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## Resinless Plywood Production by Using Oxidized Acacia Bark Powder as a Binder

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# Resinless Plywood Production by Using Oxidized Acacia Bark Powder as a Binder

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**Abstract.** Nowadays, the established technology in plywood industries for producing plywood is still using adhesive as veneer bonding agent. Utilization of the adhesive has several of weaknesses such as containing formaldehyde compound and using the unrenewable raw material. The purpose of this research was to develop a novel technique to produce plywood without involving adhesive as a binder. The oxidized bark powder of *Acacia mangium* was utilized as a binder to substitute the adhesive. Bark powder was oxidized by using hydrogen peroxide on four levels (5%, 10%, 15%, 20%) and the catalyst. The result showed that utilization of oxidized bark powder can be applied in producing resinless plywood. Unless the plywood with 15% of hydrogen peroxide, the other plywood fulfil the National Indonesian Standard (SNI) No 01-5008.2-2000 where min. 7 kg/cm<sup>2</sup> as the requirement. The plywood with 20 percent of hydrogen peroxide has the highest bonding strength (13.24 kg/cm<sup>2</sup>). After immersing this plywood in hot water (70°C) for 2 hours and drying in the oven (60°C) for 3 hours, the wood failure test also showed a good value, namely 76.15 percent. These facts indicated that the bonding and the water resistant of the plywood were relatively high. It tends that the technology for producing resinless plywood is potential to be developed.

## 1. Introduction

In 2017, Indonesia's plywood industry manufactured 3.2 million m<sup>3</sup> of plywood products [1]. The export value of this product reached 31.87 trillion rupiahs. This value was the third largest of wood products after pulp and paper. In addition to being the important commodity of forest product, utilization of plywood is getting widespread Indonesia and gradually replacing solid-wood domination.

The industries have been using formaldehyde-based adhesives in the manufacturing of plywood. It is an issue because the resins are known to produce formaldehyde emission that is harmful to health and can trigger cancer [2], mainly if plywood is used in a limited ventilation room [3]. Some additives were given to reduce the emission such as urea [4,5,6], ammonium carbonate [4,6], melamine [5,6], ammonium hydroxide [3], and activated charcoal [7,8], but the materials have not been able to reduce the emission totally. The use of urea and ammonium carbonate resulted in a decrease the bonding strength.

This study is designed as a new approach for producing high-grade plywood that is much more environmentally friendly, namely technology of plywood manufacturing without using adhesives or resinless plywood. This approach is adopted from the technology that has been intensively developed in producing particleboard, but it is unproven its possibility in plywood manufacturing technology. The



basic principle in this technology is the activation of lignin or tannin that are capable of functioning as a binding agent.

The veneers on plywood have low accessibility by oxidizing materials due to its solid form; therefore, it needs an additional ingredient on adhesive line that can increase accessibility of the chemical components and bonding strength. In this study, using bark powder of acacia which has high tannin and relatively easily oxidized may petrify in stronger bonding formation between the veneers.

## 2. Method

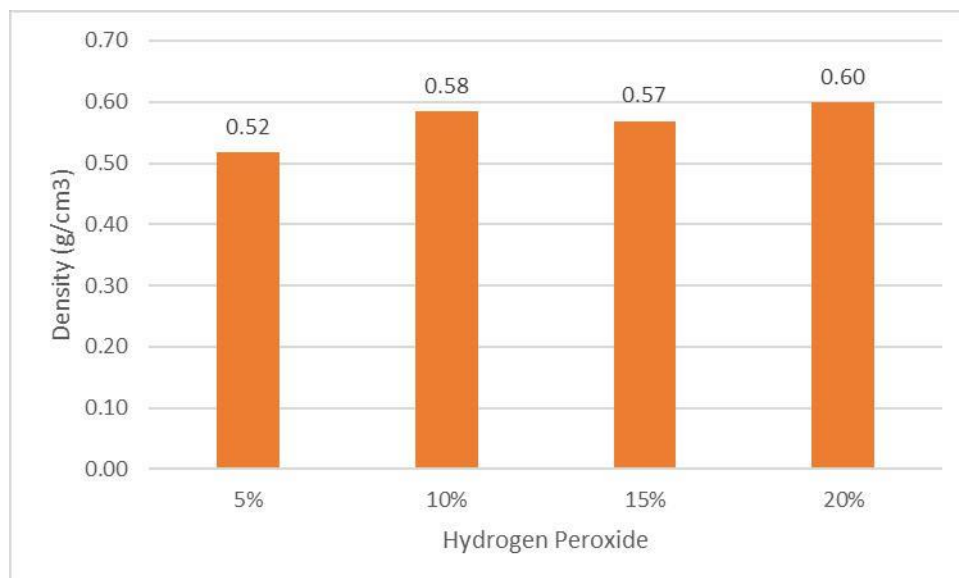
This research was conducted by using sengon (*Paraserianthes falcataria*) as veneer material, and bark of acacia (*Acacia mangium*) as bonding agents. Sengon veneer was obtained from Bogor, and acacia bark was collected from Sinjai. The veneers were air-dried to reach  $12\% \pm 2\%$  of moisture contents. The bark was made to be particles with 20 to 40 mesh of dimension.

Plywood was made with applying four oxidation treatments, they were 5, 10, 15 and 20 percent hydrogen peroxide based on oven-dry particle weight, and all of them used 5 percent of the catalyst based on hydrogen peroxide weight. Oxidation process refers to Suhasman et al. Method [9]. Weight of the particles used on each adhesive line was  $200 \text{ g/m}^2$ . The 30 cm by 30 cm by 0.3 cm plywood was manufactured with hot pressing at a pressure of  $10 \text{ kgf/cm}^2$  and temperature of  $180^\circ\text{C}$  for 5 minutes. Plywood was then conditioned for two weeks. Physical and mechanical tests were determined based on Indonesian National Standard 01 5008.2 2000.

Tannin content was determined by soaking 40 to 60 mesh of wood bark powder on 96% ethanol for three days. The extraction filtrate was then made more viscous by using rotary evaporator. Furthermore, the viscous extractive was analyzed the tannin quantitative by using UV spectrophotometer.

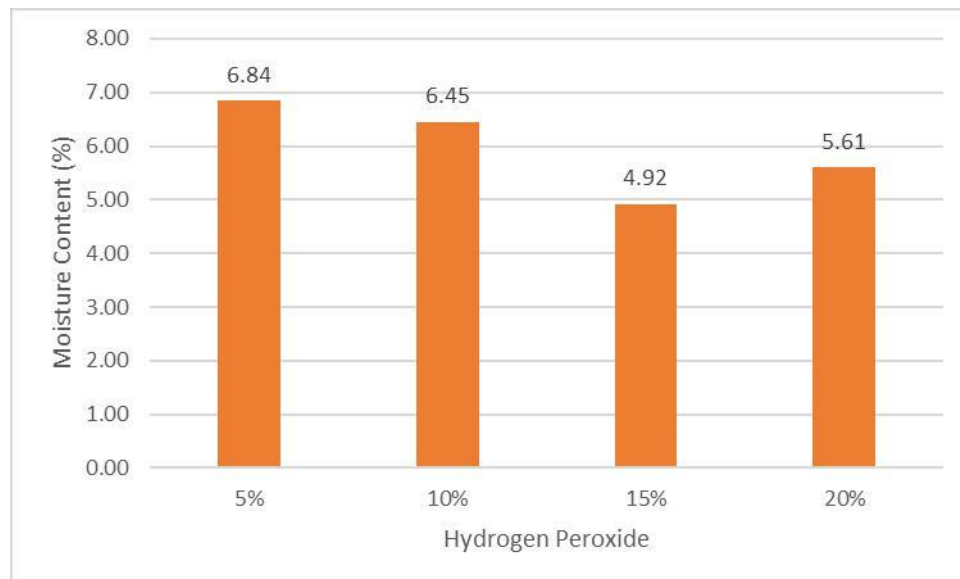
## 3. Result and Discussions

Figure 1 shows density averages of resinless plywood using acacia bark powder as bonding agents on four levels of hydrogen peroxide. The density values represent that the plywood with 20% of  $\text{H}_2\text{O}_2$  has the highest density ( $0.6 \text{ g/cm}^3$ ). Meanwhile, the plywood with 5% of  $\text{H}_2\text{O}_2$  is the lowest ( $0.52 \text{ g/cm}^3$ ). However, the result shows the plywood has a slight difference in density. It can be caused by a similar thickness of veneers used. In general, there is not significantly different density among the plywood.



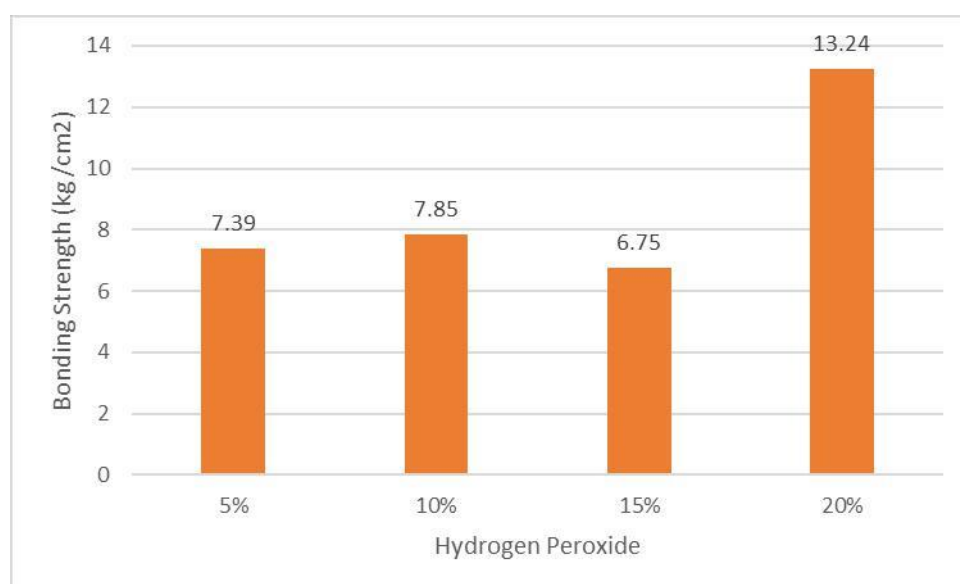
**Figure 1.** Resinless Plywood density

Moisture content (MC) of the plywood are showed in Figure 2. The plywood with 15 and 20 percent of hydrogen peroxide have moisture content lower than 6 percent. The plywood with 5 percent of hydrogen peroxide (6.84 percent) is the highest MC. However, the moisture content of the plywood is not significantly indifferent, and they fulfil the SNI (14%). In general, the moisture content of plywood is a quite low average of 6 percent. It possible happens because there is densification of the veneer.



**Figure 2.** Resinless Plywood Moisture Content

As shown in Figure 3, the plywood with 20 percent of hydrogen peroxide has the highest bonding strength (13.24 kg/cm<sup>2</sup>), and it is almost two times higher than other. It also has a great value of wood failure (76.15 percent) based on testing result. In general, only the plywood with 15 percent of hydrogen peroxide does not fulfil the SNI, but the value is slightly different to the plywood with 5 and 10 percent of hydrogen peroxide where both meet to the standard.



**Figure 3.** Bonding strength of resinless plywood

Suhasman [10] reported that internal bond of sengon binderless particleboard with oxidation method was affected by the number of hydrogen peroxide which the higher number of  $H_2O_2$  the lower their internal bond. It is caused by a high reactivity of this species of the oxidant, so they do not need to use  $H_2O_2$  in large number. However, it is different for resinless plywood in which using 5 to 15 percent of hydrogen peroxide show the relatively same bonding strength and increasing significantly on 20 percent.

The wood failure of the plywood with 20 percent of hydrogen peroxide showed an excellent characteristic. Meanwhile, the bonding strength is also affected by tannin content of the bark. Based on analyses resulted, the bark powder of acacia contained 6.2 percent of tannin. The relation between bonding strength and tannin content is caused by phenolic compound of tannin, especially hydrolysable tannins in which they have hydroxyl groups that are potentially oxidized and form radical groups.

#### 4. Conclusion

Oxidation treatment to produce Resinless Plywood is possible to be applied. The results showed that utilization of bark powder of acacia with 20 percent of hydrogen peroxide as a bonding agent is the highest bonding strength (13.24 kg/cm<sup>2</sup>) which the value is two times larger than other and it has a good value of wood failure (76.15 percent). Only plywood with 15 percent of hydrogen peroxide does not fulfil SNI for bonding strength (> 7 kg/cm<sup>2</sup>).

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