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Effects of Acetylation on the Dimensional Stability and Decay Resistance of Kenaf (Hibiscus cannabinus L.) Fiberboard

by

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ABSTRACT:

The objective of this study was to investigate the influence of the acetylation treated kenaf fiber, Phenol-formaldehyde resin content level, and three fungi species on the dimensional stability and decay resistance of high density non-wood composition boards. A standard ASTM method was used to evaluate weight loss and thickness change. The linear shrinkage and expansion of each species were also determined. All specimens were exposed to decay chambers for 16 weeks.

Test results indicated that most of the main factors significantly influence the thickness, length changes, and decay resistance of the high density kenaf fiberboards.

KEY WORDS: Brown-rot, decay, dimensional stability, durability, fiberboard, fungus, kenaf, linear-change, Phenol-formaldehyde, specific gravity, thickness change, weight loss, white-rot.

I. INTRODUCTION

In recent years, wood material for use by the fiberboard industry has become scarce and expensive in the United States because of competition with the paper industry for wood fiber. Thus board producers will be forced to seek non-wood plant fibers to supply the increasing raw material requirement in the future.

When composition board becomes wet, it swells mostly in thickness and in length, and considerable bonding degradation occurs. Phenolic resin bonded boards are preferred in building construction for protection against water and high humidity. However, fungal attack in the phenolic bonded board was as severe as that in the urea bonded board (Walters and Chow, 1975).

Weight loss during the mycological testing of particleboard and fiberboards was reported as a good measure of decay resistance (Chow et al. 1980, 1993, 1994). However, in the United States., no information concerning the dimensional stability of treated and untreated non-wood panel products is available in spite of the rapidly expanding use of these materials often in areas of potentially high decay hazard. There is a need to provide the public with general information on the effects of fiber pre-treatment, resin content, and fungal species on the dimensional stability and decay resistance of new kenaf fiberboards.

II. MATERIALS AND PROCEDURE

Non-wood fiber composition boards approximately 279- by 279-mm were made from steam-pressure refined kenaf fibers. The species is Hibiscus cannabinus L. All fibers were produced from kenaf stem chips, steamed for 2 to 5 minutes at about 7.5 Mpa, disk refined, and dried at 150 to 160° C in a rotation drier. Two levels of phenol-formaldehyde adhesive content were used: 3 and 7 percent (based on resin solids content and ovendry fiber weight).

Both the untreated fibers and the acetic acid treated fibers were used in making the experimental boards as shown in Table 1. In treating kenaf fibers, the acetic anhydride was preheated in a holding tank to 110° C, and the reaction vessel was preheated to 120° C. The fibers (5.45 kg) were placed in the sealed reactor, and the acetic anhydride introduced; the fibers were soaked for 6 hours at 120° C, and then oven-dried at 105° C. This process resulted in an acetyl weight gain of 23 percent (Rowell et al. 1988; Chow et al. 1993).

Table 1. Design of experiment.

No.	Fungus Type	Resin (5)	Kenaf Treatment[a]	Replication
1	Poria	3	UT	8
2	Poria	7	T	8
3	Gleophyllum	3	UT	8
4	Gleophyllum	7	T	8
5	Polyporus	3	UT	8
6	Polyporus	7	T	8

Kenaf fiberboards with a specific gravity of 1.0 and thickness of 3.2 mm were produced. All boards were pressed on a steam-heated press at about 190° C for 8 minutes at a maximum prssure of 7.24 Mpa for untreated boards, and at 10.34 Mpa for acetylated boards.

Ninety six board specimens approximately 25 mm square by 3.2 mm thick were cut from the experimental boards made from both treated and untreated kenaf fibers. After conditioning at a temperature of 26.7° C and 70 % relative humidity for 4 weeks, all specimens were weighed and calipered.

All specimens were tested according to ASTM Method D2017 (ASTM, 1991) using cultures of three common rot fungi (two brown rots and one white rot): *Poria placenta* (Fr.) Cook (ATCC 11538), *Gleophyllum trabeum* (ATCC 11539), and *Polyporus versicolor (L.* ex. Fr.)(ATCC 12679). The second growth cubical rot often causes decay in millworks and wood situated above ground. A replicate of eight specimens of each fungus, treatment, resin content, and fiber species condition were used. Each cylindrical 225 cm^3 culture bottle contained one specimen of the board. After 16 weeks of exposure to fungus, specimens were removed from the test bottles, reconditioned, reweighed, and recalipered to measure the weight loss and dimensional changes.

III. RESULTS

Statistical analysis indicates that the average dimensional stability and decay resistance values for all specimens were significantly (5 % level) influenced by major factors of resin content, acetylated fiber treatment, and the decay of species. The effect of resin content on the thickness change of the board specimens was found to be not significant as shown in Table 2.

Table 2. Factorial analysis.

Factor	SGR[a]	TC[b]	WL[c]	LC[d]
Fungus (3)	S[e]	S	S	S
Resin Content (2)	S	S	S	N[f]
Treatment (2)	S	S	S	S

[a] SGR = Specific gravity reduction
[b] TC = Thickness change
[c] WL = Weight loss
[d] LC = Linear expansion or shrinkage
[e] S = Significant at 5 % level
[f] N = Not significant at 5 % level

Table 3. Average specifi gravity reduction, thickness change, and weight loss of kenaf fiberboard.

Fungus Type	3 Percent Resin Content[a]		7 Percent Resin Content[a]	
	UT[b]	T	UT	T
	SPECIFIC GRAVITY REDUCTION			
GT[c]	-40	-16	-19	-9
PP	-33	-13	-17	-11
PV	-38	-13	-38	-9
	THICKNESS CHANGE (%)			
GT	+24	+21	+20	+14
PP	+48	+21	+30	+14
PV	-55	+23	+13	+15
	WEIGHT LOSS (%)			
GT	-52	-9	-26	-4
PP	-24	-10	-38	-7
PV	-81	-6	-52	-5

[a] Phenol - formaldehyde resin
[b] UT = Untreated, T = Acetylation treatment
[c] PP = *Poria placenta*, GT = *Gleophyllum trabeum*, PV = *Polyporus versicolor*

Table 4. Average moisture content (MC) before and after the decay test, and linear expansion.

Fungus Type	3 Percent Resin Content[a]		7 Percent Resin Content[a]	
	UT[b]	T	UT	T
	MC RANGE (%)			
GT[c]	11 - 193	5 - 65	10 - 113	6 - 42
PP	11 - 162	6 - 32	10 - 121	6 - 59
PV	11 - 238	5 - 54	10 - 122	6 - 54
	LINEAR CHANGE (%)			
GT	- 0.95	+ 0.41	+ 0.31	+ 0.40
PP	+ 0.41	+ 0.28	+ 0.43	+ 0.38
PV	- 6.94	+ 0.32	+ 0.36	+ 0.38

[a] Phenol - formaldehyde resin
[b] UT = Untreated, T = Acetylation treatment
[c] PP = *Poria placenta*, GT = *Gleophyllum trabeum*, PV = *Polyporus versicolor*

Table 3 shows the average specific gravity reduction (SGR), thickness change (TC), and weight loss (WL) of specimens exposed to three decay fungi for 16 weeks. Table 4 shows the effects of acetylated fiber treatment, and resin content on the moisture content before and after the decay test, and linear change (LC) of specimens. It indicates that a moisture content increase did occur to the majority of the specimens after they were exposed to three common rot fungi.

IV. SUMMARY

The following conclusions can be made from this study:

1. The effects of differences in adhesive content, acetylated fiber treatment, and the type of decay fungi on dimensional change and decay resistance were statistically significant at 5 percent level. The phenolic resin content level did not play an important role in influencing the thickness change of the specimens.

2. The treatment of acetylation on fibers resulted in highly resistant to attack by three wood-rotting fungi. In general the dimensional stability and decay resistnce of the treated kenaf fiberboard was not as good as those of the boards made from southern pine wood species. Treated board sresulted in a lower moisture content level after 16 weeks of exposure to fungus.

3. An increased resin content from 3 to 7 percent caused a significant reduction in SGR, WL, and TC values in both treated and untreated specimens.

4, Specimens of board made from untreated kenaf fibers appeared to have more resistance to *Polyporus versicolor* (a white rot fungus) than two other brown-rot fungi.

5. Most of the specimens swelled in dimension except that the thickness reduction occured in many specimens made from untreated fibers (3 % resin) after the decay.

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