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A Study of Sawdust-Produced Fiberboards Using Lac as Binder for Furniture Industry

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Abstract

There has been an extensive use of fiberboards in the furniture industry. Therefore, materials containing glue are applied to develop these fiberboards. This research investigated sawdust-produced fiberboards using lac as the binder and aimed to; (1) study the appropriate mixture proportions of sawdust and lac as the binder and; (2) explore the physical and mechanical properties of different mixture proportions of sawdust and lac at 5 wt%, 10 wt%, 15 wt%, 20 wt%, 30 wt% and 40 wt%. The research methods involved selecting sizes of dried sawdust and grinding with lac and alcohol. Then the mixture was pressed in a hot-pressing machine. After that, the produced fiberboards were tested using medium-density fibreboards Thai Industrial Standard (TIS 966-2547) in a laboratory. The results showed that the appropriate proportions was 15 wt% which met the standard defined in Thai Industrial Standard (TIS 966-2547). The fiberboards could replace medium-density plywood and could be used in furniture and the home decorative product industry.

Keywords: Fiberboards; Medium-Density Fiberboards; Sawdust; Lac

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1. Introduction

The wood and furniture industry has extensive proportions of medium and small entrepreneurs across the country. According to a recent survey (2009) conducted by the Institute for Small and Medium Enterprises, the production in wood and the wood product industry and furniture and home decorative product industry is important for SME (Small Medium Enterprises). The global wood industry is, for example the largest user of adhesives; about 80 % of all wood and wood-based products involve some form of bonding and 70 % of the total volume of adhesives produced is consumed in the woodworking industry [1]. World MDF (Medium-Density Fiberboards) capacity increased 30% in 1996 to over 12 billion square feet [2]. The potential for lower wholesale prices of fiberboard with more competition in wholesale marketing [3]. Additionally, the export statistic shows that Thailand is the 10th biggest exporter of fiberboard of wood or other ligneous materials in the world market [4]. Europe has strict control on environmental issues so its export promotes environmentally-friendly products [5]. Fiberboards made of Urea Formaldehyde as the binder releases Urea Formaldehyde to the atmosphere which is harmful to health and environment. Furthermore, the lack of wood results in increased prices of teakwood fiberboards. As a result, entrepreneurs tend to produce MDF for the furniture industry. The study investigated the use of sawdust to produce fiberboards using lac as the binder. The aims of the research were to study the appropriate mixture proportions and physical and mechanical properties which can be further applied in the furniture and home decorative product industry in the future.

2. Research Methodology

2.1 Materials

The sawdust in this study was from Dang Wood cut by a jointer, selected by sieving through the Æ 5 millimeter sieve. The binder was lac (pure Shellac) mixed with 100% alcohol.

2.2 Fiberboard Forming

The sawdust from the jointer was selected by sieving through the sieve. It was then dried at 80°C to eliminate moisture for 2 hours and then ground. The binder was pure shellac derived from lac mixed with 100% alcohol with the pure shellac at 5%, 10%, 15%, 20%, 30% and 40% W/W. All mixtures were perfectly combined and left for 5 hours and stirred again to ensure perfect blending. The binder was then added into the fibers while the mixing bowl was spinning to ensure perfect blending. After that, cool working was carried out to form the fiberboard. The formed fiberboard was left for 20 minutes and the binder was added to form the board sized 400 x 400 x 10 millimeters at 40 bar, 160°C for 10 minutes. It was then left for 24 hours to cool down. The physical and mechanical properties testing were then performed. These included density, moisture content, water absorption, thickness swelling, bending strength, modulus of elasticity and tensile strength. This research substituted collected data in the formula of medium-density fiberboard industry defined by Thai Industrial Standard (TIS 966-2547) [6]. The process of forming sheet shows in Fig. 1.

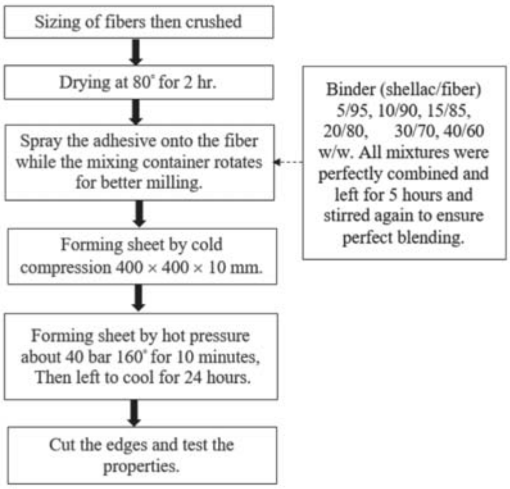

Fig. 1 The process of forming sheet

3. Results and Discussion

The results of density testing showed that the density decreased when the proportion of the binder in the fiberboards decreased. The proportions of sawdust per shellac powder mixed with alcohol were 5 wt%, 10 wt%, 15 wt%, 20 wt%, 30 wt% and 40 wt%. The weight of sawdust with the density of 700-900 kg/m^3 exceeded 400-800 kg/m^3 defined in Thai Industrial Standard (TIS 966-2547) [6]. The decreased density of the fiberboard when the binder was decreased resulted from the decreased weight of the binder. This could decrease the total weight of the material. However, the rebonding of the materials could decrease the weight as the amount of binder was insufficient to bind the sawdust. As a result, the density of the fiberboards increased as shown in Fig. 2.

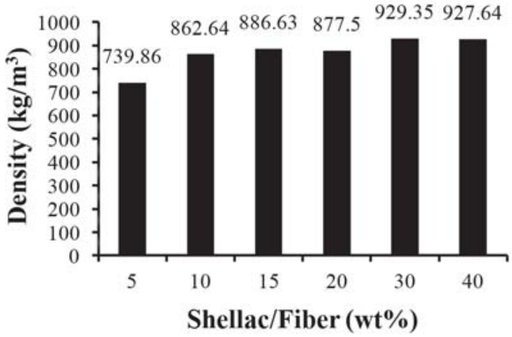

Fig. 2 The relationship between the density and the amount of binder

The moisture content of the fiberboards occurred because of two main factors. These factors included the moisture content of Dang Wood before forming the fiberboards and the water absorption of Dang Wood sawdust after forming the fiberboards. In this study, the moisture content of Dang Wood was eliminated during the material preparation stage – before forming the fiberboards – in order to minimize the moisture content to the lowest level. Even though the materials with high moisture content could form a smooth fiberboard surface and give fewer cracks, efficient binding and more strength, the surface with high moisture content get could stuck in the mold leaving a scurfy, rough surface. In addition, it also took a longer time to form. Therefore, moisture elimination of the sawdust could be performed to reduce swelling problems caused by moisture content inside the fiberboards [7].

The materials absorbed moisture in the air while being mixed with the binder. The time spent mixing the binder and forming the fiberboards of each condition should not exceed 1 hour. The moisture absorption of sawdust was different depending on specific features of Dang Wood. The results can be seen in Fig. 3.

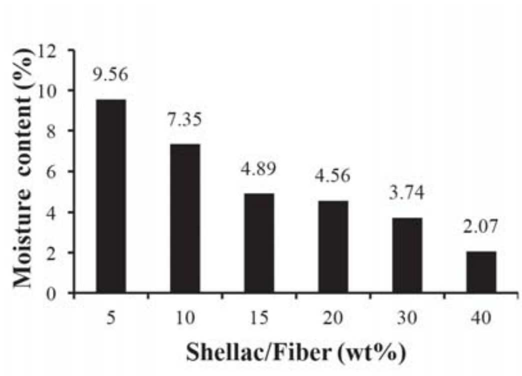

Fig. 3 The relationship between the moisture content and the amount binder

The results of the water absorption testing in the 2nd and the 24th hour in Fig. 3 shows that the water absorption behavior of the fiberboards tended to increase when the proportions of the binder was decreased. This was due to an insufficient amount of binder to fill the gaps between the sawdust particles. Some parts of the sawdust could touch and absorb water directly. Therefore, the water absorption increased when the amount of binder was decreased.

The thickness swelling (TS) test in the 24th hour are as follows: According to TIS 966-2547 [6]. When comparing the results, the thickness swelling was altered by the water absorption of the fiberboards. Nevertheless, it could not be completely summarized because there are other factors of thickness swelling such as water absorption ability of the materials and formation ability of the sawdust and density of related materials involved [8].

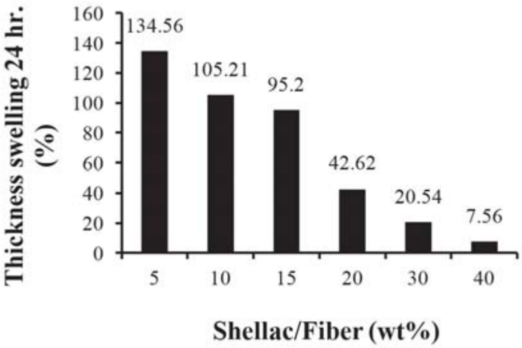

Fig. 4 The relationship between the thickness swelling in the 24th hour and the amount of binder

Fig. 4 demonstrates that the thickness swelling tended to decrease depending on the increasing amount of binder. The water absorption of the fiberboards with the proportion of 5 wt%, 10 wt%, 15 wt%, 20 wt% and 30 wt% exceeded TIS 966-2547 [6] but 40 wt% is not exceed TIS 966-2547. The swelling of fiberboards also depended on the insufficient amount of lac binder to cover or fill in the gaps between the sawdust particles.

This study investigated mechanical properties bending strength rupture and modulus of elasticity and impact strength using TIS 966-2547 [6]. The relationship between density and strength of the medium-density fiberboards yielded in the same direction. That is, if the density of the fiberboards increased, the strength of the fiberboards would increase. This allowed closer mixture of the fibers and the binder. In addition, the fiberboards had fewer gaps in the fibers compared to those with a lower density. As a result, the binder could bind the fibers effectively, enabling the fiberboards to have an effective mechanical action resistance. Therefore, increasing the density of the fiberboards could improve mechanical strength. The results revealed that bending strength depended on several factors such as the strength of sawdust which was specific feature of each material [9], sizes and shapes of the materials, the density of fiberboards and bonding ability between Dang Wood sawdust and the binder.

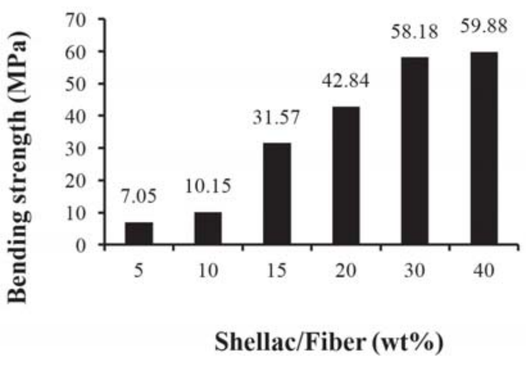

Fig. 5 The relationship between the bending strength and the amount of binder

Fig. 5 demonstrates that the bending strength of fiberboard at the proportions of 15 wt%, 20 wt%, 30 wt% and 40 wt% were higher than 22 MPa as defined in TIS 966-2547 [6] except those with the binder proportions of 5 wt% and 10 wt% which the bending strength were lower than the defined standard. Additionally, the lower the amount of binder, the poorer the effectiveness of bonding the binder would be.

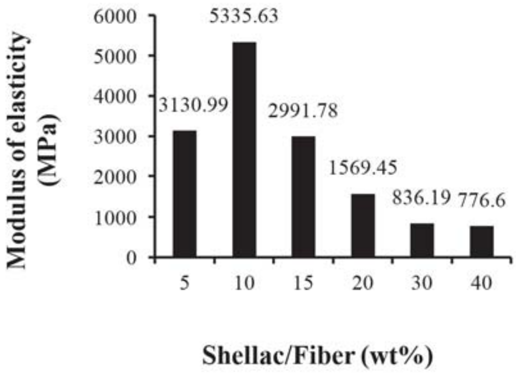

Fig. 6 Relationship between the resistance to modulus of elasticity and the amount of binder

Fig. 6 shows that the modulus of elasticity of all proportions of the fiberboards was higher than 2500 MPa as defined in TIS 966-2547 [6] except those with the binder proportions of 5 wt%, 10 wt% and 15 wt%.

Shellac 5 wt% shows low of MOE because it is not hardness enough that the force is about 3130.99 MPa. Shellac 10 wt% shows increase of MOE because it has more hardness and more toughness about 5335.63 MPa. Shellac 15 wt%, 20 wt%, 30 wt% and 40 wt% show decrease by the way of shellac increase. When added shellac, the fiberboards sheet may be hardness and brittleness that causing less force.

Moreover, the modulus of elasticity would decrease when the binder proportions increased, showing that the modulus of elasticity of the fiberboards would decrease which went opposite to the bending strength.

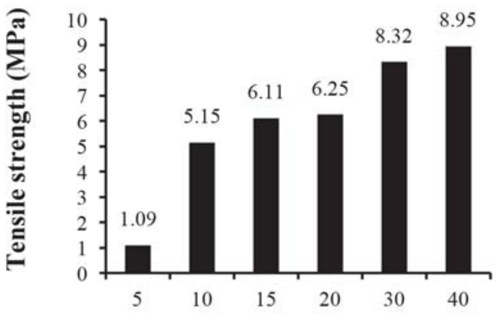

Fig. 7 Relationship between the tensile strength and the amount of binder

Fig. 7 demonstrates that the tensile strength would be higher when mixing the binder at 40 wt%. The weight decreased when the amount of binder was decreased, showing that the increased binder affects the strength of the fiberboards which met the defined stand.

4. Conclusion

It could be summarized that the sawdust-produced fiberboards using lac as the binder could produce medium-density fiberboards with appropriate proportions and with good strength. The appropriate proportions of sawdust per Shellac mixed with alcohol were 15 wt%. The fiberboards met the Thai Industrial Standard (TIS 966-2547) [6] and could replace medium-density plywood. However, it is necessary to increase the binder proportions of 20 wt% and 30 wt% to develop products that require flexibility.

The fiberboards could replace Medium-Density Fiberboards (MDF) and could be used as construction materials and for internal decoration. The fiberboards met the Thai Industrial Standard (TIS 966- 2547) [6] since the properties of Shellac could coat the fiberboards which promotes cost reduction on coating.

5. Acknowledgement

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