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AN INVESTIGATION ON COLOUR AND GLOSS CHANGES OF WOOD IMPREGNATED WITH BORATES

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ABSTRACT

This study was designed to determine colour changes and gloss values of wood impregnated with some borates. Ammonium tetrafluoroborate (AFB), sodium tetrafluoroborate (SFB), and ammonium pentaborate octahydrate (APB) were used as borates. Wood specimens were prepared from Oriental beech (*Fagus orientalis* Lipsky) and Scots pine (*Pinus sylvestris* L.). Before test, wood specimens were impregnated with 3 % aqueous solution of borates according to ASTM D 1413-76 (1976). Then, colour changes and gloss values of wood were tested.

Results showed that borate treatments darkened the both wood species. Total colour differences of Scots pine were higher than Oriental beech. Borate treatments remarkably decreased gloss values of Oriental beech and Scots pine.

KEYWORDS: Colour changes, gloss, wood, borate, impregnation.

INTRODUCTION

Among the construction materials which are used by people wood holds a special place because of its impressive range of attractive properties, including low thermal extension, low density and high enough mechanical strength (Bektha and Niemz 2003). It has been popularly and favorably used as a decorative material owing to its aesthetic appearance and characteristics properties (Chang and Chang 2001). But, wood is much more easily degraded by environmental agents, including fire, biological organisms, water, and light, than many man-made materials (Kiguchi and Evans 1998). Therefore, in recent years, there has been a rapid increase in the application of chemicals to wooden materials in order to improve their physical, mechanical, biological, and fire properties (Yalinkilic et al. 1999a, Chao and Lee 2003, Brelid et al. 2000, Wen-Yu 1997). Although, not generally classified as a wood finish, preservatives protect against weathering (in addition to decay), and a large quantity of preservative-treated wood is exposed outdoors without any additional finish (Feist 1987). However, many of the effective poisonous chemicals were also questionable. Increased public concern on the environmental effect of many wood preservatives has rendered a special importance to borates as an environmentally friendly agent. Boron compounds are recognized as inexpensive, easily applicable, flame retardant and more importantly environmentally safe preservatives (Thevenon et al. 1997, Yalinkilic et al. 1996, Arthur and Quill 1992). In addition, borate treatment of wood provides excellent protection for above ground use if treated wood is to be protected from direct exposure to rain or other free water.

Wide ranges of processing options are available for boron treatment. The choice of process depends in the first instance on treatment specification requirements and technical considerations, e.g., the treatability of a particular species by a particular process. Traditionally, boron preservatives have been applied by dipping or spraying concentrated borax/boric acid onto freshly sawn timber. A variety of alternative techniques was developed in the 1960s and 1970s to accelerate treatment either by pressure impregnation, steam and cold quench treatment, or the application of heat to accelerate diffusion (Baysal and Yalinkilic 2005).

While research on the effects of preservative treatment on gloss of wood is rather limited, many researches have focused on colour of preservative impregnated wood. For instance; borate–treated wood looks and handles just like untreated (Forintek Canada Corporation 2002). Lebow et al. (2004) reported that acid copper chromate (ACC) treated wood has a light greenish-brown colour, colour varies from olive to bluish-green for ammoniacal copper zinc arsenate (ACZA) impregnated wood. Also, while copper azole (CA) impregnated wood has a brownish-green colour, copper dimethyldithiocarbamate (CDDC) treated wood has a light brown colour. Another study, Lebow (2000) reported that the colour of the wood treated with copper naphthenate varies from light brown to dark green, depending on the type of oil and treating process. Aydin and Colakoglu (2005) investigated the effects of boric acid, borax, and ammonium acetate treatments on total colour values of rotary cut veneers manufactured from alder (*Alnus glutinosa* subsp. *barbata*) and beech (*Fagus orientalis* Lipsky) logs. They noticed that ammonium acetate caused the highest total colour change while treatment with borax caused the lowest total colour change.

In this study, it was aimed to determine colour changes and gloss values of Oriental beech and Scots pine after borate impregnation.

MATERIAL AND METHODS

Preparation of test specimens and chemicals

Wood specimens, with dimensions 11 x 70 x 150 mm (radial by tangential by longitudinal), were prepared from air-dried sapwood of Oriental beech (*Fagus orientalis* Lipsky) and Scots pine (*Pinus sylvestris* L.). Aqueous solutions of AFB, SFB, and APB were dissolved in distilled water to concentration 3 percent. Wood specimens were oven dried at 103 ± 2°C before and after treatment.

Impregnation method

Wood specimens were impregnated with 3 percent aqueous solution of borates according to ASTM D 1413-76 (1976). Retention of boron was calculated from the following equation:

$$\text{Retention} = \frac{G \times C}{V} \times 10 \quad (kg.m^{-3}) \qquad (1)$$

where: G = amount of solution absorbed by wood that is calculated by T_2 -T_1, T_2 = mass of wood impregnation (g)
T_1= mass of wood before impregnation (g)
C = solution concentration (%)
V = volume of the specimen (cm^3).

Colour test

The colour parameters a*, b*, and L* were determined by the CIELAB method. The L* axis represents the lightness, whereas a* and b* are the chromaticity coordinates. The +a* and -a* parameters represent red and green, respectively. The +b* parameter represents yellow, whereas -b* represents blue. L* can vary from 100 (white) to zero (black) (Zhang 2003). The colours of the specimens were measured by a colourimeter (X-Rite SP Series Spectrophotometer) before and after accelerated weathering. The measuring spot was adjusted to be equal or not more than one-third of the distance from the center of this area to the receptor field stops. The colour difference, (ΔEab) was determined for each wood as follows (ASTM D 1536–58 T 1964):

$$\Delta a^* = a^*_f - a^*_i \qquad (2)$$
$$\Delta b^* = b^*_f - b^*_i \qquad (3)$$
$$\Delta L^* = L^*_f - L^*_i \qquad (4)$$
$$(\Delta E_{ab}) = [(\Delta a^*)^2 + (\Delta b^*)^2 + (\Delta L^*)^2]^{1/2} \qquad (5)$$

where: Δa*, Δb*, and ΔL* are the changes between the initial and final intervals values.

Gloss test

The gloss values of wood specimens were determined according to ASTM D 523 (1970) with a measuring device (Micro-TRI-Gloss). The chosen geometry was an incidence angle of 60°. Results were based on a specular gloss value of 100, which relates to the perfect condition under identical illuminating and viewing conditions of a highly polished, plane, black glass surface.

RESULTS AND DISCUSSION

Some physical properties of impregnation solutions are given in Tab. 1. Colour changes of Oriental beech and Scots pine after borate treatments were shown in Tab. 2 and Tab. 3, respectively. The negative values of Δ*L** for both wood species indicate that borate treatments darkened both woods surface. Positive values of Δ*a** indicate a tendency of wood surface to reddish while negative values mean a tendency to greenish (Temiz et al. 2005).

Tab. 1: Some physical properties of impregnation chemicals.

Chemicals	Concentration (%)	pH		Density ($g.cm^{-3}$)	
		Before impreg.	After impreg.	Before impreg.	After impreg.
SFB	3	2.70	3.07	1.019	1.019
AFB	3	2.93	3.36	1.012	1.016
APB	3	7.98	7.86	1.013	1.013

Tab. 2: Colour of Oriental beech after borate impregnation[a].

Chemicals	Retention (kg.m^{-3})	Before impregnation			After impregnation			Change			
		L*	a*	b*	L*	a*	b*	Δ*L**	Δ*a**	Δ*b**	ΔE_{ab}
SFB	16.54	69.00	8.71	19.89	63.97	8.96	19.80	-5.03	0.25	-0.09	5.18
AFB	7.53	67.51	8.04	19.59	62.27	7.55	20.79	-5.24	-0.49	1.20	5.75
APB	17 .49	67.02	7.69	19.07	60.02	6.99	19.46	-7.00	-0.70	0.39	7.14

[a]Results reflect observations of five wood specimens.

Tab. 3: Colour of Scots pine after borate impregnation[a].

Chemicals	Retention (kg.m^{-3})	Before impregnation			After impregnation			Change			
		L*	a*	b*	L*	a*	b*	Δ*i**	Δ*a**	Δ*b**	ΔE_{ab}
SFB	16.77	77.55	7.23	27.77	66.94	9.59	29.56	-10.61	2.36	1.79	11.16
AFB	12.33	75.60	8.41	30.23	58.61	12.98	32.39	-16.99	4.56	2.17	17.83
APB	18.24	77.02	8.00	28.48	63.33	9.00	31.00	-13.69	1.00	2.53	14.30

[a]Results reflect observations of five wood specimens.

After borate treatment, Scots pine samples had a much higher chromaticity coordinates (a* and b*) than Oriental beech (Fig. 1). The increase of the chromaticity coordinates may be explained by the modification of some chromophoric groups of lignin (Grelier et al. 2000). The increase in the chromaticity coordinates, Δa^* and Δb^* for Scots pine indicated that the yellowing and reddishness due to borate treatments. The total colour changes (ΔE_{ab}) were found 5.18 to 7.14 and 11.16 to 17.83 for Oriental beech and Scots pine, respectively. ΔE_{ab} values of Scots pine were higher than Oriental beech after borate treatments (Fig. 1), because, Scots pine has light colour wood and is susceptible to discolouration induced by borate treatments.

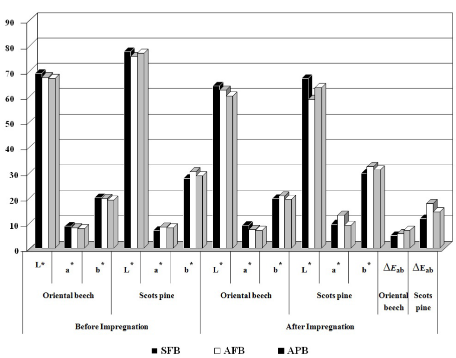

Fig. 1: Colour of Oriental beech and Scots pine after borate impregnation.

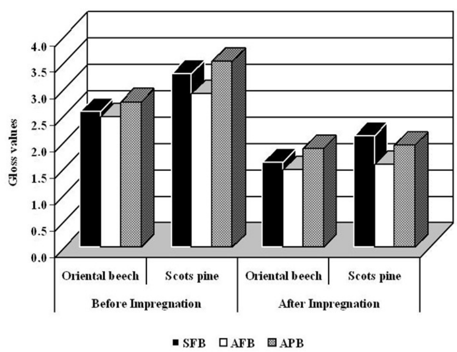

Fig. 2: Gloss values of Oriental beech and Scots pine after borate impregnation.

Gloss values of Oriental beech and Scots pine after borate treatments were given in Tab. 4 and Fig. 2. Borate treatments decreased gloss values of the wood specimens.

Tab. 4: Gloss values of Oriental beech and Scots pine after borate impregnationa.

Chemicals	Oriental beech					Scots pine				
	Before impregnation		After impregnation			Before impregnation		After impregnation		
	Mean	SD	Mean	SD	Change	Mean	SD	Mean	SD	Change
SFB	2.56	0.54	1.60	0.17	-37	3.28	0.48	2.10	0.20	-32
AFB	2.46	0.25	1.46	0.19	-31	2.90	0.42	1.56	0.17	-45
APB	2.74	0.51	1.86	0.32	-28	3.52	0.91	1.92	0.79	-45

[a]Results reflect observations of five wood specimens.

The gloss values remarkably decreased around 28-37 % and 32-45 % for Oriental beech and Scots pine, respectively. It may be due to the dispersion effect of the salt crystals deposited in the large lumens of the wide early wood sections within grains (Yalinkilic et al. 1999b).

CONCLUSIONS

Colour changes and gloss values of borate treated Oriental beech and Scots pine were studied. The results of this study indicated that borate impregnation caused the negative values ΔL^* of Oriental beech and Scots pine. Δa^* and Δb^* of Scots pine impregnated wood were found to be much higher than that of Oriental beech. The increase in the chromaticity coordinates, Δa^* and Δb^* for Scots pine indicated the yellowing and reddishness due to impregnation. Our results showed that the total colour changes (ΔE_{ab}) of Scots pine were higher than Oriental beech. Borate impregnation caused remarkable loss in gloss of Oriental beech and Scots pine.

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