ACETYLATED RUBBERWOOD FLAKEBOARD RESISTANCE TO BIO-DETERIORATION

Y.S. HADI
I.G.K.T. DARMA
F. FEBRIANTO
E.N. HERLIYANA

ABSTRACT

Flakeboards made from rubberwood (*Hevea brasiliensis* Muell. Arg.) and phenol-formaldehyde resin were used to test for resistance to dry wood termites, subterranean termites, and fungal attacks. Dried flakes were immersed in acetic anhydride and subsequently heated at 120°C to give specimens of 7 and 18 weight percent gains. Control flakeboards were also prepared for comparison. Flakeboards were put in the boxes containing 50 healthy and active dry wood nymphae of *Cryptotermes cynocephalus* Light for 4 weeks. Nymphae mortality and weight loss were determined for each sample. Flakeboards were also stacked in an arboretum for 12 weeks and protection level and weight loss of flakeboard caused by *Macrotermes gilvus* Hagen attack were determined. Flakeboards were also innoculated with *Schizophyllum commune* for 10 weeks and moisture content, weight loss, and modulus of rupture loss of flakeboard were determined. The results showed that the acetylation of the flakes increased the resistance to dry wood termite, subterranean termite, and fungal attacks. The higher the acetylation level, the greater the resistance.

Indonesia has a lot of planted rubber trees that produce latex for tires, adhesives, and other products. After a certain number of years, a rubber tree produces too small an amount of latex, and the tree must be replaced with a new one. The rubberwood is utilized for firewood, sawn timber, and also for particleboard. Unfortunately, rubberwood belongs to the lowest durability class, so it is easily attacked by fungi, dry wood termites, and subterranean termites (4). Particleboard made from rubberwood is also easily attacked by subterranean termites. In some houses in the Bogor area, when the outer wall was made from rubberwood flakeboard, the wall was attacked by subterranean termites in less than 2 years.

Martawijaya et al. (5) mentioned that among 40 investigated fungi species, there were 3 destructive fungi destroying railway sleepers, electrical poles, and woody houses, and 1 of them is *Schizophyllum commune*. A virulence test with *Schizophyllum commune* showed weight losses after some weeks were 12.8 percent for jabon wood (*Anthocephalus cadamba*), 30.0 percent for rengas wood (*Gluta renghas*), and 19.7 percent for ramin wood (*Gonystylus bancanus*). In other research, after 45 weeks of inoculation, the impact bending loss was more than 80 percent for pine wood (*Pinus merkusii*) and 30 percent for Agathis wood (*Agathis* spp.), but after 65 weeks, the impact bending loss increased to reach 50 percent. At 10 percent weight loss caused by the fungi, loss in bending strength was 80 percent for pine wood and 40 percent for Agathis wood as compared to the control.

But other researchers have stated that acetylated flakeboard is more resistant to fungal attack. Rowell et al. (7) reported that flakeboard made from acetylated flakes above about 16 percent acetyl weight gain showed little or no weight loss in *Gleophyllum trabeum*, *Tyromyces palustris*, and *Trametes versicolor* fungal tests. These boards also showed little strength loss during or after fungal attack. Nilsson et al. (6) found particleboard made from chips acetylated in a liquid phase procedure were most resistant to white-, brown-, and soft-rot fungi attack. Furthermore, Imamura et al. (3) reported that particleboards made from acetylated pine or birch chips using melamine-urea-formaldehyde resin were resistant to attack by brown- and white-rot fungi in pure single-culture tests.

The purpose of this research was to study acetylated rubberwood flakeboard resistance to dry wood termite (*Cryptotermes cynocephalus* Light), subterranean termite (*Macrotermes gilvus* Hagen), and white-rot (*Schizophyllum commune*) attacks.

The authors are Lecturers, Faculty of Forestry, Bogor Agricultural Univ., P.O.Box 168, Bogor, Indonesia. This paper was received for publication in September 1994.

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METHODS

FLAKEBOARD SAMPLES

The wood species used was rubberwood (*Hevea brasiliensis* Muell. Arg.) from a rubber tree plantation in Sukabumi, West Java. The logs were cut to be flakes with a drum-flaker. The flakes were put through a 9-mm by 9-mm sieve and screened with a 2-mm by 2-mm sieve.

The flakes were dried to approximately 3 percent moisture content (MC), immersed in acetic anhydride for 10 minutes, and then subsequently heated at 120°C for 24 hours. The acetylation level was indicated by weight percent gain (WPG) based on the ovendried weight of flakes, and in this experiment the WPGs were 7 and 18 percent. Flakes were also prepared without any treatment as controls.

A liquid phenol-formaldehyde resol-type adhesive was used at a resin level of 9 percent based on the ratio of resin solid to ovendried weight of flakes, and the target flakeboard density was 0.75 g/cm^3. The flakes were put in a drum and the adhesive was sprayed on the flakes while the drum was rotated. The boards were hot-pressed at 160°C, 30 kg/cm^2 pressure for 13 minutes. The size of the sample board was 32 cm by 32 cm by 1.25 cm.

TABLE 1. — Rating system for protection level (2).

Flakeboard condition	Rate
Sound, surface nibbles permitted	100
Light attack	90
Moderate attack, penetration	70
Heavy attack	40
Failure	0

TEST METHODS

The test flakeboards were controls, 7 percent WPG, and 18 percent WPG. The replication of each treatment was three flakeboards, and the flakeboards were cut to be certain sizes for specific tests, as described later. To analyze the data, a randomized complete design was used.

Dry wood termite test. — Flakeboard samples sized 2.5 cm by 5 cm were put in glass boxes. Fifty healthy and active nymphae of the dry wood termite (*Cryptotermes cynocephalus* Light) were put into each box, and those boxes were put in a dark room at an average temperature of 20° to 32°C and 81 to 89 percent relative humidity (RH) for 4 weeks. At the end of the test, nymphae mortality and flakeboard weight loss were determined. The weight loss percentage of each flakeboard was determined using the following formula:

$$WL = \frac{W_b - W_a}{W_b} \times 100\%$$

where:

WL = weight loss percentage
W_b = flakeboard weight prior to the test at ovendried condition
W_a = flakeboard weight after the test at ovendried condition

Subterranean termite test. — Flakeboard samples sized 5 cm by 22 cm were vertically buried in an arboretum with 20 cm of flakeboard in the ground. Each week the samples were observed to determine how much the board was attacked, and after 12 weeks the weight loss percentage was determined using the formula just described. The protection level of each flakeboard was observed using the rating system shown in **Table 1**.

Fungal test. — *Schizophyllum commune* fungi was inoculated in the glass boxes using potato dextrose agar media until it grew adequately. Flakeboard samples sized 2.5 cm by 5 cm for MC and weight loss tests, and 5 cm by 20 cm for the modulus of rupture (MOR) test, were put in the glass boxes (1). After 10 weeks of inoculation at 22° to 28°C and 80 to 90 percent RH, MC, weight loss percentage, and MOR loss percentage were determined. The average MC of the flakeboards prior to the test was 12.3 percent, and weight loss percentage was determined using the formula previously described. The MOR loss percentage was determined using the following formula:

$$ML = \frac{M_b - M_a}{M_b} \times 100\%$$

where:

ML = MOR loss percentage
M_b = MOR prior to the test at 12.3 percent MC
M_a = MOR after inoculated by fungi at present MC

TABLE 2. — Acetylated flakeboard resistance to dry wood termite, subterranean termite, and fungal attacks.

Properties	Control	WPG-7%	WPG-18%	F-test[a]
Dry wood termite test (*Cryptotermes cynocephalus*)				
Weight loss (%)	4.85	3.70	2.37	*
Mortality (%)	59.3	76.0	84.7	**
Subterranean termite test (*Macrotermes gilvus*)				
Weight loss (%)	83.6	57.1	8.65	**
Protection level	0	13.3	90	**
Fungal test (*Schizophyllum commune*)				
Moisture content (%)	112	109	74	**
Weight loss (%)	9.62	9.54	5.68	**
MOR loss (%)	67.5	42.9	25.8	**

[a] * = significant difference; ** = highly significant difference.

RESULTS AND DISCUSSION

DRY WOOD TERMITE TEST

Weight losses of flakeboard and dry wood termite mortality after 1 month of testing are shown in **Table 2**. The higher acetylation level gave statistically better flakeboard resistance to dry wood termite attack.

The weight loss of acetylated flakeboard was lower than the control flakeboard. The control flakeboard was 4.85 percent; the WPG-7 percent flakeboard was 3.70 percent; and the WPG-18 percent flakeboard was 2.37 percent. The acetylated flakeboard had higher termite mortality than the control flakeboard. The control flakeboard reached 59.3 percent termite mortality; the WPG-7 percent flakeboard reached 76.0 percent; and the WPG-18 percent reached 84.7 percent.

SUBTERRANEAN TERMITE TEST

Flakeboard weight losses and protection levels after 12 weeks of testing are shown in **Table 2**. The higher acetylation level gave statistically better flakeboard resistance to subterranean termite attack. Control flakeboards had 83.6 percent weight loss and a protection level of 0; WPG-7 percent flakeboard had 57.1 percent weight loss and a protection level of 13.3; WPG-18 percent flakeboard had 8.65 percent weight loss and a protection level of 90.

FUNGAL TEST

Weight losses, MCs, and MOR losses after 12 weeks of testing are shown in **Table 2**. The higher acetylation level gave statistically better flakeboard resistance to fungal attack.

The MC of acetylated flakeboard was lower than the control flakeboard, and the weight and MOR losses of acetylated flakeboard were lower than the control flakeboard. The MC and weight loss of WPG-7 percent flakeboard were not different from the control flakeboard, but the WPG-18 percent flakeboard showed a highly significant difference from both flakeboards. The MC of WPG-7 percent flakeboard was 109 percent and WPG-18 percent flakeboard was 74 percent compared to the control flakeboard, which reached 112 percent, and the weight loss of WPG-7 percent flakeboard was 9.54 percent and WPG-18 percent flakeboard was 5.68 percent compared to the control flakeboard, which reached 9.62 percent, and the MOR loss of WPG-7 percent flakeboard was 42.9 percent and WPG-18 percent flakeboard was 25.8 percent compared to the control flakeboard, which reached 67.5 percent.

CONCLUSIONS

Acetylated rubberwood flakeboard had better resistance to dry wood termite, subterranean termite, and fungal attacks, and the higher acetylation level gave better flakeboard resistance.

The WPG-18 percent gave much better resistance and this level must be considered for a high quality of acetylated flakeboard.

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