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Resistance of Borax–Copper Treated Wood in Aboveground Exposure to Attack by Formosan Subterranean Termites

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Abstract

The spread of Formosan subterranean termites (FSTs) in the southern United States has increased public interest in finding a preservative treatment to protect framing lumber from termite attack. This study evaluated the use of a borax-based preservative to protect wood from FST attack. Southern Pine and Douglas-fir specimens were pressure-treated with three concentrations of a borax–copper (BC) preservative composed of 93% borax (sodium tetraborate decahydrate) and 7% technical copper hydroxide. Untreated specimens and specimens pressure-treated with disodium octaborate tetrahydrate (DOT) were included for comparison. The specimens were exposed above ground, protected from the weather, at an active FST exposure site in Hilo, Hawaii. Specimens were rated for extent of termite attack after 6, 12, and 24 months of exposure. The BC treatments provided good protection of Southern Pine, but protection of Douglas-fir was variable at all BC retentions evaluated. The variability in protection for Douglas-fir was attributed to lower retentions and uneven distribution of preservative within the specimens. Average damage ratings of BC-treated Southern Pine were slightly better (less damage) than those of DOT-treated Southern Pine at equivalent B_2O_3 retentions, suggesting that either the presence of low levels of copper or the form of the borate in the BC treatment influenced efficacy. The results of this study indicate that borax-based treatments can provide adequate protection against FST in wood species or wood products that allow uniform distribution of preservative.

Keywords: Borax, DOT, copper, Formosan subterranean termites, Douglas-fir, Southern Pine, Hawaii

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Resistance of Borax–Copper Treated Wood in Aboveground Exposure to Attack by Formosan Subterranean Termites

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Introduction

There is increasing interest in treatment of framing lumber and other interior building components to prevent attack by termites and decay fungi. Borate preservatives are well suited for treatment of framing lumber because they are odorless and have relatively low human toxicity. The primary disadvantage of borate preservatives, their leachability, is also much less of a concern in an indoor application. The borate most commonly used for treatment of framing lumber is disodium octaborate tetrahydrate (DOT). Numerous researchers have evaluated the efficacy of DOT in protecting wood from termite attack (Drysdale 1994, Grace and Yamamoto 1994a, Grace and others 1992, Preston and others 1996, 1986). Based on these studies, borates have been standardized for interior treatments at retentions of 2.8 and 4.5 kg/m^3 (as B_2O_3) for areas with native subterranean termites or Formosan subterranean termites (FST), respectively (AWPA 2003a). The DOT is formed from a mixture of boric acid and borax and has greater solubility than either borax or boric acid alone. Borax has also been used as a wood preservative, but not much is known about the concentrations of borax needed to prevent attack by FST. On a weight basis, borax converts to an equivalent of 37% B_2O_3, whereas DOT converts to an equivalent of 67% B_2O_3. However, it is unclear whether B_2O_3 equivalents are an appropriate measure of the relative termiticidal properties of borate compounds. It is likely that multiple boron species exist within the treated wood. The purpose of this study was to further investigate the use of borates against FST by evaluating a borax-based preservative that is currently used for the remedial treatment of the groundline area of utility poles (Abbott and others 2001, Woodward and others 2002). The borax preservative selected also contains a small amount of copper as a cobiocide to provide further protection against attack by termites, decay, and mold fungi. The possible role of this low copper concentration is also discussed.

Materials and Methods

Specimen Preparation and Treatment

Samples (25 by 50 by 178 mm) were cut from clear Southern Pine sapwood and Douglas-fir heartwood and conditioned to constant weight in a room maintained at 23°C and 65% relative humidity. Ten replicates of each wood species were treated with one of the following solutions:

- Borax–copper (BC) (trade name CU-BOR, Copper Care Wood Preservatives, Inc., Columbus, Nebraska) with an actives composition of 7.2% technical copper hydroxide and 92.8% sodium tetraborate decahydrate (10 molar borax). This formulation was evaluated with treatment solutions containing 0.93%, 1.40%, and 2.34% actives (Table 1).
- Disodium octaborate tetrahydrate (DOT), considered 100% DOT actives. This formulation was evaluated with a 1.2% solution concentration in Southern Pine and a 1.6% solution concentration in Douglas-fir (Table 1).

Table 1—Composition of treatment solutions

Treatment solution[a]	% borax	% B as B_2O_3	% Cu as $Cu(OH)_2$	% Cu as CuO
0.93% BC	0.86	0.29	0.07	0.06
1.40% BC	1.3	0.47	0.10	0.08
2.34% BC	2.2	0.80	0.14	0.11
1.6% DOT (Douglas-fir)	—	1.07	—	—
1.2% DOT (Southern Pine)	—	0.80	—	—

[a]BC, borax–copper; DOT, disodium octaborate tetrahydrate.

The BC treatments were conducted with solutions heated to 50°C, whereas the DOT treatments were conducted at ambient temperature. All treatments were conducted using a full-cell pressure process. Following an initial vacuum maintained at –75 kPa (gage pressure) for 30 min, the treatment solution was introduced into the cylinder. Pressure was then maintained at 1.03 MPa for 1 hour on the immersed specimens. Each specimen was weighed before and after treatment to determine uptake of preservative.

Following treatment, the specimens were stacked, covered in plastic, for 1 week at room temperature to allow diffusion to occur. After the diffusion period, the specimens were air-dried and then a 50-mm-long section was cut from each specimen. Boron penetration was determined on the freshly exposed cross section using curcumin and salicylic acid indicator solutions prepared in accordance with American Wood-Preservers' Association (AWPA) Standard A3 (AWPA 2003b). The final specimen size for termite exposure was 25 by 50 by 128 mm. The freshly cut end was not sealed or treated prior to exposure.

Exposure and Evaluation of Specimens

The specimens were exposed at a Hilo, Hawaii, test site provided by Chemical Specialties, Incorporated (Charlotte, North Carolina). The site presents a substantial hazard for FST attack, as reported in earlier studies (Archer and others 1991, Preston and others 1986). The method was designed to simulate sill plates or similar construction conditions where dampness or other sources of moisture may exist. In this method, the specimens were placed horizontally out of direct contact with the ground and protected from the weather with a plywood-topped box enclosure. The specimens were placed on decorative open-faced cinder blocks with untreated feeder stakes driven through the vertical holes in the blocks and into the soil. Additional feeder stakes were laid horizontally between the rows of specimens. Each test unit covered an area of approximately 1 m^2. In this study, two test units were needed to accommodate all samples. A visual inspection of the specimens was conducted after 6, 12, and 24 months of exposure using a rating scale (10, 9, 8, 7, 6, 4, and 0). The untreated feeder stakes were replaced at each inspection to facilitate attack and were completely destroyed at 12 and 24 months. Weight loss was also determined at the conclusion of the test (24 months). At the 6-month inspection, one of the test units had no termite attack because of an ant infestation. This unit was moved to another location and did sustain FST attack at the 12- and 24-month inspections. A comparison of the ratings of similarly treated samples exposed in the two test units indicates that there was no difference in the amount of attack between the two units after 24 months of exposure.

Results and Discussion

Because of treatability differences, the amount of preservative delivered to the test specimens differed by both wood species and type of preservative. Specimens treated with DOT experienced greater solution uptake than those treated with BC, resulting in higher retentions in the wood (Table 2). The greater uptake with the DOT solutions agrees with a previous study that compared the treatability of BC and DOT across a range of wood species (Lebow and others, in press). The uptake of BC was also greater in Southern Pine than Douglas-fir, resulting in higher retentions for Southern Pine. For the BC treatments, all Douglas-fir borate retentions were below AWPA specifications (4.5 kg/m^3 as B_2O_3) for protection of wood against FST (AWPA 2003a). In contrast, the average B_2O_3 retention from DOT treatment of Douglas-fir was well above the specified level.

Following treatment, a 50-mm section was cut from the samples after treatment to assess penetration. The termites preferred to enter the samples from that cut end, suggesting that the wood in that area was not penetrated with preservative. However, based on the indicator spray, the entire cross section of these samples was penetrated with boron for all of the BC- and DOT-treated specimens, including Douglas-fir. As expected, copper penetration in the BC-treated Douglas-fir samples was limited to a shell treatment of 1 to 2 mm. Copper penetration was much more extensive in the BC-treated Southern Pine specimens, although there were small unpenetrated areas in some specimens.

These differences in treatability between wood species are reflected in the ratings of termite attack for the BC specimens (Table 2). Some Douglas-fir specimens treated with BC suffered substantial attack at each BC retention level, whereas Southern Pine specimens treated to the highest BC retention (4.8 kg/m^3) were well protected, and specimens treated with an intermediate B_2O_3 retention (2.7 kg/m^3) suffered slight attack. The variability in Douglas-fir treatment with BC resulted in a range of retentions (Fig. 1). Across this range, there appeared to be little correlation between B_2O_3 retention and termite attack for the BC-treated specimens (Fig. 1). This suggests that deficiencies in both penetration and retention may have contributed to attack of the BC-treated Douglas-fir specimens. Although the Douglas-fir specimens appeared fully penetrated with boron, the indicator solution indicates only the presence, not the concentration, of boron. The specimens probably had a gradient of boron concentration across the cross section. It also appears that Southern Pine specimens treated to similar BC retentions were better protected than their Douglas-fir counterparts. None of the Southern Pine specimens was rated below a 6 regardless of B_2O_3 retention. Copper may have also contributed to the protection of the BC-treated Southern Pine specimens, as ratings for these specimens

Table 2—Average preservative retention, termite attack ratings, and weight loss for Douglas-fir (DF) and Southern Pine (SP) specimens treated with borax–copper (BC) and disodium octaborate tetrahydrate (DOT) solutions

Wood species	Treatment solution	Retention (kg/m^3)		Ratings for termite attack, average (minimum)			% weight loss, average (maximum)
		B_2O_3	CuO	6 months	12 months	24 months	
DF	0.9% BC	1.60	0.26	9.7 (8)	8.7 (6)	7.2 (4)	17 (41)
DF	1.4% BC	2.24	0.35	9.7 (8)	8.9 (7)	5.6 (0)	26 (65)
DF	2.3% BC	3.04	0.48	10.0 (10)	9.0 (7)	5.1 (0)	25 (48)
DF	1.6% DOT	—	—	9.6 (8)	8.9 (7)	8.3 (7)	5 (12)
DF	None	—	—	9.0 (0)	7.6 (0)	0.4 (0)	71 (>90)
SP	0.9% BC	2.08	0.34	10.0 (10)	9.0 (8)	7.8 (7)	7 (24)
SP	1.4% BC	2.72	0.43	9.8 (9)	9.6 (8)	8.5 (6)	9 (34)
SP	2.3% BC	4.80	0.77	10.0 (10)	9.8 (9)	9.6 (8)	4 (12)
SP	1.2% DOT	5.12	—	10.0 (10)	9.2 (8)	8.5 (7)	3 (14)
SP	None	—	—	8.0 (0)	6.4 (0)	0.0 (0)	>90

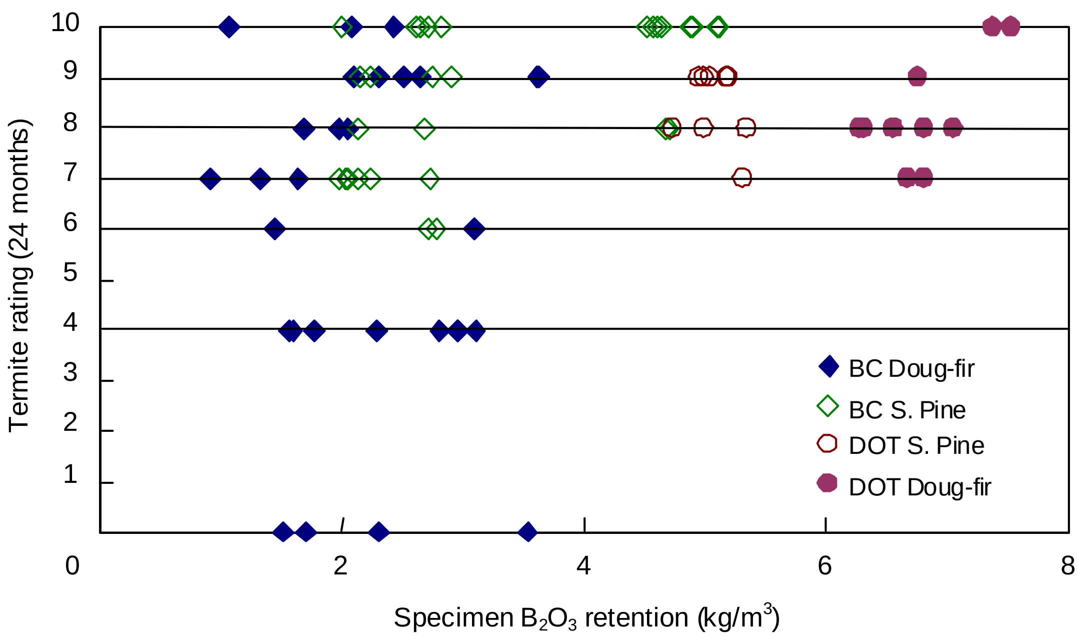

Figure 1—Relationship between 24-month termite attack rating and B_2O_3 retention for individual specimens.

were slightly higher than those treated with DOT to similar B_2O_3 retentions. It is also possible that the form of boron applied (borax or DOT) affected the efficacy of the boron. In contrast to the BC treatment, performance of DOT-treated specimens was similar for Southern Pine and Douglas-fir (Table 2; Fig. 1). Some attack was observed in both wood species although the B_2O_3 retention was above the 4.5 kg/m^3 level specified in AWPA Standards. The attack was readily visible but typically shallow, as indicated by the relatively low weight loss of these samples (Table 2). Previous researchers have also noted that wood treated with DOT to relatively high retentions may sustain some attack by FST (Grace and others 1992, 2001, Grace and Yamamoto 1994a, Preston and others 1996). Grace and Yamamoto (1994b) attributed this attack to localized variations in DOT retention within the wood substrate. This explanation is in agreement with the variable protection provided by BC treatment of Douglas-fir.

Conclusions

The BC treatments provided good protection of Southern Pine at B_2O_3 retentions slightly above that required by AWPA standards. However, protection of Douglas-fir was variable at all BC retentions evaluated, probably because of the combination of low retentions and uneven distribution of boron within the treated wood. Uptake of DOT was greater and less variable than that of BC in both the Douglas-fir and Southern Pine specimens. As has been reported previously, DOT-treated specimens suffered slight termite attack even at retentions above that specified in AWPA standards. Ratings of BC-treated Southern Pine were slightly better than those of DOT-treated Southern Pine, suggesting that either the presence of low levels of copper or the form of the borate positively influenced efficacy. The results of this study indicate that BC treatments can provide adequate protection against FST in wood species or wood products that allow uniform distribution of preservative.

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