Formosan Termite Response to Weathered Borate-Treated Wood

Michael A. Lake and Craig R. McIntyre

Abstract

Recent work to control the leaching rate of borate-based wood preservative systems has shown that significant borate levels can be retained after accelerated weathering. A 12-week regimen approved by the International Code Council-Evaluation Services (building code) uses treated deck boards (48 in. long, 1 by 6 in.) and includes heating, wetting, and freezing cycles; over 12,000 in. of "rainfall" are applied. Randomly selected boards from this weathering were evaluated by AWPA E1 Termite testing using Formosan subterranean termites (FST) and the no-choice procedure. A wide range of retentions spanning from 0.01 to 0.28 pcf B_2O_3 demonstrate that relatively low threshold retentions, one-fourth that specified by the AWPA, are effective against FSTs.

Introduction

The controlled release of borate-based preservative systems is a goal that many researchers have pursued for years. Borates are environmentally friendly, have low human toxicity, and show excellent efficacy against termites and most fungi. But, borates with no protection readily leach from wood when exposed to the outside elements, particularly rain. In some cases, near-complete fixation has been achieved, but later efficacy testing showed that these systems did not prevent fungal and termite attack. Some borate mobility is required to maintain the efficacy of the borates.

The overall objective of this work was to develop a new preservative formulation for aboveground applications by controlling the degree of leaching of various borate systems. Several leaching tests have been used during the evaluations. A previous paper described the leaching tests and the results obtained using them in detail (Robinson et al. 2005). This paper focuses on Formosan termite testing done on boards that were weathered using the International Code Council-Evaluation Services (ICC-ES) regimen.

Experimental

Formulations

Formulations were prepared in 400 gallon mixing vessels using commercially available chemicals. The borate was disodium octoborate tetrahydrate (DOT) supplied by U.S. Borax, Inc. Water was the solvent for all formulations. For this work, four different formulations were prepared; one borate-only control and three developmental MeadWestvaco (MWV) formulations.

Wood

All wood was 5/4 by 6 by 96 in. southern pine (SP) radius-edged decking. Pieces were selected to be essentially all sapwood.

Treatment

Each treating charge consisted of 30 pieces of decking boards, and four charges were treated for each formulation. The treating cylinder is 2 by 10 ft. and has vacuum and pressure capability. Each decking board was num-

Lake:
Technical Manager, Wood-Treatment Chemicals, Specialty Chemicals Division, MeadWestvaco Corporation, Charleston, South Carolina, USA

McIntyre:
President, McIntyre Associates Inc., Walls, Mississippi, USA

bered and weighed before and after treatment to obtain a weight-retention value.

Selection

Those 8-ft-long pieces of decking with gauge retentions nearest the target retention were selected for the weathering work. The selected samples were cut in half with one 4-ft-long board allocated to the Western Fire Center (WFC) in Kelso, Washington, which is accredited by the International Code Council - International Accreditation Service, Inc. (ICC-IAS) to conduct the weathering test.

Weathering Deck Modules

Seven of the 4-ft-long boards of a single formulation were attached to a treated 2 by 4 wood frame to give a "deck module." Six deck modules were constructed for each formulation, so 42 boards of each formulation were weathered.

Assays of Deck Modules

Prior to assembly of the test decks, retentions and penetrations of each charge were determined by Timber Products Inspection (TPI) following normal American Wood-Preservers' Association (AWPA) procedures. Then, after the decks were in place at WFC, borate retentions were determined by boring through the face of each board with a Forstner bit and collecting the shavings for analysis. Each week, starting with time zero, two holes per board were drilled with the two holes separated by about 2 ft. These pairs of holes were drilled in sequence, so that the pairs progressed the length of the board during the 12 weeks of weathering. As holes were drilled, they were plugged with a wood dowel. The shavings of the seven boards on each deck were collected as a composite. These composite samples were analyzed by inductively coupled plasma spectroscopy (ICP); the analyses were organized by TRI. Using this procedure, the degree of borate loss was monitored each week for each of the 24 decks being weathered at WFC.

Weathering Procedure

The ICC-ES has approved an Acceptance Criteria (AC) that details the weathering regime. This AC62 weathering consists of 12 weekly cycles with each cycle consisting of 2 days of heat (UV light and 50° to 60°C), 3 days of rain (repetitive cycles of 3-hours rain and 3-hours rest), and 2 days of freezing (–15°C). In the 12 weeks of weathering, about 12,300 in. of rain is applied to the deck module surfaces which are horizontally oriented.

Termite Specimens

Based on the leaching performance at WFC, two MWV developmental formulations were selected, in addition to the borate-only control, for termite efficacy testing. All 42 boards from each of these three formulations were sent directly to Louisiana State University (LSU). Their personnel randomly chose 20 boards from each formulation's population. In addition, since a paucity of data were expected at low borate concentrations, five boards of two formulations were selected from parallel populations exposed to more exhaustive leaching regimens that were done in Charleston. Five replicates of untreated (and unweathered) SP were included in the termite test, so 75 total samples were tested.

LSU personnel cut small wafers, each 25 by 25 by 6 mm, from the centers of the boards selected. Moisture of the wafers prior to testing was measured in small blocks that were cut adjacent to each large face of the termite wafer.

Termite Specimen Assays

Since the wafer used in the termite test could not be analyzed for borates directly, the borate levels in the adjacent moisture-analysis blocks were measured by ICP. That retention was assumed to be that of the wafer placed into the E1 termite-testing jars.

Termite Response Tests

AWPA E1 testing was done by LSU personnel using the no-choice option. The no-choice test is more rigorous than the choice test – the termites either eat the wafer of treated wood or starve during the 28-day duration of the test. Generally the no-choice option gives greater weight loss (Fox et al. 2000). Threshold retentions calculated from no-choice tests are expected to be higher than those calculated from choice tests.

The 30,000 Formosan termites required by this work were collected by LSU personnel near Lake Charles during the interim period between Hurricanes Katrina and Rita which hit Louisiana in 2005. Three responses are gathered from the E1 test: the mortality of the termites, a visual rating (1 through 10 with 10 being the best) of the resulting wood wafer exposed to termites, and the weight loss of the wafer during the test. A more complete publication on the actual termite test is planned by the LSU personnel involved.

Results and Discussion

Weathering Results

Figure 1 shows the boron levels with time under the AC-62 weathering conditions. Each data point on this curve represents an average of all six decks for each treatment's population. The boron retention is shown on the y-axis as a percentage of the boron at time zero. All of the MWV developmental formulations and the borate-only control started from the same original borate retention.

As observed in all previous work, the boron levels follow an exponential decay. In this study, there was no significant difference between the three different MWV developmental formulations. All three contained about

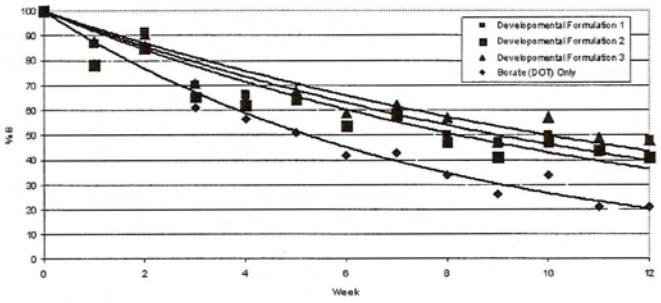

Figure 1. – *Boron levels with time under the AC-62 weathering conditions.*

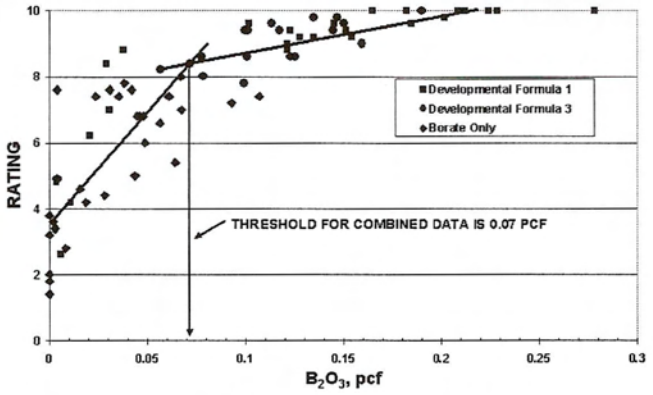

Figure 2. – *Average five person rating of wafers.*

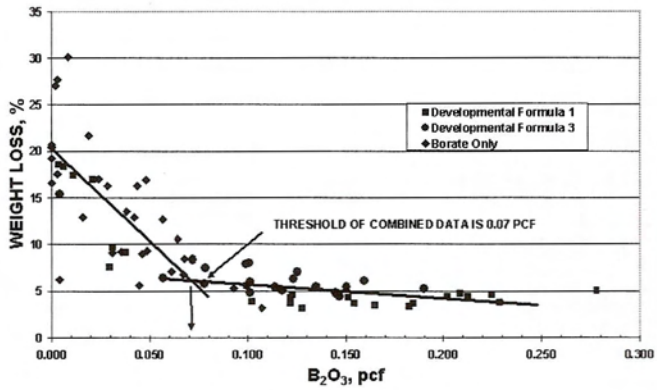

Figure 3. – *Wafer weight loss.*

twice the level of borate (40% to 50%) at the end of the 12-week weathering regimen compared to the borate-only control (20%).

The difference between the borate-only formulation and the two MWV developmental formulations tested for termites also can be observed in two of the termite efficacy response curves (**Figs. 3 and 4**). The borate-only points mostly populate the portion of the figures with boron retentions less than 0.07 pcf B_2O_3, whereas the MWV formulation data mostly populate boron retentions greater than 0.07 pcf B_2O_3.

The best two MWV formulations based on the leaching curves in **Figure 1** were chosen for the efficacy testing with termites and brown-rot fungi. Two of the MWV formulations and the borate-only control were chosen for the efficacy testing with termites and brown-rot fungi – 60 total samples. As mentioned earlier, ten samples were included that had been subjected to a more exhaustive leaching regiment to provide more low-retention data, and the study included five SP controls with no borate added.

Termite Results

Rather than segregate the results by formulation, the results were derived from the total population of data since the retentions of any one formulation were not smoothly spread over the total range.

Mortality

The termite mortality data are scattered and exhibit poor correlation with borate retentions (**Fig. 4**). The straight-line fit exhibits a slight upward trend, but the confidence of this fit is low as demonstrated by the very low correlation coefficient of 0.0084.

Visual ratings

The average visual rating data in **Figure 2** demonstrate a much better fit to an exponential curve. The curve demonstrates good "dose-response" since higher ratings up to the maximum of 10 result from higher boron retentions. The lowest ratings were observed with the SP controls containing zero boron.

Using these ratings data, the threshold of effectiveness of the borates was about 0.07 pcf B_2O_3. This threshold was determined by fitting a straight line to the data with less than 0.05 pcf B_2O_3 to obtain the steeper slope line. Then the same was done to the data greater than 0.10 pcf B_2O_3 to obtain a line with lesser slope. The intersection of the two straight lines defines the threshold.

Weight-loss

The wafer weight-loss data of **Figure 3** demonstrate good dose-response similar to that of the ratings data. The weight-loss data approach a lower-limit asymptote of about 5 percent at the higher borate retentions. Using the same calculation method that was used for the visual ratings, the threshold of effectiveness of the borates was also about 0.07 pcf B_2O_3 based on the weight-loss data.

Thresholds compared to AWPA

Thus the two thresholds calculated separately from weight loss and visual-rating data in this work are the same, 0.07 pcf B_2O_3. This threshold is one-fourth that

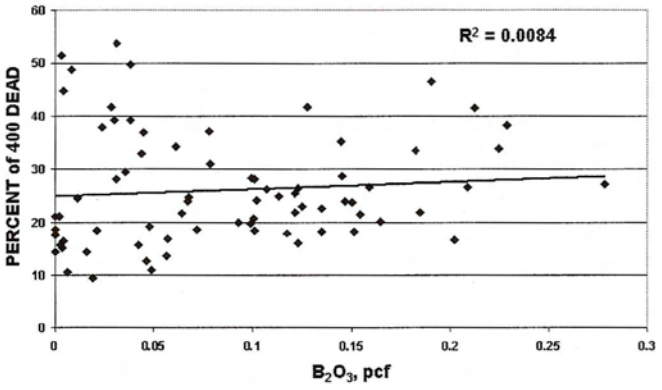

Figure 4. – *Termite mortality.*

specified by the AWPA, 0.28 pcf B_2O_3, for wood used in areas where Formosan termite attack may occur. These data suggest that there is an inordinately large "margin of safety" between the threshold and the AWPA specification. The AWPA threshold was set using a wide variety of response data, including actual field-exposure data where combinations of fungi and termite exposure exist. Recognizing that the AWPA specification was in the late 1990s and that considerably more data have become available, perhaps this study can help initiate reconsideration of the Formosan specification by the AWPA.

Future Work

Using similar weathered-wood samples as used in this work, experiments are nearing completion at LSU using the AWPA E10 Soil Block test with brown-rot fungi to determine fungal thresholds. Similar testing is planned at Mississippi State University using AWPA E1 with native termites (*Reticulitermes* sp.) that should allow comparison of Formosan and native termite thresholds.

Conclusion

Thresholds were determined using weathered borate-treated wood and the AWPA E1 Formosan no-choice termite test. The thresholds calculated from both the weight loss and visual-rating data were both about 0.07 pcf B_2O_3 which is four-times lower than the AWPA specification for Formosan termites, 0.28 pcf B_2O_3.

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Literature Cited

Robinson, P.L., J.E. Blasser, M.A. Lake, and C.R. McIntyre. 2005. Leaching tests of "controlled" borate systems. *In*: Proc., American Wood-Preservers' Association. 101: 75-83.

Fox, R.F., E.A. Pasek, and J. Patel. 2000. Laboratory termite testing of copper boron tebuconazole. International Research Group on Wood Preservation, IRG/WP 00-20192, 12 p.