Termiticidal effects of a glycol borate wood surface treatment

Technical Note

J. Kenneth Grace
Robin T. Yamamoto

Abstract

A remedial wood treatment product known as BORA-CARE®[1], which contains disodium octaborate tetrahydrate (DOT) in a solution of poly- and monoethylene glycols, was evaluated in laboratory tests against the Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae). In the first test, hemlock cubes (20 by 20 by 20 mm) were dipped twice in a 1:1 (by volume) aqueous dilution of DOT/glycol (23.54% DOT by weight) and air-dried. All termites exposed to the cubes in a laboratory test died within 2 weeks, with no feeding on the treated cubes. When a treated cube was placed on top of an untreated cube, termites moved over the treated cube, but fed only minimally on the untreated cubes before dying. In the second test, termite feeding and mortality were compared from exposure to wood treated with either the DOT/glycol solution or the ethylene glycol solvent for the product. Very limited feeding and 100 percent termite mortality resulted from exposure to wood treated with DOT/glycol. In comparison to the control blocks, treatment with the ethylene glycol solvent alone resulted in a small but significant increase in termite mortality (17%) and decrease in feeding. The high concentration of DOT in poly- and monoethylene glycols deposited on the surface of wood treated with DOT/glycol and ingested during termite grooming behavior and/or attempted feeding killed termites and protected the wood surface from termite penetration.

Remedial applications of preservative solutions are potentially useful in the prevention and control of insects and fungi in wood in service. Currently, two products containing disodium octaborate tetrahydrate (DOT) are available within the United States for remedial application to structural wood to prevent termite (Isoptera) attack. One of these is BORA-CARE® (Nisus Corp., Knoxville, Tenn.), a concentrated liquid formulation of approximately 40.6 percent disodium octaborate tetrahydrate, 11.9 percent polyethylene glycol (PEG), and 47.5 percent monoethylene glycol.[2] The concentrate is diluted 1:1 in water (by volume) and applied to the wood surface as a 23.54 percent (by weight) DOT solution.

A previous study[3] found that feeding by Formosan subterranean termites, *Coptotermes formosanus* Shiraki, on wood treated with DOT/glycol resulted in delayed toxicity, and that termites appeared to avoid feeding on wood near the treated surface. In laboratory and field studies with DOT pressure-treated lumber[4], we established that retentions of 1 percent boric acid equivalents or greater were required to limit wood weight loss from Formosan subterranean termite feeding to less than 3 percent. The present laboratory evaluation was initiated to determine 1) whether surface treatment with DOT/glycol solution would prevent termites from penetrating the wood surface; 2) whether termites would move over wood treated with DOT/glycol to attack adjacent untreated timbers; and 3) whether the ethylene glycol solvent contributed directly to treatment efficacy.

[1] Mention of trade names is for informational purposes only and does not constitute an endorsement by funding agencies or by the University of Hawaii.

[2] Palmere, V.R., A.H. Dietrich, and S.D. Galyon. 1992. Methods and composition for retarding and eradicating infestation in trees and tree derived products. U.S. Patent No. 5,104,664.

[3] Su, N.-Y. and R.H. Scheffrahn. 1991. Remedial wood preservative efficacy of BORA-CARE® against the Formosan subterranean termite and the eastern subterranean termite (Isoptera:Rhinotermitidae). Inter. Res. Group on Wood Preserv. Doc. No. IRG/WP/1504.

[4] Grace, J.K., R.T. Yamamoto, and M. Tamashiro. 1992. Resistance of borate-treated Douglas-fir to the Formosan subterranean termite. Forest Prod. J. 42(2):61-65.

The authors are, respectively, Assistant Professor and Research Associate, Dept. of Entomology, Univ. of Hawaii, 3050 Maile Way, Honolulu, HI 96822-2271. The authors gratefully acknowledge the cooperation of Nisus Corp. as well as their partial financial support and that of USDA-ARS Specific Coop. Agreement 58-6615-9-012. This is Journal Series No. 3743 of the Hawaii Institute of Tropical Agriculture and Human Resources and was received for publication in May 1992.

Forest Prod. J. 42(11/12):46-48.

Experimental procedure

Single-block test

Western hemlock, *Tsuga heterophylla* (Rafn.) Sarg., sapwood cubes (20 by 20 by 20 mm, approx. 3.5 g) were dipped twice (15-sec. soak, 4 hr. between dips) in a 1:1 (by volume) aqueous solution of DOT/glycol (as BORA-CARE) and air-dried for 10 days. To avoid any possible effects of heating on treatment efficacy, blocks intended for evaluation against Formosan subterranean termites were not ovendried. However, ovendry weights (90°C at 7 days, for consistency with our previous studies of borate-treated wood[4]) of a subsample of 5 treated blocks indicated that the DOT/glycol treatment resulted in an average 15 percent (range 11% to 18%) increase in block dry weight. For subsequent analytical purposes, pretreatment dry weights of the blocks treated with DOT/glycol were adjusted by this 15 percent weight increase due to the treatment. Following each test, the blocks were also examined visually for evidence of termite feeding.

In the single-block test, each block was placed in a separate screw-top jar (100 mm high by 80 mm wide) on a small square of Kaiser heavy-duty aluminum foil (40 by 40 mm, 0.18 mm thick) on the surface of about 150 g of washed crushed coral sand (sieved to pass a U.S. 14-mesh screen). The aluminum foil was used to minimize leaching into the moist sand and was still intact at the end of the test, indicating that it had served this purpose. Water (30 ml) and 400 Formosan subterranean termites, collected from an active field colony immediately before the test, were added to each jar. To simulate natural caste ratios within termite colonies, the 400 termites consisted of 360 workers and 40 soldiers (10%).

Hemlock blocks dipped only in distilled water were included as controls, with 5 replicates of each treatment. The jars were incubated in an unlighted temperature-controlled cabinet (29°C ± 0.5°C) for 2 weeks, dismantled, and termite mortality and ovendry wood weights were recorded. The test was terminated at 2 weeks, rather than the standard 4 weeks, due to rapid and complete termite mortality from exposure to the DOT/glycol treated blocks.

Stacked-block test

The stacked-block test was set up similarly to the single-block test, except that two blocks (one dipped in 1:1 DOT/glycol solution and one in distilled water) were stacked one on top of the other on the aluminum foil square in each test jar. This test was intended to simulate a post-construction DOT/glycol application to the substructure timbers, and investigate whether termites would move over the treated wood to attack adjacent untreated wood.

TABLE 1. — *Mean percent (± standard deviation) weight change in hemlock blocks (20 by 20 by 20 mm, 3.5 g) dipped in either BORACARE, a DOT/glycol solution, or water after 2 weeks of exposure to Formosan subterranean termites in aboveground laboratory tests.*

Test	Block position	Treatment	
		BORA-CARE®	Water
		(%)	
Two stacked blocks	Top block	−8 (± 2)[a]	+2 (± 3)[b]
	Bottom block	−9 (± 2)[a]	+4 (± 1)[a]
Single block		−7 (± 2)[a]	−26 (± 4)[c]

[a] No visible termite feeding, 100 percent termite mortality.
[b] Minor termite feeding on 4 of 5 replicates, 100 percent termite mortality.
[c] Substantial termite feeding, 5 (± 2) percent termite mortality.

Treatment and handling of the wood blocks were the same as in the single-block test. Five replicates were included of each of the two orientations of stacked blocks (DOT/glycol top or bottom, untreated block top or bottom). As in the single-block test, the test was terminated after 2 weeks due to 100 percent termite mortality in all replicates, the blocks were examined for evidence of termite feeding, and ovendry block weights were recorded.

Solvent toxicity test

A final 4-week single-block test, set up the same as the other tests, was performed to determine whether the ethylene glycol carrier contributed significantly to the termiticidal efficacy of this particular DOT/glycol formulation. Hemlock cubes were dipped for 15 seconds in a 1:1 (by volume) aqueous solution of the poly- and monoethylene glycol solvent used in BORA-CARE concentrate (supplied by Nisus Corp.), and air-dried for 10 days. Termite feeding and mortality after 4 weeks of exposure to these blocks were compared to that resulting from a second exposure to the blocks that were treated with DOT/glycol in the initial single-block test, and to control blocks dipped only in distilled water (5 replicates per treatment). Because no feeding had occurred on the DOT/glycol blocks in the initial test, those blocks were ovendried and reused. Thus, unlike the first two tests (single- and stacked-block tests), the DOT/glycol blocks were ovendried (90°C, 7 days) prior to termite exposure. Ovendry wood weight losses and percentage termite mortality (transformed by the arcsine of the square root) were subjected to analysis of variance (ANOVA) and means were separated by Duncan's Multiple-Range Test[5].

Results and discussion

Based upon our previous experience with borate-treated wood, the rapid and complete termite mortality observed from exposure to blocks dipped in DOT/glycol, in both the single-block and stacked-block tests, was unexpected (Table 1). This mortality cannot be attributed solely to possible boron contamination of the damp sand because the aluminum foil pad beneath the blocks remained intact and a previous study[6] has shown that DOT concentrations as high as 15,000 ppm (weight/weight) in sand do not kill *C. formosanus* as rapidly and completely as happened in the current experiments.

[5] SAS Institute. 1987. SAS/STAT Guide for Personal Computers, Version 6 Ed. SAS Institute, Cary, N.C.

[6] Grace, J.K. 1991. Response of eastern and Formosan subterranean termites (Isoptera:Rhinotermitidae) to borate dust and soil treatments. J. Econ. Entomol. 84:1753-1757.

TABLE 2. — *Mean percent (± standard deviation) weight loss in hemlock blocks (3.5 g) dipped in either DOT/glycol solution or ethylene glycol solvent, and Formosan subterranean termite mortality after 4 weeks of exposure in an aboveground laboratory test.*

Treatment	Wood weight loss[a]		Termite mortality[a]
	(g)	(%)	(%)
DOT/glycol	0.06 ± 0.01 A	2[b]	100 ± 0 A
Ethylene glycol[c]	0.67 ± 0.10 B	21	17 ± 5 B
Water control	1.56 ± 0.20 C	47	7 ± 1 C

[a] Means followed by different capital letters are significantly different at the $p = 0.05$ level.
[b] No visible termite feeding.
[c] Solvent (poly- and monoethylene glycols) for the commercial product BORA-CARE® was supplied by Nisus Corp. Both the DOT/glycol concentrate and the solvent blank were mixed 1:1 by volume in water.

There was no visible evidence of termite feeding on the DOT/glycol treated blocks in either test, suggesting that grooming behavior after contact with the treated wood surface may be an important means of ingesting DOT. Thus, we must attribute the 7 to 9 percent mean weight losses from these blocks to movement or loss of some portion of the treatment, which was initially responsible for a 15 percent average dry weight increase in block mass. Support for this hypothesis of treatment migration is provided by the small weight increases recorded in the untreated wood blocks stacked either over or under the DOT/glycol treated blocks (Table 1). It is likely that the migration observed here is an artifact of the test conditions, in which a very high concentration of DOT was placed in a humid environment. In subsequent tests (unpublished) with large-dimensioned timbers sprayed (rather than dipped) with DOT/water or DOT/glycol solutions, we have seen no evidence of this.

However, despite the small increase, rather than decrease, in weight of the untreated blocks in the stacked-block test, minor termite feeding scars were visible on 4 of the 5 untreated blocks stacked on top of a block treated with DOT/glycol. This indicates that termites were able to move over the 20-mm surface of the DOT/glycol blocks to feed on the untreated blocks. Interestingly, when untreated blocks were placed under the blocks treated with DOT/glycol, no evidence of termite feeding was apparent. Migration of DOT downward was probably facilitated by proximity of the untreated block to the damp sand in the jar and movement of this sand by the termites upward onto the surface of this lower block (i.e., establishment of a downward moisture gradient). The DOT/glycol treatment visibly increased the hygroscopicity of the treated wood blocks, in comparison to the untreated wood blocks, which would probably also facilitate DOT movement in the humid environment of the test jar.

Wood treated with the ethylene glycol solvent alone exhibited a low, but significant, level of toxicity to termites (17% mortality, in comparison to 7% control mortality), and significantly reduced termite feeding on the surface of the glycol-treated wood (Table 2). However, even after lengthy ovendrying (90°C, 7 days), the DOT/glycol dip treatment resulted in 100 percent termite mortality and no visible evidence of feeding on the wood surface.

In these laboratory evaluations, termites were exposed to wood completely coated through lengthy (15-sec.) dip treatment in DOT/glycol or ethylene glycol solutions. The 15 percent average dry weight gain from the treatment indicates that a heavy application of the solution and a high loading of DOT were applied to the wood surface. Due to the much greater termite mortality and feeding reduction noted here with DOT/glycol over the ethylene glycol solvent alone, and our subsequent experiences (unpublished) with wood surface-sprayed in a manner more closely approximating actual DOT/glycol field usage, we think it unlikely that the solvent carrier alone is a major contributor to the toxicity of this DOT/glycol formulation. However, the glycol solvent is certainly of value in applying a high DOT concentration, as well as possibly in coating the wood surface and promoting uptake of DOT by termites from that surface. The absence of any visible termite feeding on the wood surface and the rapid mortality noted in these tests, suggests that DOT may be ingested during grooming behavior after contact with the DOT/glycol treated surface, as well as during attempted feeding.

The rapid termite mortality and apparent migration of DOT from treated to untreated blocks observed in these tests were undoubtedly facilitated by the confined high-humidity test conditions and very heavy DOT/glycol dip application to the small test samples. Tests with more realistic spray applications to large-dimensioned timbers are currently in progress. However, even though the laboratory results presented here should be interpreted with caution, it is significant that the DOT/glycol dip treatment prevented termite feeding on the surface of the test blocks. We can conservatively conclude from these results that this DOT/glycol formulation appears to be a promising treatment to prevent termite penetration of the wood surface.