GLUE ADHESIVE PROPERTIES OF ARECANUT LEAF SHEATH BOARDS*

S.J.K. ANNAMALAI, S.R.K. MENON** AND N.M. NAYAR

Central plantation Crops Research Institute. Kasaragod 670 124, *Kerala.*

ABSTRACT

3-ply arecanut leaf sheath boards were made at the laboratory with two veneers of arecanut leaf sheath and one veneer of wood under various combinations and with different glues namely starch glue (cold pressing), animal glue (cold pressing) poly vinyl acetate (Fevicol–Pidilite –cold pressing), Epoxy resin adhesive (Araldite–Ciba Geigy–cold processing) and urea formaldehyde (hot pressing). The boards were tested for their glue shear strength and water resistance in accordance with the IS specifications for tea-chest grade plywood. Areca sheath boards made with UF resin adhesive and wood veneer as core were found to have 50% more wet glue shear strength than the other areca sheath boards. Use of extenders like tamarind seed powder and deoiled sal meal up to 15% to the UF resin adhesive and the type of wood used were found to have no adverse effect on the glue shear strength of the boards. Though the areca sheath boards satisfied only 50% of the IS requirements for tea chest grade plywood, they were found to have better wet glue shear strength over the locally purchased non–ISI grade tea chest plywood.

INTRODUCTION

Arecanut is grown in about 1,75,000 ha in India. Each palm sheds 5–7 leaves annually and the leaves provide about 120 million m^2 leaf sheaths for possible economic utilisation. Earlier studies have shown that the arecanut leaf sheaths have desirable properties which permit them to be made into plyboards in combination with wood veneers, and that these could be used for making panel products such as tea chest plywood. Since a number of glues are available in the market and their prices vary widely, glue adhesive properties of arecanut leaf sheath were taken up to find out the most suitable glue for making areca leaf sheath plyboards.

** Retired Scientist, Neelakanta Bhavan, N Parur 683 513, Ernakulam District, Kerala.

* Publication No. 199, CPCRI, Kasaragod.

MATERIALS AND METHODS

The leaf sheaths as obtained from the farms were first processed by soaking in water to about 75% moisture and then pressed in a hot platten press under a pressure of about 4 kg/cm^2 and 110°C temperature for 30 min. This produced flat sheaths of 1.0–1.5 mm thickness. These were then air-dried for easy workability. The studies were carried out on five aspects, namely, 1. Type of glue; 2. Combinations of areca leaf sheaths with wood veneer; 3. Use of extenders to the glue; 4. Type of wood veneer used and 5. Comparative performance of the areca sheath plyboards with locally purchased tea chest plywood boards.

The details of the experiments are given below:

1. Type of glue

Arecanut leaf sheaths were made into 3–plyboards in combination with a 1.5 mm thick veneer of *Vateria indica* L. (Fam. Dipterocarpaceae) (Vellapine) wood. Five different glues, namely starch glue, animal glue, poly vinyl acetate (Fevicol Pidilite) urea formaldehyde and an epoxy resin adhesive (Araldite Ciba-Giegy) were used for the study. The glue formulations are given below:

a. *Starch glue*: Vegetable starch..100 parts by weight; Water.. 500 parts by weight. Water was boiled to 100°C and then starch was added slowly and stirred.

   The boards were cold-pressed over night at room temperature under a pressure of about 4kg/cm.^{2}

b. *Animal glue*: Animal glue (Star brand) Shaw wallace: 100 parts by weight; Water..225 parts by weight; Oxalic acid as hardener — 5 parts by weight; Para formaldehyde as hardener — 10 parts by weight. The glue was allowed to soak in water for about 45 minutes. Then, the mixture was heated to 65°C, and when still hot, oxalic acid and para formaldehyde were added one after the other and stirred well.

   Gluing conditions: Cold pressing over night at room temperature under a pressure of about 4 kg/cm.^{2}

c. *Polyvinyl acetate*: Fevicol.. 100 parts by weight; Water.. 200 parts by weight. Gluing conditions: Cold pressing overnight at room temperature.

d. *Urea formaldehyde:* Urea formaldehyde resin—100 parts by weight; *Ciba hardener* — 20 parts by weight.

Gluing conditions: Hot pressing for 7 minutes with one minute breathing at 95–100°C under a pressure of about 10–12 $kg/cm.^2$

e. *Epoxy resin:* Araldite glue formulations as laid out by the manufacturers. (Ciba-Geigy)

Gluing conditions: Cold pressing overnight at room temperature under a pressure of $4kg/cm^2$ and at contact pressure for about 10 hours.

2. Combination of areca sheath with wood veneers

Three combinations were tried (Table I.). The wood veneer used was 1.5 mm thick *Vateria indica* (*Fam.* Dipterocarpaceae) (Vellapine).

Table. 1. Combination of areca sheath boards: 3 ply.

No.	*Description*			*Remarks*
	Ply	*Material*	*Direction*	
1.	Faces	Areca sheath and wood	Across the grain	
	Core	areca sheath	Along the grain	Type 1
2.	Faces	Areca sheaths both	Along the grain	
	Core	wood	Across the grain	Type 2
3.	Faces	Areca sheath and wood	Along the grain	
	Core	areca sheath	Across the grain	Type 3

3. Use of extenders to the glue

Two types of extenders namely tamarind (*Tamarindus indicus*) seed powder and de-oiled sal (*Shorea robusta* Roxb.) meal powder, were used upto a level of 15% by weight of urea formaldehyde resin to study their effect on extended resin on adhesion in 3 ply areca sheath boards. The boards comprised of areca leaf sheaths as faces and 1.5 mm thick wood veneer as core. The glue formulations and gluing conditions adopted were the same as followed for non-extended urea formaldehyde resin.

4. Type of wood

Three species of wood, namely *Vateria indica* Linn. (*Fam.* Dipterocarpaceae) (Vellapine); *Palaquium ellipticum* (*Fam.* Sapotaceae) (Pali); and *Mangifera indica* Linn. (*Fam.* Anacardiaceae) (Mango) were used as core veneer 1.5 mm thick for making 3 ply areca sheath boards with urea formaldehyde resin as glue, in order to study the performance of areca leaf sheaths when glued with different species of wood.

5. Comparative performance of areca sheath ply boards with commercially available tea-chest plywood boards (but not conforming to ISI standards).

Glue adhesion strength of areca sheath ply boards made with *Vateria indica* Linn. (Vellapine) wood veneer 1.5 mm thick as core and ureaformaldehyde resin as glue was compared with four brands of locally purchased tea chest plywoods.

The samples of all these studies were tested for their glue shear strength in accordance with the ISI specifications for Methods of test for plywood (General) IS:1734(1972). The water resistance of bonds made with different glues under various combinations of wood and areca sheaths was tested by seven days water soaking test as per the ISI specifications for plywood tea chests.

Results and Discussion

Type of glue and various combinations of wood and areca sheath veneers:

The glue shear strength of areca sheath ply boards made with various glues and in various combinations of wood and areca sheath veneers were tested.

In general, the areca sheath boards did not meet fully the ISI requirements for tea chest grade plywood. The average dry glue shear strength was 45–55 kg for all the boards (Table II). There was not any remarkable difference in the dry glue shear strength among the boards with various glues and in various combinations since the failure of the boards upon the ultimate load was mostly due to the sheath fibres.

With reference to the wet glue shear strength, the failure of the boards was predominantly due to the glue used in the case of boards made with animal glue and Fevicol, while it was mainly due to the sheath fibres in the case of boards made with urea formaldehyde. The boards made with urea formaldehyde had 50% more wet glue shear strength than those made with other glues. This may be due to the better adhesion of arecanut leaf sheaths provided by urea formaldehyde than by other glues. The adhesion of areca sheath ply boards with starch glue was so poor that the boards were delaminated even before testing them. Hence starch cannot be used for preparing areca sheath ply boards.

With the three combinations of wood and areca sheath veneers tried (Table 1), the boards made with wood veneer as core showed about 50% more wet glue shear strength than the other combinations. This may be due to the better adherent properties of the sheath-wood mating surfaces than the sheath-sheath mating surfaces.

The strength properties of areca sheath ply boards showed large variations. The coefficient of variation was more than 12% in all the cases and in some cases even 38%. This may be due to the highly heterogenous nature of areca leaf sheaths.

Water resistance studies showed (Table 3) that none of the samples withstood the seven-days' water soaking test. Comparatively, the boards made with urea formaldehyde showed the best performance. Further, the boards made with wood veneer as core did not warp, while all other boards warped on soaking in water for seven days.

Table 2. **Glue adhesion strength of Areca boards with various glues and different combinations***

Sl. No.	Glue used	Combination as in table I	Glue adhesion			Strength		
			Dry state (kg)	Coefficient of variation	% glue failure	Wet (CWR) (kg)		
			Range and Mean			Range and (Mean)	Coefficient of variation	% glue failure
1		2	3	4	5	6	7	8
1.	Animal glue	Type 1	28–142 (146)	29.0	60	4–26	30.0	70
		Type 2	42–142 (51)	24.0	50	10–22 (12)	24.0	30
		Type 3	39–110 (48)	18.0	30	6–14 (9)	11.0	50
2.	Fevicol	Type 1	48–124 (61)	29.0	10	2–6 (4)	14.0	60
		Type 2	46–142 (66)	19.0	15	7–26 (11)	19.0	70

* As per IS: 1734 — 1972

Table 2. Contd.

1	2	3	4	5	6	7	8
	Type 3	48–114 (56)	20.0	70	6–10 (7)	12.0	60
3. Urea Formal dehyde	Type 1	25–132 (65)	38.0	10	12–40 (16)	18.0	20
	Type 2	35–106 (58)	31.0	5	11–35 (17)	27.0	20
	Type 3	45–114 (52)	28.0	5	10.28 (13)	24.0	20
4. Araldite	Type 1	48–88 (56)	27.0	0	6–12 (7)	20.0	30
5. Starch	Type 1	Delaminated			Delaminated		
6. —	CWR Goude-Plywood	70	—	—	35	—	—
	ISI requirement	55			30		
		(Minimum individual)			(Minimum individual)		

Table 3. Water resistance properties of areca (sheath) ply boards

Sl. No.	*Description*	*Observation after Seven days' water soaking test (IS: 10–1976)*
1.	Animal glued boards	Delaminated after 6 days
2.	Fevicol—glued boards	Delaminated after 5 days
3.	Urea formaldehyde–glued boards	Slightly delaminated after 6 days and delaminated after 7 days
4.	Araldite-glued boards	Delaminated after 3 days
5.	Type 1 and 3 boards as in Table I	Delaminated after 3–6 days, samples warped
6.	Type 2 boards as in table I	Delaminated after 6 days, samples not warped
7.	Tea chest grade plywood ISI requirement	No delamination after 7 days and no warpage.

Use of extenders to the glue and the type of wood:

Using the extenders tamarind seed powder and deoiled sal meal powder upto 15% of the urea formaldehyde resin formulation and the species of wood used as core veneer in areca sheath boards did not adversely affect the glue shear strength of the boards (Table IV and V). The failure of the samples in both the cases was due to the sheath fibre only. Hence, the use of extenders upto 15% in the UF resin glue and the use of ordinary wood as core veneer may not affect adversely the strength of the boards. They will at the same time help to reduce the cost of production of the boards.

Comparative performance of areca sheath ply boards with locally purchased tea chest ply wood:

The comparative performance of glue shear strength of areca sheath ply boards and four brands of locally purchased tea chest plywood was studied (Table VI). The areca sheath boards were superior to the locally purchased tea chest plywoods in their wet glue shear strength.

The studies have revealed that the areca sheath plyboards made with two veneers of areca sheaths on the faces and one veneer of an ordinary wood species like *Mangifera indica* Linn. as core and bonded with extended UF resin glue make commercially acceptable boards. These boards with an average dry and wet glue shear strength of 50 kg and 12 kg respectively do not attain the ISI specifications for tea-chest grade plywood but were superior to four brands of locally purchased tea chest plywood in wet glue shear strength. Incidentally such boards are used for the shipping of 75% of tea within the country.

These areca leaf sheath ply boards can find also many other applications particularly in packaging industry.

ACKNOWLEDGEMENT

We gratefully acknowledge the facilities and assistance rendered by the Indian plywood Industries Research Institute, Bangalore and the Western India Plywoods Ltd., Baliapatam, Kerala. We thank Dr. R. N. Kumar, Technical Manager, Western India Plywoods Ltd., for the assistance given in conducting this study.

Table 4. Effect of extenders in UF resin on glue adhesion properties

Sl. No.	Description	Dry Strength (kg)			Wet strength (CWR)(kg)		
		Range and (Mean)	Coeff. of variation	% glue failure	Range and (Mean)	Coeff. of variation	% glue failure
1.	Tamarind seed powder	34—71 (53)	15.0	10	3—22 (11)	23.0	10
2.	De-oiled Sal meal (Extended 15% resin board)	30—68 (54)	16.0	10	4—19 (10)	23.0	15
3.	Non extended UF resin board(control)	37—105 (50)	23.0	10	7—19 (14)	21.0	15

Table 5. Effect of type of wood used on glue adhesion properties

Sl. No.	Timber species used	Glue adhesion: Dry/kg. Range and (Mean)	Glue adhesion: Dry/kg. Coeff. of variation	Glue adhesion: Dry/kg. % glue failure	Strength: Wet (CWR) kg. Range and (Mean)	Strength: Wet (CWR) kg. Coeff. of variation	Strength: Wet (CWR) kg. % glue failure
1.	Vellapine (*Veteria indica* L.)	36—65 (52)	21.0	15	6—16 (11)	12.0	10
2.	Pali (*Palaquium ellipticum*)	41—63 (49)	16.0	10	8—13 (11)	12.0	15
3.	Mango (*Mangifera indica* L.)	35—62 (48)	19.0	10	7—12 (9)	14.0	20

Table 6. Comparative performance of areca sheath plyboard and commercially available tea-chest plywood.

Sl. No.	Description	Glue adhesion strength		Wet (CWR) (kg)	
		Dry (Kg) Range and Mean	*% glue failure*	*Range and Mean*	*% glue failure*
1.	Commercially available tea chest plywood				
	Make I	33—56 (52)	90	1—6 (3)	100
	Make II	58—77 (65)	80	Delaminated	
	Make III	52—36 (99)	15	3—5 (4)	100
	Make IV	38—78 (59)	85	Delaminated	
2.	Areca sheath board	28—70 (51)	15	8—25 (12)	15
3.	ISI specifications for CWR grade plywood	70 (Mean) 55 (Minimum individual)		35 (Mean) 30 (Minimum individual)	

REFERENCES

DOKANIA, L.N. (1974): Progress and problems of plywood and panel industry. IPIRI.J. 4(3): 97–99

IS: 1734(1972). Methods of test for plywood (General). Indian Standards Institution, New Delhi.

IS: 10(1976). Specifications for plywood tea chests. Indian Standards Institution, New Delhi.

KADERKUTTY, A.K. (1976). Address Annual Session of Federation of India Plywood and Panel Industry. IPIRI.J. 6(2): 51–55.

KOLLMAN, E.P.F., KUENZI, F.W., and STAMM, A.J. (1975), Principles of Wood Science and Technology. II–Wood-based Materials. 703 pp. Springer-Verlag, Berlin.

MENON, S.R.K. (1972). Indian Patent No.131409. Feb, 2. 1972.