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Studies on the production and properties of board from sugar cane rind

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The tensile strength, glue bonding and decay resistance of sugar cane rind were determined. Results showed that sugar cane rind strips exposed to *C. versicolor* (COV) had high weight loss with low tensile strength retention while strips exposed to *T. palustris* (TYP) had low weight loss with high tensile strength retention. Bonded rind strips exposed to COV had high weight loss and low bond strength retention but those exposed to TYP had low weight loss with high bond strength retention. Phenol formaldehyde (PF) bonded strips exhibited the lowest weight loss and highest bond strength retention compared to isocyanate (IC) and urea-melamin formaldehyde (UMF) bonded strips.

Sugar cane rind board using different kinds of adhesives at various rind lengths were produced and the properties were evaluated. Results showed that the modulus of rupture (MOR) and modulus of elasticity (MOE) of isocyanate (IC) and urea-melamin formaldehyde (UMF) boards increased with increased rind length. Internal bond (IB) strengths differed according to glue type IC, UMF and PF in increasing order. UMF and PF boards exhibited high TS despite addition of wax compared to IC boards with low TS.

1. INTRODUCTION

Forest resources are depleting and the supply of wood, especially from tropical rain forests has been on the decline. This resulted to the rise in the price of logs causing an anticipated shortage of raw materials for board production. Thus, to conserve our remaining forests and at the same time, develop the use of available waste materials, thought has to be given to find an abundant and cheap alternative material to wood.

One such material which may replace wood is sugar cane, an agricultural crop grown widely in tropical countries. Sugar cane is a tall grass with a solid pointed stalk rich in sugar. Twenty four percent of sugar cane consists of woody fiber and bagasse[1].

Recently, a newly developed cane separator system which frees the sugar cane rind from the pith and epidermis was introduced. Rather long pith-free fibers are generated which is different from bagasse which have shorter fibers. Using this new material, a basic study done in this laboratory was successful in producing a board by pressing glued layers of rind[2].

Studies on the properties of bagasse and its use in board production has been done extensively but with not very good results. On other hand, the properties of sugar cane rind has not been fully studied. Also, except for the earlier mentioned study, research on the application of rind as a raw material in board production are limited hence, more studies must be made on this.

Therefore, this study aimed to: 1) determine the tensile strength, bond strength and decay resistance of sugar cane rind, 2) produce sugar cane rind board using different kinds of adhesives at various rind lengths and test the physical and mechanical properties of the board product.

2. Experimental

1.1 Tensile Strength Test: Tensile strength test specimens sized 70 x 10 x 1 mm were prepared from sugar cane rind strips. The maximum load to failure was measured using a universal testing machine at 1 mm/min test speed.

1.2 Bond Strength Test: Single lap shear test specimens were prepared from 40 x 10 x 1 mm strips obtained from sugar cane rind. Isocyanate adhesive (IC: PB-1605, Oshika), adhesive (PF: PB -1310, Oshika) were applied into an area of 10 x 10 mm on the surface of both strips to be bonded. Assembled pieces were pressed, conditioned then the tensile shear strength was determined using a the universal testing machine at 1 mm/min. test speed.

1.3 Decay Resistance Test: Specimens prepared in the same manner as 1.1 and 1.2

Table 1
Manufacture conditions used in the production of board from sugar cane rind

Rind Conditions		Glue Conditions		Press Conditions
length (cm.)	moisture content (%)	glue type*	wax + curing agent/additive	temperature, pressure, time
15				160°C, 20 kg/cm^2, 1 min.
10	11	IC	–	→ 10 kg/cm^2, 5 min.
5			wax (1 % of glue wt.) + curing	180°C, 20 kg/cm^2, 2 min.
	4	UMF	agent (0.5 % of glue wt.)	→10 kg/cm^2, 5 min.
		PF	wax (1 % of glue wt.) + additive (0.5 % of glue wt.)	

*glue type same as in 1.2

were exposed to decay by *C. versicolor* (COV) and *T. palustris* (TYP) in malt extract agar (MEA) medium incubated at 26 ± 2°C with 65 ± 2 % RH. The weight loss, and tensile strength and bond strength retention of the specimens were determined after 3 and 6 weeks exposure.

2) Sugar Cane Rind Board Production and Properties

Wax-less and pith-less sugar cane rind strips from Jamaica were sprayed with glue (10 % of rind weight), mat-formed and hot pressed into 30 x 30 x 1.0 cm boards with a target specific gravity of 0.60. The manufacture conditions are shown in Table 1.

Test specimens from the produced boards were taken and the density, moisture content, modulus of rupture (MOR) and modulus of elasticity (MOE) in bending, internal bond (IB) and thickness swelling (TS) were determined following JIS A-5908[3] test procedures.

3. Results and Discussion

1) Properties of sugar cane rind

Weight loss of sugar cane rind strips exposed to COV and TYP (Fig. 1) reveals that from the first 3 weeks of exposure, weight loss is higher with COV at 21.87 % than TYP at 14.78 %. This trend continued until the sixth week with COV at 52.87 % and 50.11 % although the differences in values are not really considerable. This may be an indication that because of the similarity of sugar cane and hardwood in terms of lignin content[4], white-rot fungi, COV caused more decay on sugar cane rind.

Tensile strength test of sugar cane rind strip showed that the rind had approximately a strength of 1.10 MPa However when the tensile strength of the rind were determined after exposure to COV and TYP, results (Fig. 2) showed that rinds exposed to COV had lower tensile strength retention than those exposed to TYP coinciding with the earlier result of higher weight loss by COV which may have caused more decomposition of components leading to the weakening of the rind.

The weight loss of bonded strips after fungal exposure (Fig. 3) showed that for all glue types, higher weight loss was observed with COV than with TYP exposed strips. But among glue types, PF had the lowest weight loss with either COV or TYP which may indicate greater resistance to PF adhesives.

As to bond strengths, low bond strength retention were obtained with COV exposure while high bond strength retention was obtained with TYP exposure (Fig. 4). For both COV and TYP exposures, lowest and highest

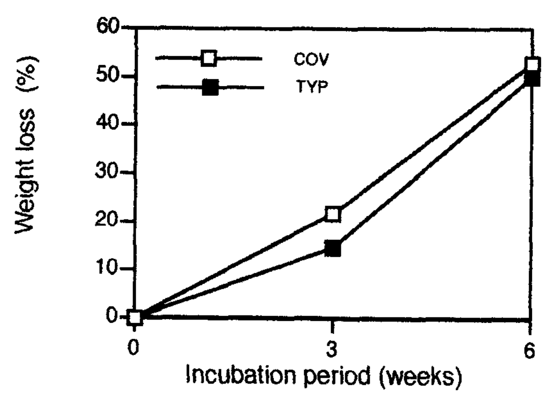

Fig. 1. Weight loss of sugarcane rind strips exposed to COV & TYP.

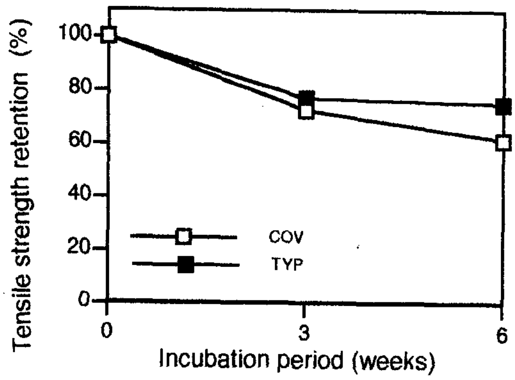

Fig. 2. Tensile strength retention of sugar cane rind strips exposed to COV & TYP.

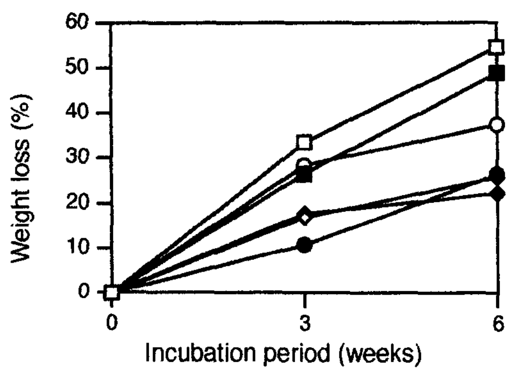

Fig. 3. Weight loss of bonded sugar cane rind strip exposed to COV & TYP.

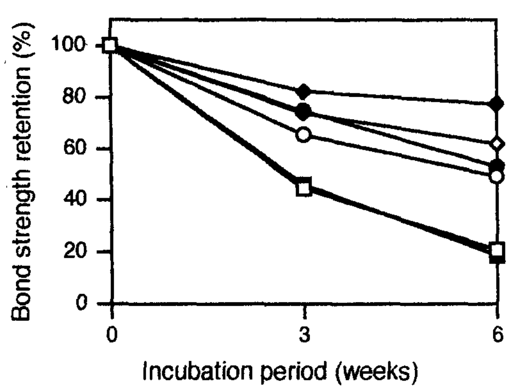

Fig. 4. Bond strength retention of bonded sugar cane rind strips exposed to COV & TYP.

Legend for figs. 3 & 4:

COV-IC TYP-IC
COV-UMF TYP-UMF
COV-PF TYP-PF

bond strength retention was in IC and PF bonds respectively.

2) Properties of the manufactured boards

MOR and MOE. Results of MOR tests (Fig. 5) showed that for both IC and UMF boards, an increase in rind length resulted to increase in MOR. This trend was not seen in PF boards wherein PF-10 board had higher MOR than PF-15 board. IC-15 board had particularly high MOR at 54.2 MPa compared to the other boards. According to literature[5], MOR in particleboards is strongly dependent on flake thickness, MOR increases as flake thickness decreases. In this study, only the length of the rind was controlled and if the above observation applies, it may be possible that IC-15 boards consisted of thinner rinds. But generally, IC boards had comparably higher MOR values among the boards brought about may be by the easier applicability of IC compared with that of UMF and PF adhesives.

MOE is dependent upon flake length and longer flakes produce particleboard with substantially higher MOE[5]. The relationship between MOE and glue type-rind length is shown in Fig. 6. Results showed similar trend with MOR i.e. for IC and UMF boards, as rind length increases, MOE also increases. The highest MOE value was for IC-15 boards at 28.6 MPa. UMF boards had generally constant slight increase in MOE with increasing rind length. Among PF boards, PF-10 had the highest MOE which is almost similar to IC-15.

IB. Most researchers have found higher IB values with increasing resin content and increasing press times and temperature. The IB strength improves as core particle configuration changes from long wide flakes to planar shavings or slivers.

The relationship between IB and glue type - rind length of the boards are shown in Fig. 7. IC boards had higher IB values at an average of 0.12 MPa then UMF at 0.10 MPa and PF boards at 0.08 MPa, the lowest. Insufficient curing of adhesive in PF boards may account for low IB strength values. During the experiment, control of MC for PF boards were difficult resulting in blisters and superfluous steam.

PF resins undergo a slower transition thus higher pressing temperatures and longer pressing times are needed, hence the moisture contents of the materials to be glued

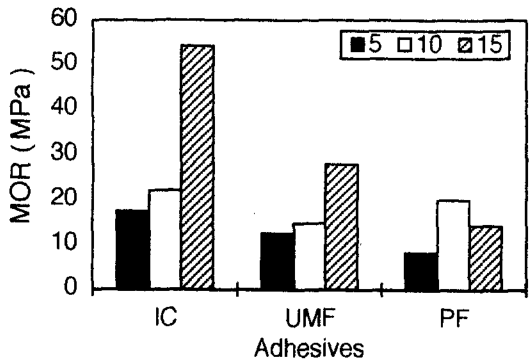

Fig. 5. MOR of sugar cane rind board bonded with different adhesives at various rind lengths.

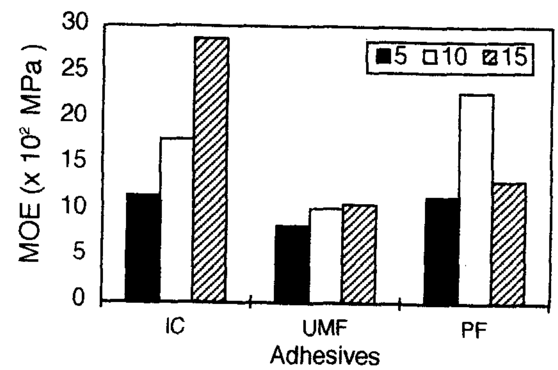

Fig. 6. MOE of sugar cane rind board bonded with different adhesives at various rind lengths.

is more critical with PF than with UF. If the moisture content is too high too much steam will be generated within the board during hot pressing which will disturb or even inhibit the curing process within the board and either blisters may occur or the board may delaminate on removal from the press.

IC-15 boards had the highest value at 0.13 MPa. In IC and UMF boards, a trend of similar values for 5 and 10 cm boards with the highest values for 15 cm boards were seen. However, in PF boards, IB decreased as rind length increased.

TS. The use of paraffin wax is widespread in the particleboard industry for UF and PF boards. It was found that a large reduction in water absorption and thickness swelling in the 24-hour water soak test by addition of wax.

In this study, wax was added to UMF and PF adhesives in an attempt to reduce swelling. Results of TS test (Fig. 8) showed that despite addition of wax, higher TS values and lower MOR and MOE values for UMF and PF boards

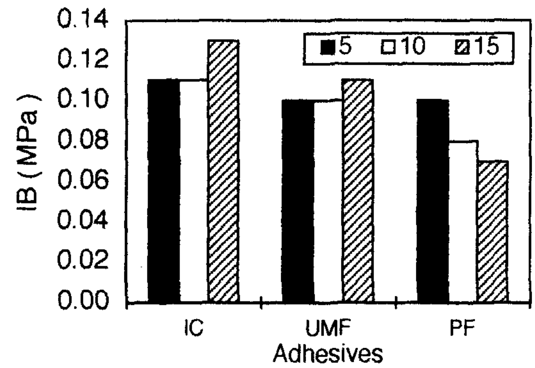

Fig. 7. IB strength of sugar cane rind board bonded with different adhesives at various rind lengths.

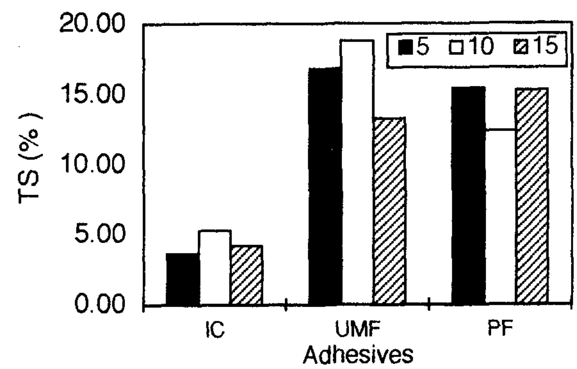

Fig. 8. TS of sugar cane rind board bonded with different adhesives at various rind lengths.

were obtained compared with IC boards. The amount of wax added might have been too much or too little and might have interfered with adhesive bonding and reduced the strength properties[5] of UMF and PF boards.

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