Technology, 12(4), 267-274, (2009)

TECHNOLOGY

IMPACT OF VARIOUS FIRE RETARDANTS ON THE RED COLOR AND YELLOW COLOR TONE OF SOME WOODS AND VARNISHES

Ayhan ÖZÇİFÇİ*, Burhanettin UYSAL*, Şeref KURT*, Günay ÖZBAY*
*Karabuk University, Technical Education Faculty, 78050, Karabuk, Turkey

Abstract

In this study, Scotch pine (*Pinus sylvestris* L.), and oriental beech (*Fagus orientalis* Lipsky.) wood impregnated according to ASTM-D 1413–76 standard varnished with polyurethane, cellulosic and synthetic varnishes according to ASTM D 3023 standard. The RCT (Red Color Tone) and YCT (Yellow Color Tone) of test specimens after the varnishing process was determined according to ASTM D 2244–02. The highest RCT value (20.692) was determined in oriental beech samples, cut tangentially, unprocessed impregnated and synthetic varnished. The lowest RCT value (4.874) was determined in scoth pine samples, cut tangentially, impregnated with borax and synthetic varnished. The highest YCT value (48.622) was determined in scoth pine samples, cut radially, unprocessed impregnated and synthetic varnished. The lowest YCT value (17.151) was determined in oriental beech samples, cut tangentially, impregnated with zinc chloride and unprocessed varnished. In consequence, varnishing prosess increased the RCT and YCT in Scoth pine and Oriental beech, but impregnation material decreased the RCT and YCT in Scoth pine and Oriental beech.

Key Words: Wood materials, Red color tone, Yellow color tone, Varnishes

1. Introduction

The versatility of wood is demonstrated by a wide variety of products. This variety is a result of a spectrum of desirable physical characteristics or properties among the many species of wood. In many cases, more than one property of wood is important to the end product. For example, to select a wood species for a product, the value of appearance-type properties, such as texture, grain pattern, or color, may be evaluated against the influence of characteristics such as machinability, dimensional stability, or decay resistance[1].

Waterborne inorganic salts are a special group of penetrating finishes. These surface treatments result in a finish similar to the semitransparent penetrating finishes because they change the color of the wood and leave a surface deposit of material similar to the pigment found in the semitransparent stains [2]. Impregnation of wood with chemical products is absolutely necessary to protect against insects, fungus, etc. in many applications. Painting and varnishing preserves unimpregnated wood surfaces for only 2 years [3].

Bleaching, impregnation, steaming, varnishing, and similar processes also cause color to change. There is no change in living trees, but when the tree is cut, the color of wood darkens or lightens. Processing the surface of wood avoids, partially or completely, this change or degradation and also makes the natural color and pattern of wood much more apparent, maintaining this look for an extended period of time [4].

Surface quality and texture play an important role in finish performance, and the variables that influence the surface characteristics of the wood are numerous. Rough sawn, sanded, saw-textured, and smooth-planed surfaces all influence finishes differently.

Corresponded Author; gozbay@karabuk.edu.tr

Wood is a kind of material which can become old with the effect of the outside unless its surface is covered. Therefore, in many places where it is used, its being impregnated with chemical substances seems to be necessary to prevent the worning out of the wood surface. In order to prevent biological detrimentals from damaging the wood, its being impregnated with boron compounds is thought to lengthen its life-span.

The aim of this experimental study was to determine the effect of impregnation materials on the red color tone and yellow color tone of Scoth pine and Oriental beech, which are widely used in the furniture industry, treated with 3 different varnishes.

2. Material and Method

2.1 Wood Species

Scotch pine (*Pinus sylvestris* L.), and oriental beech (*Fagus orientalis* Lipsky.) were chosen randomly from timber supplier of Istanbul, Turkey. A special emphasis was put on the selection of the wood material. Accordingly, non-deficient, whole, knotless, normally grown (without zone line, reaction wood, decay, insect or fungal infection) wood materials are selected.

2.2 Impregnation Chemicals

As impregnation chemicals; Borax ($Na_2B_4O_7.5H_2O$), boric acid (H_3BO_3), Zinc chloride ($ZnCL_2$) and di-ammonium phosphate [$(NH_4)_2HPO_4$] were used .

2.3 Impregnation Process

The impregnation process was carried out according to the principles of ASTM D 1413–76 [5]. A vacuum, which was equal to 760 $mmHg^{-1}$, was applied to the samples. They were then dipped for 60 min in a solution subject to open air pressure.

2.4 Varnish

2.4.1 Synthetic Varnishes

Synthetic Varnishes are, in most cases, composed of ketone or acrylic resins dissolved in mineral spirits. The advantages are that they dry rapidly, are crystal clear (unless a wax is added to create a matte finish), and are non-yellowing [6].

2.4.2 Cellulosic varnishes

A cellulose packaging film for packaging soft cheeses has a controlled permeability to oxygen, carbon dioxide, ammonia and water vapor which allows the cheese to properly ripen while wrapped in the packaging material. The cellulose packaging film is formed from a cellulose film substrate with a coating layer of a nitrocellulose varnish having distributed therein casein or starch particles which have a diameter which is greater than the thickness of the coating layer. In use, the soft cheese is wrapped with the cellulose packaging film with the nitrocellulose varnish layer facing the soft cheese. It is a nitro cellulose based, air drying, silky matt topcoat varnish. It is used to prepare a smooth surface by filling the pores on wooden surfaces. Perfectly penetrates into the surface, helping the top-coat paint stay in the surface. Reduces paint consuming [6].

2.4.3 Polyurethane Varnish

Polyurethane Varnish (two component) is mixed in the ratio of 1 part hardener to 10 parts varnish base by volume. The varnish/hardener mixture must be thoroughly shaken immediately prior to use. As the hardener contains acid, mixing should only take place in suitable vessels (either that provided, in the case of the 15 liters, or a plastic, glass or undamaged enamel vessel).

Polyurethane Varnish should be applied in a full flowing even coat, using a clean, good quality brush. Avoid overbrushing as this may produce brush marks and result in a reduction in the quality of finish and the level of protection afforded. The first coat of varnish should be lightly sanded when dry, using a fine grade abrasive paper, and the dust removed before application of the second coat. Further sanding is not necessary, and environmental advice and information [7].

2.5 Varnish Process
Approximately 120 g/m^2 varnish was applied to the surfaces of samples, based on ASTM 3023[8].

2.6 Preparation of Test Samples

The wood samples cut from sap wood were conditioned at 20 ± 2°C and 65± 3% relative humidity until they reached constant weight by holding them for 3 months in a climatization room. There were 400 test samples with 12 % average moisture with dimensions of 110x110x11 mm according to the procedure of TS 2472 for each wood species [9]. Afterwards test samples were cut 12 % average moisture with dimensions of 110x110x11 mm according to the procedure of TS 2472.

The impregnation process was carried out according to the principles of ASTM D 1413-76. A vacuum, which was equal to 760 cmHg-1, was applied to the samples. They were then dipped for 60 min in a solution subject to open air pressure. Before the impregnation process all samples were weighed and then kiln dried at 103 ± 2°C until they reached constant weight. Then, the samples were weighed in an analytic balance with 0.01-g sensitivity. After impregnation, all impregnated samples were held for 15 days in circulating air for evaporation of the solvent.

After this period the impregnated samples were oven dried at 103 ± 2°C until they reached constant weight. After cooling, all dried samples in the desiccator were weighed on the scale. The dry weights of the samples were determined and recorded. The amount of retention (R,kg/ m^3) and ratio of retention (R, %) were calculated as follows;

$$R = \frac{GxC}{V} 10^3 \ \text{kg/m}^3 \tag{1}$$

$$R(\%) = \frac{Mdi - Md}{Md} 100 \tag{2}$$

$$G = T2 - T1 \tag{3}$$

where G is the mass of the sample after impregnation (T2, kg) minus the mass of the sample before impregnation (Tl, kg), Mdi is the dry mass after impregnation (kg), Md is the dry mass before impregnation (kg), V is the volume of the sample (m3), and C is the concentration of the solution (%). The characteristic features of the impregnation chemicals were determined before and after impregnation processes. All processes were carried out at the temperature of 20 ± 2°C. Impregnated test samples were kept at the temperature of 20 ± 2°C and 65 ± 3% relative humidity until they reached constant weight.

2.7 Color Measurements

YCT and RCT measurements were performed with a colorimeter with the following calibration values: a: 4.91; b: -3.45; c: 6.00; H: 324,9, according to ASTM D 2244- 02 under 20 ± 2 °C and 50% ± 5 relative humidity conditions, both before and after the color changed [10].

2.8 Statistical Procedure

By using four impregnation chemicals and one control sample, three varnish types and control, two wood types, directions (tangentially and radially), a total of 800 samples (5x4x2x2x10 mm) were prepared using 10 samples for each parameter. Multiple analyses of variance were used to determine the differences between the YCT and RCT of the material surfaces of the prepared samples.

3. Result and Discussion

Properties of the solution used in impregnation process are given in Table 1.

Table 1. Peculiarities of Impregnation Chemicals

Impregnation Chemicals	Viscosity (20 °C) 4mm /Din cup/ sn	Solution concent. (%)	Temp. (°C)	pH		Density (g/ml)	
				BI	AI	BI	AI
Borax	10-11	5	23	9.12	9.15	1.08	1.10
Boric Acid	10	5	23	5.23	5.30	1.02	0.02
Zinc Chloride	10	5	23	6.00	6.09	1.07	1.07
Di-ammonium Phospate	11	5	23	6.89	9.98	1.11	1.13

BI:Before impregnation, AI: After impregnation

As a result of using fresh solution in every impregnation process, there is no important change in the acidity and density of the solutions before and after the impregnation, the pH values of Boric acid 5 % solution's being in acidic zone may be effectual on polysaccharide of the wood. The retention proportion of impregnation chemicals is given in Table 2.

Table 2. Proportion of Retention

Wood Species	Impregnated Materials	Retention (%)		Retention (kg/m³)	
		X	H.G.	X	H.G.
Oriental Beech	Borax	9.85	AB	3.45	A
	Boric Acid	9.47	AB	3.16	A
	Zinc Chloride	9.46	AB	2.18	B
	Di- ammonium phospate	9.12	B	2.90	AB
Scoth Pine	Borax	7.78	C	1.91	C
	Boric Acid	8.17	BC	2.01	BC
	Zinc Chloride	10.13	A	2.27	B
	Di-ammonium phospate	10.26	A	2.39	B

$\overline{X}$: Mean. HG: Homogenity group

In Scoth Pine the highest retention proportion was observed with di-ammonium phosphate and the lowest with Borax. In oriental beech the highest retention proportion was observed with Borax and the lowest with di ammonium phosphate.

The Red colour tone values of interactions between the factors are presented in Table 3. The highest red color tone value (20.692) was determined in oriental beech samples, cut tangentially, unprocessed impregnated and synthetic varnished. The lowest red color tone value (4.874) was determined in scoth pine samples, cut tangentially, impregnated with borax and synthetic varnished.

Table 3. RCT values for the combinations of wood types, grain orientation, varnish types, and chemicals.

Dir	Wood Species	Impregnated Materials	Varnish	Mean	Dir.	Wood Species	Impregnated Materials	Varnish	Mean
Rad.	S.Pine	Control	Control	9.731	Tang.	S.Pine	Control	Control	6.875
Rad.	S.Pine	Control	Cellulosic	13.968	Tang.	S.Pine	Control	Cellulosic	8.258
Rad.	S.Pine	Control	Synthetic	12.912	Tang.	S.Pine	Control	Synthetic	9.196
Rad.	S.Pine	Control	Polyurethane	13.824	Tang.	S.Pine	Control	Polyurethane	6.680
Rad.	S.Pine	Boric Acid	Control	9.002	Tang.	S.Pine	Boric Acid	Control	6.457
Rad.	S.Pine	Boric Acid	Cellulosic	9.986	Tang.	S.Pine	Boric Acid	Cellulosic	9.828
Rad.	S.Pine	Boric Acid	Synthetic	13.116	Tang.	S.Pine	Boric Acid	Synthetic	8.382
Rad.	S.Pine	Boric Acid	Polyurethane	13.030	Tang.	S.Pine	Boric Acid	Polyurethane	10.776
Rad.	S.Pine	ZC	Control	9.189	Tang.	S.Pine	ZC	Control	8.639
Rad.	S.Pine	ZC	Cellulosic	14.898	Tang.	S.Pine	ZC	Cellulosic	16.572
Rad.	S.Pine	ZC	Synthetic	12.590	Tang.	S.Pine	ZC	Synthetic	11.280
Rad.	S.Pine	ZC	Polyurethane	11.450	Tang.	S.Pine	ZC	Polyurethane	9.190
Rad.	S.Pine	Borax	Control	7.129	Tang.	S.Pine	Borax	Control	6.496
Rad.	S.Pine	Borax	Cellulosic	12.104	Tang.	S.Pine	Borax	Cellulosic	9.012
Rad.	S.Pine	Borax	Synthetic	10.920	Tang.	S.Pine	Borax	Synthetic	4.874
Rad.	S.Pine	Borax	Polyurethane	9.544	Tang.	S.Pine	Borax	Polyurethane	14.002
Rad.	S.Pine	DAP	Control	10.425	Tang.	S.Pine	DAP	Control	8.254
Rad.	S.Pine	DAP	Cellulosic	12.662	Tang.	S.Pine	DAP	Cellulosic	7.502

Rad.	S.Pine	DAP	Synthetic	15.642	Tang.	S.Pine	DAP	Synthetic	14.688
Rad.	S.Pine	DAP	Polyurethane	13.814	Tang.	S.Pine	DAP	Polyurethane	14.418
Rad.	O.Beech	Control	Control	11.465	Tang.	O.Beech	Control	Control	11.459
Rad.	O.Beech	Control	Cellulosic	13.888	Tang.	O.Beech	Control	Cellulosic	15.280
Rad.	O.Beech	Control	Synthetic	16.460	Tang.	O.Beech	Control	Synthetic	20.692
Rad.	O.Beech	Control	Polyurethane	13.278	Tang.	O.Beech	Control	Polyurethane	14.084
Rad.	O.Beech	Boric Acid	Control	11.609	Tang.	O.Beech	Boric Acid	Control	11.479
Rad.	O.Beech	Boric Acid	Cellulosic	13.832	Tang.	O.Beech	Boric Acid	Cellulosic	15.688
Rad.	O.Beech	Boric Acid	Synthetic	17.050	Tang.	O.Beech	Boric Acid	Synthetic	20.354
Rad.	O.Beech	Boric Acid	Polyurethane	13.778	Tang.	O.Beech	Boric Acid	Polyurethane	14.480
Rad.	O.Beech	ZC	Control	11.035	Tang.	O.Beech	ZC	Control	10.997
Rad.	O.Beech	ZC	Cellulosic	16.486	Tang.	O.Beech	ZC	Cellulosic	16.222
Rad.	O.Beech	ZC	Synthetic	17.006	Tang.	O.Beech	ZC	Synthetic	18.544
Rad.	O.Beech	ZC	Polyurethane	12.620	Tang.	O.Beech	ZC	Polyurethane	14.954
Rad.	O.Beech	Borax	Control	12.908	Tang.	O.Beech	Borax	Control	10.857
Rad.	O.Beech	Borax	Cellulosic	13.160	Tang.	O.Beech	Borax	Cellulosic	16.654
Rad.	O.Beech	Borax	Synthetic	16.408	Tang.	O.Beech	Borax	Synthetic	17.414
Rad.	O.Beech	Borax	Polyurethane	13.712	Tang.	O.Beech	Borax	Polyurethane	13.992
Rad.	O.Beech	DAP	Control	12.083	Tang.	O.Beech	DAP	Control	12.327
Rad.	O.Beech	DAP	Cellulosic	15.374	Tang.	O.Beech	DAP	Cellulosic	14.606
Rad.	O.Beech	DAP	Synthetic	14.638	Tang.	O.Beech	DAP	Synthetic	16.388
Rad.	O.Beech	DAP	Polyurethane	16.394	Tang.	O.Beech	DAP	Polyurethane	14.864

DAP; Di-Ammonium Phospate, ZC: Zinc Chloride
Dir.; Direction, Rad; Radial, Tang; Tangential

The results of the multy variance analyses connected with these values are shown in Table 4.

Table 4. Multy variance analysis for the effect of wood type, grain orientation, varnish type, and chemicals on RCT.

Source	Type II Sum of Squares	df	Mean Square	F	Significance
Factor A	130.706	1	130.706	35.997	0.000
Factor B	4633.784	1	4633.784	1276.148	0.000
Factor C	401.729	4	100.432	27.659	0.000
Factor D	3334.783	3	1111.594	306.134	0.000
A*B	737.305	1	737.305	203.054	0.000
A*C	109.658	4	27.414	7.550	0.000
B*C	325.769	4	81.442	22.429	0.000
A*B*C	257.707	4	64.427	17.743	0.000
A*D	19.969	3	6.656	1.833	0.139
B*D	536.298	3	178.766	49.232	0.000
B*C*D	220.696	3	73.565	20.260	0.000
C*D	891.310	12	74.276	20.456	0.000
A*C*D	413.556	12	34.463	9.491	0.000
B*C*D	691.791	12	57.649	15.877	0.000
A*B*C*D	475.395	12	39.616	10.910	0.000
Error	4066.800	1120	3.631		
Total	17247.256	1199			

Factor A = Wood Direction (Tangential, Radial), Factor B = Wood species (Scoth Pine, Oriental Beech), Factor C = Imregnated material (Borax, Borik Asit, Di- Ammonium Phospate, Zinc Choloride, Control), Factor D = Varnish (Cellulosic, synthetic, polyurethane, control)

The multy variance analyse applied on the data obtained from the RCT test is given in Table 4. According to the variance analysis, the effects of grain orientation, wood species, impregnation material and varnish type on RCT were statistically significant. The interaction between factors was statistically identical ($p< 0.05$).

The Yellow colour tone values of interactions between the factors are presented in Table 5. The highest yellow color tone value (48.622) was determined in scoth pine samples, cut radially, unprocessed impregnated and synthetic varnished. The lowest yellow color tone value (17.151) was determined in oriental beech samples, cut tangentially, impregnated with zinc chloride and unprocessed varnished.

Table 5. YCT values for the combinations of wood types, grain orientation, varnish types, and chemicals.

Dir	Wood Species	Impregnated Materials	Varnish	Mean	Dir	Wood Species	Impregnated Materials	Varnish	Mean
Rad.	S.Pine	Control	Control	28.851	Tang.	S.Pine	Control	Control	23.460
Rad.	S.Pine	Control	Cellulosic	30.932	Tang.	S.Pine	Control	Cellulosic	38.374
Rad.	S.Pine	Control	Synthetic	48.622	Tang.	S.Pine	Control	Synthetic	31.910
Rad.	S.Pine	Control	Polyurethane	33.804	Tang.	S.Pine	Control	Polyurethane	30.072
Rad.	S.Pine	Boric Acid	Control	29.547	Tang.	S.Pine	Boric Acid	Control	21.298
Rad.	S.Pine	Boric Acid	Cellulosic	37.274	Tang.	S.Pine	Boric Acid	Cellulosic	26.620
Rad.	S.Pine	Boric Acid	Synthetic	37.198	Tang.	S.Pine	Boric Acid	Synthetic	35.922
Rad.	S.Pine	Boric Acid	Polyurethane	33.862	Tang.	S.Pine	Boric Acid	Polyurethane	31.622
Rad.	S.Pine	ZC	Control	26.683	Tang.	S.Pine	ZC	Control	22.102
Rad.	S.Pine	ZC	Cellulosic	35.084	Tang.	S.Pine	ZC	Cellulosic	37.772
Rad.	S.Pine	ZC	Synthetic	36.762	Tang.	S.Pine	ZC	Synthetic	38.638
Rad.	S.Pine	ZC	Polyurethane	31.558	Tang.	S.Pine	ZC	Polyurethane	28.180
Rad.	S.Pine	Borax	Control	24.098	Tang.	S.Pine	Borax	Control	20.832
Rad.	S.Pine	Borax	Cellulosic	36.124	Tang.	S.Pine	Borax	Cellulosic	33.076
Rad.	S.Pine	Borax	Synthetic	32.536	Tang.	S.Pine	Borax	Synthetic	31.134
Rad.	S.Pine	Borax	Polyurethane	27.458	Tang.	S.Pine	Borax	Polyurethane	30.732
Rad.	S.Pine	DAP	Control	26.121	Tang.	S.Pine	DAP	Control	24.111
Rad.	S.Pine	DAP	Cellulosic	37.632	Tang.	S.Pine	DAP	Cellulosic	32.818
Rad.	S.Pine	DAP	Synthetic	39.414	Tang.	S.Pine	DAP	Synthetic	28.892
Rad.	S.Pine	DAP	Polyurethane	29.988	Tang.	S.Pine	DAP	Polyurethane	36.678
Rad.	O.Beech	Control	Control	22.873	Tang.	O.Beech	Control	Control	21.086
Rad.	O.Beech	Control	Cellulosic	29.646	Tang.	O.Beech	Control	Cellulosic	29.208
Rad.	O.Beech	Control	Synthetic	34.972	Tang.	O.Beech	Control	Synthetic	31.360
Rad.	O.Beech	Control	Polyurethane	27.334	Tang.	O.Beech	Control	Polyurethane	27.396
Rad.	O.Beech	Boric Acid	Control	20.641	Tang.	O.Beech	Boric Acid	Control	19.914
Rad.	O.Beech	Boric Acid	Cellulosic	28.554	Tang.	O.Beech	Boric Acid	Cellulosic	29.502
Rad.	O.Beech	Boric Acid	Synthetic	32.026	Tang.	O.Beech	Boric Acid	Synthetic	30.250
Rad.	O.Beech	Boric Acid	Polyurethane	23.612	Tang.	O.Beech	Boric Acid	Polyurethane	27.694
Rad.	O.Beech	ZC	Control	19.624	Tang.	O.Beech	ZC	Control	17.151
Rad.	O.Beech	ZC	Cellulosic	28.148	Tang.	O.Beech	ZC	Cellulosic	26.874
Rad.	O.Beech	ZC	Synthetic	29.734	Tang.	O.Beech	ZC	Synthetic	30.178
Rad.	O.Beech	ZC	Polyurethane	31.918	Tang.	O.Beech	ZC	Polyurethane	25.512
Rad.	O.Beech	Borax	Control	20.300	Tang.	O.Beech	Borax	Control	20.379
Rad.	O.Beech	Borax	Cellulosic	28.038	Tang.	O.Beech	Borax	Cellulosic	38.388
Rad.	O.Beech	Borax	Synthetic	33.734	Tang.	O.Beech	Borax	Synthetic	31.100
Rad.	O.Beech	Borax	Polyurethane	25.198	Tang.	O.Beech	Borax	Polyurethane	28.958
Rad.	O.Beech	DAP	Control	20.825	Tang.	O.Beech	DAP	Control	21.016
Rad.	O.Beech	DAP	Cellulosic	30.844	Tang.	O.Beech	DAP	Cellulosic	32.268
Rad.	O.Beech	DAP	Synthetic	20.276	Tang.	O.Beech	DAP	Synthetic	21.562
Rad.	O.Beech	DAP	Polyurethane	27.488	Tang.	O.Beech	DAP	Polyurethane	27.660

DAP; Di-Ammonium Phospate, ZC: Zinc Chloride
Dir.; Direction, Rad; Radial, Tang; Tangential

The results of the multy variance analyses connected with these values are shown in Table 6.

Table 6. Multy variance analysis for the effect of wood type, grain orientation, varnish type, and chemicals on YCT.

Source	Type II Sum of Squares	df	Mean Square	F	Significance
Factor A	622.815	1	622.815	41.916	0.000
Factor B	7096.916	1	7096.916	477.631	0.000
Factor C	593.514	4	148.379	9.986	0.000
Factor D	20190.734	3	6730.245	452.954	0.000
A*B	697.154	1	697.154	46.919	0.000
A*C	558.018	4	139.504	9.389	0.000
B*C	1080.739	4	270.185	18.184	0.000
A*B*C	489.524	4	122.381	8.236	0.000
A*D	867.093	3	289.031	19.452	0.000
B*D	299.441	3	99.814	6.718	0.000
B*C*D	204.972	3	68.324	4.598	0.003
C*D	3071.013	12	255.918	17.224	0.000
A*C*D	2241.659	12	186.805	12.572	0.000
B*C*D	1390.104	12	115.842	7.796	0.000
A*B*C*D	2140.755	12	178.396	12.006	0.000
Error	16641.595	1120	14.859		
Total	1085765.070	1200			

Factor A = Wood Direction (Tangential, Radial), Factor B = Wood species (Scoth Pine, Oriental Beech), Factor C = Imregnated material (Borax, Borik Asit, Di- Ammonium Phospate, Zinc Choloride, Control), Factor D = Varnish (Cellulosic, synthetic, polyurethane,control)
The multy variance analyse applied on the data obtained from the YCT test is given in Table 6. According to the variance analysis, the effects of grain orientation, wood species, impregnation material and varnish typeon YCT were statistically significant. The interaction between factors was statistically identical ($p< 0.05$).

4. Conclusion

The highest red color tone value (20.692) was determined in oriental beech samples, cut tangentially, unprocessed impregnated and synthetic varnished. The lowest red color tone value (4.874) was determined in scoth pine samples, cut tangentially, impregnated with borax and synthetic varnished.
The highest yellow color tone value (48.622) was determined in scoth pine samples, cut radially, unprocessed impregnated and synthetic varnished. The lowest yellow color tone value (17.151) was determined in oriental beech samples, cut tangentially, impregnated with zinc chloride and unprocessed varnished.
The red color tone in oriental beech the higher than in scoth pine, but yellow color tone scoth pine the higher than oriental beech.

Many species of wood have unique physical, mechanical, or chemical properties. Efficient utilization dictates that species should be matched to end-use requirements through an understanding of their properties. This requires identification of the species in wood form, independent of bark, foliage, and other characteristics of the tree[11]. Extractives can control durability, color, odor, and taste [12].

In the RCT and YCT values of the varnishes used in the experiments, a increase has been determined in cellulosic and synthetic varnishes compared to the control sample. It was also reported that YCT increased in chestnut and Scotch pine impregnated with T-CBC and varnished with synthetic and polyurethane varnishes [13]. T-CBC decreased YCT, while no considerable changes were observed in I-WR 2000. The compared values were approximately equal [14]. Surface treatment provides protection against light and water and will be affected by the weather resistance of the bonding agents of the finish (drying oils, synthetic resins, latexes, etc.). [15]

In this study, the impact of varnish type, some fire reterdant, grain orientation on YCT and RCT of wood was determined. For low RCT of wood, scoth pine samples, cut tangentially, impregnated with borax and synthetic varnish must be applied; but, for high RCT of wood, oriental beech samples, cut tangentially, unprocessed impregnated and synthetic varnish must be applied. For low YCT of wood, oriental beech samples, cut tangentially, impregnated with zinc chloride and unprocessed varnish must be applied; but, for high YCT of wood, scoth pine samples, cut radially, unprocessed impregnated and synthetic varnish must be applied.

Consequently, the type of varnish has a first degree effect, but waterborne salts have second degree effects on YCT and RCT for the tested types of wood. This result must be taken into consideration in the design and manufacture of wooden furniture and construction elements in which RCT or YCT of wood is important.

Acknowledgements; The research project was funded by Zonguldak Karaelmas University project No; NO: 2004-38-02-01.

References

1. Simpson, W., TenWolde, A., Physical Properties and Moisture Relations of Wood, Wood handbook, chapter 3, Madison. 1999.
2. Feist, C. W., Hon, D.N.-S., Chemistry of weathering and protection, The chemistry of solid wood, Chapter 11, PP 401-451, Madison, 1983.
3. Evans, P.D., Michell A.J. and Schmalzl, K., Studies of the degradation and protection of wood surfaces. Wood Sci. Technol. 26: 151-163, 1992.
4. Cassens, D.L. and W.C. Feist. Exterior wood in the south: selection, application and finishes. USDA Forest Service. Fpl-Gtr- 69: 55, 1999.
5. ASTM D 1413–76, Standart Test Methods of Testing Wood Preservatives by Laboratory Soilblock Cultures, Annual Book of Astm Standarts, 452-460, 1976,
6. Ozdemir, T., “The investigations of varnishes’ features at some tree species grown in Turkey”. PhD Thesis, Karadeniz Technical University, Turkey, 2003.
7. Kurtoğlu, A., “Ağaç Malzeme Yüzey İşlemleri”, İstanbul Üniversitesi, Orman Fakültesi, Üniversite Yayın No; 4262, Fakülte Yayın No; 463, İstanbul, 2000.
8. ASTM 3023, Practica For Determination of Resistance of Factory Applied Coating on Wood. Product of Stain and Reaperts, ASTM, USA. 1988.
9. TS 2472, Odunda Fiziksel ve Mekaniksel Deneyler için Birim Hacim Ağırlığı, TSE, Ankara, 1976.
10. ASTM D 2244–02, Standard practice for calculation of color tolerances and color differences from instrumentally measured color coordinates. ASTM Standards. West Conshohocken. PA. USA, 2003.
11. Miller, R. B., Structure of Wood, Wood handbook, chapter 2, Madison, 1999.
12. Bodig, J., Jayne, B. A., Characteristic of wood composites, Mechanics of wood and wood composites, Florida, 1993.
13. Uysal, B., Sonmez, A., Atar, M., Ozcifci, A., Ağac malzemede renk acma işlemleri ve verniklerin renk değiştirici etkileri. Turk J. Agric. For. 23: 849-854, 1999.
14. Atar, M. Renk Açıcı Kimyasal Maddelerin Ağac Malzemede Ust Yuzey işlemlerine Etkileri. Doktora Tezi. Gazi Universitesi, Fen Bilimleri Enstitusu. p.120-121, 1999.
15. Feist, W.C., Hon, D.-S. “Chemistry of Weathering and Protection”,The Chemistry of Solid Wood, Chapter 11, pp 401-451, Madison, 1984.