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Biodegradation of Acetylated Southern Pine and Aspen Composition Board

by

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ABSTRACT:

The objective of this study was to investigate the influence of the acetylation treated wood fiber, Phenol-formaldehyde resin content level, two wood fiber species, three fungi species on the dimensional stability and decay resistance of high density composition boards. A standard ASTM method was used to evaluate weight loss and thickness change. Thc 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 and length changes and the decay resistance of the high density composition boards.

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

I. INTRODUCTION

Because of the high cost of lumber products, the increase in production of wood-based panel materials has been substantial in recent years. In fact, the United States has been both the world's leading user and producer of wood composition board, such as plywood, fiberboard, and particleboard. More than half of these panels arc used in both residential and commercial construction including interior walls and exterior wall sheathing floors, sidings, and roof sheathing (Chow and Gerdemann, 1980).

When composition board becomes wct, 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, 1993), However, in the United States, little information concerning the dimensional stability of both treated and untreated commercial wood-base 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 in the areas of the effects of fiber pre-treatment, resin content wood species and fungal species on the dimensional stability and decay resistance of the composition boards.

II. MATERIALS AND PROCEDURE

Wood fiber composition boards approximately 279-by 279-mm were made from steam-pressure refined fibers. The wood species included aspen, and southern pine. All fibers were produced from 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 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 acetic anhydnde 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 and Chow et al., 1993).

Table 1. Design for the experiment

No.	Fungus Type	Resin (5)	Species	Treatment*	Replication
1	*Poria*	3	Aspen	UT	8
2	*Poria*	3	Aspen	T	8
3	*Poria*	7	S. Pine	UT	8
4	*Poria*	7	S. Pine	T	8
5	*Gleophyllum*	3	Aspen	UT	8
6	*Gleophyllum*	3	Aspen	T	8
7	*Gleophyllum*	7	S. Pine	UT	8
8	*Gleophyllum*	7	S. Pine	UT	8
9	*Polyporus*	3	Aspen	UT	8
10	*Polypurus*	3	Aspen	T	8
11	*Polypurus*	7	S. Pine	UT	8
12	*Polypurus*	7	S. Pine	T	8

* UT = No pretreatment for wood
T = wood fibers were acetylated prior to composition board making.

Composition boards with a specific gravity of 1.0 and a thickness of 3.2 mm were produced for each fiber species, resin content, and treatment condition. All boards were pressed on a steam-heated press at about 190°C for 8 minutes at a maximum pressure of 7.24 MPa for untreated boards, and at 10.34 MPas 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 aspen and southern pine 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 brown cubical rot often causes decay in millworks and wood situated aboveground. 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 specimens of the board, After 16 weeks 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 wood species, resin content, acetylated fiber treatment, and the decay 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	N [f]	S	S
Wood Species (2)	S	S	S	S
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 = Significnat at 5% level
[f] N = Not significant at 5% level

Table 3. Average specific gravity reduction, thickness change, and weight loss of composition boards.

Fungus Type	Wood Species	3 Percent Resin Content UT [a]	3 Percent Resin Content T	7 Percent Resin Content UT	7 Percent Resin Content T
		SPECIFIC GRAVITY REDUCTION			
GT [c]	Aspen	-31.5	-1.7	-15.2	-1.8
	S. Pine	-31.6	-1.0	-29.4	-1.0
PP	Aspen	-30.8	-1.6	-29.7	-1.9
	S. Pine	-28.3	-1.5	-21.7	-2.5
PV	Aspen	-61.7	-2.8	-46.0	-3.3
	S. Pine	-23.4	-1.5	-24.0	-1.1
		THICKNESS CHANGE (%)			
GT	Aspen	+7.8	+5.0	+8.7	+4.9
	S. Pine	+8.2	+3.4	+8.9	+4.2
PP	Aspen	+12.2	+4.5	+11.7	+3.8
	S. Pine	-7.1	+3.4	+7.6	+3.8
PV	Aspen	-37.4	+5.0	-20.8	+4.7
	S. Pine	+24.7	+3.5	+16.7	+4.1
		WEIGHT LOSS (%)			
GT	Aspen	-47.0	-1.7	-30.0	-1.0
	S. Pine	-44.6	-0.9	-36.9	-0.4
PP	Aspen	-50.8	-1.1	-40.8	-1.1
	S. Pine	-50.0	-2.5	-34.3	-2.5
PV	Aspen	-80.0	-2.2	-60.9	-2.9
	S. Pine	-18.1	-2.3	-21.3	-2.2

[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	Wood Species	3 Percent resin content		7 Percent resin content	
		UT	T	UT	T
		MC RANGE (%)			
GT	Aspen	8.8-171.2	3.7-38.9	8.7-117.1	3.7-35.7
	S. Pine	8.3-164.0	3.4-34.6	8.6-107.7	4.8-28.3
PP	Aspen	8.9-126.6	4.2-35.6	9.0-84.5	4.2-29.0
	S. Pine	9.1-179.2	3.3-38.2	8.7-116.1	4.7-39.1
PV	Aspen	9.0-217.4	3.9-35.7	8.5-144.1	3.9-37.7
	S. Pine	8.7-70.2	3.4-55.4	8.7-62.7	5.1-51.6
		LINEAR CHANGE (%)			
GT	Aspen	-0.696	+0.407	+0.254	+0.389
	S. Pine	-0.255	+0.296	+0.223	+0.290
PP	Aspen	-0.756	+0.290	+0.273	+0.296
	S. Pine	-0.354	+0.210	-0.161	+0.253
PV	Aspen	-1.353	+0.314	-0.366	+0.308
	S. Pine	+0.453	+0.210	+0.334	+0.203

[a] Phenol-formaldehyde

[b] UT = Untreated, T = Acetylation treated

[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 wood decay fungi for 16 weeks. Table 4 shows the effects of fiber species, 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 type of fiber furnish, adhesive content, acetylated fiber treatment, and type of decay fungi on dimensional change and decya 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 decay resistance of the treated aspen boards was not as good as those of the boards made from southern pine wood species. Treated boards resulted in a lower moisture content level after 16 weeks of exposure to fungus.

3. As increased resin content from 3 to 7 percent caused a significnat reduction in SGR, WL, and LC values in untreated specimens.

4. Specimens of board made from untreated southern pine fibers appeard 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 and length shrinkage occurred in many specimens made from untreated fibers after the day exposure.

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