ENVIRONMENTAL FRIENDLY GYPSUM PARTICLEBOARD FILLED WITH RICE HUSK AND OIL PALM TRUNK

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ABSTRACT

This study set out to investigate the usefulness of two major agricultural wastes in Malaysia which are rice husk and oil palm trunk. The potential of these two materials were evaluated as filler in the production of gypsum particleboard. A gypsum based particleboard with 1.2 g/cm^3 target density was prepared with 6 different conditions based on the percentage of fillers added (control, 5%, 10%, 15%, 20% and 25%). From the collected data, the gypsum particleboard added with 20% gives an excellent mechanical properties compared to the control sample. In term of physical properties, there are no major differences among the sample except the control samples which is free from any filler failed in the thickness swelling and water absorption test. The mechanical properties of gypsum particleboard showed an increament as the percentage of filler increased but start to decreased as 25% of filler was added.

Keywords: Mechanical properties, oil palm trunk, physical properties, rice husk.

INTRODUCTION

Gypsum particleboard is one of the panel products that is widely used in the applications such as wall partitions and ceiling. Calcium sulfate hemihydrate ($CaSO.0.5H_2O$) is the main material use in the making of gypsum particleboard. It is easily reacted with water to produce calcium sulfate dihydrate ($CaSO.2H_2O$) or gypsum. The characteristics of gypsum based particleboard which are able to act as fire resistant and heat insulator make it suitable to be use as building materials [1] Besides these excellent characteristics, the low availability of wood is one of the reason that make gypsum is more favorable.

The addition of fillers in the production of gypsum particleboard is one of the technique to improve the physical as well as mechanical properties of this products. Previous studies by other researchers [2][3] showed that the selection of right fillers enable to enhance the properties of the products hence, it helps to diversify it applications. Agricultural wastes such as rice husk and oil palm trunk are the example of natural based fillers that has a potential to be use as gypsum particleboard fillers.

Besides Indonesia, Malaysia also known as the main palm oil producer [4]. This fact is supported by 32.86 million hectares of land in Malaysia covered with oil palm tree plantation that make it 41% of palm oil production worldwide [5]. Despite this industry gives a huge impact on the Malaysia economic growth, the drawback dealing with this highly influence industry is the management problem of its waste after the cut down of the tree. The tree that has been cut down need to be manages wisely in order to ease the replanting process. High percentages of moisture (±70%) in freshly cut tree make it impossible to be burnt directly [6]. Left to rot is the most favorable way to dispose the oil palm trunk in Malaysia which may takes up to 6 years for fully decomposes [7]. However, some irresponsible land owners tend to burn the trees after its moisture content decrease to make it possible for replanting within short period of time that will contribute to air pollutions.

The utilizations of rice husk as gypsum particleboard filler has been carried out by Kim [8] and its prove it enable to improve the properties of gypsum particleboard. One of the characteristic of rice husk that attract researchers to used it as gypsum filler is the presence of silica that may improve the fire retardant properties of gypsum particleboard. Normally the rice husk which is also known as the rice by product was burnt to generate energy during the rice processing and for some application it was used as bedding material [9].

The selection of these two materials as the new types of gypsum particleboard fillers not only to help the disposal problem but also to convert agricultural by products into something valuable. In this study, the rice husk was mixed with the oil palm trunk with a numbers of ratios for the production of gypsum particleboard.

Materials and methods

The oil palm trunks obtained from a local plantation in Kuala Selangor, Malaysia and cut into disc form. The oil palm trunk disc was further processed by manually cut and grind to produced smaller particles. The rice husk were collected from Bernas rice mill in Kepala Batas, Pulau Pinang and ground to an average size < 1 mm using Willey Mill. Both raw materials were dried in the oven to ensure the moisture content of the particles in the range of 7-8%. The main material used in this study which is calcium sulfate hemihydrate, ($CaSO.0.5H_2O$) was obtained from Sigma Aldrich.

Particleboard making

The gypsum particleboard making methods used in this study is almost similar to other previous work by other researchers especially in the laboratory scale production. One of the drawbacks dealing with the gypsum particleboard production method is the gypsum itself are prone to the contamination of dust and other materials. To study the effect of fillers on the properties of gypsum particleboard, the particleboard with 1.2 g/cm^3 target density was produced with 6 different ratio of fillers (control, 5%, 10%, 15%, 20% and 25%) based on overall weight with 2 different types of fillers are mixed together (50% rice husk and 50% oil palm trunk in each ratio). In order to produced gypsum based particleboard that satisfy the standard, 0.8:1 water to gypsum ratio was used in the particleboard making [10]. To slow down the setting time of the gypsum, 2% of citric acid monohydrate, ($C_6H_{10}O_8$) based on overall gypsum weight was added.

Samples evaluation

All particleboard prepared were evaluated by physical (density, moisture content, thickness swelling and water absorption) as well as mechanical properties (flexural strength, internal bond) based on JIS A5903 [11].

RESULTS AND DISCUSSIONS

As presented in **Table 1**, there are no major differences in term of density and moisture content of the samples. The average moisture content of all test pieces fall in the range of 8-10%. This is because all the sample was prepared under the same surrounding temperature and each sample were conditioned in the same room temperature. In addition, before the particleboard making the moisture content of the particles used are maintained in between 5-6%. For thickness swelling and water absorption, all samples tend to fail in less than 2 hours. Once the samples immersed in the water, the water rapidly absorb into the test pieces and as the result, the sample start to break during the measurement process. The rapid water absorption which contribute to sample failure is caused by the presence of void. The water tend to fill in the void that exists during gypsum setting that caused by the unreacted free water. Those free water will evaporated and leaving a voids that will gives an effect on physical and mechanical properties of the gypsum particleboard [2]. Besides that, the properties of both rice husk and oil palm trunk that easily absorb water are the reason why the thickness swelling and water absorption of gypsum particleboard filled with these agricultural waste tend to failed after the water immersion. To overcome this problem, the application of surface coating using water proof paper which is also used in the common gypsum board in the market can be apply on the prepared gypsum particleboard.

Table 1. Physical properties of gypsum based particleboard filled with different ratio of fillers

Sample	Density, g/cm^3	Moisture content, %	Water absorption, %	Thickness swelling, %
Control sample	1.21 (3.03)	5.57 (1.22)	-	-
5%	1.20 (0.06)	5.75 (2.16)	-	-
10%	1.24 (2.04)	5.92 (2.14)	-	-
15%	1.22 (0.15)	5.40 (1.92)	-	-
20%	1.23 (1.51)	6.01 (1.50)	-	-
25%	1.23 (2.42)	5.74 (2.41)	-	-

*Values in parenthesis represent the standard deviation

The evaluation of mechanical properties consists of flexural strength test and internal bond test. Based on collected data showed in **Table 2**, the flexural strength of the gypsum particleboard increased as the percentage of fillers added increased. The highest reading was shown by the sample added with 20% fillers with 4.04 MPa. The lowest average reading was recorded in control sample with 2.70 MPa. Although the flexural strength of the particleboard incresed as the ratio of fillers increase, the flexural strength of the sample decreased when 25% of fillers added. The sample treated with 25% fillers gives an average reading 3.71 MPa which is lower than 20% fillers treated sample.

Table 2. Mechanical properties of gypsum based particleboard

Sample	Bending strength (MOR), MPa	Bending modulus (MOE), MPa	Internal bond strength, MPa
Control sample	2.70 (3.19)	546.60 (8.12)	0.82 (7.33)
5%	3.18 (2.03)	803.43 (6.86)	0.89 (4.91)
10%	3.26 (5.73)	832.84 (7.56)	0.97 (2.58)
15%	3.85 (1.44)	901.70 (5.77)	1.40 (6.48)
20%	4.04 (2.50)	926.13 (6.14)	1.73 (2.21)
25%	3.71 (3.39)	872.27 (6.95)	1.35 (8.46)

*Values in parenthesis represent the standard deviation

The similar trend were observed in internal bond strength where the highest average reading was recorded by 20% fillers added sample with 1.73 MPa. **Table 2** shown the 5% treated sample gives the lowest average reading which is almost similar with the control sample with 0.82 MPa and 0.89 MPa respectively. The addition of 25% fillers into the gypsum particleboard showed a decreased average internal bond strength with 1.35 MPa. The 20% fillers added test pieces gives an excellent strength for both mechanical tests which surpass the standard requirement based on JIS A5903 [11].

From the collected data, the flexural strength and internal bond strength decreased after the addition of fillers more than 20%. The filler added in the gypsum particleboard will compacted and embedded in the gypsum matrix hence, decrease the presence of void that will contributed to higher flexural strength. The void presence in the gypsum particleboard will become the weak point of the gypsum particleboard when a load is applied. However, high percentage of fillers which is more than 20% could be the main factor attributed to the decreament of both properties since it will interrupt the bonding in the gypsum matrix.

CONCLUSIONS

Throughout this study, the increased of fillers percentage will increased the mechanical properties of the gypsum based particleboard. However, for physical properties there are no major changes between the control sample and the filler added sample. The mixture of rice husk and oil palm trunk showed a potential to be use as a gypsum filler. The mixture of rice husk and oil palm trunk showed a potential to be use as a gypsum filler. In future, hopefully this method could be use by the gypsum based industry in the production of gypsum board in order to diversify the waste utilizations and at the same time will help the disposal PROCESS.

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