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Abstract: The aim of this research was to determine the effects of bleaching chemicals on the bending strength of wood. For this purpose, sodium hydroxide + hydrogen peroxide, sodium hydroxide + calcium hydroxide + hydrogen peroxide, hypochlorite and hydrochloric acid were applied to pine (Pinus sylvestris L.), oriental beech (Fagus orientalis Lipsky), ash (Fraxinus excelsior L.) and oak (Quercus petraea spp.) for bleaching. The results indicate that the hypochlorite and hydrochloric acid solutions caused the greatest decrease in the bending strength of the woods used in the experiment.

Renk Açıcı Kimyasal Maddelerin Ahşap Malzemenin Eğilme Direnci Üzerine Etkileri

Özet: Bu çalışmada sodyum hidroksit + hidrojen peroksit, sodyum hidroksit + kalsiyum hidroksit + hidrojen peroksit, hipoklorit ve hidroklorik asit ile rengi açılmış sarıçam (Pinus sylvestris L.), Doğu kayını (Fagus orientalis lipsky), dişbudak (Fraxinus exclsior L.) ve sapsız meşe (Quercus petraea spp.) odununun statik eğilme direncinde meydana gelen değişmeler incelenmiştir. Deneyler sonucunda; en fazla eğilme direncindeki azalmaya asidik karakterdeki hipoklorit ve hidroklorik asit çözeltileri neden olmuştur.

Introduction

Each type of wood 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 (1).

There are two reasons for the discoloration of wood. The first is damage, drying of branches, disease etc. in live trees (2). 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 (3).

In wooden furniture, color is as important as size and form. The color of wooden furniture should be suitable for the type of carpet, curtains, textiles, wall coverings, ceiling and floor used in interior decoration. The color of natural wood cannot usually satisfy this kind of need, and, for this reason, wooden furniture may be bleached or painted (4).

Bleaching is the removing of color pigments in the structure of wood using various bleaching chemicals and bleaching systems (5).

While there are many materials available, the two most common chemicals used as wood bleaching agents are sodium hydroxide and hydrogen peroxide. The aims of bleaching on the wood surface before finishing are as follows (6):

– to obtain a more uniform color or remove dark streaks within a panel or other assembled parts,

– to obtain lighter colors and retain all grain character,

– to control color and improve stability,

– to upgrade materials or make more “off” colored wood useable and upgrade the final product,

– to use several closely related species, such as oak or ash, or multiple species of wood if needed,

– to make it easier to control color from one batch or cutting of furniture to another batch and also to make it possible to have multiplant production of the same pieces and maintain an acceptable color range,

– to obtain better color stability and decrease the probability of fading or color change due to the chemical nature of some woods,

– to help bleached woods such as oak and walnut to perform better in light exposure, especially when chemical filtering agents (ultraviolet light exposure absorbents) are combined in the finishing system,

– to obtain controlled surface characteristics and properties. This determines good quality and long lasting finishes.

In addition, specialty bleaches are available for many uses, including the removal of iron stains, mineral streaks, fungus discoloration and chemical stains. In summary, furniture is bleached to bring out character and obtain lighter, brighter and clearer finishes.

After bleaching, deposits of bleaching chemicals may remain on the surface of the wood. If the deposits are not neutralized, they can affect the subsequent finish coats. For this reason, after bleaching, the surface of the wood is neutralized and sanded to remove raised grain (7). This sanding also removes deposits of bleaching chemicals from the surface of the wood, but the bleached surface should be sanded lightly. Otherwise, unbleached parts may appear.

Acidic chemicals bleach and whiten the color of the wood (8). However, acid in wood decreases its strength. The strength of wood materials decreases parallel to increases in heat (9).

Water soluble salts, especially fire retardant chemicals, increase the humidity of wood, and may cause a decrease in the strength of wood (10).

It has been determined that 18% HCl solution decreases the adhesion strength of varnishes (11). In another study, it was determined that in varnishing, after bleaching the wood species, bleaching chemicals in different concentrations and different types of varnish affected the layer hardness of varnish (12).

Experimental Procedure

Materials

Scotch pine (Pinus sylvestris l), oriental beech (Fagus orientalis Lipsky.), ash (Fraxinus exclsior L.) and oak (Quercus petraea spp.) were the wood materials used. The wood samples were chosen randomly from a timber merchant in Ankara.

The bleaching chemicals used were: sodium hydroxide (NaOH), hydrogen peroxide (H_2O_2), calcium hydroxide ($Ca(OH)_2$), hypochlorite acid (HClO) and hydrochloric acid (HCl). Acetic acid (CH_3COOH) was used for neutralization.

Preparing of Test Samples

The timber was kiln–dried at 20°C±2°C and 65%±3% relative humidity for approximately three months. Samples were cut (20 x 20 x 300 mm) from the climatized timbers and dried to 12% humidity. Five samples were cut from each type of wood for each of the four chemical solutions: 5 x 4 = 20 pieces from the scotch pine, 5 x 4 = 20 pieces from the oriental beech, 5 x 4 = 20 pieces from the oak, 5 x 4 = 20 pieces from the ash and 5 x 4 = 20 pieces from the control samples. Thus, a total of 100 pieces were cut. After the sanding process, the test samples were prepared for bleaching.

Preparation, Application and Drying of Solutions

The solutions used for bleaching were prepared as follows:

Solution I: 50% NaOH (125 g. NaOH was dissolved in 250 ml pure water), 17.5% H_2O_2 (43.7 g. H202 was dissolved in 250 ml pure water).

Solution II: 50% NaOH (125 g. NaOH was dissolved in 250 ml pure water), 50% $Ca(OH)_2$ (125 g. $Ca(OH)_2$ was dissolved in 250 ml pure water), 17.5% H_2O_2 (43.7 g. NaOH was dissolved in 250 ml pure water).

Solution III: 25% HClO (62.5 g. NaOH was dissolved in 250 ml pure water).

Solution IV: 36.5% HCl (126.1 g. HCl was dissolved in 250 ml pure water).

The solutions were applied to the samples with a sponge. They were applied, first, parallel to the grain, then against the grain, and, finally, parallel to the grain again. After a waiting period for chemical absorption by the wood samples, more solution was applied. The samples were left for a day in room conditions to improve the effets of bleaching. Then the samples with solutions I and II were neutralized with 15% CH_3COOH solution and all the samples were washed with pure water. After neutralization, all the samples were dried at 20°C±2 °C and 65%±3% relative humidity to 12% humidity.

Static Bending Strength Test

The tests were carried out according to TS 2474 using a “Seidner” test machine, with the capacity to exert a force of 3000 kg. The speed of the test machine was adjusted to 6mm/min. for breakage to occur in 1–2 minutes.

The following formula was used for calculating the bending strength:

$$\sigma E = \frac{3F\ maxL}{2b.h^2}\ kp/cm^2$$

σE = Bending strength (Kp/cm^2)

F = Maximum force (Kp)

L = Space between the two supports (24 cm)

b = Width of sample (cm)

h = Thickness of sample (cm)

Statistical Analysis

The data obtained from the experiments were analyzed using a statistical package. When the effects of factorial variance analyses were found to be significant at $P<0.01$ and 0.05, the value of LSD was used for comparison (Table 1).

Results

The Effects of Bleaching Chemicals on the Bending Strength of Wood

Table 2 and Figure 1 show that in the oriental beech, compared with the natural material the bleached material lost 6.6% bending strength with $NaOH+H_2O_2$ solution 13.9% with $NaOH+Ca(OH)_2+H_2O_2$ solution, 10.8% with HClO solution, and 30% with HCl solution.

In the ash, compared with the natural material the belached material lost 1.4% bending strength with $NaOH+H_2O_2$ solution, 1.01% with $NaOH+Ca(OH)_2+H_2O_2$ solution, 12.7% with HClO solution, and 7.2% with HCl solution.

In the oak, compared with the natural material the bleached material lost 11.9% bending strength with $NaOH+H_2O_2$ solution, 12% with $NaOH+Ca(OH)_2+H_2O_2$ solution, and 7.9% with HCl solution. The bleached material with HClO solution showed no loss.

Table 1. Results of Variance Analysis according to Wood Material and Chemicals.

Source	Degrees of freedom	Sum of squares	Mean square	F value	Prob.
Material	3	38386.722	12788.907	419.434	0.0000
Chemical	4	6424.979	1606.245	52.679	0.0000
Material+chemical	12	5117.558	476.463	15.626	0.0000
Error	80	2439.269	30.491	–	–
Total	99	52948.528	–	–	–

Table 2. The Effects of Bleaching Chemicals on the Bending Strength of Wood (N/mm^2).

Chemicals	Wood Kind							
	Oriental beech	LSD	Ash	LSD	Oak	LSD	Scotch pine	LSD
Natural	157.23	A	131.22	E	126.63	F	95.44	J
NaOH+ H2O2	146.88	B	129.42	EF	111.59	I	94.77	J
NaOH+ Ca(OH)+ H2O2	135.46	D	129.96	E	111.51	I	85.50	L
HClO	140.32	C	114.66	H	126.63	F	89.82	K
HCl	111.33	I	123.20	G	117.90	H	60.51	M

LSD value: 0.1631.

In the scotch pine, compared with the natural material the bleached material lost 1.13% bending strength with $NaOH+H_2O_2$ solution, 10.9% with $NaOH+Ca(OH)_2+H_2O_2$ solution, 6.4% with HClO solution, and 37% with HCl solution.

After the bending strength test, the oven dry specific gravity and humidity of the test and control samples were determined. The values are given Table 3.

Table 3 shows that compared with the natural material there was no important change in the specific gravity of the materials which were bleached.

Conclusion

According to the data obtained from the test, the following results can be stated.

1. The greatest decrease in bending strength in the oriental beech occurred with HCl solutions.

2. The greatest decrease in bending strength in the ash occurred with HClO solution.

3. The greatest decrease in bending strength in the oak occurred with $NaOH+H_2O_2$, $NaOH+Ca(OH)_2+H_2O_2$ and HCl solutions.

4. The greatest decrease in bending strength in the scotch pine occurred with HCl solution.

5. Compared with the natural material, there was no important change in the specific gravity of the woods which were bleached.

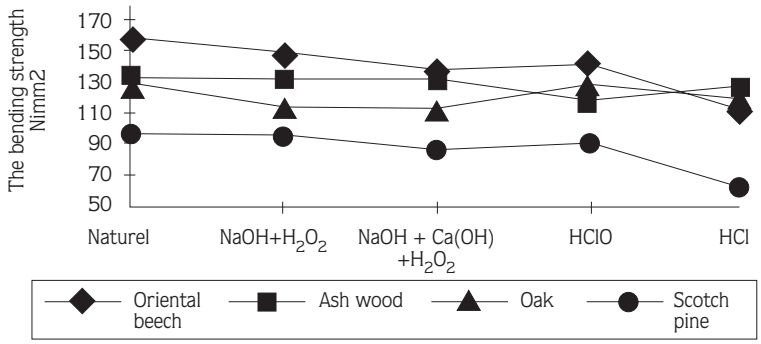

Figure 1. The Effects of Bleaching Chemicals on the Bending Strength of Wood (N/mm^2).

Table 3. Oven Dry Specific Gravity and Humidity of the Test Samples.

Wood type	Chemicals	Specific gravity (gr/cm^3)	% Humidity
	Natural	0.65	12
	$NaOH+H_2O_2$	0.65	12
Oriental beech	$NaOH+Ca(OH)_2+H_2O_2$	0.66	12
	HClO	0.65	12
	HCl	0.64	12
	Natural	0.66	12
	$NaOH+H_2O_2$	0.65	12
Ash	$NaOH+Ca(OH)_2+H_2O_2$	0.66	12
	HClO	0.65	12
	HCl	0.62	12
	Natural	0.63	12
	$NaOH+H_2O_2$	0.60	12
Oak	$NaOH+Ca(OH)_2+H_2O_2$	0.59	12
	HClO	0.63	12
	HCl	0.61	12
	Natural	0.50	12
	$NaOH+H_2O_2$	0.49	12
Scotch pine	$NaOH+Ca(OH)_2+H_2O_2$	0.51	12
	HClO	0.53	12
	HCl	0.53	12

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