Preliminary

Influence of Boric Acid Addition on the Biological Resistance of Wood-Inorganic Material Composites by Double Diffusion Treatment*[1]

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Introduction

As previously reported[1)], the addition of boric acid into the treating solutions improved the biological resistance of wood-inorganic material composites (WIC). Without the aid of boric acid, relatively high weight increase was required to well resist the attacks by decay fungi and termites, whereas their attacks were virtually depressed at about 10% weight increase by water-insoluble deposits when boric acid was incorporated in the treating solutions. Boric acid, therefore, seemed to play an important role for the enhancement of biological resistance of WIC, although it must be mostly leached out during the dipping process in non-running water. This paper deals with the fate of boric acid introduced into treated wood, and its possible role in the improvement of resistance against decay fungi and termites.

Materials and Methods

Treatment Wood blocks, measuring 20 (T)$\times$20 (R)$\times$10 (L) (mm), were prepared from sound sapwood of *Cryptomeria japonica* D. Don and served for double diffusion treatment[1)]. Treatment codes are shown in Table 1. Treatments A–D were differentiated with the addition of boric acid : without addition (A), addition into the first (cation) solution (B), addition into the second (anion) solution (C), and addition into both solutions (D). Treatment E was a treatment with boric acid only.

Leaching Following the treatment, the blocks were exposed to non-running water with 10 times volumes of blocks at 26°C.

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Analysis of boric acid The determination of boric acid content in leaching solution and leached blocks was made periodically until no boric acid was detected in leaching solution, by using Ion Chromatographic Analyzer and RI detector. Prior to the analysis, the leached blocks were cut into shavings and subjected to hot water extraction for 3 hours.

Analysis of water-insoluble deposits Water-insoluble deposits formed in each treated wood were qualitatively analysed by X-ray diffractometer.

Biological resistance test Decay and termite tests were basically conducted according to Japan Wood Preserving Association (JWPA) Standard-3 (1992) and JWPA Standard 11(1) (1992), respectively.

Results and Discussion

Weight increase and water-insoluble deposits in wood after double diffusion treatment, and boric acid content in wood after soaking in non-running water were shown in Table 1. In treatment E, no boric acid was remaining in wood after 70 hours, while less than 0.5 kg/m^3 of boric acid was present even after 132 hours in WICs prepared by treatments B, C and D in which boric acid was incorporated into the inorganic salt solution (s). The X-ray

Table 1. Water-insoluble deposits formed after double diffusion treatment for wood-inorganic material composites, and boric acid content in wood blocks after various hours soaking in non-running water.

Code	Chemicals/Conc. (%)		WI[a] (%)	Deposits formed	Content of boric acid (kg/m^3-wood)				
	Solution I	Solution II			Water-soaking time (h) 0	4	20	52	132
A	$BaCl_2 7H_2O$ 7.1	$(NH_4)_2HPO_4$ 31.6	12.9	BHP[b]	—	—	—	—	—
B	$BaCl_2 7H_2O$ 7.1 H_3BO_3 12.4	$(NH_4)_2HPO_4$ 31.6	13.4	BHP INB[c]	21.6	10.0	3.0	0.50	0.28
C	$BaCl_2 7H_2O$ 7.1	$(NH_4)_2HPO_3$ 31.6 H_3BO_3 12.4	11.2	BHP INB	91.8	37.7	8.4	0.78	0.43
D	$BaCl_2 7H_2O$ 7.1 H_3BO_3 12.4	$(NH_4)_2HPO_4$ 31.6 H_3BO_3 12.4	11.2	BHP INB	108.7	39.8	8.2	0.88	0.46
E	H_3BO_3 12.4	H_3BO_3 12.4	—	—	108.5	52.2	9.0	0.07	0

[a] Weight increase, [b] Barium hydrogenphosphate, [c] Inorganic borate.

diffractometric analyses evidenced the formation of some kind of inorganic borate and it still remained in treated block after 132 hours' soaking in water. Therefore, at least some parts of incorporated boric acid formed water-insoluble borate, even if other parts existed in wood as free state forms during the water-soaking.

Table 2. Weight loss of wood-inorganic material composites after 90 days exposure to brown-rot fungus *Tyromyces palustris* and 21 days exposure to subterranean termites *Coptotermes formosanus*.

Code[a]	Weight loss (%)[b] by *T. palustris*			Weight loss (%)[c] by *C. formosanus*		
	Water-soaking time (h)			Water-soaking time (h)		
	0	52	132	0	52	132
A	44.8	—	—	11.0	—	—
B	—	0.9	6.8	—	2.1	5.0
C	—	0	4.0	—	2.1	9.0
D	—	0	3.0	—	2.1	7.0
Control	40.4	—	—	14.1	—	—

[a] See Table 1, [b] Average of nine replicates, [c] Average of five replicates.
Notes: In the treatment with boric acid only, retention (kg/m^3)/ weight loss (%) was as follows: For *T. palustris*; 0.44/8.8, 0.87/0.8, For *C. formosanus*; 0.44/12.5, 0.87/6.3, 1.75/3.2, 4.38/1.0.

Results of decay and termite tests done with the wood blocks after 52 and 132 hours' soaking in water were shown in Table 2. When no boric acid was added (treatment A), treated blocks had a poor resistance against both a brown-rot fungus *Tyromyces palustris* and subterranean termites *Coptotermes formosanus*. In the case of a treatment with boric acid only, virtual depression of decay by *T. palustris* was gained at the retention of 0.87 kg/m^3, but weight loss due to attack by *C. formosanus* was higher than 5% at this retention level. When boric acid was incorporated into any treating solution, WIC well resisted these organisms. However, the biological resistance clearly decreased with the period of water soaking as well demonstrated with the blocks after 132 hours' soaking. This suggests the existence of free boric acid within wood and its gradual leaching from wood.

From the present investigation, improved biological resistance of WIC incorporating boric acid impregnation can be explained on the basis that inorganic borate and free boric acid aid the effect of deposition of water-insoluble barium hydrogenphosphate in suppressing biological attacks.

Reference

1) K. TSUNODA *et al.*: Proc. the International Syposium on Chemical Modification of Lignocellulosics, November, 1992, Rotorua, New Zealand, *FRI Bulletin*, No. **176**, 117–123 (1992).