MARINE PERFORMANCE OF *BOMBAX CEIBA* TREATED WITH INORGANIC PRESERVATIVES

B. Tarakanadha[1], K. S. Rao[1], P. Narayanappa[1] & J. J. Morrell[2,*]

[1]*Institute of Wood Science and Technology, Bangalore, India*

[2]*Department of Wood Science and Engineering, Oregon State University, Corvallis, Oregon 97331, United States of America. E-mail: Jeff.Morrell@orst.edu*

Received June 2004

TARAKANADHA, B., RAO, K. S., NARAYANAPPA, P. & MORRELL, J. J. 2006. Marine performance of *Bombax ceiba* treated with inorganic preservatives. The performance of *Bombax ceiba* treated with selected inorganic preservatives was assessed in marine exposures over a 44-month period in southern India. Panels treated to high retentions with ammoniacal copper zinc arsenate (ACZA) provided the best protection, followed by the higher chromated copper arsenate (CCA) retention. Pholads tended to be the dominant organisms on ACZA- and CCA-treated wood. Teredinids were more prevalent on ammoniacal copper citrate (CC) or ammoniacal copper quaternary (ACQ) treatments. The potential for using these preservatives to extend service life of this species in tropical waters was discussed.

Keywords: Marine borers, ammoniacal copper zinc arsenate, chromated copper, arsenate, ammoniacal copper quaternary, ammoniacal copper citrate, *Martesia*, shipworms, pholads

TARAKANADHA, B., RAO, K. S., NARAYANAPPA, P. & MORRELL, J. J. 2006. Prestasi kayu *Bombax ceiba* di laut selepas dirawat dengan bahan pengawet tak organik. Prestasi kayu *Bombax ceiba* yang dirawat dengan bahan pengawet tak organik terpilih dikaji dengan mendedahkannya di laut di selatan India selama 44 bulan. Panel yang dirawat dengan kuprum zink arsenik berammonia (ACZA) pada penahanan tinggi memberi perlindungan terbaik, diikuti oleh kuprum krom arsenik (CCA) yang mempunyai penahanan tinggi. Folad merupakan organisma dominan pada kayu yang dirawat dengan ACZA dan CCA. Teredinid lebih banyak menyerang kayu yang dirawat dengan kuprum sitrat berammonia (CC) atau kuprum kuaterner berammonia (ACQ). Keupayaan bahan pengawet tersebut untuk melindungi spesies ini di dalam air di kawasan tropika dibincangkan.

Introduction

Wood plays a major role in the economies of many developing regions, providing materials for a variety of essential infrastructure components. Nowhere is this more apparent than along the coast of India. For centuries, rural fishermen have journeyed seaward in wooden catamarans. Biodeterioration poses a major threat to the serviceability of these vessels, which often last only six to seven years before they are no longer seaworthy (Rao 1997). The need for timber to replace these vessels stresses the finances of subsistence fishermen and further exacerbates a limited wood supply brought on by decades of deforestation in this region.

The Indian government has responded to the environmental threats posed by deforestation by instituting substantial programmes to develop plantation forests. A variety of species have been explored for this purpose. Among these is *Bombax ceiba*, a fast-growing hardwood native to the region. This species has a variety of potential applications, including use for catamarans, but there is little data on the performance of this species in marine applications in tropical environments (Pendleton 1988, Rhatigan *et al.* 2000, Zahora *et al.* 2000). The results of marine exposures of *B. ceiba* wood treated with selected copper-based biocides were reported here.

Materials and methods

Bombax ceiba blocks (37.5 × 37.5 × 150 mm) were cut from freshly felled trees grown near Bangalore, India. The samples were oven dried to retard microbial attack, then conditioned to constant weight at 23 °C and 70% relative humidity. The samples were weighed, then divided into eight treatment

**Author for correspondence*

groups of 12 specimens each as part of a larger study evaluating the treatability of this species with waterborne preservatives (Narayanappa *et al.* 1999). All specimens were treated using a full cell process including a 30-min vacuum (80 kPa) followed by a 5-hour pressure period (880 KPa). Following treatment assessment, samples treated to each of two retentions with ammoniacal copper zinc arsenate (ACZA) [21.2 or 32.4 kg m^{-3}], chromated copper arsenate (CCA) [18.9 or 32.0 kg m^{-3}], ammoniacal copper quaternary (ACQ) [21.7 or 35.0 kg m^{-3}] or ammoniacal copper citrate (CC) [20.9 or 31.0 kg m^{-3}] were selected for testing (Table 1) [AWPA 2000a].

These samples, along with untreated *B. ceiba* controls, were assembled in rope racks which were immersed in Krishnapatnum, a harbour located at the east coast of India (latitude 13° 2' to 13° 59' N, longitude 80° 10' to 80° 16' E). The harbour has only recently been developed as a port and its clean waters are habitat to a variety of marine borers.

The samples were inspected every two months. Each sample was scraped clean of surface fouling and visually evaluated on a scale from 100 (completely sound) to 0 (destroyed). The number of visible pholads or shipworms was recorded.

Results and discussion

Untreated *B. ceiba* samples were rapidly destroyed by marine borers within three months, illustrating the susceptibility of this wood to marine borer attack and the intensity of borer activity at the harbour. A variety of marine borers were observed such as *Martesia striata, M. nairi, Teredo furcifera, T. fulleri, T. parksi, Lyrodus pedicellatus, L. massa, Bankia companellata* and *Nausitora hedleyi.*

Panels treated to low and high retentions with ACZA experienced attack after 10 and 16 months respectively and panels treated to lower retentions failed after 26 months of exposure (Table 1). A single panel treated to the higher retention remained in test after 44 months but all others failed after 36 months of exposure. These results did not differ markedly from those found with CCA. As with CCA, pholads tended to be the dominant marine borers on both low and high ACZA retention samples. This shows the tolerance of these species towards inorganic arsenical preservatives (Figure 1). Pholad attack increased from 0.6 to 31.5 pholads/panel for the low retention samples between 10 and 24 months, while it increased from 1.2 to 43.0 pholads/sample between 16 and 42 months at the higher retention. Shipworm (teredinid) frequencies reached 11.0/sample on the lower retention and 10.5/sample at the higher retention.

Panels treated with CCA to retentions of 18.9 and 32.0 kg m^{-3} were free of marine borer attack for 6 and 14 months of exposure respectively (Table 1). Panels treated to the low retention all failed within 24 months, while those treated to the higher level survived for 38 months. Pholads were the primary marine borers attacking panels treated to the lower retention (Figure 1). Pholad frequency rose from 2.4/panel after 8 months to 38.0/panel after 33 months. Only 2.7 shipworms were found per panel after 22 months. Pholads also dominated the higher retention samples, increasing in frequency from 1.1 to 31.0/panel between 16 and 40 months. However, shipworms were present at higher levels than in lower retention samples. Elevated shipworm frequency may reflect the longer exposure periods that increased the potential for successful shipworm colonization.

ACQ-treated panels were attacked after six and eight months at the low and high retentions respectively and were destroyed after 16 and 28 months of exposure respectively (Table 1). Pholads and teredinids tended to attack the lower retention ACQ samples at similar rates increasing to 44.3 or 47.8/panel after 18 months respectively (Figure 1). Teredinid attack dominated on panels treated to the higher ACQ retention increasing to 58 teredinids/sample after 26 months, while only 15.5 pholads were found at the same time point. Copper-based biocides are generally presumed to be relatively ineffective against pholads, but the higher copper loadings coupled with the presence of the quaternary ammonia compound appeared to have delayed pholad attack, although the effect was largely negated by teredinid attack.

Table 1 Condition of *Bombax ceiba* panels treated to low and high retentions of ACZA, CCA, ACQ or CC

Preservative	Panel retention ($kg\ m^{-3}$)	Average panel condition by month: 4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44
ACZA	21.2	100	100	100	96(5)	90(0)	80(9)	70(7)	64(11)	52(15)	38(13)	20(13)	–	–	–	–	–					
	32.4	100	100	100	100	100	100	97(5)	97(5)	95(5)	85(10)	78(12)	70(17)	63(19)	58(16)	43(15)	32(15)	24(16)	14(13)	8(0)	0	–
CCA	18.9	100	100	96(7)	90(11)	75(12)	69(15)	60(15)	45(29)	36(17)	28(23)	–	–	–	–	–	–	–	–	–	–	–
	32.0	100	100	100	100	100	100	97(5)	93(8)	89(7)	71(11)	63(16)	54(23)	42(23)	32(20)	28(20)	20(21)	10(10)	–	–	–	–
ACQ	21.7	100	99(4)	84(12)	65(11)	48(9)	21(16)	10(5)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	35.0	100	100	97(5)	90(8)	84(7)	74(13)	61(21)	50(14)	36(18)	33(5)	23(0)	10(0)	5(0)	–	–	–	–	–	–	–	–
CC	20.9	97 (5)	89(9)	67(23)	46(25)	17(19)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	31.0	100	100	94(5)	87(5)	70(14)	66(11)	46(5)	33(7)	22(3)	10(0)	–	–	–	–	–	–	–	–	–	–	–

Values represent means of four to eight samples. Figures in parentheses represent standard deviations. Ratings range from 100 (sound) to 0 (destroyed). CCA = chromated copper arsenate, ACZA = ammoniacal copper zinc arsenate, CC = ammoniacal copper citrate and ACQ = ammoniacal copper quaternary. Untreated control panels were destroyed after two months of exposure.

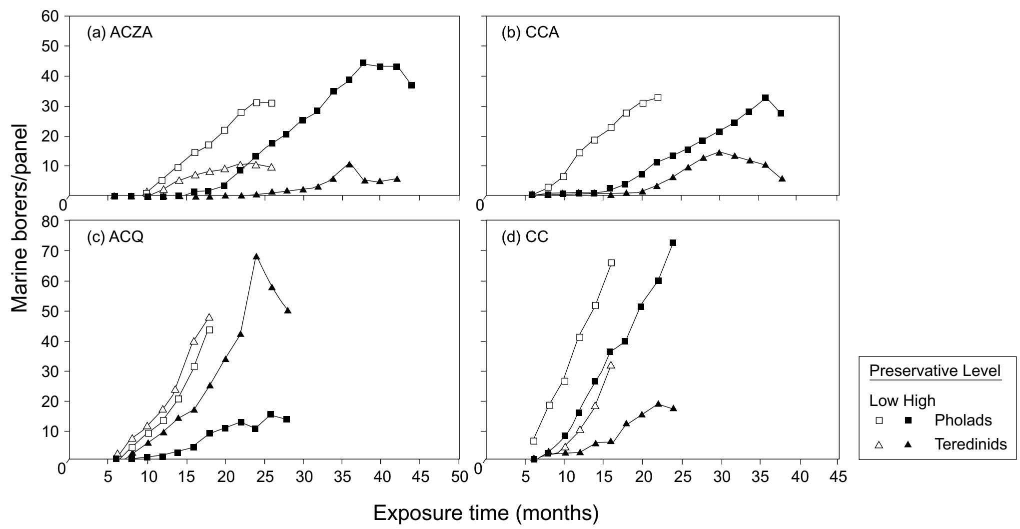

Figure 1 Frequency of pholads and teredinids on *Bombax ceiba* panels treated with (a) ACZA, (b) CCA, (c) ACQ or (d) CC to low or high retentions and exposed for up to 44 months

Samples treated with CC to low and higher retentions experienced marine borer attack within four and eight months of immersion respectively, and failed after 12 and 22 months respectively (Table 1). CC exhibited poorer performance than the other three systems evaluated, although it is important to note that the higher CC retention was only 31 kg m^{-3}, compared with 32–35 kg m^{-3} for the other systems. Pholads tended to be more frequent on samples treated to the lower CC retention, but the differences were not as great as those found with CCA or ACQ. Teredinid attack was less frequent at the higher CC retention, suggesting that the copper was effective against these organisms.

Conclusions

Copper-based biocides provided variable protection to *B. ceiba* in an extreme marine borer exposure. Multi-metal systems substantially out-performed copper systems containing quaternary ammonium compounds or citrate as co-biocides. While these results indicate that inorganic arsenical based preservatives do not provide the prolonged service life found with similar treatments in more temperate marine environments, it is important to note that treatment to 32–35 kg m^{-3}, which was slightly below the 40 kg m^{-3} recommended for marine treatments with these chemicals (AWPA 2000b), increased service life nearly 15-fold over untreated timber.

References

AWPA (American Wood Preservers' Association). 2000a. Standard P5. Waterborne preservatives. Pp. 9–14 in *AWPA Book of Standards.* American Wood Preservers' Association, Granbury.

AWPA (American Wood Preservers' Association). 2000b. Standard C3. Piles-preservative treatment by pressure processes. Pp. 45–58 in *AWPA Book of Standards.* American Wood Preservers' Association, Granbury.

Narayanappa, P., Chang, A. B. & Morrell, J. J. 1999. Treatment of two Indian wood species with waterborne inorganic wood preservatives. *Journal of Tropical Forest Products* 5(2): 149–153.

Pendleton, D. E. 1988. Inspections of experimental piling at Pearl Harbor, Hawaii. Pp. 267–274 in *Proceedings of American Wood Preservers' Association, 84th Annual Meeting.* 8–11 May 1986. Minneapolis.

Rao, K. S. 1997. *The Present Status of Wooden Catamarans Along the Indian Coast.* Document No. IRG/WP/97/10231. International Research Group, Stockholm.

Rhatigan, R. G., Morrell, J. J. & Zahora, A. R. 2000. *Marine Performance of Preservative Treated Southern Pine Panels. Part 1. Exposure in Newport, Oregon.* Document No. IRG/WP/10368. International Research Group, Stockholm.

Zahora, A. R., Preston, A. F., Archer, K. J. & Kleinschmidt, S. 2000. *Marine Performance of Preservative Treated Southern Pine Panels. Part 2. Exposure at Mourilyan Harbour, Queensland, Australia.* Document No IRG/WP/10337. International Research Group, Stockholm.