Pertanika J. Sci. & Technol. 11(1): 65 - 72 (2003)

ISSN: 0128-7680

Resistance of CCA and Boron-Treated Rubberwood Composites Against Termites, *Coptotermes curvignathus* Holmgren

Zaidon A., C. S. Moy, A. S. Sajap & M.T. Paridah
Faculty of Forestry,
Universiti Putra Malaysia
43400 UPM, Serdang, Selangor, Malaysia

Received: 23 October 2001

ABSTRAK

Kajian telah dijalankan untuk menilai ketahanan papan komposit kayu getah yang dirawat dengan kuprum-kromium-arsenik (CCA) dan boron terhadap serangan anai-anai, *Coptotermes curvignathus* Holmgren. Bahan yang digunakan ialah papan tatal berorientasi (OSB) berperekat fenol-formaldehid (PF), papan serpai (particleboard) berperekat melamin-urea-formaldehid (MUF) dan papan venir laminasi (LVL) berperekat urea-formaldehid (UF). Larutan (CCA, 0.5-4.0% w/w, berat kering ketuhar serpai) dan sebatian boron setara asid borik (BAE, 0.5-1.5% w/w) disemburkan ke atas adunan serpai berperekat semasa pembuatan papan komposit. LVL dan sebahagian daripada OSB dan papan serpai tidak dirawat dan digunakan sebagai kawalan bagi tujuan perbandingan. Blok-blok ujian berukuran 25 mm x 25 mm x 12 mm dipotong dari setiap papan komposit dan didedahkan kepada 1.0 ± 0.05 g (10% jenis askar dan 90% pekerja) di dalam botol ujian selama empat minggu (ASTM D:3345-92). Peratusan kehilangan berat blok-blok ujian dan kadar kematian dikira. OSB yang dirawat dengan CCA pada kepekatan 2.0% mempunyai nilai kehilangan berat yang terendah (3.0%) dibandingkan dengan OSB yang dirawat pada lain-lain kepekatan (nilai kehilangan berat 4.1%-6.8%) dan papan tanpa rawatan (18.4%). Nilai kehilangan berat untuk OSB yang dirawat menggunakan larutan 1.0% dan 1.5% BAE ialah masing-masing 6.9% dan 3.8%. Tahap ketahanan papan serpai terhadap serangan anai-anai meningkat 77% apabila ia dirawat dengan 1% BAE. Purata nilai kehilangan beratnya adalah 6.1%. Di antara papan-papan komposit kayu getah tanpa rawatan, OSB berperekat PF mempunyai daya ketahanan tertinggi terhadap serangan anai-anai. LVL berperekat UF lebih tahan daripada papan serpai berperekat MUF. Nilai kehilangan berat untuk kedua-dua papan ini adalah masing-masing 19.3% dan 26.3%. Di akhir tempoh ujian, kematian anai-anai yang diletakkan bersama blok-blok yang dirawat dengan bahan pengawet ialah 100%, manakala kematian anai-anai yang diletakkan bersama papan komposit dan kayu getah pejal yang tidak dirawat ialah di antara 0-16%.

ABSTRACT

A study was conducted to evaluate the resistance of copper-chromium-arsenic (CCA)–and boron-treated rubberwood composites against subterranean termite, *Coptotermes curvignathus* Holmgren. The materials tested were phenol formaldehyde (PF)-bonded oriented strand board (OSB), melamine urea formaldehyde (MUF)-bonded particleboard and urea formaldehyde (UF)-bonded laminated veneer lumber (LVL). Solutions of CCA (0.5-4.0%, w/w of oven dry weight of particles) and boron compounds (boric acid equivalent

(BAE), 0.5 – 1.5% w/w) were separately sprayed onto the furnish during boards manufacturing. The untreated LVL, some of the OSB and particleboard were served as control for comparing purposes. Test blocks, 25 mm x 25 mm x 12 mm were cut from each of the composites and were exposed to 1$\pm$ 0.05 g termites (10% soldiers and 90% workers) in test bottles for 28 days (ASTM D: 3345-92). Weight losses of the blocks and termite mortality were calculated. OSB treated with 2.0% CCA had the lowest weight loss value (3.0%) compared to those treated with other concentrations (weight loss values = 4.1-6.8%) and those untreated (18.4%). The weight loss for 1.0% and 1.5% BAE-treated OSB blocks were 6.9% and 3.8%, respectively. The resistance of particleboards against termite attack increased by 77% when they were treated with 1% BAE. The mean weight loss value for these boards was 6.13%. Among the untreated rubberwood composites, PF-bonded OSB had the highest resistance against termite attack. UF-bonded LVL was significantly more resistant to termite attack than MUF-bonded particleboards. The weight loss value for the former was 19.3% and the latter was 26.3%. At the end of the test periods, the mortality of termites that were placed together with the treated blocks was 100%, whereas for those placed together with the untreated composites and solid rubberwood, the mortality ranged from 0-16%.

Keywords: Particleboard, oriented strand board, laminated veneer lumber, copper-chromium-arsenic, boric acid, *Coptotermes curvignathus*

INTRODUCTION

Currently in Malaysia, rubberwood has been extensively used for the production of various boards such as particleboard, medium density fibreboard, and cementboard. These products are generally less susceptible to biodeterioration agents compared to solid wood (Behr 1972), unless used in situations where exposure to moisture or risk of deterioration is likely. Biodeterioration may then occur.

Incorporation of boron compounds or copper-chromium-arsenic (CCA) in urea formaldehyde and melamine formaldehyde-bonded particleboard, and phenol formaldehyde-bonded oriented strand board (OSB) had enhanced the resistance of the boards against white rot fungus (Zaidon *et al.* 1998a; 1998b; 2001; Wong 2000). However, the resistance of these composites against termite attack has not been investigated. This study is crucial since there was a rather alarming report of high incidences of subterranean termites attacking wooden cabinets (Sajap 1992).

This paper discusses the resistance of boron- and CCA-treated rubberwood PF-bonded OSB, boron-treated MUF-bonded particleboard and laminated veneer lumber against subterranean termites.

MATERIALS AND METHODS

Sample Preparation

Oriented Strand Board (OSB), particleboard and Laminated Veneer Lumber (LVL) which were manufactured from rubberwood were used in this study. The OSB was bonded with phenol formaldehyde (PF) with 5% resin. The board density was about 700 kg/m^3. The OSB was treated separately with copper-chromium-arsenic (CCA) and with boron compounds (a mixture of boric acid and disodium tetraborate decahydrate (borax); 1 : 1.54 parts. The concentration levels for CCA treatment were 0.5%, 1.0%, 2.0% and 4.0% (w/w of oven-dried weight of particles) whilst for boron compounds, they were 1.0% and 1.5% boric acid equivalent (BAE) (w/w of oven-dried weight of particles). Each solution was sprayed onto the furnish during blending.

The particleboard was bonded with 11% (w/w) melamine urea formaldehyde (MUF). The board density was 650 kg/m^3. Boron solutions at 0.5% and 1.0% (boric acid equivalent, BAE) were incorporated into the furnish during blending of the particles. LVL bonded with 11% (w/w) urea formaldehyde (UF) was also used in this study.

Durability of Composite Panels Against Termites

The test on durability of the treated composite panels and LVL against subterranean termites, *Coptotermes curvignathus* Holmgren was carried out in the laboratory using the method specified in ASTM D3345-93 (Anon 1993). The efficacy of the treatment was evaluated based on the percent weight loss of the materials due to termite attack. Five test blocks (each from different treatment levels, and composite types) 25.4 mm by 25.4 mm by 12.0 mm were randomly selected and conditioned in the laboratory until they reached constant weights. The weights were measured and the blocks were placed in test bottles filled with sand. The bottles, together with their contents, were sterilised at 120°C for 2 h.

About 1 ± 0.05 g termites (*Coptotermes curvignatus*) comprising 10% soldiers and 90% workers were introduced in each of the test bottles. They were then conditioned in a conditioning room maintained at 25 ± 2°C and 65-75% relative humidity overnight. The bottles were then covered with a black paper and kept at room temperature (25-27°C) for a period of four weeks. At the end of the test period, the blocks were removed and cleaned. They were again left in the conditioning room until their weights were constant. The percentage weight loss $(W_a - W_b) / W_a) \times 100$ from the conditioned weight before (W_a) and after exposure (W_b) was calculated. The percentage mortality of termites, $(N_o / N_i) \times 100$, in the test bottle was also calculated based on the number of dead (N_o) and the original number (N_i) of termites. The activities of termites during the testing period were also observed and recorded.

Data were analysed statistically to determine differences in weight losses and mortality rates amongst the composite products and between the preservatives.

RESULTS AND DISCUSSION

Durability of Composite Products

The mean weight loss values for preservative-treated and untreated rubberwood composite blocks after 4 weeks of exposure to subterranean termites are shown in Table 1. The percent increase in resistance of treated boards and the untreated ones and the mean mortality of termites are also listed.

PF-bonded Oriented Strand Board – All the OSB blocks tested were attacked by termites as reflected by the weight loss values. Untreated blocks showed significantly higher weight loss values (18.4%) when compared to those treated blocks (3.8-6.9%). For CCA-treated blocks, the weight loss values reduced as the concentration level of CCA used in the treatment increased from 0.5% to 2.0%. The 0.5% CCA-treated OSB blocks had a mean weight loss value of 6.8%, followed by 1.0% CCA-treated blocks (5.0%) and 2.0% CCA-treated blocks (3.0%). Higher weight loss (4.1%) was found on blocks treated with 4% CCA compared to those treated with 2.0% CCA. However, the difference was not significant. The average weight loss value for untreated OSB was 18.4%. The same trend was also observed for boron-treated OSB. Boards which had been treated with 1.0% and 1.5% boric acid equivalent (BAE) solution had mean weight loss values of 6.91% and 3.82%, respectively.

TABLE 1

Mean weight loss of sample blocks of preservative-treated and untreated rubberwood composites and percent mortality after 28 days exposure to subterranean termites (*Coptotermes curvignathus*)

Sample blocks	Preservative Treatment (%, w/w)	Mean[1] Weight loss (%)	Increase in resistance against untreated boards (%)	Mortality (%)
PF-bonded	-	18.40[a2] ± 2.17	-	16.2
OSB	CCA-0.5%	6.80[b] ± 2.47	63	100
	CCA-1.0%	5.03[c] ± 1.89	72.3	100
	CCA-2.0%	3.04[d] ± 0.92	83.5	100
	CCA-4.0%	4.14[d] ± 2.92	77.5	100
	BAE-1.0%	6.91[b] ± 1.61	62.4	100
	BAE-1.5%	3.82[d] ± 1.14	79.2	100
MUF-bonded	-	26.30[a] ± 1.74	-	0
Particleboard	BAE-0.5%	11.59[b] ± 2.57	55.9	100
	BAE-1.0%	6.13[c]± 0.96	76.7	100
UF-bonded LVL	-	19.26 ± 3.00	-	0
Solid rubberwood	-	80.3 ± 4.12	-	0

[1] Means of 5 sample blocks

[2]Means followed by the same letter are not significantly different (a = 0.05) using Duncan Multiple range test.

The results indicated that the incorporation of both boron compounds and CCA in the rubberwood composites increased their resistance against termite attack. As can be seen in Table 1, CCA treatment increased the resistance of the OSB against termite attack by 63-83.5%, whilst BAE treatment increased the resistance by 62.4-79.2%. The resistance against termite attack apparently increased with an increase in concentration of CCA or boric acid used in the treatments.

MUF-bonded Particleboard – The presence of boron in the particleboard also reduces the destruction caused by the termites. As indicated in Table 1, the mean weight loss values (6.13%-11.59%) for the treated particleboard were significantly lower than the values (26.3%) for the untreated boards. The resistance against termite attack increased with the increase in BAE concentration during treatment, i.e., about 60% and 77% for those treated with 0.5% and 1.0% BAE, respectively.

Between CCA and boron compounds, the former was more effective to protect rubberwood composites against termites. At 1% (w/w), the CCA-treated OSB lost only about 5% of its weight, whilst boron-treated OSB and particleboard lost 6-7%. Although the preservatives are effective in controlling the termite attack, an undesirable green colour found on the surface of the CCA-treated boards reduces the aesthetic value. Boron compounds, on the other hand, adversely affect some of the strength and adhesion properties of the composite panels (Zaidon *et al.* 1998a, 1998b; Wong 2000). Treatment at higher concentrations of boron compound rendered more brittle and rigid flakes (Lloyd and Manning 1995), which induced dimensional instability to the board (Wong 2000).

Untreated Rubberwood Composites – The difference in weight loss values among the untreated composites is also presented in Table 1. All untreated composites showed lower mean weight loss than solid wood. Solid rubberwood had a mean weight loss value of 87%. Amongst the untreated composites, MUF-bonded particleboard (weight loss = 26.3%) was the least resistant whilst PF-bonded OSB (18.4%) was the most resistant towards subterranean termites. This shows that the resins used to bond the boards had an influence on the resistance of the boards. Kajita and Imamura (1991) stated that the resistance of the bonded composites towards termites was due to the inability of termites to digest the materials.

Termite Mortality

PF-bonded OSB – The termite activities and mortality throughout the test period was observed daily. The cumulative mortality of termites in the test bottles containing treated and untreated OSB blocks is illustrated in *Fig. 1.* During the first four days of exposure, about 2 to 10 dead termites were seen in the bottles containing preservative-treated OSB. The mortality of termites increased drastically after the fourth day. 100% mortality was noted in the bottles containing 1% and 2% CCA-treated OSB blocks on the fifth and sixth days. A longer period was taken, i.e., 15 and 18 days, to reach 100% mortality

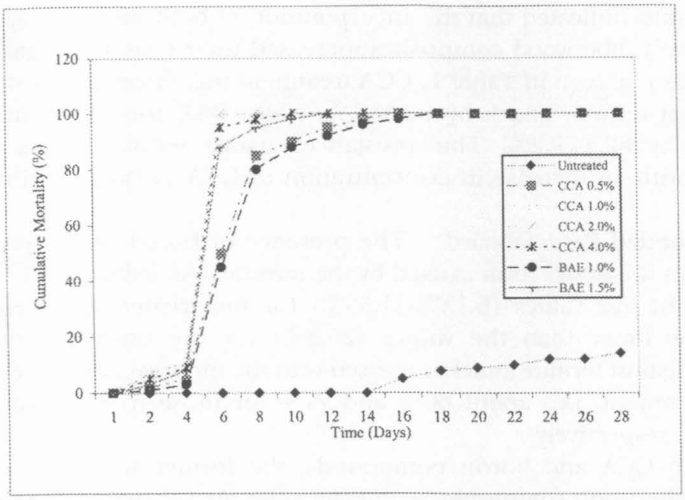

Fig. 1: Cumulative mortality of termites when placed together with treated and untreated OSB blocks in test bottles for up to 28 days

in the bottles containing 0.5% CCA-treated and 1-1.5% BAE-treated blocks. For the untreated OSB blocks, 100% survival was recorded up to 14 days of exposure, but at the end of the test period (28 days), 16.2% of the termites were dead.

MUF-bonded particleboard – *Fig. 2* shows the cumulative mortality of termites in the test bottles containing treated and untreated particleboard blocks. For CCA-treated particleboards, the mortality of termites was only seen after 2 days of exposure. The mortality increased markedly after the fourth and eighth days for particleboard treated with 1.0% and 0.5% BAE, respectively. 100% mortality was recorded after 12 days of exposure for particleboard treated with low concentration of BAE and after 20 days for those treated at a higher concentration. All the termites in the bottles containing untreated particleboard and LVL survived until the end of the test period.

Grace *et al.* (1992) reported that wood blocks treated with more than 0.35% BAE killed all termites within 3 weeks and resulted in 10% weight loss of the blocks. The low mortality of termites for the treated blocks at the early stage of exposure was probably due to the availability of suppliants in the termites which enabled them to survive. At the later stage, the mortality was attributed to the reaction of the toxicant which was ingested by the termites (Mauldin and Karl 1996). The results indicate that the survival periods for the termites were very much related to the toxicity and the chemical loadings in the composite products (Gay and Wetherly 1958; Mauldin and Karl 1996).

Untreated Rubberwood Composites – At the end of the test period, among the untreated composites, dead termites were found only in the bottles containing PF-bonded OSB (*Fig. 1*). The mortality rate increased gradually, and after 28

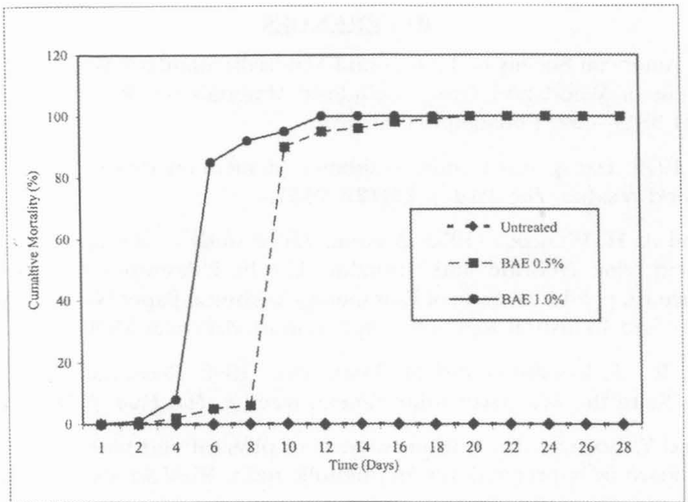

Fig. 2: Cumulative mortality of termites when placed together with treated and untreated particleboard blocks in test bottles for up to 28 days

days of exposure, 16% of the termites died. However, in the bottles containing untreated MUF-bonded particleboard (*Fig. 2*), untreated LVL and solid wood (Table 1), all termites survived after the test period. The results indicate that the PF resin was more toxic to termites than MUF and UF resins. Kajita and Imamura (1993) also reported that the mortality rate for termites fed on phenolic resin treated particleboard gradually increased as the test period continued. The effect was due to the inability of termites to digest the materials.

CONCLUSION

Incorporation of preservatives in oriented strand board, particleboard and laminated veneer lumber provides better resistance against termite attack when compared to the untreated composites. Treatment of PF-bonded OSB with at least 2% of CCA or 1.5% BAE (w/w oven dried flakes) will reduce the damage of termite attack by about 80%. The resistance of UF-bonded particleboards against termite attack increased by 77% when they were treated with 1% BAE. Among the untreated rubberwood composite products, PF-bonded OSB had the highest resistance against termite attack. UF-bonded LVL was more resistant compared to MUF-bonded particleboards. After 4 weeks, all termites which were placed in containers that contained either CCA or boron-treated blocks died. About 16.2% termites survived in containers containing untreated PF-bonded OSB. None of the termites died when they were placed together with MUF-bonded particleboards, UF-bonded LVL and solid rubberwood.

REFERENCES

ANON. 1993. American Society of Testing and Materials: Standard Method of Laboratory Evaluation of Wood and Other Cellulosic Materials for Resistance to Termites. ASTM D 3345 - 92, Philadelphia, U.S.A.

BEHR, F. A. 1972. Decay and termite resistance of medium density fibreboards made from wood residue. *For. Prod. J.* **22(12)**: 48-51.

GAY, F. J. and A. H. WETHERLY. 1958. A comparative study of the anti-termitic value of boric acid, zinc chloride and "Tanalith U". In Laboratory Studies of Termite Resistance III. p. 3-14. Division of Entomology Technical Paper No. 4, Commonwealth Scientific and Industrial Research Organization, Australia Melbourne.

GRACE, J. K., R. T. YAMAMOTO and M. TAMASHIRO. 1992. Resistance of borate-treated Douglas fir to the Formosan subterranean termite. *For. Prod. J.* **42(2)**: 61-65.

KAJITA, H. and Y. IMAMURA. 1991. Improvement of physical and biological properties of particleboard by impregnation with phenolic resin. *Wood Sci. and Tech.* **26(1)**: 63-70.

LLOYD, J. D. and M. J. MANNING. 1995. Development in borate preservation technology. B.W.P.D.A. Record of 1995 Convention, Cambridge, July 7th. B.W.P.D.A., Stratford, London, UK. p. 59-64.

MAULDIN, J. K. and B. M. KARD. 1996. Disodium octaborate tetrahydrate treatments to slash pine for protection against formosan subterranean termite and Eastern subterranean termite *(Isoptera: Rhinotermitidae)*. *J. Econ. Ento.* **89(3)**: 682-687.

SAJAP, A. S. and Y. A. WAHAB. 1997. Termites from selected building premises in Selangor, Peninsular Malaysia. *Mal. For.* **60(4)**: 203-215.

WONG, L. Y. 2000. Properties and durability of boron-treated oriented strand board against white rot fungus *(Pycnoporous sanguineus)*. B. Sc. (For) Thesis. Unpublished. Faculty of Forestry, UPM.

ZAIDON, A., H. RAYEHAN, M. T. PARIDAH and M. Y. NOR YUZIAH. 1998. Incorporation of preservative in particleboards: Properties and durability. *Pertanika T. Trop. Agri. Sci.* **21(2)**: 88-92.

ZAIDON, A., B. JUNAIDI, M. T. PARIDAH and M. Y. NOR YUZIAH. 2001. Properties and durability of MUF-bonded particleboard treated with boron compounds. *Sains Malaysiana* **30(2001)**: 177-186.