RESISTANCE OF PINE TREATED WITH CHROMATED COPPER ARSENATE TO THE FORMOSAN SUBTERRANEAN TERMITE

J. KENNETH GRACE†

ABSTRACT

Two 4-week, no-choice laboratory tests were performed with CCA-treated southern yellow pine and radiata pine against Formosan subterranean termites, *Coptotermes formosanus*. CCA retentions as low as 0.05 kg/m^2 (0.03 pcf) provided protection from all but light termite attack (rating of 9 on a 10-point visual scale). However, consistent light attack (grazing) on wafers containing retentions as high as 6.4 kg/m^3 (0.4 pcf), coupled with complete termite mortality, demonstrates that the mode of action of CCA treatments relies upon toxicity rather than having any repellent effects against termites.

Although wood treated with chromated copper arsenate (CCA) is frequently included for purposes of comparison in laboratory and field evaluations of termite resistance (6,10), and CCA is generally accepted as a very effective preservative treatment with certain wood species (2), there is surprisingly little published documentation of its efficacy against different termite species. The fact that many such evaluations are performed as industrial research and development efforts and never published is undoubtedly a contributing factor, as is the relatively long period of time over which CCA has been in commercial use. Approvals of CCA and other long-standing preservatives were largely based upon long-term field studies in which the treated wood was exposed to a complex of wood-destroying fungi and insects. So far as laboratory studies are concerned, decay resistance has historically been considered of primary importance in North America and Europe. Only recently, particularly as a result of continuing introductions and spread of the Formosan subterranean termite (*Coptotermes formosanus* Shiraki) in North America, has this focus shifted toward an emphasis on termite resistance, and even a concern with possibly specifying different preservative retentions (or entirely different preservatives) for protection against different termite species.

To contribute to the availability of information on the action of CCA against specific termite species, this paper reports the results of two different laboratory evaluations of CCA-treated pine wood against *C. formosanus*. The emphasis here is on the performance of the various CCA retentions included in these tests relative to the untreated (water only) controls. One of these tests was an evaluation of several pre-commercial wood treatments for southern yellow pine (*Pinus* spp.), in which CCA was included for comparative purposes; the other test was performed as part of an international collaborative comparison of laboratory procedures and the performance of radiata pine (*Pinus radiata*) treated with copper naphthenate or CCA against different termite species. Complete reports on the performance of the other preservatives included in these studies are in preparation.

MATERIALS AND METHODS

In the first test, flatsawn southern yellow pine (*Pinus* spp.) wafers (each about 2 g), 25 by 25 by 6 mm (1 by 1 by 0.25 in.), were pressure-impregnated to target CCA retentions of 0 (controls), 1.6 kg/m^3 (0.1 pcf), 3.2 kg/m^3 (0.2 pcf), 4.8 kg/m^3 (0.3 pcf), or 6.4 kg/m^3 (0.4 pcf). After treatment, the wafers were placed in plastic bags at room conditions for 7 days, then air-dried. A subset of wafers at each retention was weathered according to AWPA E10-91 (4). Wood treatments and weathering were performed at the Wood Research Institute, Michigan Technological University.

The author is a Professor, Dept. of Entomology, Univ. of Hawaii, 3050 Maile Way, Honolulu, HI 96822-2271. He wishes to thank C.H.M. Tome for technical assistance; P.E. Laks, J.R.J. French, and J.W. Creffield for preparation of wood samples; and P.I. Morris and A.F. Preston for helpful comments on an earlier draft. Preliminary results were reported to the 1997 Annual Meeting of the Inter. Res. Group on Wood Preservation. Funding was partially provided by McIntire-Stennis and by USDA-ARS Specific Coop. Agreement 58-6615-4-037. This is J. Series No. 4309 of the Hawaii Inst. of Tropical Agriculture and Human Resources. This paper was received for publication in June 1997. Reprint No. 8682.
† Forest Products Society Member.

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In the second test, radiata pine (*Pinus radiata*) wafers, cut to the same dimensions as in the first test, were pressure impregnated to target CCA retentions of 0 (controls), 0.5 kg/m^3 (0.03 pcf), 1.0 kg/m^3 (0.062 pcf), 2.0 kg/m^3 (0.125 pcf), or 4.0 kg/m^3 (0.25 pcf). These wafers were treated and dried at the CSIRO Division of Forest Products, Melbourne, Australia.

TABLE 1. — Results of a 4-week, no-choice laboratory test of CCA-treated southern yellow pine wafers exposed to 400 Formosan subterranean termites.

CCA retention		Visual rating[a]	Mean rating	Mean mass loss	Mean mass loss	Mean termite mortality
(kg/m^3)	(pcf)			(mg)	(%)	
Unweathered wafers						
6.4	0.6	10	9.6	19.50 (7.44)[b]	0.81 (0.30)	100 (0)
		10				
		9				
		9				
		10sn				
4.8	0.4	10	9.6	13.72 (4.79)	0.62 (0.22)	100 (0)
		9				
		9				
		10sn				
		10				
3.2	0.2	9	9.4	29.72 (8.64)	1.28 (0.34)	100 (0)
		10sn				
		10sn				
		9				
		9				
1.6	0.1	9	9	16.26 (13.53)	0.72 (0.61)	100 (0)
		9				
		9				
		9				
		9				
0	0	4	3.2	832.28 (62.05)	35.61 (2.31)	29.20 (14.39)
		4				
		4				
		0				
		4				
Weathered wafers						
6.4	0.6	9	9.4	17.22 (8.03)	0.74 (0.35)	100 (0)
		10sn				
		10sn				
		9				
		9				
4.8	0.4	9	9.6	20.62 (4.40)	0.91 (0.18)	100 (0)
		10sn				
		10sn				
		10sn				
		9				
3.2	0.2	9	9.4	29.80 (3.56)	1.28 (0.17)	100 (0)
		9				
		10sn				
		10sn				
		9				
1.6	0.1	10sn	9.4	40.82 (2.94)	1.82 (0.16)	100 (0)
		9				
		9				
		9				
		10				
0	0	0	2.4	857.66 (91.36)	37.42 (5.65)	11.65 (4.43)
		4				
		4				
		4				
		0				

[a] sn = surface nibbles.
[b] Values in parentheses are standard deviations.

Both tests were 4-week, no-choice laboratory bioassays based upon the AWPA E1-72 (3) and ASTM D 3345-74 (1) standard methods. Our bioassay makes two additions to these methods: 1) evaluation of termite mortality; and 2) evaluation of the ovendry wood mass loss in addition to visually rating the test wafers. Visual ratings used the standard AWPA and ASTM scale: 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure).

Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) were collected from an active field colony on the Manoa campus of the University of Hawaii immediately before their use in laboratory assays, using a trapping technique (11). Test containers were 80-mm-diameter by 100-mm-high screw-top jars, each containing 150 g washed and ovendried silica sand and 30 ml distilled water. The test wafers were ovendried (90°C for 24 hr.), weighed, and allowed to equilibrate to laboratory conditions for several hours before test initiation. In both studies, one test wafer was placed on the surface of the damp sand, and 400 termites (360 workers and 40 soldiers, to approximate natural caste proportions) were added to each jar. In the first test, each treatment was replicated five times; while in the second test each treatment was replicated six times. Jars were placed in an unlighted controlled-temperature cabinet at 28 ± 0.5°C for 4 weeks (28 days). At the conclusion of the test, percentage termite mortality was recorded, the wafers were visually rated according to the 0 to 10 scale, and the ovendry mass change was measured for each wafer.

RESULTS AND DISCUSSION

In these 4-week tests, CCA treatment provided very good protection against termite feeding at retentions as low as 1.6 kg/m^3 (0.1 pcf) in the first test (**Table 1**), and 0.5 kg/m^3 (0.03 pcf) in the second test (**Table 2**). No individual wafers at any CCA retention in either test were visually rated less than 9 (light attack), and in neither test did the mean percentage mass losses at any retention exceed 3 percent. In comparison, control southern pine wafers in the first test had average visual ratings of 3.2 (unweathered) and 2.4 (weathered), and sustained average mass losses of 36 and 37 percent, respectively. In the second test, all of the radiata pine control wafers failed completely (rating of 0), with an average mass loss of 80 percent.

Although CCA provided excellent protection at very low retentions, at no retention were the wafers completely untouched by termites. Even at the highest retention of 6.4 kg/m^3 (0.4 pcf), light attack (visual rating of 9) was noted on two of the five unweathered wafers, and on three of the five weathered wafers. Very minor feeding scars (defined as "surface nibbles" in the standard) were also visible on the majority of the wafers receiving the highest rating of 10 (sound). These results demonstrate that CCA treatments are not repellent to termites. Rather, the treatments are simply toxic to the insects, as evidenced by the universal 100 percent termite mortality with all CCA retentions in both tests. Termites "taste" the wood surface, but only a small amount of preservative-treated wood must be ingested to kill a termite. Termite mortality occurs more rapidly with CCA than with other non-repellent wood treatments, such as disodium octaborate tetrahydrate, resulting in only very minor evidence of grazing. As has been hypothesized with borates, it is likely that termites dying near CCA-treated wood in the field, and in the galleries leading to that food source, deter other termites from foraging in the vicinity.

Results of these studies demonstrate the efficacy of CCA treatments to pine wood in preventing damage by the Formosan subterranean termite, and provide evidence of the toxic rather than repellent mode of action of waterborne preservatives. Lund (8) came to this same conclusion from laboratory studies with the termites *Reticulitermes flavipes* and *Reticulitermes virginicus*, and in fact identified 0.5 kg/m^3 (0.03 pcf) as the threshold CCA value for minimal damage by these termite species. Oil solvents, in contrast, have been shown to repel termites (7), and at least some short-term repellence may also be a factor with ammoniacal waterborne systems (9).

Since both of the studies reported here used pine wafers, neither addressed the issue of the treatability of different wood species. Preston et al. (10) demonstrated

TABLE 2. — Results of a four-week, no-choice laboratory test of CCA-treated radiata pine wafers exposed to 400 Formosan subterranean termites.

CCA retention		Visual rating	Mean rating	Mean mass loss	Mean mass loss	Mean termite mortality
(kg/m^3)	(pcf)			(mg)	(%)	
4.0	0.25	10	9.3	49.23 (8.62)[a]	3.0 (0.50)	100 (0)
		9				
		9				
		10				
		9				
		9				
2.0	0.125	9	9.2	49.47 (7.88)	3.0 (0.50)	100 (0)
		9				
		9				
		9				
		9				
		10				
1.0	0.06	9	9.5	44.93 (10.64)	2.8 (0.63)	100 (0)
		10				
		10				
		9				
		9				
		10				
0.5	0.03	10	9.7	40.53 (8.99)	2.5 (0.57)	100 (0)
		10				
		10				
		10				
		9				
		9				
0	0	0	0	1306.05 (76.41)	80.3 (2.75)	11.65 (2.35)
		0				
		0				
		0				
		0				
		0				

[a] Values in parentheses are standard deviations.

that an unbroken CCA shell treatment of Douglas-fir (*Pseudotsuga menziesii*) could provide protection from termite attack for at least a year. However, Grace and Yamamoto (6) noted termite penetration of the untreated interior wood in 1 of 10 test pieces of Douglas-fir lumber with a similar CCA shell treatment when the lumber was cut and exposed to heavy termite pressure in a 6-week field test, and Doyle (5) reported both cosmetic surface damage and complete termite penetration of the exterior CCA treatment on unincised spruce-pine-fir (SPF) and lodgepole pine boards after 4 years in ground contact at a *R. flavipes* test site in Kincardine, Ontario.

These laboratory results with pine wafers demonstrate that wood thoroughly impregnated with CCA at even low retentions can be protected from all but superficial cosmetic damage by Formosan subterranean termites. However, long-term efficacy of a thin shell treatment on a refractory timber in preventing termite access to the untreated wood below the surface is not supported by published field observations (5,9,12). Although relatively low retentions of CCA may be required for efficacy, thorough penetration of the lumber is likely a prerequisite for long-term protection.

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