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PHYSICAL AND MECHANICAL PROPERTIES OF FIBREBOARDS FROM OIL PALM FIBRES AND POLYETHYLENE

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ABSTRACT

Three different oil palm based fibreboards were used in this study, each using different types of fibres. The fibre types were frond (OPF), trunk (OPT) and empty fruit bunch (EFB). Four different plastics mixes of 0%, 5%, 12% and 20% was used for each of the fibreboard types. There were a total of twelve fibreboard types (3 fibres types X 4 polyethylene percentage content) used in this study. The fibreboards were manufactured to a targeted density of 850 kg/m^3. Urea formaldehyde (UF) adhesive was used as part of the matrix at resin level of 10 percent. All the OPF boards and hybrid boards with 5% and 12% plastic content irrespective of the fibre types satisfied the 200-type board for modulus of rupture (MOR) as stated in the JIS-A-5906. The OPT boards and hybrid boards with 20% plastic content passed the JIS-A-5906 150-type board. The EFB boards only passed the JIS-A-5906 type-50 for the MOR. For Internal bonding (IB), all the fibreboards were able to meet the requirements of JIS-A-5906 type-300 board. In the case of thickness swelling (TS), all the fibreboards failed to meet the requirement as specified in the JIS-A-5906 standard. However, the dimensional stability of the fibreboards increases with increase quantity of plastic used.

Keywords: hybrid fibreboard, oil palm fibres, polyethylene, physical and mechanical properties

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1. INTRODUCTION

The advancement of technology has enabled the agricultural wastes and other industrial by-products to be utilised in the manufacture of bio-composites. Research on the effect of combining ligno-cellulosics including oil palm biomass with other materials such as glass, metal, inorganic, plastic and synthetic fibres in producing new materials are still being carried out[1]. One of the disadvantages of bio-composites is its high affinity towards moisture that could afflict adverse effects on its characteristics and properties[1,2]. Therefore, development of bio-composites with greater dimensional stability and improved physical and mechanical properties is necessary. Improvement of these properties can be overcome via combination with plastic polymers[3].

In this study, fibreboards were made from different mixtures of oil palm fibres and polyethylene. The primary objective of this study was to investigate the physical and mechanical properties of the oil palm fibreboards.

2. EXPERIMENTAL METHODS

Laboratory experiment was conducted to investigate the variation of physical and mechanical properties of the different oil palm fibreboards of 3 mm thick. Twenty-four (32 cm X 32 cm) sample fibreboards were prepared for the testing. The oil palm fibres were obtained from Palm Oil Research Institute of Malaysia (PORIM) while the fibreboard manufacturing process was performed at Forest Research Institute Malaysia (FRIM). Test samples were cut from the fibreboards to a prerequisite dimension in accordance with the Japanese Industrial Standard (JIS) and tested after conditioning in the laboratory.

The raw materials used were oil palm frond (OPF) with parenchyma, oil palm trunk (OPT) with parenchyma, empty fruit bunches (EFB) with parenchyma, polyethylene, Urea Formaldehyde of 10% resin content. The oil palm trunks, fronds and empty fruit bunches chips were refined by cold refining process. Fibres obtained were dried in an electric oven to attain moisture content of 8 to 12 percent. Later the fibres were fluffed to separate the bulking (cluster) fibres before being dried again until 5 to 7% moisture content. The fibres were then mixed with polyethylene at various contents by weight (0%, 5%, 12%, 20%). The fibreboard fabrication was done using a non-woven process. The fibreboards were then conditioned at room temperature for 24 hours.

2.1 Testing Procedure

The testing procedure followed was in accordance with the Japanese Industrial Standard[4] for medium density fibreboard (MDF). The tests conducted in this study were bending strength, internal bonding, thickness swelling, water absorption, density and moisture content.

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3. RESULTS AND DISCUSSION

3.1 Physical Properties of the Boards

All the fibreboards manufactured in this study were brownish in colour since the natural colour of the fibres used was also brownish. However, the EFB boards were darker than both the OPF and OPT boards with the OPF boards being the lightest.

Table 1 indicated that the addition of plastics improve significantly the dimensional stability of the board. All fibreboards with plastics had lower thickness swelling (TS). The TS of these fibreboards decreased with increase of plastic content. Among the fibreboards without polyethylene, the OPT fibreboards had the highest TS while the EFB fibreboards had the lowest TS. This may be due to the present of oil traces in EFB fibres. As for the water absorption (WA), among the fibreboards without plastics, the OPF fibreboards had the highest percentage. In the fibreboards with different plastic content, the WA showed a similar trend to TS which was decreasing WA with increasing plastic content.

Table 1 also shows that the OPF fibreboards had the highest density value followed by OPT and EFB fibreboards. It also shows that the fibreboards with 12 % plastic content had the highest density whereas the fibreboards with 0% plastic content had the lowest density. Statistically, this was not significantly different (Table 1). Interaction between fibre and plastics showed no significant influence on the change in density. Addition of different fibre types did not significantly affect density change. It is possible that the polyethylene had filled-up the spaces between the oil palm fibre matrixes, consequently, increasing the density of the fibreboards.

3.2 Mechanical Properties of the Boards

The OPT fibreboards had the highest MOE value followed by OPF and EFB respectively (Table 1). The presence of residual parenchyma among the fibres might have resulted in the higher MOE readings in the OPT boards compared to the OPF and EFB boards. Table 1 revealed that the boards with 12% plastic content had the highest Modulus of Elasticity (MOE) value among the hybrid fibreboards. The value decreased when plastic content was increased to 20%. This could be due to that as the plastic content increases the fibreboards will acquire increase plasticity, therefore, the MOE will be reduced. The table also exhibit that between the fibreboards without polyethylene, the oil palm frond fibreboard had the highest Modulus of Rupture (MOR) followed by the OPT fibreboard and EFB board. The fibreboards from empty fruit bunches had the lowest MOR when compared to all other types of fibreboards. Among the hybrid boards, the fibreboard with 5% plastic content had the highest MOR. The fibreboards without plastic content had the lowest MOR. As indicated in Table 1, the polyethylene helps to improve the IB. Without the

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polyethylene the strength of the fibreboards would be lower. The 12% plastic content might be the critical value where beyond this point the board acquire more plastic properties which might be accompanied by lower MOE and MOR. The lower MOE might not be due to the addition of polyethylene but might be due to the bonding. Bonding of the polyethylene with the UF should be studied at the macroscopic level to understand the bonding mechanism in more detail. Table 1 shows that OPF fibreboards had the highest IB followed by the OPT and EFB fibreboards respectively. Among the hybrid boards, the fibreboards with 12% polyethylene content had the highest IB whereas the boards with 20% plastic content had the lowest IB as shown in the Table 1.

Table 1. Physical and mechanical properties of fibreboards from oil palm fibres and polyethylene.

	Boards Without Polyethylene				Boards With Polyethylene		
	EFB	OPF	OPT	Average	5%	12%	20%
MOE (MPa)	929.0 (a_1)	1,668.0 (b_1)	1,996.0 (c_1)	1,531.06 (a_2)	1,902. 76 (b_2)	1,788.22 (b_2) (c_2)	1,490.28 (a_2) (c_2)
MOR (MPa)	10.21 (a_1)	28.27 (b_1)	15.19 (c_1)	17.89 (a_2)	21.17 (b_2)	20.34 (b_2) (c_2)	18.94 (a_2) (b_2)
IB (MPa)	0.66 (a_1)	1.05 (a_1)	0.80 (b_1)	0.64 (a_2)	0.95 (b_2)	0.98 (b_2) (c_2)	0.78 (a_2) (b_2)
Density (Kg/m^3)	779.3 (a_1)	807.77 (a_1)	789.56 (a_1)	792.22 (a_2)	846.77 (a_2) (b_2)	890.14 (b_2)	814.40 (a_2) (b_2)
MC (%)	5.52	6.55	5.6	6.22	5.35	5.05	4.81
TS (%)	21.61 (a_1)	37.12 (b_1)	37.74 (c_1)	32.15 (a_2)	27.11 (b_2)	22.98 (c_2)	17.72 (d_2)
WA (%)	84.43 (a_1)	95.98 (b_1)	85.72 (c_1)	88.71 (a_2)	73.49 (b_2)	64.81 (b_2) (c_2)	61.05 (c_2) (d_2)

Note: Groups followed by a common letter in brackets are not significantly different from one another at the 95% significant level.

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4. CONCLUSION

In this study, it can be concluded that the dimensional stability of the hybrid fibreboard increases with increase quantity of plastic used. In the MOR test, all OPF fibreboards and all hybrid fibreboards with 5% and 12% plastic content passed the JIS-A-5906 200-type board. The OPT fibreboards and the hybrid fibreboards with 20% plastic content passed the JIS-A-5906 150-type board. The EFB fibreboards only passed the JIS-A-5906 50-type board. In the IB test, all the boards were able to meet the requirements of 300-type board as specified in JIS-A-5906. The thickness swelling test indicated that all the boards failed to meet the requirements as specified in the JIS-A5906. However, the value decreased with increased plastic content.

5. RECOMMENDATIONS

Further investigation should be carried out to verify some of the indicative finding, as well as to improve the properties and performance of the hybrid bio-composite manufactured using oil palm fibres and polyethylene. For better physical and dimensional stability, the oil palm fibres should be used without parenchyma since parenchyma tends to absorb moisture and this will affect dimensional stability of the manufactured boards. The additional costs in removing the parenchyma should be kept to a minimum. In manufacturing thin MDF (3 mm) using UF resin, several factors should be considered such as pressure and pressing time. This improves the mechanical properties of the hybrid bio-composite because adequate pressure and pressing time will result in good compaction of the fibre and also allow the resin to completely cure hence increase the inter-bonding of the fibres. The bonding characteristics and properties of the polyethylene should be further studied at the macro-level to understand its overall contributing strength to the hybrid board. Further studies should also be carried out on the cushioning effect of parenchyma on the bending properties of oil palm fibre based composite. As this study had indicated that the bio-composite with the trunk fibres (the most parenchymatous tissue) had the highest MOE value.

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