Effect of Resin Particle Size and Wax Content on the Properties of Oil Palm Board

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ABSTRACT

Homogenous layer of oil palm boards were produced using urea formaldehyde as binder. The three particle sizes (unscreened, 1.0 and 2.0 mm) used were sprayed with 8, 10 & 12% resin. A 1% wax content was also added. The oil palm board was hot-pressed at 165 °C for 6 minutes. Results of the board testing showed that with increasing resin content all the mechanical and physical properties improved significantly. Bigger particles gave better mechanical but lower physical properties compared to smaller particles. With wax addition, mechanical properties were not affected while physical properties improved significantly.

Keywords: *Oil palm board, properties, resin, particle size, wax content*

Introduction

Malaysian particleboard industry at present is facing hard times in getting a constant supply of rubberwood as a raw material for board manufacture. Rubberwood is also being sought after by wooden furniture and other wood industries. Hardwood wastes are now being utilised as supplement to rubberwood. In view of this raw material crisis, other raw material sources should be looked for and exploited.

Currently, Malaysia has a total of 4.05 million hectares of oil palm trees. Besides palm oil, the industry also generates massive quantities of oil palm trunks (OPT), oil palm fronds (OPF) and empty fruit bunch (EFB) available from replanting and though routine field and mill operation. Assuming a 25 year rotation of replanting regime, it is estimated that more than 70,000 hectares of oil palm will be due for replanting every year. This would involve the felling of approximately 9 million palms. Hence, the amount of oil palm trunk (wet weight) that is available annually is estimated to be 13.92 million tonnes or 21.63 million cubic meters. Mohd Basri et. al (2006) reported that with the huge quantities of OPT still available, they could make very substantial contribution to the production of palm-based composites for a wide range of application without depleting the nation's fiber resources from the natural forest and forest plantations.

At present, the trunks are usually burnt or left to rot and decay to produce immediate fertiliser to regenerating oil palm saplings Lim and Gan (2005). The most practical solution is to use the oil palm trunk as raw material to produce particles for the production of particleboard. This will provide an alternative raw material to the particleboard industry and also preserve a clean environment as well as to achieve a zero-waste strategy. The objectives of the study are to determine the properties of three layer oil palm boards and the effect of resin and wax content on the oil palm board properties.

Materials and Methods

Field Procedure

Oil palm trunks were supplied by Malaysian Oil Palm Board, Serdang in the form of sawn blocks (4' x 10" x 10") after bark removal. The blocks were further cut into smaller 8" x10" x10" blocks for processing using a disc flaker. The particles produced were then dried and screen to remove the fines. After fines removal, the particles were further screened into >1.0 and 2.0 mm sizes. Particles were, then, redried in the oven at 80° C for at least 48 hours before board manufacturing.

Board Manufacture

In the manufacturing of three-layer particleboard urea formaldehyde resin was used. The resin was made available by a local resin company and was formulated according to commercial use. The resin specifications are given in Table 1.

Table 1: Specifications of Urea- Formaldhyde Resin

Property	Urea Formaldehyde
Viscosity (p) 30 C	2.50
pH	8.44
Density at 30 °C	1.280
Gel Time (sec.)	46
Free Formaldehyde (%)	0.44
Solid Content (%)	65.0

Homogenous particleboards were produced with unscreened particle size (after fines removal), of 1.0mm and 2.0mm particles. The particles were sprayed with 8%, 10% and 12% resin content. The hardener (ammonium chloride) solution used had a concentration of 20% equivalent to 3% of the weight of the resin solution used. A 1% wax content was used based on oven dry particles weight.

For board manufacturing a weighted amount of particles was placed in the particle glue mixer and sprayed with a resin mix containing resin and hardener. The glue mix was sprayed as a fine mist at an air pressure of 1.8MPa to obtain an even distribution of resin over the oil palm particles. After spraying, the sprayed particles were then manually laid in a wooden mould over a caul plate with a dimension of 35 X 35cm and, then, pre-pressed at 3.5 MPa for 30 seconds. The wooden frame was removed and two metal stops of 12 mm were placed near the sides of the consolidated mat before another caul plate was laid on top of it. The consolidated mat was, then, finally pressed to the required thickness of 12 mm at 165°C for 6mins. and the maximum pressure at the metal stops was set at 120MPa. The target board density was approximately 650 kgm^{-3}. A total of two boards were produced for each condition.

Sample Cutting and Conditioning

All the boards produced were cut according to a cutting plan made to obtain a random selection of samples throughout the board size of 350 mm x 350mm. The sizes of the tests samples are shown in Table 2.

Table 2: Tests Samples Sizes

Property	Sample sizes	No. of test pieces/board
1. Modulus of rupture	320 x 50 mm	3
2. Thickness swelling and Water absorption	50 x 50 mm	5

The cut samples were left in a conditioning room with a relative humidity of 65 ± 5 % and a temperature of 20 ± 2°C as required by the British Standard Method (BS EN: 1993) with a moisture content of below 10%.

Board Evaluation

The tests samples were tested for its mechanical properties, namely, modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB) and dimensional stability properties, water absorption (WA) and thickness swelling (TS). The mechanical tests were conducted using an Instron Universal testing machine model 4204. The test results were, then, compared with the mean quality values as given in the British Standards (BS 5669).

Results and Discussions

Statistical Significance

Summary of the analysis of variance of resin content on the board properties is shown in Table 3. Resin and wax content show a significant effect on all the board properties tested.

Table 3: Analysis of Variance on the Oil Palm Board Properties

Source	Df	MOR	MOE	IB	WA	**TS**
RC	2	1.52ns	2.22ns	9.92*	34.3*	36.24*
W	1	13.27*	14.98*	0.004*	476.64*	30.76*
PS	2	20.71*	4.16*	9.64*	343.43*	199.07*
W X RC	2	7.82*	11.44*	13.23*	11.48*	0.43ns
PS X RC	4	3.12*	6.83*	7.38*	11.24*	27.32*
W X PS	2	6.68*	3.94*	3.10*	30.02*	12.63*
RC X W X PS	4	1.18ns	3.07*	2.41*	32.47*	21.40*

Note: * F-values are significant at $p<0.05$ level

Effect of Resin Content on Mechanical Properties

The effect of resin content on the mechanical properties is shown in Figure 1. Increments of resin content showed significant effect on the mechanical properties. Increasing the resin content from 10 to 12% increased the MOR by 9.5 %, MOE by 0.3% and IB by 22%. The increase in the mechanical properties is due to the higher resin available for bonding. Similar observations on the mechanical properties-resin content relationship were also reported by other work on wood (Talbott & Maloney, 1957; Moslemi, 1974), bamboo (Chew et. al, 2003) and oil palm fruit bunches (Shaikh et. al, 1993).

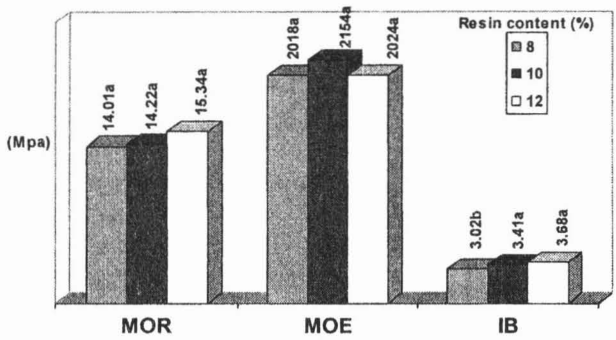

Figure 1: Effect of Resin Content on the Mechanical Properties

Effect of Resin Content on the Physical Properties

The effect of resin content on the physical properties is shown in Figure 2. Increasing the resin content from 8% to 12%, improved the WA by 11% and TS by 18%. The improved WA and TS values are due to the higher amount of resin available for bonding leading to less void being created.

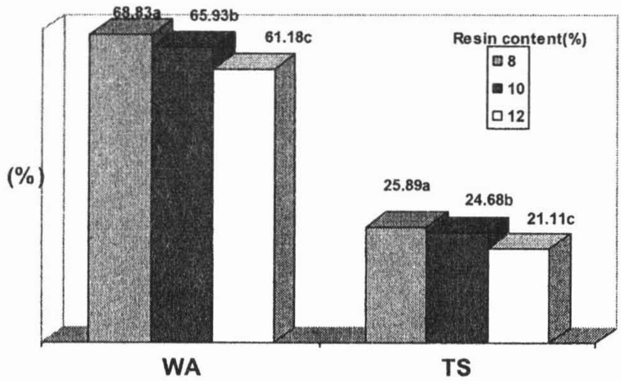

Figure 2: Effect of Resin Content on the Physical Properties

Effect of Particle Sizes

Figure 3 and 4 shows the effects of particle sizes on the mechanical and physical properties of oil palm board, respectively. Figure 3 showed that bigger particle size had better mechanical properties compare to smaller particles. An increase in PS from 0.5 mm to 2.0 mm increases the MOR by 31%, MOE by 11% and IB by 12%. With bigger particles more resin are available for effective bonding compared to smaller particles with higher surface area.

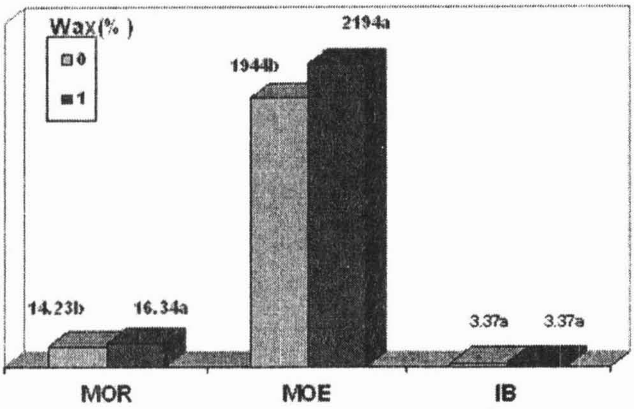

Figure 3: Effect of Particle Size on the Mechanical Properties

Figure 4 indicates that with bigger particles had higher water absorption and thickness swelling compared to smaller particles. The better WA and TS values exhibited by smaller particles are due to the higher compaction ratio (Shaik, 1991) that exists during the pressing of the board. The WA improves by 26% while TS by 36%.

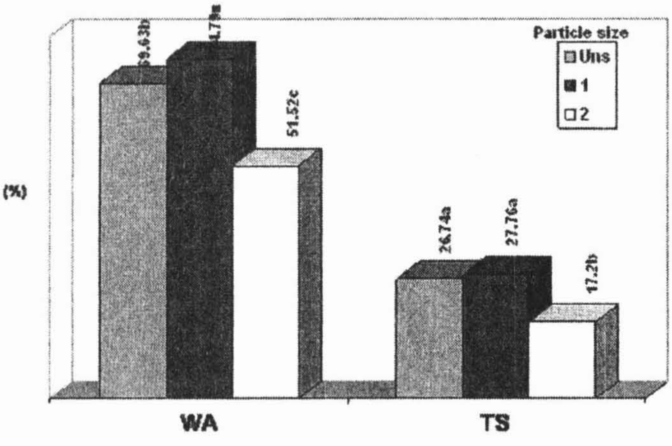

Figure 4: Effect of Particle Size on the Physical Properties

Effect of Wax Addition

The effect of wax addition on the mechanical properties is shown in Figure 5. An addition of 1% wax was observed to increase the MOR by 15% and MOE by 13%. Usually the slip characteristic of wax imparted on to the particle surface causes a reduction of bonding between particles. However in this study it seems to give a good impact on the mechanical properties. The effect of wax addition on the physical properties is shown in Figure 6. Addition of 1% wax content was observed to improve the WA by 23% and TS by 10%, respectively. This improvement is due to the wax resisting the uptake of water during soaking by coating the particles efficiently.

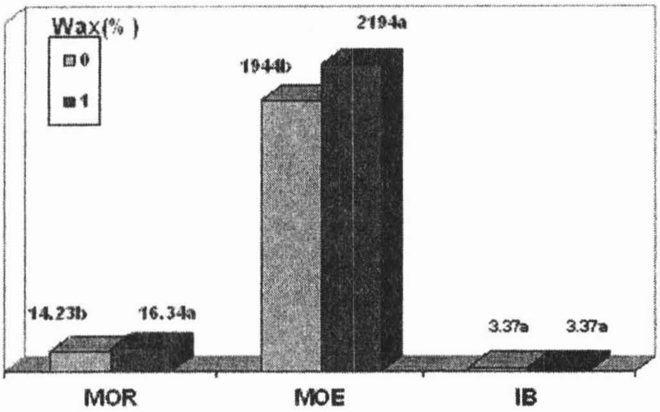

Figure 5:Effect of Wax Addition on Mechanical Properties

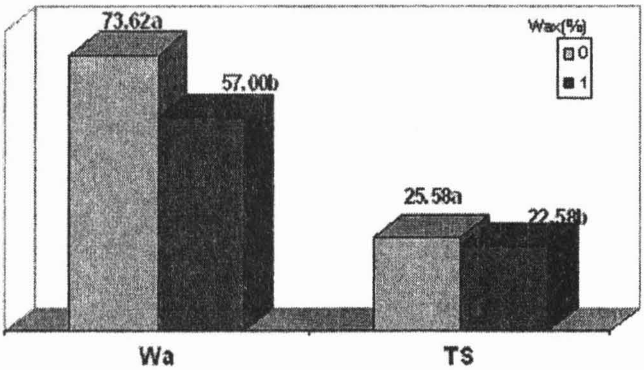

Figure 6: Effect of Wax Addition on the Physical Properties

Conclusion

From the study, it was shown that with increasing resin content used, all the mechanical and physical properties were improved. Bigger particles had better mechanical properties but lower physical properties. With 1% wax addition, it was shown not to affect the mechanical properties and improved the physical properties significantly.

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