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PRODUCTION OF PARTICLE BOARD FROM RICE HUSKS

N. F. Mohamad[1,a,*], A.R. Hidayu[1,b], S.I.S. Jamaludin[1,c], M. Onn[2,d], N. S. A. Roslan[1,e] , M. D. H. Nordin[1,f]

[1]Faculty of Chemical Engineering, UiTM Cawangan Johor, Kampus Pasir Gudang, Bandar Seri Alam, 81750 Masai, Johor

[2]Faculty of Applied Sciences, UiTM Cawangan Johor, Kampus Pasir Gudang, Bandar Seri Alam, 81750 Masai, Johor

*Corresponding author: fadilah8591@johor.uitm.edu.my

[a]fadilah8591@johor.uitm.edu.my, [b]hidayurani@uitm.edu.my , [c]iziuna7858@johor.uitm.edu.my,[d]munirah591@johor.uitm.edu.my [e]erysyahna@gmail.com, [f]danishaziq97@gmail.com

Abstract

Rice husk is one of environmental concerns due to its non-commercialized value and the huge amount of waste disposals. Rice husk is an agricultural by-product with high silica content. In Asia, the source rice husks are abundant as rice is the major food in that continent. Traditionally, the rice husks are burnt in air to manage the disposal. This contributes to the primary pollution. In this study, the rice husks are mix with the adhesive to produce particle board. Characterization of received rice husk are 5% of moisture content and the chemical bonding exists n rice husk is detected by Fourier-transform infrared spectroscopy (FTIR) analysis. The FTIR result of the raw rice husk contains Si-O-Si bond the highest compared to other bond such as-OH bond, C-H stretching and other. Si-O-Si shows that the rice husk contains high concentration of silica which can increase the rate at which the material gains strength. The rice husk boards are made with different sizes of rice husks after being sieved. The sizes are 250 μ, 125 μ, 65 μ. The rice husks are mix with the adhesive of Carpenter™ Wood Glue, shape into the mould of 13.3 cm x 8.9 cm x 1.2 cm, pressed and dried in the oven. As for the fabrication, the rice husks are mixed with 10 g of sugarcane bagasse and the application of 90.91mL resin is introduced. All dried samples are then labeled and tested. The performance of the boards is examined by water absorption test, 10 kg load test and tensile test. The tests show the rice husk of the smallest size (65 μ) is the most suitable substitute for the wood products. It can stand 10 kg load test, absorbs water the less with only 3.923% absorption and shows the highest in tensile strength with 823.33 N. The structure looks tough and easy to mould as the rice husk used are the smallest. As for the modification, the addition of bagasse makes the particle board lighter and more attractive. Besides, it is able to reduce the sugarcane bagasse wastes. The application of the resin makes the particle board more resistance to water but not in strength. The resin can be used as a coating to make the particle board more resistant towards water. The developed particle board can be used as building material as they are wood-like, cheap and able to prevent termites.

Keywords: Rice husk; Particle boards; Wood glue;

1.0 INTRODUCTION

Since as early as 7000BC, the woods are used in many applications most significantly in industries that utilizing sledges. The trees were cut to the level where some parts of the forest have been bald to produce furniture and papers. Aside from the source problem, as more wood-based products are produced means that more wastes are too. Waste papers, wood chips and used furniture are the example of the wastes. In recent years, the world is concerning about the earth and the future generations. The material science fields are more focused on the sustainable development [1]. Many ways are implemented such as reducing energy, reuse, recycle and substitution of materials. As the number of trees being cut keeps increasing, and the time needed for the new trees to grow took years, the production of wood based products cannot overcome the demand of the world. Therefore, alternative materials need to be used.

The current demand for wood-based products is increasing. The consumers are more attracted to use the wood-based products as they are heat and electric current resistant, and more appealing than plastics products. Even though the plastics last longer than the woods, people choose the wood-based products in their home. A major drawback for the wood-based products is the termites. Termites cause billions of dollars in material damages each year [2]. They are not just primarily feed on wood, but also damage papers and books. They are known as the "silent destroyer" due to their abilities to chew non-stop and being undetected. Usually they start to eat the inner part of the wood, leaving the empty side in the wood. This leads to destruction of the wood-based products.

The consumers need a wooden-like product that are last long, resistant to termites and lighter in weight. The rice husk (RH) is the most suitable substitute for the wood. The source is cheap and abundant. As the rice husk is already small in sizes, they only need to be bind together with the help of the adhesives: wood glue and resin. Rice husk also are easy to be powdered and turn into ash. Rice husk can be used in production of particle boards, Medium Density Fiber Boards (MDF), and other boards according to their sizes and finest [3]. Recent study shows that rice husk can be used in producing the eco-friendly cutleries as they are easy to shape, paintable, biodegrable and compostable.

The advantages of using rice husks are the sources are abundant and available as rice are the most commonly eaten food in Malaysia and the husks are underutilized. Besides that, the rice husks contain silica and lignin that can prevent the termites [4]. Other than that, they are lighter than the wood. The rice husks ash can act as a good absorbent as they absorb more water than wood ash [5].

Rice husk is the outer part of the rice grain that as the encasing protector. It is yellow in color and brings 20 percent of the weight of a rice grain. The rice husks also known as rice hulls and rice chaffs. According to S.M. Shafie, Malaysia is one of the main country that produces rice and the rice husk can achieve 0.48 Million tonnes a year [6]. It is a huge number of wastes from the rice milling industries. Previously, the alternatives of managing the rice husk are burning them to the open air and as a decoration to the plants which are ineffective and contributing to the primary air pollution [7]. Rice husk is now one of the focused on sustainable materials as it is also used as low cost adsorbent in waste water treatment and the source of power generation [8]. Other than that, one of the ways is reusing the rice particle in a commercialized way such as producing the boards by binding them together by the help of adhesives [9].

Production of rice husk can be added with the bagasse to reduce the weight of the board [10]. This also helps in decreasing the waste other than rice husk. The addition of bagasse will make the boards look attractive as the fibers are white in color. The board that contains bagasse is believed to have a lighter weight and less in density. This will make the products easy to transport and handle. The pressing should be done in order to achieve compacted particle board [11].

The major concern about this production is the usage of the adhesives. The adhesives used are wood glue and the epoxy resin [12]. The resins have a higher strength than the wood glue but it may emit more toxic and may take a very long period of time to set. As the products need to be high in bond strength, the resins need to be use [13]. The concern on the safety issues of the product is not ignored as the resins contain formaldehyde and styrene that may cause cancer [14]. The board produced can be sealed with the more fined rice husks that are bind with the wood glue as the protective layers of the boards to reduce the exposure. The use of resin can help to make the particle board become water resistant board and act naturally as a protective layer. The high amount of silica in the rice husk can prevent the termites and the high bonding strength in resin can protect the board from breaking due to harsh weather and humidity [2].

As more agricultural waste is produced daily, and the current way to dispose them is harming the environment, the waste should be properly managed in order to preserve the earth. Therefore, objective of this study is to manage the prevalent rice husk wastes from local rice mills by turning them into commercialized product which is the particle board.

Therefore, the objective of this study to utilize the waste (rice husk ash) into valuable product which is particle board that is resistant to the termites and have light weight. Compare to other studies that had been done on particle board from rice husk, this study focus on the size of particle rice husk to determine the suitable size that can produce high performance of particle board in terms of strength and water absorption.

2.0 EXPERIMENTAL

2.1 Materials

Rice husk was collected from one of the agriculture farm at Pontian, Johor. The sugarcane bagasse was collected from the local stall. The bagasse was cleaned and oven dried at 100°C for about 3 hours to remove the moisture. The bagasse is then cut and grinded by using grinder. Both sugarcane bagasse and rice husk were sieved to classify the size of the particles. The rice husks separated with sizes of 250 µ, 125 µ and 65µ by using a sieve machine. Carpenter™ Wood Glue and Resin were use adhesive for the production of particle board.

2.2 Characterization of Rice husk

2.2.1 Moisture Content

Moisture content analysis was done to know quantity of water contained in rice husks. 100 g of rice husk was heated in the oven at temperature 100°C, for 1 hour. After 1 hour, the rice husk was weighted and the final weight was recorded. The percentage of moisture content was calculated by suing Eq (1). The moisture content analysis was done using oven drying method [15].

Percentage of the moisture content

$$= \frac{Initial\ Weight\ of\ RRH - Final\ Weight\ of RRH}{Initial\ Weight\ of\ RRH}\ X\ 100 \ ....(1)$$

2.2.2. Fourier-transform infrared spectroscopy (FTIR)

Infrared measurements were performing on a Perkin Elmer Spectrum One FTIR spectrometer, with a spectral resolution of 2 cm^{-1} using a technique of measurement intensity of infrared radiation as a function of frequency or wavelength. In the wave number range from 4000 – 400 cm^{-1} using ATR powder as reference. This technique is used to study the bonds of substances [16]. 20 mg of raw rice husk (RH) was analyzed to determine the bonding exist in rice husk.

2.3 Particle Board Production

For the production of particle board, the fine particle of rice husk was mixed with two types of binding compound which are Carpenter™ Wood Glue and Resin. For controlled sample, 100 g of the 250 μ rice husk is mixed with 75 mL of Carpenter™ Wood Glue. The rice husk added gradually until it covers the mixture. The rice and glue were mix by using pinching motion to ensure the entire rice husk and the adhesive are mixed evenly as shown in Fig. 1. This method is repeated for different size of rice husks according to Table 1.

Fig. 1. Mixing of Rice Husk and Adhesive

Table 1: Preparation of Particle Board using Wood Glue

Size of rice husk use	Carpenter™ WoodGlue (mL)
250 mic	75
125 mic	75
65 μ	75

The mould of 15cm x 9 cm was prepared and attached with greaseproof paper to prevent the rice husk to glued to the mould. After the mixing process, the mixture is then poured into the 13.3 cm x 8.9 cm x 1.2 cm mould. The mixture is pressed and rolled by using pestle to fill up the empty spaces in the mould as shown in Fig. 2. The mixture can be press by using heat pressed machine or only getting the mixture to dry by hot air [9]. After the pressing, the molded mixture is oven dried at 105°C for 3 hours. Consequently, the sample is removed from the mould and air dried to cools it down. Fig. 3 shows the labelled samples after drying process. All the samples are ensured to be dried and ready for the tests and analysis.

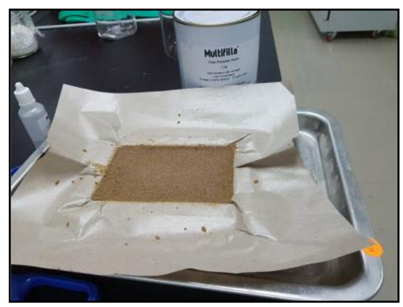

Fig. 2. Press and Moulding the Particle Board

Fig. 3. Particle Board after Drying Process

2.3.1 Fabrication of Particle Board

The modification is done on the production of the particle board. The modification is the adhesive substitution and the addition of sugarcane bagasse. Table 2 shows the modification of the particle board. The modification consists of addition of sugarcane bagasse and the usage of other adhesive which is resin. The resin use is 90.91 mL for 13.3 cm x 8.9 cm x 1.2 cm mould.

Table 2: Modification of Particle Board

Modification	Adhesive
95 g of Rice husk + 10 g of bagasse	Wood Glue
Rice Husk (non-sieved)	Polyester Resin

2.4 Performance of Particle Board

2.4.1 Water Absorption

Water absorption test is done to study the ability of the particle board to absorb water under certain period of time. Small part of the particle boards is cut with average weight around 0.8 g to 2 g. Fig. 4 shows the immersion of samples inside 100 mL of water at room temperature. The initial weights were recorded. The sample was weighted at 15 min, 30 min and 24 hours after immersed. The percentage of water absorption is calculated by using Eq(2).

Percentage of water absorption

$$= \frac{\text{Initial Weigtht of Sample} - \text{Final Weight of Sample}}{\text{Initial Weigtht of Sample}} \, x \, 100 \ldots\ldots\ldots(2)$$

Fig. 4. Water Absorption Test

2.4.2 10 kg Load Breaking Test

For load breaking test, the samples were hung with loads gradually added until the loads reaches 10 kg. The distance of the middle and the edges are constant. The test was stops once the particle boards were broken.

2.4.3 Tensile Test

Tensile test is also known as the tension test provides the information of tensile strength, flexibility and the yield strength of a material. In the test, the samples are cut into the same sizes of 9 cm x 3.5 cm before the test began. The samples are gripped and pulled with addition of the forces until it reaches its necking point. The test was made at Faculty of Mechanical Engineering Material Laboratory, UiTM Pasir Gudang.

3.0 RESULTS AND DISCUSSION

3.1 Characterization of Rice husk

3.1.1. Moisture Content

The received rice husk was already in the crushed sizes. The rice husks have the moisture content of 5%. 5% is considered as a good value and suitable for making a particle board. This is because the glue is less effective if it is contacted with water since the glue will form bonds with the water instead of the rice husks.

3.1.2. Fourier-transform infrared spectroscopy (FTIR)

The mid infra-red study ranges between 4000 cm^{-1} to 400 cm^{-1} that focused on the framework vibrations of rice husk was performed. Fig. 5 shows the FTIR result of the raw rice husk. Table 3 shows the analysis of FTIR for rice husk. From Table 3, the highest bend is at the functional group of Si-O-Si. This shows the silica functional group is high in the raw rice husk. The strong band at this wavenumber is because of the structural siloxane framework and the peak shift usually shows the incineration of the rice husk. This proof the rice husk contains high amount of silicone dioxide [12]. At the C=O stretching of aromatic group marks the second peak. Consequently, at the third peak, the –OH and Si-OH indicates existence of free hydroxyl group caused by O-H surface vibrations [17].

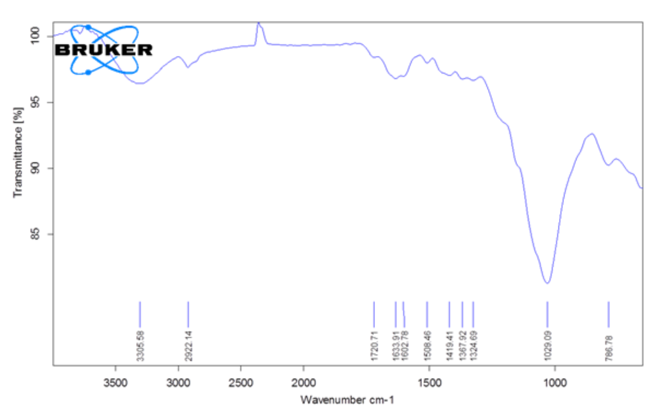

Fig. 5. FTIR of Rice Hus

Table 3. Analysis of FTIR

Wavenumber (cm^{-1})	Functional Group
3305.58	-OH and Si-OH
2922.14	C-H stretching of alkenes
1720.71	C=O stretching of aromatic groups
1633.91	C=C stretching of alkenes
1602.78	and aromatic
1508.48 1419.41	CH_2 and CH_3
1324.69 1367.92	Aromatic CH and carboxyl-carbonate
786.78, 1029.09	Si-O-Si

Table 4. Water Absorption of Rice Husk

Sample	Initial (g)	Weight After Length of Exposure(g)			Differences of Weight After Immersion(g)			Percentage of Absorption (%)		
		15 min	30 min	24 hrs	15 min	30 min	24 hrs	15 min	30 min	24 hrs
125 μ	1.0064	1.0344	1.0579	1.087	0.0280	0.0515	0.0806	2.782	5.117	8.008
250μ	1.2889	1.2978	1.3554	1.6544	0.0089	0.0665	0.3655	0.691	5.159	28.357
65 μ	1.5599	1.5604	1.5702	1.6211	0.0005	0.0103	0.0612	0.0321	0.660	3.923
Bagasse + 125 μ	0.8969	1.003	1.0126	1.0350	0.1061	0.1157	0.1381	11.830	12.890	15.397
Resin	2.4037	2.4087	2.4095	2.4202	0.005	1.0318	0.0165	0.208	0.429	0.686

3.2 Performance of Rice Husk Particle Boards

3.2.1. Water Absorption

Table 4 shows the percentage of water absorption test of each particle board. At first 15 minutes, the sample of the mixture of bagasse and rice husk marks the highest absorptivity. This is due to the gaps between sugarcane bagasse and rice husk. The water gets through the gaps easily. The lowest is the sample of 65μ rice husk. This is because the particle board is compacted as the size of the rice husk is constantly small.

For the 30 minutes, the resin particle rice husk board is the lowest absorptivity. This is because the resin makes the particle board to resist water [18]. The mixture of bagasse has the highest absorptivity. For the 24 hours, the lowest absorptivity of water is the particle board with the application of resin and the highest absorptivity is the mixture of bagasse and rice husk. The increasing sequence of absorptivity is resin particle board, 65 μ particle board, 125 mic particle board, 250 mic particle board and mixture of bagasse and rice husk particle board. The absorptivity of rice husk board is increasing with size. The air gaps make the construction ventilated and dries faster, but at the same time makes it easier for the outdoor humidity to be absorbed [19].

3.2.2. 10kg Load Breaking Test

Table 5 shows the breaking point load of each samples with the addition of load gradually. The result shows that the particle board that used the wood glue can withstand up to 10 kg of load. Whereas, the particle board that used resin can only hold 1 kg of load. The result is not supporting the reference from Nayif that emphasize the resin is the best adhesive to be used [13]. This may be due to the wrong proportion between the resin and the catalyst used. The curing time for resin varies according to its ratio, some of it may not be cure at longer length of time. The application of resin makes the particle board have tensile strength up to 38 MPa and flexural test of 94.67 MPa [19]. If the application of resin succeeded, the particle board will be the toughest.

The result from Table 5 shows that the sample that used wood glue can withstand 10kg of load without breaking. This is due to the similar properties of rice husk to the wood [20]. The wood glue is suitable for the wood and the rice husk. It contains polyvinyl acetate that is the raw material to make other polymer. Besides, it has a good bonding performance and environmental friendly [21].

According to [21], the application of wood glue of 5% gave 0.77 MPa of bond strength and 25% gave 1.92 MPa. Both gave bond strength of 7.852 cm^2 and 19.578 cm^2 respectively. It means for the maximum strength of board in every centimeter squared, it can withstand nearly 20 kg. The hybridized rice husk particle board that contains 15% of rice husk that bonded with vynilester has a tensile strength of 30 MPa [19].

Table 5: Result of 10kg Load Test

Sample	Load Interval (kg)						
	1	3	5	7	9	10	Not Broken
125 mic	/	/	/	/	/	/	/
250 mic	/	/	/	/	/	/	/
65 µ	/	/	/	/	/	/	/
Bagasse + 125 mic	/	/	/	/	/	/	/
Resin 125 mic	/	X	X	X	X	X	

/ = can stand the load x= can't stand the load

As for the different sizes of rice husk, the fined rice husk of size 65µ is observed to have the toughest body. This is because the smaller sizes of rice husk make no air space in between. Compacting the smaller substance makes the product high in strength.

3.2.3. Tensile Test

The Fig. 6 shows the tensile test result. The particle boards of sizes 250 µ, 125 µ, 65 µ, and bagasse and 125 µ rice husk are 579.69 N, 619.88 N, 823.33 N and 341.9 N respectively. The particle board of size 65 µ marks the highest in tensile strength. The 823.33 N is equivalent to 89.96 kg by conversion. The high strength is because of the small size of the rice husks used. As the size is small, it is easier for the glue to bond the rice husks particle. The small size also makes it easier for the pressing process. The fabricated particle board holds the lowest value because they are spaces between sugarcane bagasse and the rice husk. The materials that have air gaps has the low strength [22].

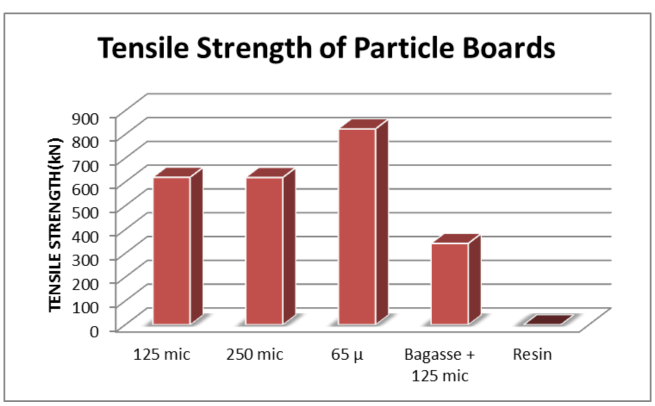

Fig. 6: Tensile Strength of Particle Board

4.0 CONCLUSION

It is concluded that rice husk has a commercial value and can be utilized in the manufacture of wood-like particle board. The particle boards produced are using 80% waste product. This can help the world to reduce the agriculture wastes. The use of wood glue is suitable to be used in this production as it emits low exposure of formaldehyde. The observation from the tests and analysis showed that the rice husks can produce the particle board. By this method, the rice husk waste can be reduced. From this study, the size of rice husk with 65 µ shows highest performance in tensile strength and water absorption with value of 823.33 N and 3.923% respectively.

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