ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 398-403

EFFECT OF BLEACHING CHEMICALS ON SOME VARNISHING PROPERTIES OF SPRUCE WOOD

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Abstract:
This study was performed to determine the effect of bleaching chemicals on surface adhesion strength and surface roughness in Spruce wood. For this purpose, five different bleach chemicals like sodium hydroxide-hydrogen peroxide, oxalic acid, peracetic acid, peracedic acid diluted 1/3, peracedic acid diluted 1/6 and spruce wood (Piceaorientalis L. (Link.)) were used. In this study, effect of heartwood, sapwood ratio and flat, edge grained cross section surface roughness and adhesion strength on spruce wood were determined. All specimens were varnished with cellulosic varnish. Surface roughness of coated samples was also measured using a stylus method. Adhesion strength was determined according to related standards for bleaching and control samples.The results indicated that all bleaching chemicals increased the surface roughness. The highest adhesion strength was determined for the samples treated with perasetic acid bleaching.

Key words: *spruce; bleaching; surface roughness; adhesion strength.*

INTRODUCTION

Each type of wood species has its own variation of color, texture and grain pattern. Some cuts of solid wood and flitches of veneer may be lighter or darker than others. To obtain a uniform color for use in furniture, the choice is generally limited to a color equal to or darker than the natural color of the wood. The only way to avoid this darkening is to bleach the wood or use a bleaching toner on the wood before finishing (Gerard 1983) There are two reasons for the discoloration of wood. The first is damage, drying of branches, disease etc. in alive trees (Shigo 1973). The second is oxidation, iron stains, fungi discoloration and chemical stains occurring on wood cut from trees. This kind of discoloration degrades the quality of wood material (Bauch 1999). Bleaching is moving of color pigments in the structure of wood using various bleaching chemicals and bleaching systems (Ejechi and Obuekwe 1996). While there are many materials available, the most common chemicals used as wood bleaching agents are sodium hydroxide and hydrogenperoxide (Edwin and Carter 1983).

Finishing of wood material is one of the most important processes influencing overall quality of the final product. Physical characteristics, in particular, appearance of the finished product is affected by not only the type of finish but also interaction between finish and the substrate. It is a well known fact that species, wood density and roughness of the substrate are considered major parameters to have an effect on finishing process. Wood being non-homogenous material also creates certain challenges for an ideal finished member. Sapwood and heartwood ratio within its anatomical structure would also be important element affecting interaction between the finishing material and the substrate.In certain species having extractives and other chemicals in the heartwood would create some barrier having good adherence of finish to the surface of wood substrate. Various studies investigated adhesion strength of different wood species coated using different types of finishing materials (Jaic & Zivanovic 1995, Jaic et al. 1996, Zavarin 1984, Ozdemir et al. 2009).

In one of these past works, surface roughness of beech, spruce, fir and alder specimens were measured using a stylus type equipment before they were coated with cellulosic based varnish (Ozdemir & Hiziroglu 2009). Adhesion strength of such samples was determined and it was found that rougher specimens resulted in higher strength values than smoother samples (Ozdemir & Hiziroglu 2009). In another study, moisture content of different wood species was determined as an important factor influencing overall adhesion strength of the finish (Ozdemir et al. 2009). Zavarin found that porosity of wood can be considered as an important factor influencing adhesion strength of finished samples (Zavarin 1984).Another past study evaluated surface characteristics of radial and tangential grain orientations of three different hardwood species and concluded that rougher surfaces required higher amount of finishing material and overall quality of finishing was influenced by the surface roughness of the substrate (Ozdemir & Hiziroglu 2007).Adhesion

strength of oak and beech specimens coated with polyurethan varnishes was studied by Jaicand Zivanovic. It was found that 10.3% moisture content of the samples resulted in the highest adhesion values for both species (Burdurlu et al. 2006). Pull-off test set up is one of the most commonly used one to determine adherence quality between finish and substrate. Adhesion strength of cellulosic varnish coated wood species as function of their surface roughness was evaluated using a pull-off type equipment by Ozdemir and Hiziroglu (Ozdemir et al. 2009).

Adhesion strength of different wood species including beech, alnus, fir, spruce, oak and maple have also been evaluated as function of their surface roughness, moisture content and type of coating materials in several studies (Jaic & Zivanovic 1995, Jaic et al. 1996, WoodHandbook 1999). Currently there is very limited information on adhesion strength of wood species coated with cellulose varnish as function of sapwood and heartwood ratio. Therefore, the objective of this work was to get an initial data on adhesion strength characteristics of such samples from four species, namely beech, alder, fir and spruce coated with cellulose varnish. Results from this work are expected to be used as quality control tool to finish these species with a better efficiency and effectively so that any furniture of cabinet members manufactured from these species can be used more efficiently during their service life.

OBJECTIVE

The main objective of the present research was to evaluate bleaching effect on the varnish properties of spruce wood. Five different bleach chemicals which sodium hydroxide-hydrogen peroxide, oxalic acid, peracetic acid, peracedic acid diluted 1/3, peracedic acid diluted 1/6 and spruce wood (Piceaorientalis L. (Link.)) were used. In this study, the effect of heartwood,sapwood ratio and flat, edge grained cross section surface roughness and adhesion sterngth on spruce wood were determined.

MATERIALS AND METHODS

The wood species, namely spruce (Picea orientalis L. Link) were used for the experiments. A total of 300 defect free heartwood (flat and edge grained) and sapwood samples (flat and edge grained) with dimensions of 400mm by 100mm by 200mm were prepared and conditioned in a climate room having a relative humidity of 65% and a temperature of 20^{o}C until they reach to equilibrium moisture content of 12%. Conditioned specimens were sanded with 80-grit and 180-grit sand paper using a commercial sanding machine (Feed speed: 12m/min, sanding pressure: 0.5MPa). A stylus type equipment, Mitutoyo SJ-301 profil meter was employed to measure surface roughness of the samples. Equipment has stylus with 2.5µm radius and 90° contact angle running at a speed of 0.5mm/s. A total of 40 random measurements with a span of 15mm were taken from the surface of each sample in radial and tangential direction across the grain orientation. Mean peak-to-valley height (Rz) was used as an indicator for the surface quality of the samples (Wick et al. 1998, Vistosyte et al. 2012). In the next step both heartwood and sapwood specimens were coated with cellulosic based varnish using a pressurized spray gun at a spread rate of 120g/m^2 and cured in the convection drying chamber.

Erichsen Adhesion-525 MC pull-off type tester was employed for adhesion strength evaluation of the specimens. Twenty five random measurements were taken from the surface of the samples by gluing steel head with 20mm diameter using epoxy resin on the samples. A constant speed of 100mm/min was applied the force to the surface layer by pulling the coating from the surface and adhesion strength value of the finishing was determined in N/mm^2 on the display of the pull-off testing unit. Five mm small cubes from each species were also cut for microscopic evaluation. Scanning electron microscope was used to determine penetration of the coating on cross section. Finally variance analysis (ANOVA) and Duncan tests were used to analyze the experimental results.

RESULTS AND DISCUSSION

Table 1

Results of percentage of surface roughness

		2	3	4	5	6
Sapwood	**EdgeGrained**	20.286 (3.057)	54.674 (9.681)	31.136 (3.213)	51.777 (5.769)	57.533 (12.310)
	Flatgrained	36.920 (8.632)	69.954 (14.613)	60.834 (7.207)	56.812 (7.787)	56.367 (16.449)
Heartwood	**EdgeGrained**	103.550 (22.759)	78.502 (15.780)	108.620 (26.786)	132.560 (36.999)	51.355 (12.715)
	Flatgrained	109.610 (35.904)	70.825 (11.747)	44.473 (9.050)	66.623 (25.299)	68.832 (17.359)

2-sodium hydroxide-hydrogen peroxide,3-oxalic acid, 4-peracetic acid, 5-peracedic acid diluted 1/3, ,6-peracedic acid diluted 1/6

The results of percenatage of surface roughness are presented in Table 1. Statistical analysis (Table 3) showed that there was a significant effect between five different bleach chemicals [sodium hydroxide-hydrogen peroxide, oxalic acid, peracetic acid, peracedic acid diluted 1/3, peracedic acid diluted 1/6] on the spruce wood. This study effect of heartwood, sapwood ratio and flat, edge grained cross section surface roughness on spruce wood were determined (Fig. 1). As it is expected surface roughness is usually considered as intent physical property of wood and wood based products. According to Table 1, spruce edge grained sapwood which was pretreated with peracedic acid diluted 1/6 had the highest surface roughness value with 57.533. The spruce flat grained sapwood which was pretreated with oxalic acid had the highest surface roughness value with 69.954. The spruce edge grained heartwood which was pretreated with peracedic acid diluted 1/3 had the highest surface roughness value with 132.560. The spruce flat grained heartwood which was pretreated with sodium hydroxide-hydrogen peroxide had the highest surface roughness value with 109.610.

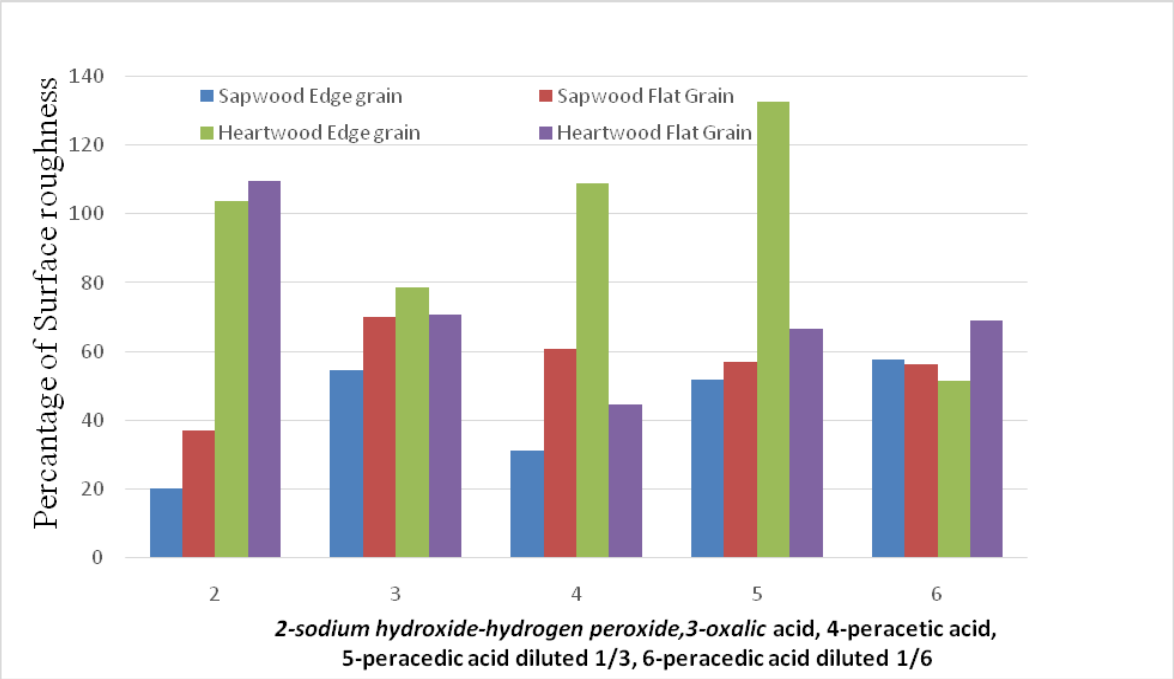

Fig. 1.
Percentage of surface roughness.

As a results in Table 3, there was no significant difference between flatgrained and edgegrained surface rouhghness. On the other hand, there was a significant diference between bleaching chemicals in Table 3. As can be seen Table 4, peracedic acid diluted 1/3 had higher surface roughness than the other bleaching chemicals.

Table 2

Results of adhesion strength (N/mm^2)

SPRUCE				
Sapwood/Heartwood	Edgegrain/flatgrain	NO*	Average	Standard Deviation
Sapwood	EdgeGrain	1	1,49	0,37
		2	1,59	0,08
		3	0,82	0,35
		4	1,84	0,08
		5	1,80	0,11
		6	1,76	0,15
		Toplam	1,55	0,41

	FlatGrain	1	1,56	0,13
		2	1,68	0,17
		3	0,98	0,26
		4	1,80	0,16
		5	1,78	0,19
		6	1,73	0,16
		Toplam	1,59	0,33
Heartwood	EdgeGrain	1	1,55	0,20
		2	1,75	0,14
		3	0,86	0,30
		4	1,75	0,10
		5	1,76	0,19
		6	1,72	0,14
		Toplam	1,57	0,37
	Flatgrain	1	1,63	0,13
		2	1,76	0,14
		3	0,74	0,20
		4	1,80	0,08
		5	1,78	0,15
		6	1,79	0,15
		Toplam	1,58	0,41
*1:Control, 2-sodium hydroxide-hydrogen peroxide,3-oxalic acid, 4-peracetic acid, 5-peracedic acid diluted 1/3, ,6-peracedic acid diluted 1/6				

According to Table 2, all bleaching chemicals increased the adhesion strength. The highest adhesion strength was determined for peracetic acid bleaching. Spruce edge grained sapwood which was pretreated with peracetic acid had the highest adhesion strength with 1.84N/mm^2. According to Table 3, effect of heartwood and softwood and effect of edge grained and flat grained were not significant. but there was a significant difference between bleaching chemicals. While peracetic acid had the highest adhesion strength, oxalic acid had the lowest adhesion strength.

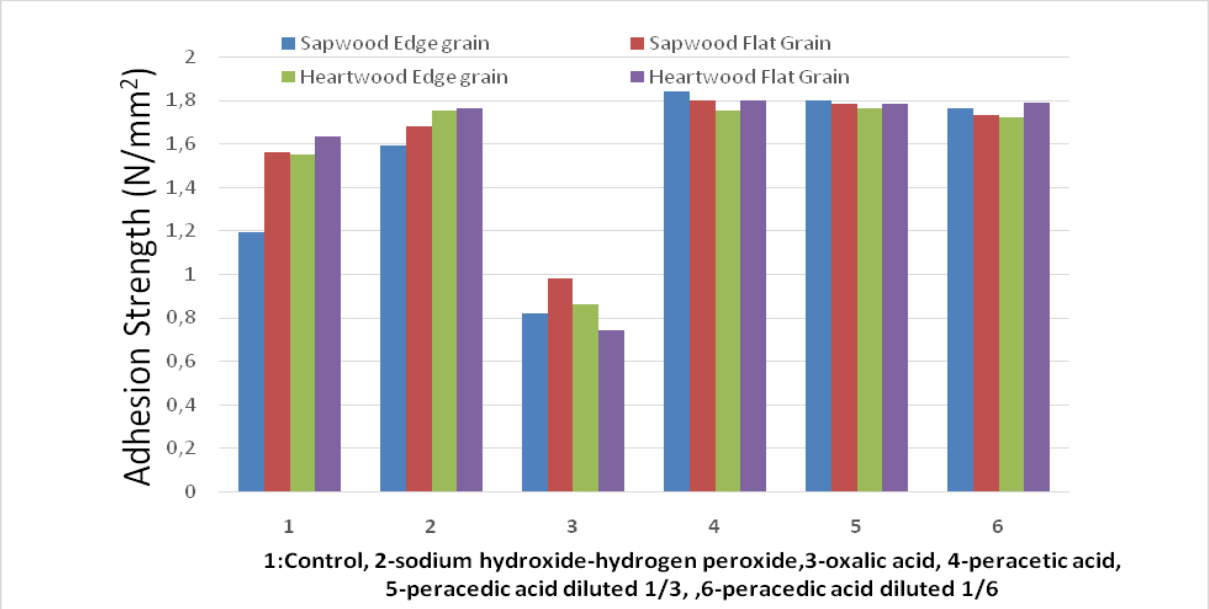

Fig. 2.
Adhesion strength.

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 398-403

Table 3

Statistical analysis of the roughness and adhesion strength -test results

Surface Roughness					
Source	Sum of squares	df	Mean square	F value	Significance level
Effect of heartwood and sapwood (A)	34406,601	1	34406,601	106,938	***
Effect of flat and edge grained(B)	712,556	1	712,556	2,215	NS
Effect of bleaching chemicals(C)	4925,570	4	1231,393	3,827	**
AxB	9687,415	1	9687,415	30,109	***
AxC	20967,353	4	5241,838	16,292	***
BxC	7888,633	4	1972,158	6,130	***
AxBxC	12556,345	4	3139,086	9,756	***
Error	32174,466	100	321,745		
Total	654982,486	120			
Adhesion Strength					
Source	Sum of squares	df	Mean square	F value	Significance level
Effect of heartwood and sapwood (A)	0,002	1	0,002	0,052	NS
Effect of flat and edge grained(B)	0,46	1	0,46	1,265	NS
Effect of bleaching chemicals(C)	26,472	5	5,294	144,037	***
AxB	0,009	1	0,009	0,242	NS
AxC	0,308	5	0,062	1,678	NS
BxC	0,4	5	0,008	0,217	NS
AxBxC	0,252	5	0,5	1,37	NS
Error	7,94	216	0,37		NS
Total	630,923	240			NS

N.S: Non-significant *Significant at the α=0.05 level **Significant at the 0.01 level *** Significant at the α=0.001 level

Table 4

Duncan test results

Strength Properties	**Factors**	**LS Mean**	**Homogenous Groups***
Percentage of Surface Roughness	Bleaching Chemicals		
	sodiumhydroxide-hydrogen peroxide	7.593	ab
	oxalic acid	68.488	ab
	peracetic acid	61.265	a
	peracedic acid diluted 1/3	76.942	b
	peracedic acid diluted 1/6	58.521	a
	Grain		
	Edge grain	68.999	a
	Flat Grain	64.125	a
	Wood		
	Heartwood	83,495	a
	Sapwood	49,626	b
Adhesion Strength	Bleaching Chemicals		
	Control	1,56	b
	sodiumhydroxide-hydrogen peroxide	1,7	c
	oxalic acid	0,85	a
	peracetic acid	1,8	d
	peracedic acid diluted 1/3	1,78	cd
	peracedic acid diluted 1/6	1,75	cd
	Grain		
	Edge grain	1,527	a
	Flat Grain	1,555	a
	Wood		
	Heartwood	1.544	a
	Sapwood	1.538	a

CONCLUSIONS

The effect of bleaching chemicals on the spruce wood quality was evaluated. Bleaching chemicals increased surface activation. Thus, the results indicated that, all bleaching chemicals increased the surface roughness. The highest adhesion strength was determined for peracetic acid bleaching.

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