of application, lower adhesion strength. The adhesion strength reduction from control (no natural preservative application) to 1; 2 and 3 application number by gadung tubers extract were 20; 42 and 66 % consecutively. Pulai bark extract reduction of adhesion strength were 24; 30 and 57 % consecutively, while kumis kucing leaves extract application reduced the adhesion strength were 22; 37 and 75 % consecutively.

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