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Laboratory Evaluation of the Formosan Subterranean Termite Resistance of Borate-treated Rubberwood Chipboard

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Abstract

Both no-choice and two-choice 4-week AWPA laboratory tests were performed to evaluate the resistance of borate-treated rubberwood (*Hevea brasiliensis*) chipboard prepared from a commercial mill run, against the Formosan subterranean termite *Coptotermes formosanus*. Boric acid (technical granular) was incorporated into the boards during manufacture to achieve loadings of 1.0% or 1.1% boric acid equivalents (BAE). In the no-choice test, both the untreated chipboard and solid rubberwood controls sustained heavy termite attack (respective mean visual ratings of 4.6 and 2.7 on a 10-point AWPA scale), while the two retentions of borate-treated chipboard showed only light grazing (mean rating 9.2). The two-choice test demonstrated a preference of termites for solid rubberwood (mean rating 2.4) instead of untreated chipboard (rating 8.4), and for untreated (mean rating 8.4 and 8.8) instead of borate-treated (mean ratings 9.8 & 9) chipboards. Complete termite mortality in the presence of borate-treated chipboard in both laboratory tests demonstrates the toxicity of borates to Formosan subterranean termites.

KEY WORDS: Rubberwood, *Hevea brasiliensis*, *Coptotermes formosanus*, borate wood treatment, termite test, wood composite

Introduction

The availability of cost-effective wood protecting chemicals with low environmental impact would offer a considerable marketing advantage to the wood preservation industry at a time when some of the traditional wood preservatives are being subjected to heavy regulatory scrutiny. Borates have relatively low mammalian toxicity and environmental impact, and are widely reported to effectively protect solid wood from decay fungi, wood-boring beetles and termites, under non-leaching conditions (Cockcroft and Levy 1973, Drysdale 1994, Grace 1997, Tsunoda *et al* 1998, Grace *et al* 2000). However studies on the biological resistance of borate-treated wood-based composites are relatively limited (Manning and Laks 1997, Grace 1997, Laks and Manning 1997). Furthermore the toxic threshold (expressed as boric acid equivalents, or BAE) of borates in either solid wood or wood composites may differ in relation to the type of borate preservative, the particular species of test organism studied (e.g., variation in toxicity of borates between subterranean termite species), and whether field tests or laboratory tests were performed.

Borate treatment has the potential to promote wider utilization of low-durability (Hong and Wong 1994) rubberwood (*Hevea brasiliensis*) under non-leaching conditions, such as in furniture or certain wood composites. In this paper, we report the results of a laboratory termite test on borate-treated rubberwood chipboard samples performed to establish that borate retentions of 1% and 1.1% BAE in panels produced from a semi-commercial mill run could provide adequate protection against aggressive subterranean termites. The chosen retentions were based upon previous studies on borate-treated solid wood (reviewed by Grace 1997,) in which retentions between 1 and 2% (Manning *et al* 1997) and 1.1% BAE (Grace *et al* 1992) provided protection from *C. formosanus*, with only minor surface etching observed on the test wood samples, due to the non-repellent nature of borates.

Materials and Methods

Untreated and borate-treated rubberwood chipboard panels incorporating boric acid technical granular (to achieve 1.0% and 1.1% BAE) were prepared from a semi-commercial mill run, and each panel cut into replicate test wafers of 1.0 x 0.88 x 0.25 (thick) inches. Replicated untreated solid rubberwood blocks of the same size were also prepared. All blocks were oven dried at 35^{o}C for 3 days and weighed.

Two types of 4-week laboratory termite tests were conducted according to the American Wood-Preservers' Association (AWPA) test procedure (AWPA 1997), exposing the test blocks to the voracious Formosan subterranean termite *Coptotermes formosanus*, collected from the vicinity of eucalyptus at the Waimanalo experiment station (Island of Oahu, Hawaii) of the University of Hawaii. Four hundred termites (360 workers and 40 soldiers) were added to each screw-cap glass jar containing 150 g sterilized silica sand moistened with 30 ml distilled water, and either one or two test wafers. The no-choice test used a single test wafer per jar of either borate-treated chipboard (5 replications per BAE retention), untreated chipboard (5 replications) or untreated rubberwood (3 replications). The two-choice test used two paired test wafers per jar of the 3 combinations: untreated chipboard against untreated rubberwood, untreated chipboard against 1.0% BAE borate-treated chipboard, and untreated chipboard against 1.1% BAE borate-treated chipboard (4-5 paired replications per combination). To protect borate treated wafers from contact with moist sand, all wafers were placed on aluminum foil slightly exceeding the dimensions of the wafers on each side.

On termination of the termite test, wafers were removed from the jars, carefully cleaned by brushing off adhering debris, and again oven dried (35^0C) for 3 days before weighing. The measured parameters were: percentage and actual (mg) mass losses of the test blocks, visual rating of termite attack on test blocks based on the AWPA rating scale of 10 (sound with surface nibbles permitted) to 0 (test block destroyed), and percentage termite mortality in each jar.

Results and Discussion

Results of the no-choice and two-choice laboratory evaluations of the resistance of borate treated chipboard to the subterranean termites *Coptotermes formosanus* are shown in **Tables 1 and 2**.

Interpreting the objectives of the AWPA E1-97 termite test (AWPA 1997) relative to the present study, the no-choice procedure is useful for determining the toxicity (and the toxic limits) of a wood protecting chemical to termites, and whether the treated material is either sufficiently toxic or repellent to prevent termite feeding despite lack of an alternative food source for the termites. From the no-choice test (**Table 1**), both the untreated chipboard (mean visual rating 4.6; mean block mass loss 685.7 mg) and solid rubberwood (mean rating 2.7; mean mass loss 926.5 mg) were rated as termite-susceptible, though the latter wood material was more palatable. Borate-treated chipboard (at retentions of 1.0% and 1.1% BAE) were clearly termite-resistant, with only slight grazing on the surfaces of some of the composite wafers (joint mean rating 9.2; mean mass loss of 218.8 mg and 200.8 mg respectively). These treatments were also highly toxic to termites, with both retentions yielding 100% termite mortality. The present study was not designed to determine the absolute minimum BAE that would be sufficient to protect rubberwood chipboard from termites, since a review of the literature suggested that the toxic threshold against *C. formosanus* would be in the range of 1-2% BAE (Grace *et al* 1997, Manning *et al* 1997).

The rationale for the two-choice procedure in the present study was to examine if the borate treated chipboard was repellent or toxic to termites given the presence of untreated chipboard, and to determine if termites exhibited a preference between untreated chipboard and solid rubberwood. The results in **Table 2** demonstrate that solid rubberwood was preferred (mean visual rating: 2.4; mean mass loss 1126.2 mg) over untreated chipboard (mean visual rating: 8.4; mean mass loss: 409.6 mg).

In the two-choice test, both retentions of borate-treated chipboard when paired with untreated chipboard, showed similar high termite resistance (mean rating of 9.8 for 1.0% BAE, and 9.0 for 1.1% BAE). Feeding on the untreated chipboard wafers paired with these treatments was also low, most probably due to the 100% termite mortality occurring in this test (**Table 2**).

Table 1. Four-week no-choice laboratory test of borate-treated rubberwood chipboard exposed to 400 Formosan subterranean termites

Wood material	**AWPA visual rating**[1,2]	**Mean visual rating**	**Mean mass loss (mg)**		**Mean mass loss (mg)**		**Mean termite mortality**	
Untreated chipboard	4 4 4 4 7	4.6	685.7	(57.2)[3]	18.2	(1.8)	40.8	(4.6)
Borate-treated chipboard (1.0% BAE)	9 9 9 9 10	9.2	218.8	(14.8)	5.8	(0.4)	100	(0)
Borate-treated chipboard (1.1% BAE)	9 9 9 10 9	9.2	200.8	(23.1)	5.2	(0.5)	100	(0)
Rubberwood (solid wood)	4 4 0	2.7	926.5	(132.8)	33.7	(7.3)	57.1	(37.3)

1. AWPA termite rating scale: 10 (sound or surface nibbles), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure)
2. Block replications: 5 (chipboards), 3 (rubberwood)
3. Values in parentheses are standard deviations

Although termites fed upon the untreated chipboard when no other food source was available (mean rating of 4.6 in the no-choice test, **Table 1**), untreated rubberwood was clearly preferred in the two-choice test (**Table 2**). It is possible that either the adhesive or textural differences in the composite material may impart some degree of insect deterrence. Boric acid clearly added a high degree of termite-resistance, however. Thus, the results of this study, supported by results reported from other studies of borate-treated building materials, indicate that rubberwood composites can be effectively protected from subterranean termite damage by suitable borate wood treatment technology.

Table 2. Four-week two-choice laboratory test of borate-treated rubberwood chipboard exposed to 400 Formosan subterranean termites

Paired wood materials	AWPA visual rating[1,2]	Mean visual rating	Mean mass loss (mg)	Mean mass loss (mg)	Mean termite mortality
Untreated chipboard	7 9 9 7 10	8.4	409.6 (30.4)	11.0 (1.6)	48.6 (32.9)
Rubberwood (solid wood)	4 4 0 4 0	2.4	1126.2 (183.6)	42.1 (9.8)	
Untreated chipboard	9 9 10 7	8.8	384.4 (79.6)	10.0 (1.5)	100 (0)
Borate-treated chipboard (1.0% BAE)	10 10 8 10	9.8	203.0 (5.4)	5.4 (0.6)	
Untreated chipboard	7 7 7 9	7.5	404.5 (50.2)	10.8 (1.5)	100 (0)
Borate-treated chipboard (1.1% BAE)	10 10 9 7	9	185.4 (20.4)	4.8 (0.3)	

1 AWPA termite rating scale: 10 (sound or surface nibbles), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure)
2 Block replications: 4 or 5 (chipboards), 5 (rubberwood)
3 Values in parentheses are standard deviation

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