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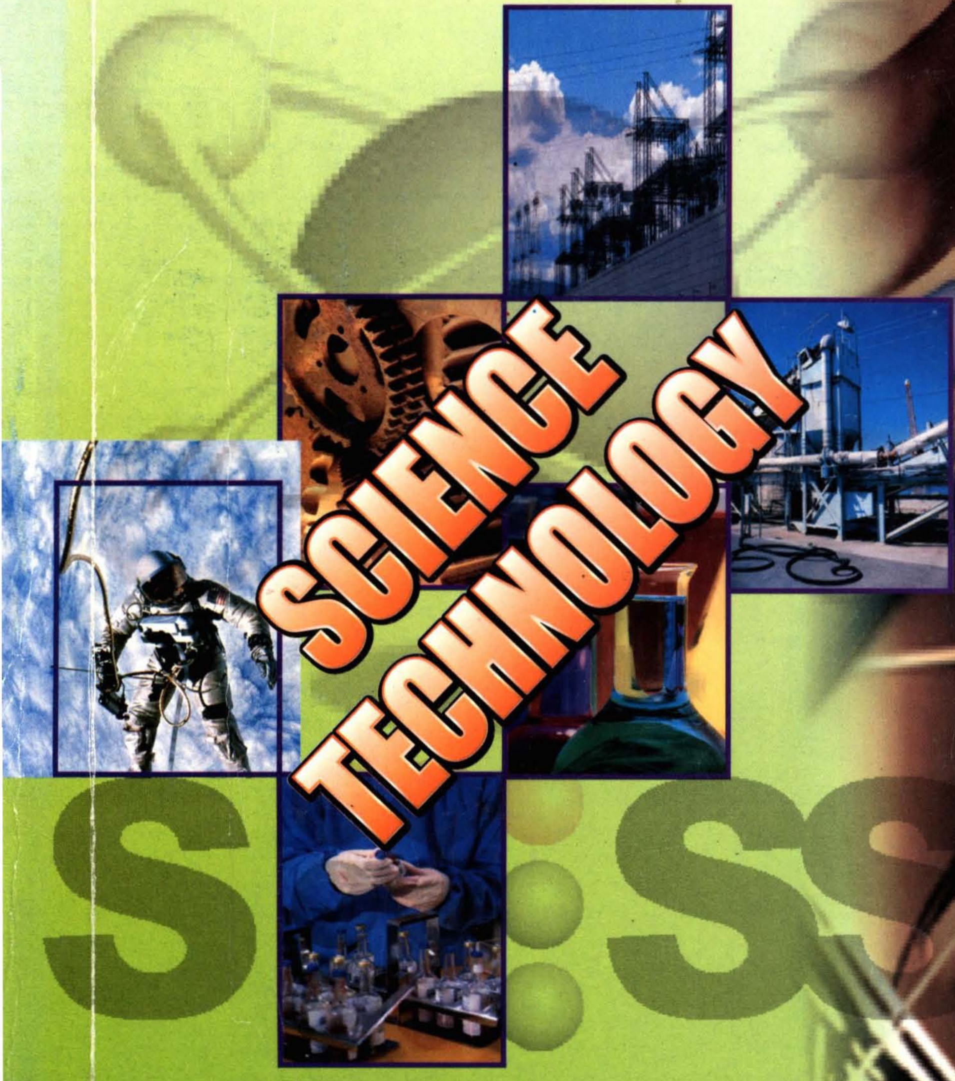

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Phenol Formaldehyde as Binder for Rubberwood Oriented Strand Board (OSB)

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ABSTRACT

Phenol formaldehyde (PF) is a thermoset resin that has been widely used as binder for wood composite products. Since the products differed in material and applications, the resin is usually varied in term of physical and chemical properties to tailor with the requirements as to give good properties to the products. The preparation method of PF resin was one of the factors affecting its properties. This study was carried out to look into the effect of preparation method on the properties of PF resin and oriented strand board (OSB) made from rubberwood. Two alkaline resins were synthesised in the laboratory. They were similar in chemical molar ratios but used slightly different preparation method. The viscosity, solids content, alkalinity, specific gravity, pH and gel time of the resins were determined. The resins then mixed with rubberwood flakes. Boards at 650 kg/m^3 density had been produced with resin loading of 3, 5 and 7% of the board weight. The furnish boards were tested according to European Standards to determine the modulus of rupture, modulus of elasticity, internal bond and thickness swelling. The results showed that the resins differed in the viscosity and gel time. Boards produced with the resins have significant different in the physical and mechanical properties.

Keywords: *Phenol formaldehyde, rubberwood, oriented strand board*

Introduction

Oriented strand board (OSB) is a kind of wood composite products made from long, thin and narrow strands that aligned parallel within others and bonded together under heat and pressure with a water proof resin (Youngquist, 1999). The board basically consists of three layers in which the panel surfaces are generally aligned parallel to the panel-length direction while the core layers are usually aligned across to the surface layers (SBA 1996). Generally, OSB is used in almost similar application of plywood as the panel has demonstrated that it is comparable to plywood in terms of its strength, appearance, versatility, and cost (Doyle 1996). In North America and Europe, the board is normally used in housing construction besides for industrial and non-industrial applications (Flynn 1998; WBPI 1999).

Phenol formaldehyde (PF) resin is a product of condensation reaction between phenol and formaldehyde in the presence of alkaline or acid catalyst. Alkaline PF resin known as resol resin is usually used as a binder for OSB manufacture (Caesar 1997). The resin is varied in term of physical and chemical properties to tailor with the requirements as to give good properties to the products.

Phenol formaldehyde resins for wood adhesive application usually have formaldehyde to phenol molar ratio (F/P) between 1.9 and 2.5, sodium hydroxide to phenol molar ratio (NaOH/P) up to 0.8, and solids content between 40 and 60% (Kim et al. 1994). For OSB, PF resin with solids content of 40 to 55% and viscosity in the range of 150 to 250 cp is used (Kim et al. 1994; Wu 1999; Generalla, Biblis & Carino 1989; Myers et al. 1991). The F/P and NaOH/P ratio of PF resin for OSB varies from 1.32 to 2.24 and 0.2 to 0.29 respectively (Myers et al. 1991; Ellis & Steiner 1991; Ellis 1996).

The objective of this study was to determine the effect of preparation method on the properties of PF resin and OSB made from rubberwood.

Materials and Methods

About 3 kg of phenol formaldehyde resins, labelled as PF1 and PF2, were prepared at a fixed F/P and NaOH/P ratio. The resins were set to have solids content in the range of 50 to 52% and viscosity of less than 200 centipoises (cp).

In PF1 preparation, phenol (100%), formalin (100%), NaOH (50%), and water were mixed in a reaction flask. The mixture was heated slowly and remained its reaction temperature between 70 to 90°C. The viscosity of the mixture was monitored gradually by using Brookfield viscometer. Once the target viscosity was achieved, the reaction was retarded by cooling down the mixture. Excess of NaOH and water were added later. The resin physical properties i.e. viscosity, specific gravity, solids content, pH, alkalinity and gel time were then determined (De Bruyne & Houwink 1951; Meese 1974; Sellers 1985).

For PF2 resin, phenol (100%), NaOH (50%) and formalin (90%) were mixed and heated to 90°C. Sodium hydroxide (25%) and excess of formalin were added into the mixture at 70 cp viscosity. The reaction was retarded once the target viscosity was achieved and followed by the addition of excess NaOH. The properties of the resin were determined at ambient temperature.

Eighteen pieces of rubberwood OSB (target density 650 kg/m^3 and dimensions 380 x 380 x 12 mm) were produced using PF1 and PF2 as binder. The resin content was varied at 3, 5 and 7% of the oven dried weight of board.

First, rubberwood strands of approximately 0.5 mm thickness and 75 mm length were prepared by flaking of rubberwood billets using a disc flaker. The strands were screened to remove from fines before drying to moisture content of less than 5%. Weighed strands were sprayed with a measured quantity of PF resin in a rotary mixer. The resinated strands were arranged parallel with each other in a square mould consisted of slots. In this study, three-layer-mat was produced in which the core layer has perpendicular direction than the surfaces. The consolidated mat was pressed to 12 mm thickness in a hydraulic hot press at 180°C for six and half minutes until the resin were completely cured.

The boards were tested accordingly to European Standards for modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB) and thickness swelling (TS) (BSI 1993a; 1993b; 1993c).

Results and Discussion

With the exception of the viscosity values, the resins had almost similar properties as shown in Table 1. The results were expected as they were set at the same chemical ratios and amounts of solids. The difference in the preparation method had varied the resin viscosity, gel time and shelf-life. Even though the resin reaction was retarded at the same viscosity level, the final viscosity of PF1 was higher than the PF2. The PF1 resin probably had higher reactive molecule that shortened its gel time and shelf-life. Gel time is the time required by the resin to become solid after continuous heating at 105°C. OSB using PF2 was expected to have longer hot pressing duration in order to completely cured the resin. On the other hand, PF2 resin could be stored longer prior to use thus favours to material handling and production planning.

Table 1: Properties of phenol formaldehyde resins

Property	Resin	
	PF1	PF2
Solids content (%)	51.1	51.0
Specific gravity	1.172	1.162
pH	9.9	10.3
Alkalinity (%)	2.94	2.93
Viscosity (cp)	180	130
Gel time (min)	12	13
Shelf-life (days)	2	7

The mechanical properties of OSB manufactured using PF1 and PF2 resin are shown in Table 2. The MOE and MOR values complied with the minimum standard requirement. However for boards using 3 and 5% of PF1 resin, the MOR values were below the standard. The increment of PF1 loading in boards had improved the MOE and MOR significantly but for PF2 resin, the addition did not give significant effect. Except for PF1 resin at 3% resin content, boards using the synthesised resins had IB values that exceeded the standard requirement. The increment of resin content in boards improved the IB values significantly especially when PF2 resin was used as binder. Overall, the mechanical properties were higher in rubberwood OSB using PF2 resin even at low resin content.

The physical properties (TS values) of rubberwood OSB complied with the standard specification in boards using both PF resins. However the TS value has exceeded the maximum limit in boards contained 3% of PF1 resin. The swelling in boards was reduced significantly as the resin content increased. Nevertheless, the increment in TS values were not significant in boards using PF2 resin.

Table 2: Properties of rubberwood OSB using PF1 and PF2 resins

Resin	Resin content (%)	MOE (N/	MOR (N/mm^2)	IB (N/mm^2)	TS (%)
PF1	3	3307 d	10.01 d	0.109 d	28.06 a
	5	4035 c	17.87 c	0.379 c	14.74 bc
	7	4798 b	22.66 bc	0.402 c	11.36 c
PF2	3	5252 ab	27.56 ab	0.419 c	18.42 b
	5	5557 a	30.19 a	0.560 b	16.52 b
	7	5612 a	32.00 a	0.815 a	14.74 bc
BS EN 300	(BSI, 1994)	min. 2500	min. 18	min. 0.28	max. 25

Note: Means with the same letter within the same column are not significantly different at 5% level of significance

Conclusion

The resin preparation method affects the properties of PF resin and rubberwood OSB using the resin as binder. The shelf-life of PF resin and mechanical properties of rubberwood OSB could be improved by modifying the preparation method.

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