IMPROVED RATTAN THROUGH PHENOLIC RESIN IMPREGNATION - A PRELIMINARY STUDY

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WAN TARMEZE WAN ARIFFIN, KOH, M.P. & MOHD. TAMIZI MUSTAFA. 1993. Improved rattan through phenolic resin impregnation - a preliminary study. *Calamus manan* (manau) canes were vacuum-pressure impregnated with phenol formaldehyde resins of three different solids content levels. Effects of the resin solids content on improvements in physical and mechanical properties of the samples were studied. Results showed that the antishrink efficiency, specific gravity, hardness and nail withdrawal resistance increased with higher resin solids content. There was an optimum resin solids content to be used to obtain maximum improvement in the modulus of rupture, compression and shear strength.

Key words: *Calamus manan* - phenol formaldehyde resin - solids content - mechanical properties

WAN TARMEZE WAN ARIFFIN, KOH, M.P. & MOHD. TAMIZI MUSTAFA. 1993. Peningkatan mutu rotan melalui proses pemadatan resin fenol - satu kajian awal. Rotan manau (*Calamus manan*) telah dipadatkan secara tekanan-hampagas dengan tiga tahap kepekatan resin fenol-formaldehida (PF) yang berlainan. Kesan kepekatan resin ke atas sifat-sifat fizikal dan mekanikal rotan itu telah dinilai. Keputusan telah menunjukkan bahawa kecekapan daya tahan kecut, graviti tentu, kekerasan dan daya rintangan tarikan paku rotan telah meningkat dengan kepekatan resin yang lebih tinggi. Terdapat kepekatan resin yang optima yang perlu digunakan untuk mendapatkan peningkatan maksima di dalam moduli pecah, mampatan dan kekuatan ricih.

Introduction

Rattan, a spiny climbing plant belonging to the subfamily *Calamoideae* (Dransfield & Uhl 1986), is an important forest product in Peninsular Malaysia and is ranked second to timber (Choo & Daljeet 1985).

There are about 104 species found in Peninsular Malaysia (Dransfield 1979), but only about 20 species are widely used while the others are left unexploited due to their inferior physical, mechanical or machining properties (Abdul Latif *et al.* 1990).

Unlike wood, which has been used in many forms such as veneer, particleboard and wood-plastic composite for a wide range of applications, rattan is used without further modifications and mainly for furniture.

In this preliminary work, an attempt was made to improve the physico-mechanical properties of a popular rattan species through phenol formaldehyde resin impregnation. This would be a starting point in rattan modification research not only to improve the popular species and their products, but also to promote the use of underutilized species for different end uses.

Materials and methods

Rattan

Boiled manau (*Calamus manan*) canes were obtained from a local rattan supplier. The rattans, of unknown age, had been harvested from the middle of the culms. Eighteen poles of the rattan were peeled to approximately 32 *mm* in diameter. Each pole was then cut into four 50 *cm* length samples as shown in Figure 1. A summary of the experimental design and sampling is given in Table 1.

Table 1. Experimental design

PF solids content (%)	Poles	Portions	Tests
45.0	1, 2, 3	A, C	X
	4, 5, 6	A, C	Y
24.5	7, 8, 9	A, C	X
	10, 11, 12	A, C	Y
12.0	13, 14, 15	A, C	X
	16, 17, 18	A, C	Y

Note: Portions B & D were controls (untreated); X = static bending, Y = compression, hardness, shear, nail withdrawal resistance; dry resin uptake, specific gravity and anti-shrink efficiency were measured from all samples.

Chemical

Water soluble phenol formaldehyde (PF) resin, Young 3816, was used at three different solids content, namely, 45 (undiluted), 24.5 and 12%. This type of PF resin has a low degree of polymerization and a lighter colour compared to the commercial PL-60M resin.

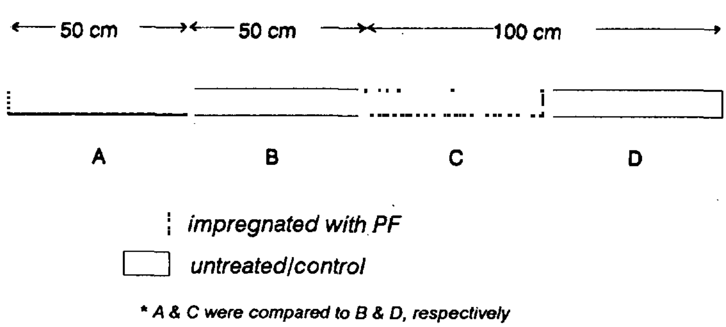

Figure 1. Peeled *C. manan* pole

Impregnation

The impregnation process was carried out using the apparatus (Figure 2)similar to that described by Meyer (1965). The rattan samples were subjected to a reduced pressure of 1 *mm* Hg or less for 2 *h* before being flooded with the PF resin of various solids content. After 24 *h* of soaking, the excess resin was drained and the impregnated samples were then cured in a constant temperature oven at 40°*C.*

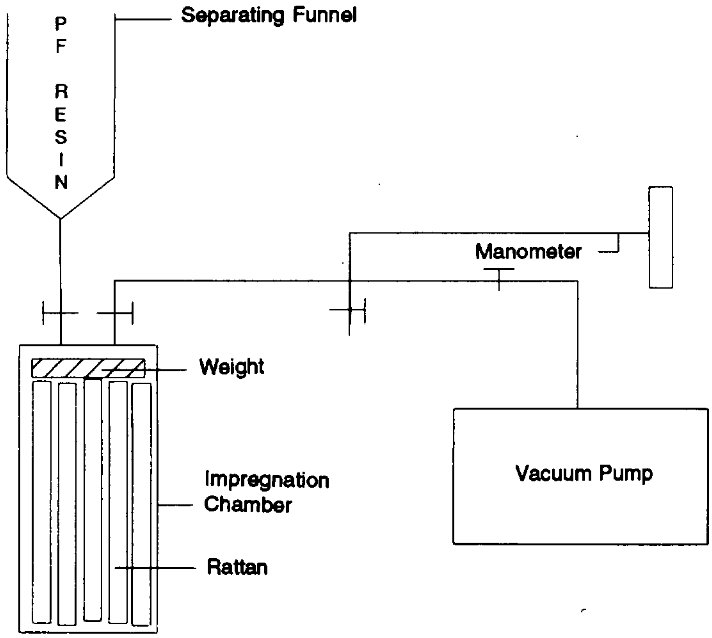

Figure 2. Apparatus used to impregnate the rattan

Testing

Dry resin uptake and antishrink efficiency of the impregnated samples were determined using the formulae below:

$$\text{Dry resin uptake (\%)} = \frac{\text{Wt - Wo} \times 100}{\text{Wo}} \qquad (1)$$

$$\text{Antishrink efficiency (\%)} = \frac{\text{Su - St} \times 100}{\text{Su}} \qquad (2)$$

where Wo and Wt are the oven dried weight of samples before and after treatment; Su and St are percent volumetric swelling (the increase in volume of the oven-dried sample after it was soaked in distilled water for 24 *h*) before and after treatment respectively.

The specific gravity of the untreated and PF impregnated samples was determined according to ASTM D143-83 (Anonymous 1983). The samples were conditioned at 20°C and 65% relative humidity for two weeks before subjected to static bending, compression parallel to grain, hardness, shear and nail withdrawal tests using the Shimadzu Computer Controlled Universal Testing Machine. The test methods used were ASTM D143 and BS 373 (Anonymous 1986) but with modifications in the sample size (Table 2). Improvements in the physical and mechanical properties of each PF impregnated sample over its control (untreated) were recorded. Statistical tests were performed to determine the variation in dry resin uptake, antishrink efficiency and physico-mechanical properties improvements between samples impregnated with PF of different solids content.

Table 2. The size of the samples for physical and mechanical test

Test	Size (diameter × length), *mm*
Specific gravity	32 × 50
Anti-shrink efficiency	32 × 50
Static bending	32 × 450 (span = 390)
Compression	32 × 110
Hardness	32 × 100
Shear	32 × 40
Nail withdrawal	32 × 100

Results and discussion

The average values of dry resin uptake and antishrink efficiency of the PF impregnated samples are shown in Table 3. The average values of the physical and mechanical properties are shown in Table 4. Summaries of analyses of variance on the dry resin uptake and antishrink efficiency, and improvements in the properties are tabulated in Tables 5 and 6 respectively.

Table 3. Average values of dry resin uptake and antishrink efficiency of PF impregnated *Calamus manan*

Solids content level (%)	Average dry resin uptake (%)	Average antishrink efficiency (%)
45	40.3	65.8
24.5	18.1	45.9
12	10.0	38.1

The results (Table 3) indicate that dry resin uptake and antishrink efficiency of the impregnated rattan increased significantly (Table 5) with higher resin solids content used. This suggests that the shrinkage, a common problem that degrades rattan, especially the unpopular species, could be overcome by resin impregnation.

Table 4. Physical and mechanical properties of untreated and PF impregnated *Calamus manan*

Properties, Units	Solids content level								
	45% Mean			24.5% Mean			12% Mean		
	Untreated	Treated	% Change	Untreated	Treated	% Change	Untreated	Treated	% Change
1. *Specific gravity*	0.506	0.776	53.3	0.506	0.621	22.7	0.526	0.575	9.54
2. *Static bending*									
Stress at proportional limit, *Mpa*	15.16	18.08	22.3	15.60	19.38	25.5	13.00	18.03	42.6
Mod. of rupture, *Mpa*	50.39	57.47	14.4	50.14	62.14	24.7	49.15	60.56	23.5
Mod. of elasticity, 1000 *Mpa*	2.17	2.41	11.1	2.19	2.50	14.6	2.20	2.52	15.3
3. *Compression*									
Parallel to grain, *Mpa*	17.68	20.15	12.4	19.59	26.37	35.4	21.49	26.98	25.5
4. *Hardness*									
Perpendicular to grain, *kN*	2.87	3.92	36.1	3.24	4.22	32.7	3.40	4.23	24.4
Parallel to grain, *kN*	3.76	5.60	49.8	4.25	5.56	31.0	4.79	5.608	17.2
5. *Shear, Mpa*	7.97	8.85	13.2	8.13	10.58	30.2	8.17	10.19	24.6
6. *Nail withdrawal resistance* (Nail diameter = 2.12 *mm*)									
Perpendicular to grain, $N\ mm^{-1}$	16.60	40.73	146.6	18.27	26.32	46.4	21.12	25.42	21.1
Parallel to grain, $N\ mm^{-1}$	8.32	21.18	153.6	9.74	13.48	42.7	10.41	13.53	30.0

Note: "% Change" is an average value of the improvements in individual PF impregnated sample (treated) over its control (untreated).

Table 5. Analysis of variance on the dry resin uptake and antishrink efficiency of *Calamus manan* impregnated with phenol formaldehyde resin

Source of variation	F-ratios and statistical significance		
	Df	Dry resin uptake	Antishrink efficiency
Solids content of PF resin	2	131.47**	9.26**

Note: ** = significant at 99% probability level : F.01, 2, 33 = 5.33.

Table 6. Analysis of variance on the improvement in physical and mechanical properties of *Calamus manan* impregnated with phenol formaldehyde resin

Source of variation	Df	S.gravity	Stresspl	MOR	MOE	Compress//	Hard ⊥	Hard //	Shear	Nail ⊥	Nail //
		F-ratios and statistical significance: *Improvement in physical and mechanical properties of PF impregnated C. manan*									
Solids content of PF resin	2	124.04**	2.49ns	4.55*	1.17ns	22.66**	4.24*	17.92**	6.93**	34.14**	33.80**

Note: Df = degree of freedom; stress pl = stress at proportional limit; MOR = modulus of rupture; MOE = modulus of elasticity; Compress = compression; Hard = hardness; Nail = nail withdrawal resistance; // = parallel to grain; ⊥ = perpendicular to grain; ns = not significant at 95% probability level; * = significant at 95% probability level; ** = significant at 99% probability level; $F_{.01, 2, 33}$ = 5.33; $F_{.05, 2, 33}$ = 3.29; $F_{.01, 2, 15}$ = 6.36; $F_{.05, 2, 15}$ = 3.68.

The impregnated samples had higher physical and mechanical properties than the untreated ones (Table 4). The degree of improvement (% change) varied between the properties and was greatest for the nail withdrawal resistance. The better nail holding properties of the PF impregnated rattan could improve quality and service life of its furniture joints.

The statistical analyses (Table 6) show that, except for the stress at proportional limit and modulus of elasticity, improvements in the other physical and mechanical properties differed significantly between the solids content of resin used. The results also indicate that the specific gravity, hardness and nail withdrawal strength improved further with higher resin solids content. This agrees with the findings in previous studies on wood (Stamm & Seborg 1962, McNamara & Shaw 1972).

However, for the modulus of rupture, compression and shear strength, better improvements were obtained using 24.5% solids content resin than with the 45% resin. This might be due to the fact that the high alkalinity (pH 12) in the 45% solids content PF could degrade the cellulose chain (Meyer 1981) and thus prevent further improvements in the properties. The results also suggest that there is an optimum level of resin solids content to be used to obtain maximum improvements in the properties.

Conclusion

Impregnation of *Calamus manan* with phenol formaldehyde resin improved all its physical and mechanical properties and most of the improvements varied significantly with the resin solids content used. Thus, the rattan could be tailored for wider end uses. This rattan modification study could be extended to the lesser known species as the results may make commercial utilization of the species possible.

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