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GLOSSINESS, COLOR STABILITY, AND SURFACE ROUGHNESS OF WOOD TREATED WITH SOME BLEACHING CHEMICALS

Ayhan Ozcifci, Fatih Yapici, Suat Altun
Karabuk University, Karabük Technical Education Faculty, Karabük, Turkey

Hilmi Toker, Ergun Baysal
Mugla University, Technical Education Faculty, Kötekli, Mugla, Turkey

Ahmet Senel,
Gazi University, Industrial Arts Education Faculty,
Dept. of Industrial Technology Education, Ankara, Turkey

Hakan Şimşek,
Gaziosmanpasa University, Vocational High School of Koyulhisar,
Department of Furniture & Decoration, Koyulhisar,Sivas-Turkey

ABSTRACT

The aim of this study was to determine the effects of different bleaching chemicals and their treatment time on glossiness, color stability, and surface roughness of wood. Spruce (*Picea orientalis* L.) and oak (*Quercus sessiliflora* Salisb.) wood specimens were bleached with aqueous solutions of 25% hydrogen peroxide (H_2O_2), 25% ammonia (NH_3), and their mixture (1:1;volume:volume) for 10, 20, and 30 minutes immersing. Glossiness of wood specimens parallel and perpendicular to grain values were measured with Glossmeter at 60-degree incident angle. Color measurements and surface roughness were wade according to ISO 7724 – 2, and ISO 4287 standards, respectively.

Results showed that the highest glossiness decrease (0.99) was observed in oak wood treated with ammonia solution perpendicular to grain for 20 min. immersing. The highest total color chance (18.88) was observed in oak wood treated with ammonia solution for 30 minutes immersing. All bleaching solutions increased the surface roughness of wood specimens.

KEY WORDS: wood, bleaching, glossiness color stability, surface roughness.

INTRODUCTION

The physical properties like taste, color, smell, texture etc. of wood are different. Color degradation in wood may occur because of oxidation of some chemicals or forming

heartwood or contact of wood including tannin with metals besides wound of living trees, knots, defects etc. (Banks and Miller 1982). Bleaching is the process of removing color pigments in structure of wood by various bleaching chemicals and bleaching systems (Ejechi and Obuekwe 1996). Changing or bleaching colors of painted wood surface may be needed to get desired color for wood surface. Wood stains generally add color to wood surface while bleaching chemicals produce deeply light colors and brightness. Bleaching chemicals generally affect extractive compounds of wood. They do not eliminate colors of wood but by affecting the extractive compounds of wood make them transparent (Wagner and Kiclighter 1986).

Most of the research on bleaching chemicals of treated wood concern NaOH and H_2O_2 treated woods (Ozcifci et al. 1999, Uysal and Kantay 1999, Budakci and Atar 2001, Sonmez and Budakci 2001, Atar 2002, Mononen et al. 2005). Ozcifci and Atar (2002) studied bleaching on elm wood tretaed with 25 % aqueous solution of NaOH + H_2O_2 and $NaSiO_3$ + H_2O_2. After bleaching, wood surface was covered with polyurethane and polyester varnish. The effect of bleaching chemicals on red color tone on the varnished wood surface was measured. It was noted that, polyurethane varnish must not be applied to the bleached surfaces directly. If the transparent filler varnish is used, the polyurethane varnish can be applied on the wood surface as a last layer.

The surface roughness of plywood treated with various fire retardants was investigated (Ayrilmis et al. 2006). Veneer of Akaba wood (*Tetraberlinia bifoliolata*) was treated with 3% and 6% concentration of borax, boric acid, monoammonium phosphate, and diammonium phosphate solutions, then experimental plywood panels were made from these veneer sheets. Three main roughness parameters, mean arithmetic deviation of profile (Ra), mean peak-to-valley height (Rz), and maximum roughness (Rmax) obtained from the surface of plywood were used to evaluate the effect of chemical treatments on the surface characteristics of the specimens. Samples treated with 3% concentration of borax had the smoothest surface, while the roughest surface was found for the samples treated with 6% boric acid. Results revealed that the surface quality of the panels is reduced with increasing chemical concentration.

The effects of drying temperature and borax, boric acid, ammonium acetate treatment on surface roughness and color values of rotary cut veneers manufactured from alder (*Alnus glutinosa subsp.* barbata) and beech (*Fagus orientalis* Lipsky.) logs was investigated by Aydin and Çolakoğlu (2005). They noticed that high temperature drying process caused a darkening on the surface of veneers, and ammonium acetate caused the highest color change while treatment with borax caused the lowest changes in total color change value. Considerable changes in surface roughness after treating with these solutions did not occur on veneer surfaces. In a similar study about surface roughness of wood parquets obtained from some tree species grown in Turkey, average surface roughness values were 5.18 μm, 5.07 μm, 4.73 μm, and 5.19 μm in crown oak, rift oak, crown beech, and rift beech parquets, respectively (Unsal and Kantay 2002).

Although extensive research has been conducted in wood surface roughness, generally focus was on machine and processing parameters. To the best of our knowledge, there isn't any significant study about effect of bleaching chemicals on surface roughness of wood. Change of surface roughness after bleaching process is significant for finishing process.

In this study, it was aimed to determine the effect of different bleaching chemicals and its treatment time on surface roughness and glossiness, and color changes of wood.

MATERIAL AND METHODS

Preparation of wood specimens and bleaching chemicals

In this study, spruce (*Picea orientalis L.* Link.) and oak (*Quercus sessiliflora* Salisb.) woods were used. 25% aqueous solutions of hydrogen peroxide (H_2O_2), 25% (NH_3), and their mixture (1:1; volume:volume) were used as bleaching chemicals. Specimens were immersed aqueous solutions of bleaching chemicals for 10, 20, and 30 minutes. Experiment layout is given in Tab. 1. Test samples were prepared with the dimensions of 100x100x20 mm (longitudinal x tangential x radial) using universal woodworking machines and then sanded with 220 grit sandpaper. After sanding process, samples were conditioned at 20 ± 2°C and at 65 ± 3 % relative humidity for 6 weeks. After bleaching, samples were neutralized with 5% acetic acid solution and dried for 2 hours at 50°C. Dried samples were conditioned for 2 days at 20 ± 2°C and at 65 ± 3 % relative humidity in the acclimatization chamber, and then the surface roughness, color, and glossiness values were measured.

Tab. 1: Experiment layout

Wood species	Concentration (%)	Bleaching chemicals	Treatment time (Minutes)
Spruce	25	Hydrogen peroxide (HP)	10
	25	Ammonia (A)	20
	25	(HP+A)*	30
Oak	25	Hydrogen peroxide (HP)	10
	25	Ammonia (A)	20
	25	(HP+A)	30

* (1:1; volume: volume)

Glossiness

Glossiness parallel and perpendicular to grain values were measured with Glossmeter at 60-degree incident angle. Obtained values were evaluated with analysis of variance and Duncan test using statistical software.

Color changes

The color changes of wood specimens were measured with CIEL*a*b* color system (Fig. 1) using Superchroma color measurement device (Braive Instruments) according to ISO 7724–2 (1984). Total color change (ΔE^*) of wood specimens were calculated using following equations:

$$\Delta L^* = L^*_t - L^*_1 \quad (1)$$

$$\Delta a^* = a^*_t - a^*_i \quad (2)$$

$$\Delta b^* = b^*_t - b^*_i \quad (3)$$

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (4)$$

where the subscripts t and i indicate the values for bleached samples and untreated control samples, respectively.

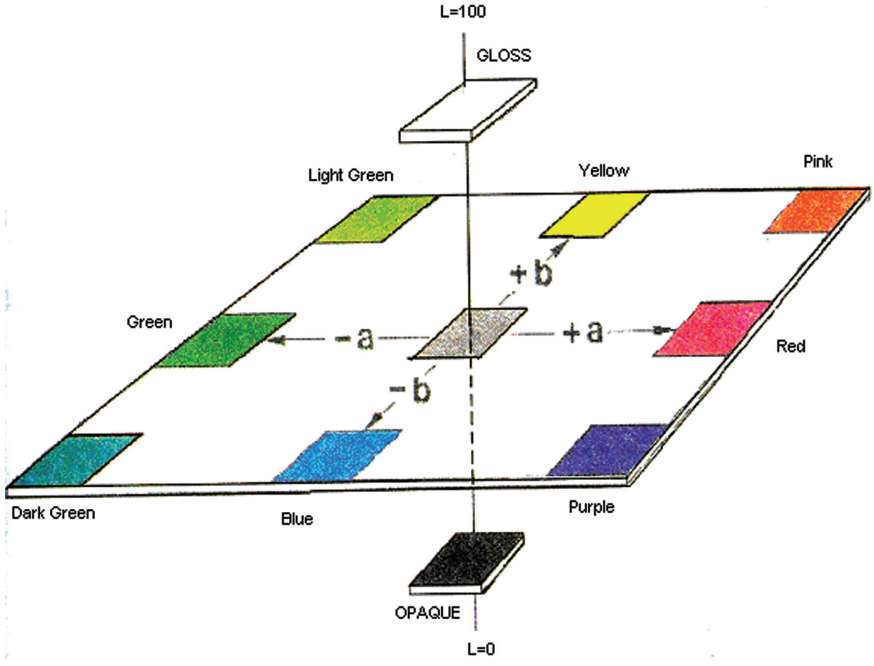

*Fig. 1: CIEL*a*b* color system*

Surface roughness

Surface roughness of wood specimens, a stylus type profilometer named TR200 (Time Group Inc.) were used. Five roughness parameters (arithmetical mean deviation of profile (Ra), maximum height of profile (Rz), maximum depth of profile peak (Rp), maximum depth of profile valley (Rv) and mean spacing of profile elements (Rsm) were measured according to ISO 4287 (1997). Tracing length (Lt) was 12.5 mm, cut-off (λ) was 2.5mm, tracing speed 1 mm.s^{-1}, stylus tip diameter was 2 μm, measured force of the scanning arm on the surfaces was 4mN (0.4g).

RESULTS AND DISCUSSION

Glossiness

All the bleaching solutions showed a decrease on glossiness parallel to grain and perpendicular to grain of wood. Hydrogen peroxide (HP) and a mixture of hydrogen peroxide and ammonium (A) solutions caused an increase on lightness, while ammonium solution caused decrease on lightness. It can be seen in Tab. 3 that the bleaching solutions are effective on glossiness parallel and perpendicular to grain and color values (L^*, a^*, b^*). Tab. 4 indicates that the highest decrease in glossiness parallel to grain was seen in treatment with ammonia solution. Mixtures of HP and A solution caused the lowest decrease in glossiness parallel to grain. The treatment time values showed that immersing time in treatments with A and HP+A solutions did not affect glossiness parallel to grain. A statistical significant difference was only seen between 10 and 20 minutes immersing in HP solution. The highest glossiness was seen in oak wood treated with ammonia solution for 20 minutes in perpendicular to grain, and statistical significant differences were observed between 20 and 10 minutes immersing. A significant difference was seen between 10 and 20 minutes immersing contrary to between 10 and 30 minutes and between 30 and 20 minutes immersing in HP solution in oak wood. No significant difference was observed between immersing times in HP+A solution. All three bleaching solutions increased the glossiness parallel and perpendicular to grain of both oak and spruce wood and statistical significant differences were seen between them. Glossiness in both wood species between the equal immersing time treatments, statistical significant differences were observed between all treatments for 10 and 30 minutes contrary to between the treatments with HP and HP+A solutions for 20 minutes. HP+A and hydrogen peroxide solutions caused the lowest decrease in glossiness on oak wood and spruce wood, respectively. It was obtained that the treatment time of bleaching with ammonia and HP+A solutions did not cause any significant change in the glossiness perpendicular to grain of spruce wood. This can be interpreted that immersing time in bleaching with ammonia and its mixture solutions is ineffective on the glossiness perpendicular to grain. Bleaching with HP solution for 30 minutes caused clearly higher change compared to others in the glossiness perpendicular to grain. The acidic character of HP solution may be effective in this result. It was obtained that the effect of all three bleaching solutions on glossiness parallel and perpendicular to grain is statistically significant and causes decrease. Similar result has been expressed by Budakci and Atar (2001).

Color changes

The highest total color change value *(ΔE^*)* was obtained in treatment with ammonia solution for 20 minutes on oak wood. Ammonia solution caused higher total color change in comparison with the others on spruce wood, too. It was observed that the total color change on oak wood was higher than the total color change on spruce wood. Fig. 2 shows the total color change of wood specimens after bleaching. A general decrease observed on redness after bleaching. Ammonia solution caused a slight color change on redness of spruce, while HP and HP+A solutions caused much more change toward green. Furthermore, when HP+A solution was used, red color of the sample totally disappeared ($a^* = 0.01$). Mixtures of hydrogen peroxide and ammonia solutions caused a slight decrease in redness value of oak wood, while the decrease was more explicit when HP+ A solution was used. No clear changes were obtained in yellowness (b^*) after bleaching. While mixtures of hydrogen peroxide and ammonia solutions caused slight increase on yellowness of oak; it caused slight decrease on yellowness of spruce wood. Hydrogen peroxide solution slightly increased the yellowness of oak. It was seen that

lightness (L*) value decreased clearly in treatment with ammonia solution in both wood species. No significant change was observed between 10 minutes immersing in HP solution and the control group in oak wood. A statistical significant change was observed between control group and treatments with HP solution for 20 and 30 minutes and treatments with HP+A solution in all immersing time. According to Tab. 4, in both wood species, treatment with HP+A solution for 30 minutes caused the highest increase in redness (a*) value. There was not any significant statistical difference between all the treatments with HP and HP+A solutions for 10 and 20 minutes in both wood species. The yellowness (b*) value of spruce wood decreased in treatment with HP+A solution while increased in treatments with the other solutions. Ammonia solution caused the highest increase in b* value. Treatment with HP solution caused an increase in b* value, too. It was seen that solution type was effective on b* values, but treatment time was not. The highest increase in L* (lightness) value of oak wood was obtained in bleaching with the HP+A solution for 30 minutes. It was concluded that the immersing time was an important factor in this. Similar result has been expressed in literature (Sonmez and Budakci 2001). Ammonia solution decreased the L* value of spruce wood while others increased. All the treatment time of HP and HP+A solutions placed in the same group. It was concluded that immersing time was ineffective on the decrease in a* (redness) value in point of the interaction of wood species and solution type. But, the highest a* value was observed in control samples. Similar result has been expressed in literature (Ozcifci et al. 1999). Hydrogen peroxide solution caused the highest increase in b* (yellowness) of oak wood while ammonia solution caused decrease. According to this, it is seen that there are statistical significant differences between treatment groups and untreated control group.

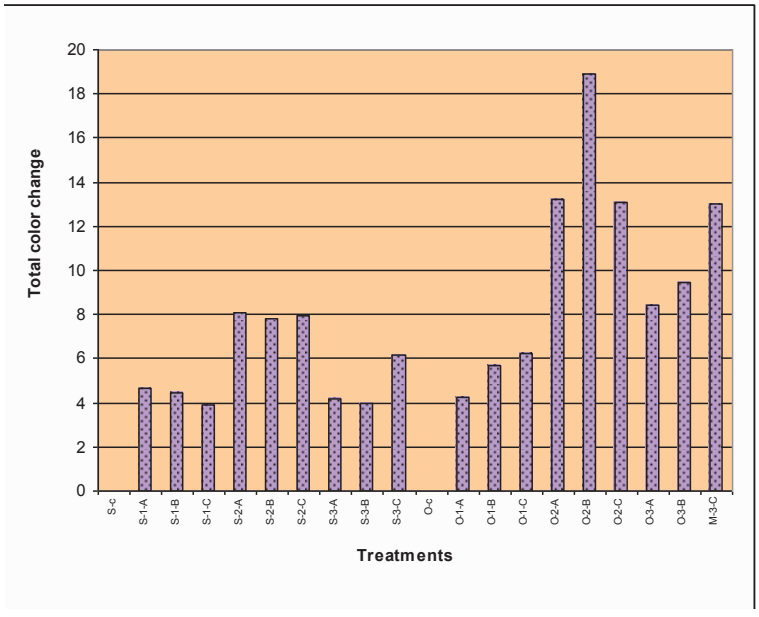

Fig. 2: Total color change (ΔE) of wood specimens after bleaching*

Surface roughness

Mean values of surface roughness, glossiness, and color changes of wood specimens after bleaching are given in Tab. 2.

Tab. 2: Mean values of glossiness, color and surface roughness of wood specimens

Glossiness					Color						Surface Roughness									
Parallel to grain			Perpendicular to grain		L^*		a^*		B^*		Ra		Rz		Rp		Rv		Rsm	
Groups	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
S-c	4,95	0,60	4,16	0,39	82,71	0,34	5,84	0,62	18,22	1,01	3,83	0,23	30,23	5,84	10,20	1,18	20,04	5,28	0,23	0,12
S-1-A	4,02	0,44	2,76	0,20	83,85	1,23	2,12	0,65	20,77	0,73	10,71	2,92	49,17	10,77	26,38	5,94	22,79	5,38	0,19	0,06
S-1-B	3,60	0,23	2,79	0,39	84,71	0,57	2,34	0,74	20,12	1,17	7,82	1,89	36,01	6,35	18,38	3,24	17,63	3,30	0,18	0,11
S-1-C	4,27	0,41	3,16	0,41	84,00	0,85	3,10	0,75	20,70	1,03	5,72	1,57	31,33	9,48	16,07	3,88	15,27	6,03	0,11	0,02
S-2-A	3,21	0,43	2,30	0,12	76,59	1,14	5,19	0,64	23,44	0,84	12,32	3,58	57,17	12,35	28,02	4,88	29,15	8,07	0,28	0,26
S-2-B	2,50	0,29	2,03	0,08	77,15	1,55	5,07	0,88	23,62	0,99	12,54	2,75	59,26	11,01	30,83	7,68	28,43	4,62	0,19	0,05
S-2-C	2,66	0,32	2,15	0,11	76,86	0,90	4,76	0,42	23,45	0,73	17,05	5,56	61,95	13,63	38,49	19,66	23,46	19,89	0,29	0,10
S-3-A	3,53	0,69	2,55	0,33	84,24	0,66	2,22	0,59	16,72	0,92	10,80	2,71	43,18	4,44	22,28	2,04	20,90	3,47	0,23	0,12
S-3-B	3,39	0,35	2,70	0,35	83,77	0,99	2,58	0,67	16,17	1,37	13,25	6,51	63,83	25,96	33,65	12,78	30,18	13,52	0,21	0,07
S-3-C	3,14	0,17	2,56	0,10	84,45	1,05	-0,01	0,58	17,17	0,97	13,36	2,74	50,47	5,82	26,55	3,78	23,92	3,56	0,28	0,07
O-c	2,85	0,36	2,51	0,26	67,72	0,70	7,72	0,74	18,78	1,34	4,63	0,15	42,22	6,07	7,24	0,69	34,98	6,20	0,93	0,45
O-1-A	1,76	0,07	1,47	0,05	67,28	1,20	4,76	0,37	21,77	0,98	7,91	2,48	42,71	10,02	18,40	3,31	24,31	7,63	0,35	0,13
O-1-B	2,10	0,00	1,78	0,04	71,84	1,10	4,71	0,26	21,24	0,31	7,67	1,69	44,84	9,05	24,97	21,87	19,87	18,02	0,32	0,10
O-1-C	1,89	0,20	1,61	0,06	71,71	2,54	4,74	0,49	22,51	0,98	6,30	1,40	38,66	7,24	16,24	3,48	22,43	4,98	0,31	0,10
O-2-A	1,47	0,09	1,21	0,03	54,70	1,45	5,90	0,50	19,88	1,40	7,04	3,03	41,24	14,62	18,05	4,90	23,19	10,75	0,29	0,13
O-2-B	1,20	0,07	0,99	0,06	49,12	1,96	5,65	0,33	16,32	0,83	4,89	1,14	31,01	5,24	13,86	2,57	17,15	4,18	0,22	0,05
O-2-C	1,35	0,21	1,24	0,07	55,17	3,55	4,68	0,61	16,78	1,32	9,78	1,62	50,06	11,26	23,44	6,65	26,63	7,79	0,33	0,08
O-3-A	2,38	0,11	1,99	0,03	74,37	1,87	2,60	0,48	19,84	1,16	7,43	1,79	43,78	11,65	21,49	5,83	22,29	8,95	0,31	0,11
O-3-B	2,32	0,11	1,91	0,07	75,25	1,80	2,04	0,50	19,33	1,11	5,15	1,70	31,78	9,15	16,73	5,64	15,05	4,85	0,23	0,10
O-3-C	2,49	0,16	2,09	0,10	79,01	1,25	1,28	0,25	17,97	1,40	7,19	2,64	40,58	9,66	18,54	3,29	22,04	7,87	0,26	0,08
Total	2,75	1,04	2,20	0,76	74,22	10,59	3,86	1,95	19,74	2,60	8,77	4,40	44,47	14,50	21,49	10,92	22,98	9,84	0,29	0,21

Note c: Control, S: Spruce wood, 1: Hydrogen peroxide, 2:Ammonia, 3: Hydrogen Peroxide + Ammonia, A: 10 minutes immersing time, B: 20 minutes immersing times, C: 30 minutes immersing time

All the bleaching chemicals showed a decreasing effect on surface roughness of wood. The highest increase of Ra value was obtained in treatment with ammonia solution for 30 minutes in both oak and spruce wood. An increase was seen in Rz value in parallel with Ra value. It was observed that; change in peak of profile was large in comparison with change in valley of profile when Rp and Rv values were investigated. No significant change was seen in mean spacing of profile elements (Rsm) value in comparison with untreated control samples. According to the results of ANOVA, there were significant statistical differences ($\alpha = 0.05$) in all parameters. The results of variance analysis are given in Tab. 3. Results showed that the bleaching solutions were effective on surface roughness parameters (Ra, Rz, Rp, Rv, Rsm) of wood. The result of Duncan test performed to determine which groups were different than the others are given in Tab. 4. Mixtures of hydrogen peroxide and ammonia solutions did not cause a significant change in Ra values of wood. Treatments with HP solution for 10 and 20 minutes and with the ammonia solutions for 30 minutes caused significant increase in Ra values compared to the untreated control group. But, there was not significant difference between them. For treatment time, only treatment with the ammonia solution for 30 minutes was statistically different than treatments for 10 and 20 minutes. Treatment time was ineffective on oak wood when HP and HP+A solutions were used. For spruce wood, all solutions except treatment with HP for 30 minutes caused statistical significant increase in Ra (Tab. 5).

Tab. 3: The results of variance analysis (α = 0.05)

		Sum of squares	Df	Mean square	F value	Sig.
Glossiness parallel to grain	Between groups	194,80	19	10,25	100,11	0,000
	Within groups	18,43	180	0,10		
	Total	213,24	199			
Glossiness perpendicular to grain	Between groups	106,28	19	5,59	125,54	0,000
	Within groups	8,02	180	0,04		
	Total	114,30	199			
L^*	Between groups	21882,52	19	1151,71	499,38	0,000
	Within groups	415,13	180	2,31		
	Total	22297,66	199			
a^*	Between groups	699,26	19	36,80	110,70	0,000
	Within groups	59,84	180	0,33		
	Total	759,11	199			
B^*	Between groups	1141,71	19	60,09	53,04	0,000
	Within groups	203,92	180	1,13		
	Total	1345,62	199			
Ra	Between groups	2407,68	19	126,72	15,80	0,000
	Within groups	1443,30	180	8,02		
	Total	3850,98	199			
Rz	Between groups	20082,50	19	1056,97	8,74	0,000
	Within groups	21778,07	180	120,99		
	Total	41860,57	199			
Rp	Between groups	11410,42	19	600,55	8,79	0,000
	Within groups	12301,55	180	68,34		
	Total	23711,96	199			
Rv	Between groups	4890,94	19	257,42	3,22	0,000
	Within groups	14391,54	180	79,95		
	Total	19282,48	199			
Rsm	Between groups	5,02	19	0,26	12,25	0,000
	Within groups	3,89	180	0,02		
	Total	8,91	199			

Tab. 4: Results of Duncan analysis related to the glossiness parallel and perpendicular to grain and color changes (L^*, a^*, b^*)

Glossiness Parallel to grain			Glossiness Perpendicular to grain			L^* (lightness)			a^* (redness)			b^* (yellowness)		
Groups	Mean	HG*	Groups	Mean	HG	Groups	Mean	HG	Groups	Mean	HG	Groups	Mean	HG
O-2-B	1,20	a	O-2-B	0,99	a	O-2-B	49,12	a	S-3-C	-0,01	a	S-3-B	16,17	a
O-2-C	1,35	a	O-2-A	1,21	b	O-2-A	54,70	b	O-3-C	1,28	b	O-2-B	16,32	a
O-2-A	1,47	a	O-2-C	1,24	b	O-2-C	55,17	b	O-3-B	2,04	c	S-3-A	16,72	a
O-1-A	1,76	b	O-1-A	1,47	c	O-1-A	67,28	c	S-1-A	2,12	c	O-2-C	16,78	a
O-1-C	1,89	bc	O-1-C	1,61	cd	O-c	67,72	c	S-3-A	2,22	c	S-3-C	17,17	ab
O-1-B	2,10	cd	O-1-B	1,78	de	O-1-C	71,71	d	S-1-B	2,34	c	O-3-C	17,97	bc
O-3-B	2,32	de	O-3-B	1,91	ef	O-1-B	71,84	d	S-3-B	2,58	cd	S-c	18,22	c
O-3-A	2,38	def	O-3-A	1,99	fg	O-3-A	74,37	e	O-3-A	2,60	cd	O-c	18,78	cd
O-3-C	2,49	ef	S-2-B	2,03	fg	O-3-B	75,25	e	S-1-C	3,10	d	O-3-B	19,33	de
S-2-B	2,50	ef	O-3-C	2,09	fg	S-2-A	76,59	f	O-2-C	4,68	e	O-3-A	19,84	ef
S-2-C	2,66	fg	S-2-C	2,15	gh	S-2-C	76,86	f	O-1-B	4,71	e	O-2-A	19,88	ef
O-c	2,85	g	S-2-A	2,30	h	S-2-B	77,15	f	O-1-C	4,74	e	S-1-B	20,12	ef
S-3-C	3,14	h	O-c	2,51	i	O-3-C	79,01	g	S-2-C	4,76	e	S-1-C	20,70	fg
S-2-A	3,21	h	S-3-A	2,55	i	S-c	82,71	h	O-1-A	4,76	e	S-1-A	20,77	fg
S-3-B	3,39	hi	S-3-C	2,56	i	S-3-B	83,77	hi	S-2-B	5,07	e	O-1-B	21,24	gh
S-3-A	3,53	i	S-3-B	2,70	ij	S-1-A	83,85	hi	S-2-A	5,19	ef	O-1-A	21,77	i
S-1-B	3,60	i	S-1-A	2,76	j	S-1-C	84,00	hi	O-2-B	5,65	fg	O-1-C	22,51	ij
S-1-A	4,02	j	S-1-B	2,79	j	S-3-A	84,24	i	S-c	5,84	g	S-2-A	23,44	jk
S-1-C	4,27	j	S-1-C	3,16	k	S-3-C	84,45	i	O-2-A	5,90	g	S-2-C	23,45	jk
S-c	4,95	k	S-c	4,16	l	S-1-B	84,71	i	O-c	7,72	h	S-2-B	23,62	k

* Homogeneity groups

Tab. 5: Results of Duncan analysis related to the surface roughness parameters

Ra			Rz			Rp			Rv			Rsm		
Groups	Mean	HG*	Groups	Mean	HG	Groups	Mean	HG	Groups	Mean	HG	Groups	Mean	HG
S-c	3,83	a	S-c	30,23	a	O-c	7,24	a	O-3-B	15,05	a	S-1-C	0,11	A
O-c	4,63	ab	O-2-B	31,01	ab	S-c	10,20	ab	S-1-C	15,27	a	S-1-B	0,18	ab
O-2-B	4,89	abc	S-1-C	31,33	ab	O-2-B	13,86	abc	O-2-B	17,15	ab	S-2-B	0,19	abc
O-3-B	5,15	abcd	O-3-B	31,78	abc	S-1-C	16,07	bcd	S-1-B	17,63	ab	S-1-A	0,19	abc
S-1-C	5,72	abcd	S-1-B	36,01	abcd	O-1-C	16,24	bcd	O-1-B	19,87	abc	S-3-B	0,21	abc
O-1-C	6,30	abcd	O-1-C	38,66	abcde	O-3-B	16,73	bcde	S-c	20,04	abc	O-2-B	0,22	abc
O-2-A	7,04	bcde	O-3-C	40,58	abcdef	O-2-A	18,05	bcdef	S-3-A	20,90	abcd	S-3-A	0,23	abc
O-3-C	7,19	bcde	O-2-A	41,24	abcdef	S-1-B	18,38	bcdef	O-3-C	22,04	abcd	O-3-B	0,23	abc
O-3-A	7,43	bcde	O-c	42,22	bcdef	O-1-A	18,40	bcdef	O-3-A	22,29	abcd	S-c	0,23	abc
O-1-B	7,67	cde	O-1-A	42,71	cdef	O-3-C	18,54	bcdef	O-1-C	22,43	abcd	O-3-C	0,26	abc
S-1-B	7,82	de	S-3-A	43,18	def	O-3-A	21,49	cdefg	S-1-A	22,79	abcd	S-2-A	0,28	bc
O-1-A	7,91	de	O-3-A	43,78	def	S-3-A	22,28	cdefg	O-2-A	23,19	abcd	S-3-C	0,28	bc
O-2-C	9,78	ef	O-1-B	44,84	def	O-2-C	23,44	defgh	S-2-C	23,46	abcd	S-2-C	0,29	bc
S-1-A	10,71	fg	S-1-A	49,17	efg	O-1-B	24,97	efgh	S-3-C	23,92	abcd	O-2-A	0,29	bc
S-3-A	10,80	fg	O-2-C	50,06	efg	S-1-A	26,38	fghi	O-1-A	24,31	abcd	O-1-C	0,31	bc
S-2-A	12,32	fg	S-3-C	50,47	fg	S-3-C	26,55	fghi	O-2-C	26,63	bcde	O-3-A	0,31	bc
S-2-B	12,54	fg	S-2-A	57,17	gh	S-2-A	28,02	ghi	S-2-B	28,43	cde	O-1-B	0,32	bc
S-3-B	13,25	g	S-2-B	59,26	gh	S-2-B	30,83	hij	S-2-A	29,15	cde	O-2-C	0,33	bc
S-3-C	13,36	g	S-2-C	61,95	h	S-3-B	33,65	ij	S-3-B	30,18	de	O-1-A	0,35	C
S-2-C	17,05	h	S-3-B	63,83	h	S-2-C	38,49	J	O-c	34,98	e	O-c	0,93	C

* Homogeneity groups

There was a significant difference between treatments with HP solution for 10 minutes and treatments for 20 and 30 minutes and between treatments with ammonia solution for 30 minutes and 10 and 20 minutes, contrary to insignificant effect was seen between treatments in other solutions and times. For oak wood, all the solutions and treatment time groups placed in the same homogeneity group with the untreated control. Although there are differences between treatments, owing to the lack of statistical significant difference, it can be told that bleaching solutions are not effective on Rz value of oak wood (Tab. 5). Rz values measured in treatments with HP solution for 10 and 20 minutes placed in the same homogeneity group with the untreated control of spruce wood. There was not a significant difference among all three immersing times in ammonia solution. The highest increase in Rz value of spruce wood was obtained in treatment with HP+A solution for 20 minutes and all three immersing time groups of ammonia solutions, which is placed in the same group with it. All the treatments except the treatment with ammonia solution for 20 minutes, placed in different homogeneity group with the untreated control when the Rp values of oak wood were analyzed. For oak wood, treatment with ammonia solution for 30 minutes and treatment with HP solution for 20 minutes, which the highest increase in Rp value was seen, placed in the same homogeneity group and all the other treatments placed in another homogeneity group. For spruce wood, treatments with HP solution for 10 and 20 minutes placed in the same group with the control group; the others placed in different groups. There was not a significant difference between treatments with HP solution for 30 and 20 minutes and treatment with HP+A solution for 10 minutes. Also, there was not a statistical significant difference neither between treatments with HP solution for 10 and 20 minutes and treatment with HP+A solutions for 10 and 30 minutes nor between treatment with HP+A and 10 minutes immersing in the all the three solutions. For Rp values of spruce wood, only treatment with HP+A solution for 20 minutes placed in a different group from control group. Although, there were differences among other treatment groups, owing to the fact that they were not different from control group, they can be ignored. For Rp values of oak wood, all the treatments except treatment with the ammonia solution for 30 minutes, placed in the same homogeneity group, which is different from control group. For Rsm values of oak wood, all the treatments placed in the same homogeneity group, which is different from control group, and showed a decreasing effect. The highest decrease in Rsm value of oak wood was seen in treatment with ammonia solution for 20 minutes. The highest decrease in Rsm value of spruce wood was seen in treatment with HP solution for 30 minutes and spruce wood placed in different homogeneity group with treatments with ammonia solution for 10 and 30 minutes and treatment with HP+A solution for 30 minutes increased the Rsm value. All the other treatments placed in the same homogeneity group in Rsm value of spruce wood.

CONCLUSION

In this study, effects of different bleaching chemicals and their treatment time on glossiness, color stability, and surface roughness were investigated. The lowest color stability of wood specimens was obtained treated with ammonia solution. Results showed that all three bleaching solutions increased the surface roughness of wood specimens. The highest increase in Ra value was observed in treatment with ammonia solution for 30 minutes in both wood species. But, there were not statistically significant difference between treatment times. Therefore, bleaching chemicals were effective on surface roughness independent of the immersing time.

In conclusion, it can be suggested that bleaching with ammonia for 20 minutes is worthwhile when oak wood will be used in applications, which is needed aesthetic and bright surface. Color

change occurs on spruce wood when exposed to outdoor conditions. Therefore, desired results can be achieved if the wood species that have a color change tendency towards yellowness and redness are chosen based on the application environment. In this way, more aesthetic view can be provided to furniture components.

REFERENCES

1. Atar, M., 2002: Effects of bleaching and impregnation processes on the hardness of varnish layer on chestnut (*Castanea sativa* Mill.) wood. G.U. Journal of Sci 15(2): 373-384
2. Aydin, I., Colakoglu, G., 2005: Effects of surface inactivation, high temperature drying and preservative treatment on surface roughness and color of alder and beech wood. Appl Surface Sci 252: 430-440
3. Ayrilmis, N., Korkut, S., Tanritanir, E., Winandy, J.E., Hiziroglu, S., 2006: Effect of various fire retardants on surface roughness of plywood. Building and Environment 41(7): 887-892.
4. Banks, W.B., Miller, E.R., 1982: Chemical aspects of wood. Technology Sweden Forest Products J 34: 45-67
5. Budakci, M., Atar, M., 2001: Effects of bleaching process on hardness and glossiness of pine wood (*Pinus sylvestris* L.) exposed to outdoor conditions. Turkish J Agric For. 25(4): 201-207
6. Ejechi, B.O., Obuekwe, C.O., 1996: Micromechanical studies of wood degradation by brown rot and white rot fungi in two tropical timbers. International Biodeterioration Biodegradation 38(2): 119-122 Nigeria
7. ISO 4287., 1997: Geometrical product specifications (GPS) – surface texture: profile method – terms, definitions and surface texture parameters. Geneva, Switzerland: International Organization for Standardization
8. ISO 7724-2., 1984: Paints and varnishes, Colorimetry—Part 2: Color Measurement, ISO standard
9. Mononen, K., Alvila, L., Pakkanen, T.T., 2005: Changes in color and structure of birch wood (*Betula pendula* Roth) caused by bleaching with hydrogen peroxide solution. Holzforschung, Vol. 59: 59–64
10. Ozcifci, A., Atar, M., Uysal, B., 1999: The effects of wood bleaching chemicals on the surface gloss and the adhesion strength of varnishes. Turkish J. Agriculture For., 23: (Supp.3): 763-770
11. Ozcifci, A., Atar, M., 2002: The effects of some chemical materials on colour of tone for elm wood (*Ulmus Campestris* Spach). Technology, 5(1-2): 21-28
12. Sonmez, A., Budakci, M., 2001: Using of bleaching chemicals for patina staining, G.U. Journal of science 14 (4): 1131-1146
13. Uysal, O., Kantay, R., 2002: Researches on surface roughness of parquets produced from quercus and beech wood. I.U. J Forest Faculty, Line A, 52(1): 81-97
14. Wagner, H.W., Kiclighter, E.C., 1986: Modern woodworking. Finisher and finishing. Bleaching and disassembly. Pp. 169-170, USA

Ayhan Ozcifci
Karabuk University
Karabük Technical Education Faculty
78050 Karabük
Turkey
E-mail: aozciftci@hotmail.com

Fatih Yapici
Karabuk University
Karabük Technical Education Faculty
78050 Karabük
Turkey

Suat Altun
Karabuk University
Karabük Technical Education Faculty
78050 Karabük
Turkey

Hilmi Toker
Mugla University
Technical Education Faculty
Kötekli 48000
Mugla
Turkey

Ergun Baysal
Mugla University
Technical Education Faculty
Kötekli 48000
Mugla
Turkey

Ahmet Senel
Gazi University
Industrial Arts Education Faculty
Dept. of Industrial Technology Education
06500 Ankara
Turkey

Hakan Şimşek
Gaziosmanpasa University
Vocational High School of Koyulhisar
Department of Furniture&Decoration
Koyulhisar
Sivas
Turkey