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COPPER BORATE FOR THE PROTECTION OF ENGINEERED WOOD PRODUCTS

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Summary

Copper borate was evaluated for use in protecting wood composites from mould, decay, and termites. Aspen OSB bonded with either phenolic or isocyanate resin was treated with several formulations of copper borate at various loadings from 0.26 to 4 percent by weight. These panels were then tested to determine the impact of the preservative on mechanical properties as well as resistance to fungal decay, mould, and Formosan termite attack. With proper resin selection, acceptable panels could be produced with both phenolic and isocyanate resin. The 10% copper hydroxide formulation of copper borate provided superior protection against mould, while all formulations tested gave adequate protection against fungal decay and Formosan termite attack. This paper summarizes over 5 years of research and the production of several hundred panels.

1. Introduction

Sales of engineered wood composite materials have grown rapidly in North America and worldwide over the last decade. The products are being put into service in increasingly challenging environments as the occurrence moisture ingress through building envelopes is becoming more and more prevalent. These products are subject to the same biological degradation as the solid wood from which they are made and there is a need for decay, insect and mould resistant products (Morrell 2001).

Fungal decay of composite products has been widely recognized (Goroyias and Hale 2000, Sean et al. 1999), and it is assumed their susceptibility to termite attack is similar to the solid wood from which they are derived. However, Miles (1994) reports that waferboard is particularly susceptible to termite damage that results in structural weakening and in the case of untreated aspen waferboard, is actually preferred as a feeding substrate to solid white pine. Therefore, if wood composite products are to be used in areas where termite problems exist, it is essential that they are protected by some form of preservative.

Mould has also become a major issue over the last decade and there is a perception that OSB is less resistant to mould fungi than softwood plywood. In the United States, the threat of mould contamination now exceeds that of decay and termite damage in terms of incidence of problems, insurance claims and health issues (Kartal et al. 2003). Borate compounds are present in many anti-sapstain formulations and it is well documented that they do provide some degree of mould protection to wood (Laks et al. 1993, Kartal et al. 2003, Fogel and Lloyd 2002).

While it is highly desirable to increase the durability of these composite products, problems can be encountered with adding protective chemicals to the wood furnish. One of the most important considerations when adding a preservative to a composite material prior to pressing is its impact on physical properties. Many additives can have an adverse effect on the mechanical properties of wood composites, especially those bonded with phenol-formaldehyde resins (Sean et al. 1999).

There are several advantages to the use of copper borate for the protection of wood composites. Most importantly, copper borate can easily be added to the furnish at the blender. This results in very little capital investment for a mill to begin production of a treated product. This method of application provides fairly uniform treatment as each strand of wood is coated in preservative as it tumbles in the blender. This form of copper borate is also heat stable, does not decompose or gas off, is relatively safe to handle and does not constitute a disposal risk.

The purpose of this research was to determine the effectiveness of copper borate as a fungicide, mouldicide, and insecticide for the treatment of wood composites such as oriented strand board. In addition to proving the biological effectiveness of copper borate, it was also essential to ensure that the use of this preservative would not negatively impact the physical properties of the treated material.

2. Methodology

Experimental panels were prepared at the Alberta Research Council in Edmonton, Alberta (a pilot-scale facility using standardized procedures that simulate industrial production). While many conditions were varied over the span of the research, the typical production parameters (those used for the material reported herein) were as follows. Aspen (*Populus spp.)* strands for OSB manufacture were obtained from a commercial OSB manufacturer in Alberta and dried to approximately 3 percent moisture content. Both polymeric diphenylmethane diisocyanate (MDI) and phenol-formaldehyde – liquid (LPF) and powder (PPF) commercial resins were evaluated at commercial addition rates. Incorporation of the liquid additive was conducted by spinning disk while the powder was tumbled in the blender. Slack and emulsified waxes were used at different times throughout the research, with a target addition rate of 1 percent solids. All additive levels were calculated as a percent of oven dry wood, exclusive of preservative treatment level. Copper Borate powdered preservative (see Table 1 for different formulations tested) was added to the blender to achieve various target contents (see tables for each test conducted for individual preservative retentions) based on ovendry furnish weight. Furnish MC was adjusted to approximately 6 percent by adding water in the blender prior to application of adhesive.

The furnish material was hand-formed with random orientation into 34" by 34" billets. The billets were then pressed using ARC's Pressman© Press Monitoring System to program, monitor and control the press. Panels were pressed to a target thickness of 0.437 inches and target density of 40 lb/ft^3. After removal from the press, the panels were trimmed and then hot stacked in an insulated box for 15 hours. Panels were tested for modulus of rupture, modulus of elasticity, internal bond, thickness swell, and water absorption. All tests were performed according to CSA test standard 0437.1-93 for OSB and Wafer board.

Table 1. Composition of Copper borate Formulations Tested.

	2.9% Cu Formulation	**5% Cu Formulation**	**10% Cu Formulation**	**25% Cu Formulation**
Copper Hydroxide	2.87	5	10	25
Boric Acid	7.93	7.93	7.93	7.93
Disodium Octaborate Tetrahydrate (DOT)	89.2	87.07	82.07	67.07

Samples were sent to Forintek Canada to evaluate their mould resistance in a modified ASTM D3273-94 test. The chamber temperature was maintained at 25°C instead of the 32.5°C specified and the test was continued for 8 weeks rather than for the 4 weeks specified in the standard. This method is currently being reviewed by AWPA for standardization. Zinc borate, copper borate, and boric oxide treated panels were included as well as untreated OSB controls and Douglas fir plywood. The zinc borate specimens were commercially treated OSB produced by Louisiana-Pacific Corp while the boric oxide panels were produced at the Alberta Research Council along with the copper borate treated panels. Test products, treatment levels and type, as well as panel thickness of the OSB and plywood are summarized in Table 3. The following four mould cultures were used: *Alternaria tenuissima, Aspergillus niger, Aureobasidium pullulans* and *Penicillium citrinum*. Both the soil and the samples were inoculated The samples were rated every two weeks for extent and intensity of fungal growth with emphasis placed on surface area covered and degree of discolouration on the 2 faces instead of the edges. Samples were rated on a scale of 0 to 10 where 0 represents no growth and 10 represents extensive and intense fungal growth.

A second mould study was conducted to verify the findings obtained from the initial mould test (Table 4). In this study, two copper borate formulations were included; the 10% copper hydroxide formulation from the initial study as well as a 25% copper hydroxide formulation. Reference panels included boric oxide and zinc borate treated OSB, untreated controls and Douglas fir plywood. Panels with both PF and MDI resin were included in this study to observe the effect of the resin on mould resistance.

Additional panels were also sent to Forintek to test for resistance to fungal decay in a laboratory soil jar decay test according to AWPA E10-91 (AWPA 1997). Blocks were exposed to the brown rot fungi *Gloeophyllum trabeum* (Table 5) and *Postia placenta* as well as the white rot fungus *Coriolus versicolor* (Table 6) for 12 weeks. Several different resin combinations and preservative loadings were included in the test. Zinc borate, copper borate, and boric oxide treated panels were included as well as untreated controls. The weight losses were evaluated based on ovendry weight of samples before and after the 12 week fungal exposure.

From the panels originally sent to Forintek for mould and decay testing, samples were also evaluated for resistance to attack by Formosan subterranean termites in a rigorous laboratory test at the University of Hawaii. The samples were evaluated according to AWPA E1-97 (AWPA 2001) which consists of a no-choice assay, in which each wood sample is exposed in a jar to 400 termites for the duration of 28 days. Zinc borate, copper borate, and boric oxide treated panels were included as well as untreated OSB controls (Table 7).

3. Results and Discussion

Values for physical properties are presented in Figures 1 to 3 and Table 2. This information shows the effects that the addition of copper borate has on the strength and durability of the panel. Figures 1 to 3 show the results obtained with unidentified commercial phenolics resins and a Huntsman R1840 MDI resin when applied at commercial levels. It can be seen that there was only a minimal effect on internal bond strength (IB), modulus of rupture (MOR) and modulus of elasticity (MOE). Throughout the course of panel production however, it became apparent that certain resin systems performed better than others. MDI seemed to perform well in all situations, but certain phenolic resins gave poorer mechanical properties when applied in conjunction with the copper borate preservative.

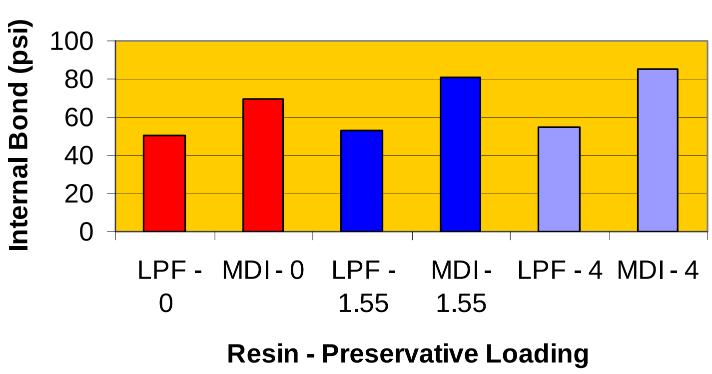

Figure 1. Internal Bond Strength of OSB panels produced with varying loadings of copper borate (10% formulation) and either LPF or MDI resin.

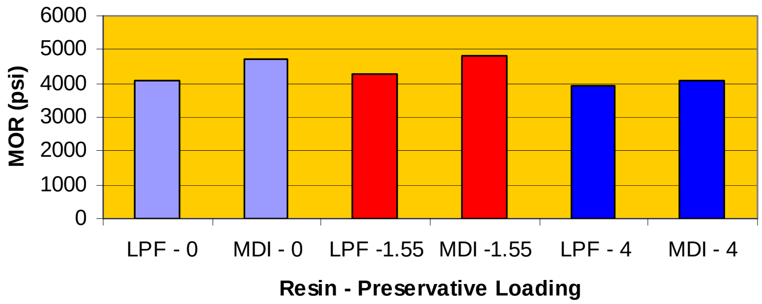

Figure 2. Modulus of Rupture of OSB panels produced with varying loadings of copper borate (10% formulation) and either LPF or MDI resin.

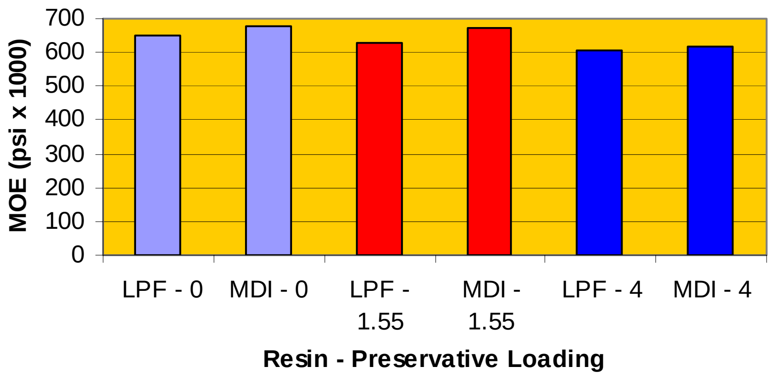

Figure 3. Modulus of Elasticity of OSB panels produced with varying loadings of copper borate (10% formulation) and either LPF or MDI resin.

As a result of the inconsistent results with different phenolics resins, Hexion, a phenolic resin manufacturer, was approached. The information in Table 2 shows the results obtained with their initial resin recommendations. It can be seen that the two powder PF resin systems performed quite well with only marginal reductions in mechanical properties. The liquid PF resin however, fared somewhat worse, which was consistent with earlier work conducted by Genics at the Alberta Research Council. These results reflect some of the findings of previous work with disodium octaborate tetrahydrate (DOT) (Laks et al., 1988), where it was reported that MDI provided much better mechanical properties than phenolics resins. While the current research with copper borate also showed excellent performance for MDI panels, PF resins (such as those in Table 2) also showed acceptable performance. This is partly due to resin selection, but may also be affected by the differences in the behaviour of copper borate and DOT. DOT has rapid solubility in water which results in the borate being readily available to interact with the resin. This interaction likely results in a gelling of the phenolic adhesive before it can penetrate and bond with the opposing wood surface (Vick et al. 1990). Copper borate is much slower to solubilize, and is therefore not as available to negatively impact the bonding ability of the resin. Further research is planned to better understand the reason for the decreased mechanical properties in copper borate panels produced with certain phenolics resins and to further optimize the resin selection for both PPF and LPF.

Table 2. Physical property testing results of OSB panels made with liquid and powder phenolics resins.

Resin System	Copper Borate (%)	Internal Bond (psi)	Thickness Swell (%)	Water Absorption (%)
W91B/W3154N	-	54.82 (12.64)	15.3 (4.2)	34.3 (5.3)
(Powder)				
W91B/W3154N	2	56.56 (14.7)	16.8 (5.6)	38.4 (3.3)
(Powder)				
W71B/W800C	-	65.76 (14.54)	14.4 (6.4)	36.1 (2.9)
(Powder)				
W71B/W800C	2	60.4 (10.9)	17.7 (7.2)	41.2 (6.6)
(Powder)				
LP02/HPC51	-	61.39 (8.44)	13.1 (5.4)	30.5 (4.7)
(Liquid)				
LP02/HPC51	2	49.52 (11.18)	19.2 (9.4)	42.7 (3.3)
(Liquid)				

Table 3. Test Products and Analyzed Borate Content for samples included in modified ASTM D3273-94 mould resistance test.

Panel Type	Actual Thickness (mm)	Analyzed Borate Content (% BAE)*	Comments
OSB - No additive	11	NA	Control
OSB-Genics 2.9% Cu/borate	11	0.88 (0.25)	
OSB-Genics 5% Cu/borate	11	0.98 (0.26)	
OSB-Genics 10% Cu/borate	11	1.28 (0.31)	
OSB - Anhydrous Boric Oxide	11	0.58 (0.21)	Borate only
OSB- Anhydrous Boric Oxide	11	1.13 (0.21)	Reference material
T&G - Zinc Borate	18	-	Reference material
OSB - Zinc Borate	12	0.89 (0.09)	Reference material
Douglas fir Plywood	9	NA	Plywood Control

***** Average with standard deviation shown in parenthesis.

Figure 4 shows the performance of copper borate treated OSB after an 8 week modified D3273-94 test. The 10% copper borate samples showed superior performance to all other treatments tested. The difference in performance can partly be attributed to increased concentration of copper borate in the panel, but a comparison to the samples with similar loading of boric oxide reveals that the increase in copper in the formulation is making a significant contribution to the performance of the treated panel against mould growth.

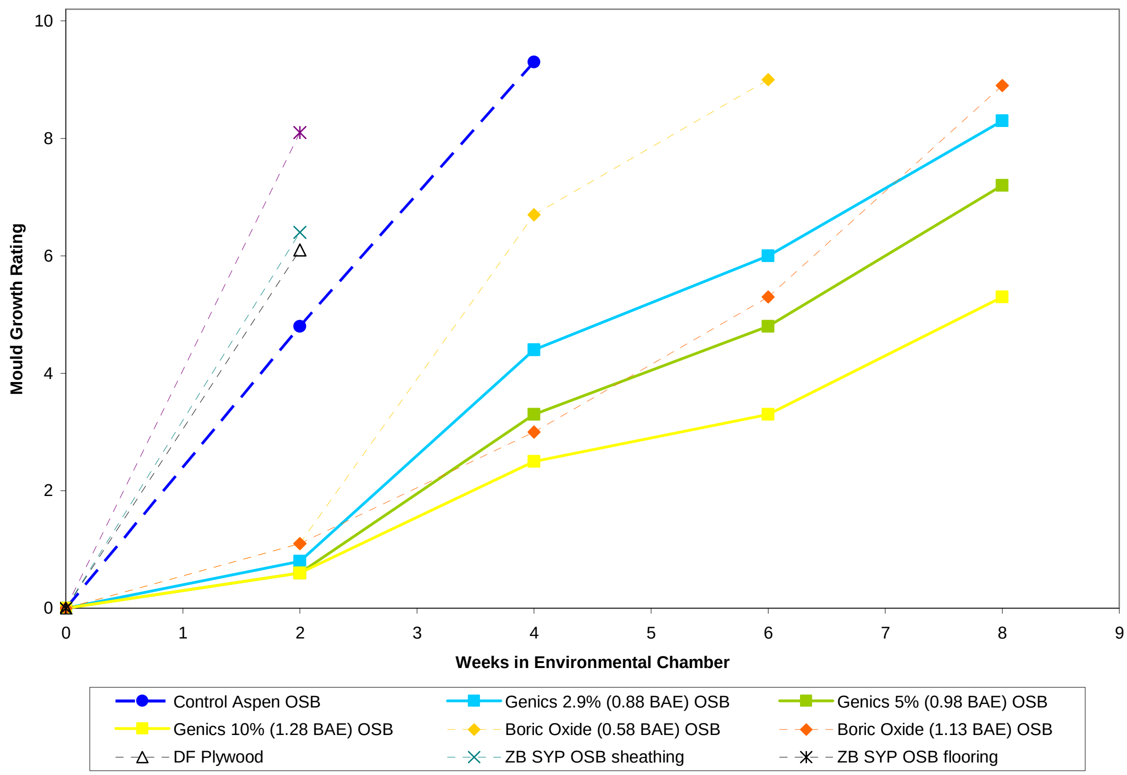

Figure 4. Mould Rating vs Time of treated and untreated OSB panels as well as a plywood control in an 8 week modified ASTM D3273-94 test.

Surprisingly, the zinc borate treatments gave very poor performance compared to both the other borate products and the untreated OSB. This was contrary to the findings of previous work (Laks et al. 1993, Fogel and Lloyd, 2002) that report that zinc borate does impart mould protection and actually performs better than DOT. Later testing (internal testing at Genics) as well as work conducted by Forintek (2005) showed that aspen is more resistant to mould growth than southern yellow pine. Since the zinc borate panels were commercial panels produced from southern yellow pine, this accounts for a large part of the difference in performance between it and the aspen based panels which were treated with either copper borate or boric oxide.

The second mould study confirmed the findings of the initial study for copper borate (Table 4). Once again the 10% Cu formulation showed superior performance to all other treatments in the study including the 25% Cu formulation which was added after finding that the higher copper levels in the 10% Cu formulation resulted in superior mould resistance in the first study. By observing the 10% Cu formulations alone, it was also apparent that MDI resin imparted greater resistance to mould growth than did either type of phenolic. In general, a dose/response effect was apparent for the 10% Cu formulation. That data was plotted on a graph and it appears that a loading of 2% BAE within the panel would effectively prevent any growth of mould, even under the harsh conditions of this 8 week test (Figure 5). This second study also included zinc borate and boric oxide treated OSB as reference materials. In this study, the zinc borate treated material performed similar to Douglas fir plywood which was superior to the untreated OSB controls. Boric oxide however, provided resistance greater than zinc borate which is in line with the findings of Laks et al. (1993).

Table 4. Test Product Info, Fungal Rating and Moisture Content for samples included in second modified ASTM D3273-94 mould resistance test.

Panel Type/Formulation	Resin Type	Estimated Ret'n (%BAE)*	8 week Fungal Growth Rating (0-10)**	Percent Moisture Content (8 week)**
OSB-NA (control)	LPF/MDI	NA***	10.0 (0.0)	27.6 (2.3)
OSB-NA (control)	MDI	NA	10.0 (0.0)	28.9 (1.2)
OSB-NA (control)	LPF/PPF	NA	10.0 (0.0)	29.3 (0.7)
OSB-10% Cu	LPF/PPF	0.52 (0.07)	9.5 (0.5)	31.0 (0.7)
OSB-10% Cu	MDI	0.55 (0.06)	4.8 (2.3)	29.3 (2.5)
OSB-10% Cu	LPF	0.54(0.06)	8.2 (1.2)	29.3 (2.5)
OSB-10% Cu	LPF/PPF	0.79 (0.07)	4.2 (1.5)	31.0 (2.8)
OSB-10% Cu	LPF	1.17 (0.16)	2.2 (0.8)	32.0 (1.8)
OSB-25% Cu	LPF/PPF	0.36 (0.03)	9.7 (0.5)	29.3 (2.2)
OSB-25% Cu	LPF/PPF	0.52 (0.06)	8.8 (1.6)	29.4 (2.7)
OSB-25% Cu	LPF/PPF	0.63 (0.11)	6.8 (1.7)	31.5 (3.5)
OSB-25% Cu	LPF/PPF	0.72 (0.11)	5.2 (1.7)	30.5 (1.4)
OSB-25% Cu	LPF	0.99 (0.19)	5.2 (2.5)	32.5 (2.6)
OSB-25% Cu	LPF	1.93 (0.44)	5.8 (1.8)	35.6 (6.4)
OSB-Boric Oxide	LPF/PPF	0.59 (0.07)	10.0 (0.0)	30.7 (1.3)
OSB-Boric Oxide	LPF/PPF	0.75 (0.10)	8.3 (0.5)	29.4 (0.9)
OSB-Zinc Borate	MDI	0.81 (0.12)	9.8 (0.4)	25.4 (1.3)
D. fir plywood	NA	NA	9.5 (0.5)	28.0 (1.6)

***** Average of 6 panel analyses from each of 3 panels with standard deviation shown in parenthesis.
** Average with standard deviation shown in parenthesis.
*** NA – Not Applicable

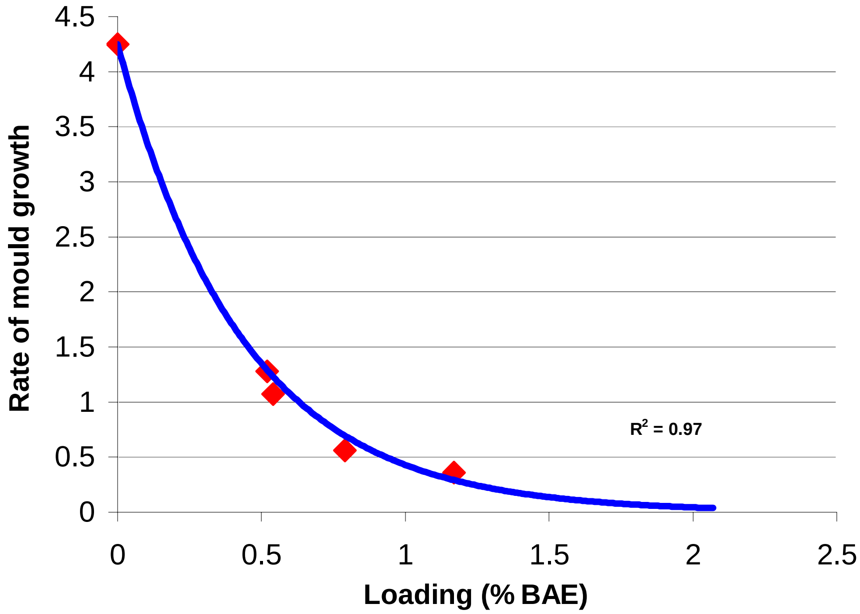

Figure 5. Mould rating vs loading of copper borate (%BAE) of treated OSB panels in an 8 week modified ASTM D3273-94 test.

Fungal decay test results are presented in Table 5 and Table 6 for the fungi *Gloeophyllum trabeum* and *Coriolus versicolor* respectively. This was the second decay test conducted and it included lower concentrations of borate preservatives than in the initial study as there was no decay observed in that study when samples contained between 0.5 and 1% BAE of the borate preservatives. Weight losses for all treated panels were under 2% for all samples containing either copper borate, boric oxide or zinc borate. The lowest concentration of copper borate tested in the 10% Cu formulation was 0.26% BAE. It appears that the threshold level for protection of OSB is somewhere below this level but the exact level is unknown. Tests to determine the resistance of the treated OSB against *Postia placenta* was also included, however, the untreated controls showed very poor decay so the test results had to be considered unreliable. However, from the results obtained in this second test, it appears that copper borate provides similar protection to that offered by other borate products.

Table 5. Test Product Info, Weight Losses and Moisture Content in Treated and Untreated OSB Blocks Exposed to *Gloeophyllum trabeum.*

Panel Type	Resin Type	Estimated Ret'n (%BAE)*[1]	Weight Loss (%)*[2]	Moisture Content (%)*
Untreated Control	LPF/MDI	-	58.82 (3.46)	59.34 (18.11)
Untreated Control	MDI	-	54.80 (6.4)	45.78 (7.43)
Untreated Control	LPF/PPF	-	58.97 (4.0)	45.19 (4.54)
10% Cu/Borate	LPF/PPF	0.26 (0.03)	1.89 (0.61)	47.81 (5.13)
10% Cu/Borate	LPF/PPF	0.54 (0.04)	1.32 (0.07)	59.78 (2.45)
10% Cu/Borate	LPF / MDI	0.59 (0.07)	1.34 (0.15)	52.72 (3.26)
10% Cu/Borate	MDI	0.58 (0.06)	1.26 (0.09)	51.92 (3.26)
10% Cu/Borate	MDI	0.60 (0.06)	1.04 (0.10)	48.80 (8.88)
10% Cu/Borate	LPF	0.56 (0.08)	1.47 (0.27)	69.99 (3.39)
10% Cu/Borate	LPF/PPF	0.80 (0.10)	1.14 (0.12)	68.65 (7.93)
Boric Oxide	LPF/PPF	0.33 (0.04)	1.67 (0.70)	44.25 (3.15)
Boric Oxide	LPF/PPF	0.61 (0.09)	1.12 (0.11)	54.82 (3.85)
Boric Oxide	LPF/PPF	0.81 (0.14)	1.3 (0.13)	57.53 (9.75)
Commercial ZB	MDI	0.82 (0.12)	1.21 (0.14)	37.17 (1.7)

***** Average with standard deviation shown in parenthesis.

[1]Estimated retention was calculated for each test sample based on the analysed retention of an edge-matched block beside the test sample. The estimated retention is a 6-sampled average of the calculated retention for each test block.

[2=]Weight losses are 6-sample averages.

Table 6. Test Product Info, Weight Losses and Moisture Content in Treated and Untreated OSB Blocks Exposed to *Coriolus versicolor.*

Panel Type	Resin Type	Estimated Ret'n (%BAE)*[1]	Weight Loss (%)*[2]	Moisture Content (%)*
Untreated Control	LPF/MDI	-	29.89 (16.33)	46.42 (7.45))
Untreated Control	MDI	-	13.23 (8.55)	37.70 (10.39)
Untreated Control	LPF/PPF	-	17.48 (16.14)	36.46 (2.72)
10% Cu/Borate	LPF/PPF	0.26 (0.03)	0.26 (0.08)	54.77 (3.31)
10% Cu/Borate	LPF/PPF	0.57 (0.06)	0.12 (0.14)	84.16 (7.06)
10% Cu/Borate	LPF / MDI	0.58 (0.08)	0.14 (0.09)	73.82 (6.59)
10% Cu/Borate	MDI	0.54 (0.06)	0.30 (0.20)	60.34 (6.52)
10% Cu/Borate	MDI	0.62 (0.04)	0.35 (0.08)	61.96 (4.85)
10% Cu/Borate	LPF	0.57 (0.08)	0.35 (0.13)	75.54 (4.86)
10% Cu/Borate	LPF/PPF	0.77 (0.07)	0.03 (0.18)	93.48 (4.62)
Boric Oxide	LPF/PPF	0.34 (0.08)	0.42 (0.27)	55.00 (5.66)
Boric Oxide	LPF/PPF	0.61 (0.05)	0.15 (0.17)	73.08 (5.16)
Boric Oxide	LPF/PPF	0.81 (0.15)	0.13 (0.06)	66.67 (6.11)
Commercial ZB	MDI	0.80 (0.16)	0.15 (0.08)	42.35 (4.23)

***** Average with standard deviation shown in parenthesis.

[1]Estimated retention was calculated for each test sample based on the analysed retention of an edge-matched block beside the test sample. The estimated retention is a 6-sampled average of the calculated retention for each test block.

[2=]Weight losses are 6-sample averages.

Formosan termite resistance was evaluated using the 0 to 10 rating scheme with 0 indicating that the sample was virtually destroyed and 10 representing a sample in perfect condition. The data in Table 7 shows that all three of the borate treatments (zinc borate, boric oxide, and copper borate) performed quite well. Only minor feeding damage occurred with AWPA visual ratings of 7.67 to 9.17. Weight loss ranged from 1.98 to 4.33 for the borate treated material and termite mortality was greater than 98% for all treatments. Untreated OSB controls however, gave AWPA ratings of 0.67 to 1.33, weight losses of 24.43 to 26.04 and termite mortalities from 9.88 to 13.58.

Table 7. Test Product Info, AWPA Rating, Weight Losses and Termite Mortality in Treated and Untreated OSB Blocks in AWPA E1-97 Formosan Termite Test.

Panel Type	Resin Type	Estimated Ret'n (%BAE)[1]	Weight Loss (%)[2]	Mortality (%)[3]	Mean AWPA Rating[4]
Control	LPF/MDI	NA	25.82 (1.28)	13.58 (2.39)	0.67
Control	MDI	NA	26.04 (3.46)	9.88 (3.46)	0.33
Control	LPF/PPF	NA	24.43 (3.54)	13.0 (3.42)	0.67
10% Cu	LPF/PPF	0.55 (0.07)	3.10 (0.22)	99.92 (0.20)	8.83
10% Cu	LPF/PPF	0.78 (0.09)	2.89 (0.60)	100.0 (0.0)	8.67
25% Cu	LPF/PPF	0.50 (0.05)	2.59 (0.68)	99.83 (0.41)	7.67
25% Cu	LPF/PPF	0.71 (0.14)	2.75 (0.53)	100.0 (0.0)	9.17
25% Cu	LPF/PPF	0.56 (0.15)	3.29 (0.34)	99.54 (0.75)	8.67
10% Cu	MDI	0.54 (0.04)	3.12 (0.27)	100.0 (0.0)	8.67
10% Cu	MDI	0.60 (0.02)	3.23 (0.18)	100.0 (0.0)	8.67
25% Cu	LPF	1.99 (0.57)	2.05 (0.43)	99.08 (2.25)	9.0
25% Cu	LPF	0.92 (0.10)	2.96 (0.35)	100.0 (0.0)	8.67
10% Cu	LPF	1.18 (0.04)	3.68 (3.22)	100.0 (0.0)	9.17
10% Cu	LPF	0.58 (0.07)	4.33 (0.63)	100.0 (0.0)	7.67
Boric Oxide	LPF/PPF	0.59 (0.09)	4.11 (0.80)	100.0 (0.0)	8.33
Boric Oxide	LPF/PPF	0.84 (0.12)	3.59 (0.73)	99.83 (0.41)	8.67
Zinc Borate	MDI	0.79 (0.19)	1.98 (1.02)	98.88 (1.15)	8.67

[1]Estimated retention was calculated for each test sample based on the analysed retention of an edge-matched block beside the test sample. The estimated retention is a 6-sampled average of the calculated retention for each test block.
[2]Weight losses are 6-sample averages.
[3]Weight losses are 6-sample averages.
[4]AWPA E1-97 visual rating scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack, penetration), 4 (heavy attack), 0 (failure).

Performance of all three borate treatments was comparable to that seen with other commercial preservative treatments in similar tests (Grace 1998, Grace 1997). This study shows that, as with other borate treatments, termites are not repelled by the copper borate (although high levels of copper have been shown to cause repellence), but die rapidly after initiating feeding on the treated wood. Current field studies underway in Hawaii and Japan of DOT-treated lumber demonstrate that this feeding will only result in minor surface scarring and will not progress to the level of structural damage even after 6 years in the field (Grace et al. 2004). This laboratory evaluation, combined with the numerous studies previously conducted on other borates, indicates that the copper borate formulation is an effective preservative against Formosan subterranean termite attack.

4. Conclusion

From the results presented in this study it can be seen that copper borate is an effective preservative treatment for wood composites where protection against mould, decay, and termites is required. Oriented strand board containing the 10% copper hydroxide formulation showed superior resistance to mould growth compared to all other treatments tested. It also provided similar protection as the reference materials zinc borate and boric oxide against fungal decay and Formosan termite attack.

It was noted throughout the course of the research that copper borate could have a negative impact on physical properties when certain phenolic resins were used. Further research has reduced this impact, and with proper phenolic resin selection, or the use of MDI resin, adequate physical properties can be obtained. Further work is ongoing to this end to determine additional phenolic resins that are compatible with copper borate and to understand the reasons for their compatibility.

5. Literature

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