# Properties of Urea-formaldehyde Particleboard from Particles of Mixed Timber Species

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ABSTRACT

*Mixed hardwood particles were used in the manufacture of urea-formaldehyde particleboard. Three different resin contents (8, 10 and 12%) and 1% wax content were used in the study. The target density was 700 kgm$^{-3}$. Increasing resin content resulted in an increase in the mechanical and dimensional properties of the particleboard. Wax addition improved the dimensional stability of the particleboard. However, all particleboards failed in their thickness swelling exceeding the 8% benchmark as stipulated in the British standards.*

**Keywords**: *urea-formaldehyde particleboard, resin content, wax content, mechanical and dimensional properties*

## Introduction

The use of wood-based material is expanding through modernization of living quality in our country, Malaysia. Today, more wood is being used for furniture, construction materials, paper and other uses. Due to this usage the volume of trees in the forest is reducing from year to year. Scientists at present are trying to find alternative methods and ways to replace these valuable sources and millions of Malaysian Ringgit is being used to carry out research to utilize the wood wastes of the wood industries. Particleboard is one of the oldest composites to be produced and still remains the world's dominant furniture panel and also for structural application. This paper presents data on the suitability of the particles from mixed timber species as a raw material in the manufacture of urea-formaldehyde particleboard. The effects of resin content and wax content are also presented.

## Materials and Methods

### Materials and Board Preparation, Pressing and Board Testing

All the timber species (kelempayan, ketapang and geronggang) were longitudinally cut using a re-saw into one-inch thick planks and a width of approximately one inch and a length of about 7 feet. The planks were then chipped in the Pallman Drum Chipper. The chips were further processed into particles in the Pallman Knife-ring Flaker. The particles were then air-dried for two weeks and screened into various particle sizes viz; < 0.5, 0.5-1.0, 1.0-2.0 and > 2.0 mm. The particles were then oven-dried in an oven at 60°C for 48 hours. A moisture content of about 5% is attained. Bulk density and particle analysis on unscreened sample were carried out before particle screening. In this study, the effects of resin content (R.C) of 8%, 10% and 12% and wax content of 0 and 1% were analysed. The board thickness was set at 12mm. In the manufacture of particleboard, a measured weight of particles was sprayed with a resin mix containing resin, hardener and wax in a glue blender. The resin used had a solid content of 65%, wax (W) and hardener, ammonium chloride at 20% concentration. The sprayed particles were then laid in a wooden mould and pre-pressed at 3.5Mpa for about 30 sec. The consolidated mat was finally pressed for 6 mins at 165°C in a Taihei hot-press. The boards were then cooled and conditioned at 65% relative humidity (RH) and 20°C for 48 h in accordance with British Standards 326-1 (Anonymous, 1994). The following tests were conducted; thickness swelling (TS) and water absorption (WA) in accordance with British Standards EN 317 (Anonymous, 1993a) and Modulus of rupture (MOR) was determined in accordance with British Standards EN 310 (Anonymous, 1993b).

## Results and Discussions

### Bulk Density and Particle Analysis

The bulk density and particle analysis of the particles from the mixed hardwood species is shown in Table 1.

Bulk density of the mixed hardwood sample is low, that is less than 100 g/l requiring large amount of particles to produce a single board at a

Table 1: Bulk Density and Particle Analysis of Mixed Timber Species

| Particles | Sampel 1 | Sampel 2 | Average |
|---|---|---|---|
| Bulk Density(g/l) | 92.0 | 90.0 | 91.0 |
| Particle length (mm) *l* | 15.58 | 14.56 | 15.07 |
| Particle thickness(mm) *t* | 0.66 | 0.60 | 0.63 |
| *l/t* ratio | 23.60 | 24.27 | 23.92 |

specified board density. The l/t ratio is also low less than 100 indicating the sample has a high surface area requiring high amount of adhesive during blending.

## Strength and Physical Properties

The strength and physical properties of particleboard made from mixed hardwood particles according to resin and wax content are shown in Table 2. Board produced at a resin content of 12% and with 1% wax addition gave the highest MOR (15.60 MPa) and MOE (2358 MPa) value. The board also had the lowest WA (37%) and TS (11.07%). However, all boards produced failed to meet the minimum requirements of the BS for TS (< 8%).

Table 2: Strength and Physical Properties of Particleboard According to Resin and Wax Content

| Board Density ($kgm^{-3}$) | Resin Content (%) | Wax Content (%) | MOR (MPa) | MOE (MPa) | WA (%) | TS (%) |
|---|---|---|---|---|---|---|
| 700 | 8 | 0 | 12.03 | 1862 | 89.75 | 20.73 |
| | 10 | 0 | 11.10 | 1919 | 82.83 | 17.85 |
| | 12 | 0 | 13.54 | 2262 | 66.90 | 14.64 |
| 700 | 8 | 1 | 14.37 | 1994 | 47.06 | 19.34 |
| | 10 | 1 | 17.38 | 2420 | 43.99 | 14.93 |
| | 12 | 1 | 15.60 | 2358 | 37.00 | 11.07 |
| BS | 5669 | 1989 | >8.00 | >2000 | na | <8.00 |

## Statistical Significance

The analysis of variance of the effects of the resin and wax content on the particleboard properties is shown in Table 3.

Table 3: Analysis of Variance of the Effects of Resin and Wax Content on the Particleboard Properties

| SOV | df | MOR | MOE | WA | TS |
|---|---|---|---|---|---|
| Resin (R) | 2 | 2.67* | 16.43* | 47.18* | 83.03* |
| Wax (W) | 1 | 48.67* | 19.45* | 686.18* | 33.35* |
| R X W | 2 | 6.08* | 5.50* | 7.13* | 2.00ns |

Note: SOV - source of variance, df - degree of freedom, ns - F-ratio not significant at $p < 0.05$ and * - significant at $p < 0.05$

## Effect of Resin Content

The effects of varying resin content on the particleboard properties are shown in Figure 1. By increasing the resin content from 8% to 12%,

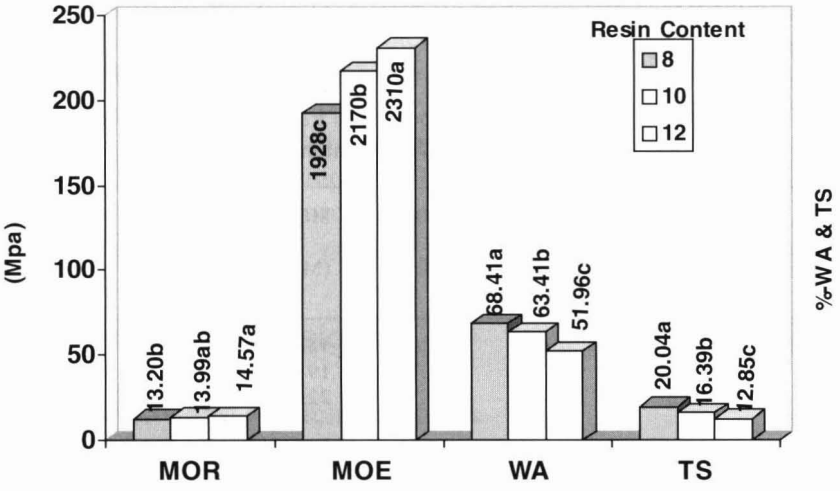


Fig. 1: Effects of Resin Content on the Particleboard Properties

Note: Same alphabet along the column are not significantly different at $p < 0.05$

MOR was shown to increase by about 10% and MOE by about 20%. On the other hand the properties of WA and TS were found to decrease by about 24% and 36%, respectively. This is obvious since at higher resin content more resin is available for inter-particle bonding thus increasing the mechanical and dimensional properties.

### Effect of Wax Content

It is known that the addition of wax is to confer a degree of water repellency on the board. Figure 2 shows that the addition of 1% wax gives significantly better WA and TS properties. However, wax was found to increase MOR and MOE values. With 1% wax, the WA and TS decreases by about 46% and 15%, respectively.

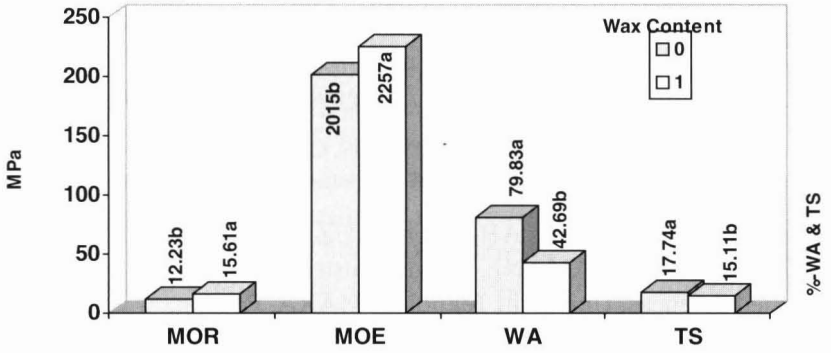


Fig. 2: Effects of Wax Addition on the Particleboard Properties

Note: Same alphabet along the column are not significantly different at $p < 0.05$

## Conclusion

From the study, it was found that by increasing the resin content, both the mechanical and dimensional properties of the mixed hardwood particleboard are increased. A 1% wax addition enhanced the dimensional properties without reducing the mechanical properties. However, all the particleboards produced failed in their thickness swelling exceeding the 8 % benchmark as required in the British Standards BS 5669.

## References

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