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Impact of Impregnation with Imersol-Aqua on the Yellow Color Tone of Some Woods and Varnishes

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Abstract: This study was performed to determine the effects of impregnation on the yellow color tone (YCT) of some woods and varnishes. For this purpose, the test specimens prepared from Oriental beech (*Fagus orientalis* Lipsky) and oak (*Quercus petrea* Liebl.) according to ASTM D 358 were impregnated with Imersol-Aqua according to ASTM D 1413-99 and the manufacturer's instructions by short-term, medium-term, and long-term dipping, and were then coated with synthetic, acrylic, waterborne, and polyurethane varnishes according to ASTM D 3023. The YCT of test specimens after the varnishing process was determined according to ASTM D 2244-02. As a result, the highest YCT value was obtained in oak, with medium-term dipping and synthetic varnish, whereas the lowest YCT was in Oriental beech with long-term dipping and waterborne varnish. Considering the interaction of wood type, period of impregnation, and type of varnish, YCT was the highest in oak + short-term dipping + synthetic varnish, and the lowest in Oriental beech + short-term dipping + waterborne varnish. Varnishing increased the YCT in oak and Oriental beech, but impregnation period increased the color tone in Oriental beech and decreased it in oak. This effect must be taken into consideration in applications where the YCT of wood is important.

Key Words: Oriental beech, oak, Imersol-Aqua, yellow color tone, varnish

Imersol-Aqua ile Emprenye Etmenin Bazı Ağaç Malzeme ve Verniklerde Sarı Renk Tonuna Etkisi

Özet: Bu çalışma, Imersol-Aqua ile emprenye işleminin bazı ağaç malzeme ve verniklerin sarı renk tonuna etkisini belirlemek amacıyla yapılmıştır. Bu maksatla Doğu kayını (*Fagus orientalis* Lipsky) ve meşe (*Quercus petrea* Liebl.) odunlarından ASTM D 358 esaslarına uyularak hazırlanan örnekler, ASTM D 1413-99 ve üretici firma önerilerine uyularak Imersol-Aqua ile kısa, orta ve uzun süreli daldırma yöntemiyle emprenye edildikten sonra yüzeyleri ASTM D 3023 esaslarına göre sentetik, akrilik, su bazlı ve poliüretan vernikler ile kaplanmıştır. Vernikleme işleminden sonra örneklerin sarı renk tonu ASTM D 2244-02 esaslarına göre belirlenmiştir. Sonuç olarak sarı renk tonu değeri; en yüksek meşede, orta süreli emprenyede, sentetik vernikte, en düşük, meşede, uzun süreli emprenyede ve su bazlı vernikte , ağaç türü, emprenye süresi ve vernik çeşidi etkileşimi bakımından en yüksek; meşe + kısa süreli emprenye + sentetik vernikte , en düşük; Doğu kayını + kısa süreli emprenye + su bazlı vernikte elde edilmiştir. Buna göre vernikler, meşe ve doğu kayınında sarı renk tonunu arttırıcı etki göstermiştir. Bu durum sarı renk tonunun önemli olduğu uygulamalarda dikkate alınabilir.

Anahtar Sözcükler: Doğu kayını, meşe, Imersol-Aqua, sarı renk tonu, vernikler

Introduction

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 (Evans et al., 1992).

Color variation may occur because of bruises on living parts of the tree, the formation of dead knots, formation of reaction wood, diseases, and so forth. In addition, the oxidation of some chemicals in wood, the formation of heartwood in older trees, and metal contact with tannin wood are also known to cause change in the natural color

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of wood (Shigo et al., 1973). Furthermore, differences between the specific weights of the growing rings may also result in color variation.

In wood, the yellow and brown colors occur by the chemical degradation of extractive materials and lignin in open air conditions (Anderson et al., 1991).

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 (Cassens et al., 1999). Technical surface processes also increase the esthetic and economic value of wood.

The aim of this experimental study was to determine the effect of impregnation with Imersol-Aqua on the yellow color tone (YCT) of Oriental beech and oak, which are widely used in the furniture industry, treated with 4 different varnishes.

Materials and Methods

Wood Materials

The woods of Oriental beech and oak were chosen randomly from timber merchants in Ankara, Turkey. Special emphasis was given for the selection of the wood material. Accordingly, non-deficient, knotless, normally grown (without zone line, without reaction wood, and without decay and insect mushroom damage) wood materials were selected.

Varnishes

Synthetic, acrylic, waterborne, and polyurethane varnishes were supplied by merchants in Ankara and used according to the manufacturer's instructions. Technical specifications of the varnishes are given in Table 1 (DYO, 1996).

Impregnation Material

The Imersol-Aqua used to impregnate the material in this study was supplied from Hemel Hickson Timber Products Ltd., İstanbul. Imersol-Aqua is a non-flammable, odorless, fluent, waterborne, completely soluble in water, and non-corrosive material with a pH value of 7 and a density of 1.03 g cm^{-3}. It is available as a ready-made solution. It contains 0.5% w/w tebuconazole, 0.5% w/w propiconazole, 1% w/w 3-Iodo-2-propynyl-butyl carbonate, and 0.5% w/w cypermethrin. Before the application of Imersol-Aqua on the wood material, all drilling, cutting, turning, and milling operations should be completed, and the relative humidity should be in equilibrium with the test environment. In the impregnation process, dipping duration should be at least 6 min and the impregnation pool must contain at least 15 l of impregnation material for each 1 m^3 of wood. The impregnated wood should be left to dry for at least 24 h at 20 ± 2 °C and 65% ± 3 relative humidity. The wood material can be painted, varnished, or glued after it is fully dried (Hickson, 2000).

Determination of Density

The densities of wood materials used for the preparation of test specimens were determined according to TS 2472 (TSE, 1976). For determining the air-dry

Table 1. Technical specifications of some varnishes.

Type of varnish	pH value	Density (g cm^{-3})	Viscosity (snDINCup/4mm)	Amount applied (g m^{-2})	Nozzle gap (mm)	Air pressure (bar)
Polyurethane (filler)	5.94	0.980	18	160	1.8	2
Polyurethane (finishing)	4.01	0.990	18	160	1.8	2
Synthetic	7.00	0.940	18	120	-	-
Waterborne ASTM D17 (primer)	9.17	1.014	18	150	1.3	1
Waterborne ASTM D65 (filler)	9.30	1.015	18	80	1.3	1
Waterborne ASTM D45 (finishing)	8.71	1.031	18	80	1.3	1
Acrylic (filler)	4.30	0.95	18	120	1.8	2
Acrylic (finishing)	4.60	0.97	18	120	1.8	2

density, the test specimens, with a dimension of 20 x 30 x 30 mm, were kept in conditions of 20 ± 2 ºC and 65% ± 3 relative humidity until they reached a stable weight. The weights were measured with an analytic scale with a sensitivity of 0.01 g. Afterwards, the dimensions were measured with a digital compass with 0.01 mm sensitivity. The air-dry densities of the specimens were calculated by the formula

$$\delta_{12} = M_{12} / V_{12} \qquad (1)$$

where M_{12} is the air-dry weight of the specimen and V_{12} is the air-dry volume.

The specimens were kept at 103 ± 2 ºC in the drying oven until they reached a stable weight for the assessment of full-dry density. Afterwards, full-dried specimens were cooled in a desiccator containing $CaCl_2$. Finally, they were weighted on a scale with 0.01 g sensitivity and their dimensions were measured with a compass with a sensitivity of 0.01 mm. The volumes of the specimens were determined by stereometric method and the densities calculated by the formula

$$\delta_0 = M_0 / V_0 \qquad (2)$$

where M_0 is full-dry weight of the specimen and V_0 *is f*ull-dry volume.

Determination of humidity

The humidity of the test specimens, both before and after the impregnation process, was determined according to TS 2471 (TSE, 1976). Thus, the specimens with a dimension of 20 x 20 x 20 mm were weighed and then oven dried at 103 ± 2 ºC until they reached a stable weight. Then the specimens were cooled in desiccators containing $CaCl_2$ and weighed with an analytic scale with 0.01 g sensitivity. The humidity of the specimens (h) were calculated by the formula

$$h = \frac{M_r - M_o}{M_o} \times 100 \qquad (3)$$

where *Mr* is initial weight of the specimens and *M* is full-dry weight.

Preparation of test specimens

The rough drafts for the preparation of the test and control specimens were cut from the sapwood parts of massive woods with a dimension of 190 x 140 x 15 mm and then conditioned at 20 ± 2 ºC and 65% ± 3 relative humidity for 3 months until they reached 12% humidity distribution according to ASTM D 358 (ASTM, 1983). Air-dry specimens with a dimension of 150 x 100 x 10 mm were cut from the drafts for impregnation and varnishing.

The test specimens were impregnated according to ASTM D 1413-99 (ASTM, 1999), TS 344 (TSE, 1981), and TS 345 (TSE, 1974). The specimens were dipped in the impregnation pool to a depth 1 cm below the upper surface for 10 min (short-term dipping), 2 h (medium-term dipping), or 5 days (long-term dipping). The specifications of the impregnation solution were determined before and after the process. The processes were carried out at 20 ± 2 ºC. Retention of impregnation material (R) was calculated by the formula

$$R = \frac{G.C}{V}\ 10, \quad G = T_2 - T_1 \qquad (4)$$

where *G* is the amount of impregnation solution absorbed by the specimen, T_2 is the specimen weight after impregnation, T_1 is the specimen weight before impregnation, *C* is the concentration (%) of the impregnation solution, and *V* is the volume of the specimens. Impregnated test specimens were kept in conditions of 20 ± 2 ºC and 65% ± 3 relative humidity until they reached a stable weight.

Varnishing

Test specimens were varnished according to ASTM D 3023 (ASTM, 1981). The surfaces of the specimens were sanded with abrasive papers to remove the fiber swellings and the resulting dust was cleaned off before varnishing. The manufacturer's instructions were followed for the composition of the solvent and hardener ratio and 1 or 2 finishing layers were applied after the filling layer. Spray nozzle distance and pressure were adjusted according to the manufacturer's instructions and moved in parallel to the specimen surface at a distance of 20 cm. Varnishing was done under 20 ± 2 °C and 65% ± 3 relative humidity conditions. Synthetic varnish was applied with a brush that was hard and strong.

Method of Testing

Color measurements

YCT 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 (ASTM, 2003) under 20 ± 2 °C and 50% ± 5 relative humidity conditions, both before and after the color changed.

Statistical analysis

By using 2 different types of wood, 3 methods of impregnation + 1 control specimen, and 4 types of varnish + 1 control specimen, 200 specimens (2 x 4 x 5 x 5) were prepared with 10 specimens for each parameter. Multiple variance analysis (a = 0.05) was used to determine the differences in YCT of the specimens. Duncan's test was used to determine the significant difference between the groups.

Results

Full-dry Density

Statistical values for the full-dry densities of the test specimens impregnated with Imersol-Aqua are given in Table 2.

Full-dry densities changed by type of wood and impregnation period. The densities of the control specimens and impregnated ones were approximately the same for Oriental beech and oak.

Air-dry Density

Statistical values for the air-dry densities of the wood specimens impregnated with Imersol-Aqua are given in Table 3.

Air-dry densities differed depending on the type of wood and duration of impregnation. Air-dry densities of impregnated woods increased along with dipping duration.

Table 2. Full-dry densities of wood specimens (g cm^{-3}).

Impregnation Periods (IP)	Statistical Values	Oriental Beech	Oak
Control	x	0.65	0.65
	Min.	0.60	0.59
	Max.	0.67	0.57
	S	0.019	0.02
	v	0.0003	0.0002
Short-term Dipping (S)	x	0.65	0.65
	Min.	0.63	0.60
	Max.	0.68	0.69
	S	0.01	0.02
	v	0.0001	0.0007
Medium-term Dipping (M)	x	0.66	0.65
	Min.	0.64	0.62
	Max.	0.69	0.70
	S	0.01	0.02
	v	0.0002	0.0005
Long-term Dipping (L)	x	0.66	0.66
	Min.	0.64	0.63
	Max.	0.69	0.70
	S	0.01	0.02
	v	0.000229	0.0004

x: mean, Min.: minimum, Max.: maximum,
S: standard deviation, v: variance

Table 3. Air-dry densities of wood specimens (g cm^{-3}).

Impregnation Periods (IP)	Statistical Values	Oriental Beech	Oak
Control	x	0.67	0.67
	Min.	0.65	0.65
	Max.	0.70	0.69
	S	0.01	0.013
	v	0.0002	0.0001
Short-term Dipping (S)	x	0.68	0.67
	Min.	0.66	0.65
	Max.	0.70	0.70
	S	0.01	0.01
	v	0.0002	0.0002
Medium-term Dipping (M)	x	0.68	0.67
	Min.	0.66	0.66
	Max.	0.71	0.70
	S	0.01	0.01
	v	0.0002	0.0001
Long-term Dipping (L)	x	0.69	0.68
	Min.	0.66	0.66
	Max.	0.72	0.79
	S	0.01	0.01
	v	0.0002	0.0001

x: mean, Min.: minimum, Max.: maximum,
S: standard deviation, v: variance

Peculiarities of Impregnation Solutions

The pH value and density of Imersol-Aqua did not change, either prior to or after impregnation. This may have been due to the use of a fresh solution for each impregnation process.

Retention Quantities

The retention amounts of the 2 woods for different impregnation periods are given in Table 4. Amounts of retention differed depending on wood type and impregnation period. Retention was the highest in Oriental beech and lowest in oak. As dipping period increased, the amount of retention increased and was the highest in long-term dipping.

Table 4. Retention amounts of wood specimens (kg m^{-3}).

Impregnation Periods (IP)	Statistical Values	Oriental Beech	Oak
	x	79.22	22.86
Short-term	S	48.24	2.04
Dipping (S)	v	1862.15	3.35
	Min.	40.70	20.06
	Max.	158.25	25.06
	x	149.29	31.57
Medium-term	S	101.18	8.18
Dipping (M)	v	8191.10	53.53
	Min.	59.90	23.84
	Max.	270.09	42.01
	x	388.14	204.82
Long-term	S	89.29	54.82
Dipping (L)	v	6379.29	2404.26
	Min.	293.82	120.09
	Max.	532.65	265.39

x: mean, Min.: minimum, Max.: maximum,
S: standard deviation, v: variance

Yellow Color Change

YCT mean values for wood types, varnish types, and periods of impregnation are given in Table 5.

Table 5. YCT mean values for wood types, varnish types, and periods of impregnation.

Types of Material	x	HG
Wood materials*		
Oriental Beech (I)	30.58	B
Oak (II)	33.36	A
Varnishes **		
Unvarnished (Uv)	21.27	E
Synthetic (Sv)	38.63	A
Acrylic (Ac)	34.16	C
Waterborne (Wb)	28.80	D
Polyurethane (Pu)	37.00	B
Impregnation Periods ***		
Control (Co)	29.78	D
Short-term dipping (S)	32.81	B
Medium-term dipping (M)	33.42	A
Long-term dipping (L)	31.88	C

I: Oriental Beech, II: Oak, HG = degrees of homogeneity, x: mean,
*LSD = 0.2814, **LSD = 0.6292, ***LSD = 0.3979

YCT was the highest in oak and the lowest in Oriental beech. This result may have been due to the structural properties of Oriental beech. As for varnishes, YCT was the highest in synthetic varnish and the lowest in waterborne varnish. Varnishes increased YCT. For the period of impregnation, YCT was the highest in medium-term dipping and the lowest in long-term dipping. As the period of dipping increased, YCT decreased.

For the combination of wood type + impregnation period, wood type + varnish type, and varnish type + impregnation period, YCT mean values are given in Table 6.

YCT in wood type + varnish type combination was the highest in oak + synthetic varnish and the lowest in Oriental beech + waterborne varnish. For the combination of wood type + impregnation period, as the period of impregnation increased from medium-term to long-term, YCT decreased. On the other hand, for varnish type + impregnation period, it showed an increasing effect on all types of varnishes. This effect was the highest in medium-term dipping. Statistical values for the combination of wood type + varnish type + period of impregnation are given in Table 7.

Table 6. YCT mean values for combinations of wood type, varnish type, and period of impregnation.

Types of Material	x	HG
Wood materials + varnishes*		
I	20.58	I
I + Synthetic varnish	37.84	C
I + Acrylic varnish	32.92	E
I + Waterborne varnish	26.21	G
I + Polyurethane varnish	35.35	D
II	21.96	H
II + Synthetic varnish	39.42	A
II + Acrylic varnish	35.41	D
II + Waterborne varnish	31.39	F
II + Polyurethane varnish	38.64	B
Wood materials + dipping periods **		
I	28.32	E
I + S	30.94	D
I + M	31.77	C
I + L	31.29	CD
II	31.25	CD
II + S	34.67	A
II + M	35.07	A
II + L	32.46	B
Varnishes + dipping periods ***		
Synthetic varnish	36.19	CD
Synthetic varnish + S	40.16	A
Synthetic varnish + M	39.72	A
Synthetic varnish + L	38.46	B
Acrylic varnish	32.09	G
Acrylic varnish + S	33.89	F
Acrylic varnish + M	35.73	D
Acrylic varnish + L	34.95	E
Waterborne varnish	25.89	I
Waterborne varnish + S	29.74	H
Waterborne varnish + L	29.84	H
Polyurethane varnish	33.95	F
Polyurethane varnish + S	36.68	C
Polyurethane varnish + M	38.59	B
Polyurethane varnish + L	38.76	B

I: Oriental Beech, II: Oak, x: mean, HG: degrees of homogeneity,
*LSD = 0.2256, **LSD = 0.5628, ***LSD = 0.6292

Table 7. YCT values for the combinations of wood types, varnish types, and impregnation periods.

		Wood Material Type									
IM	SV	Oriental beech					Oak				
		Type of Varnish					Type of Varnish				
		Uv	Sv	Ac	Wb	Pu	Uv	Sv	Ac	Wb	Pu
	x	19.5	36.6	26.43	23.5	33.2	24.04	37.3	32.50	26.3	35.6
	S	0.50	0.82	1.36	0.30	0.20	0.74	1.24	0.28	0.89	1.1
Co	v	0.20	0.53	1.48	0.07	0.03	0.44	1.24	0.06	0.63	0.98
	Min.	18.3	34.4	28.76	23.5	31.6	21.7	35.2	32.64	26.9	34.5
	Max.	19.7	36.4	32.1	24.2	32.1	23.45	37.6	33.3	28.8	37.2
	x	23.6	40.4	32.42	25.7	34	25.02	42.4	34.29	32.6	41.1
	S	1.21	0.3	1.36	0.88	1.66	0.64	0.87	1.32	1.44	0.96
S	V	1.17	0.09	1.49	0.62	2.20	0.33	0.61	1.40	1.67	0.73
	Min.	19.9	38	31.31	25.5	33.8	24.46	40.9	33.03	31	37
	Max.	23	38.9	34.72	27.8	37.8	25.88	43.2	36.63	34.5	39.3
	X	19.9	38.2	34.95	26.3	37.6	27.15	40.8	36.80	31.6	39.8
	S	1.20	1.19	0.64	1.89	0.58	1.10	0.89	0.54	0.64	1.33
M	V	1.15	1.14	0.32	2.87	0.27	0.97	0.63	0.23	0.33	1.41
	Min.	19.9	37.4	33.45	24.8	36.5	24.19	38.5	36.32	32	36.9
	Max.	22.9	40.5	34.87	29.2	37.9	26.93	40.9	37.63	33.4	40.2
	X	19.8	37.3	34.9	26.5	38.4	12.50	40.3	36.76	32.8	41
	S	0.40	0.60	0.97	1.18	0.65	1.23	1.09	0.62	1.12	0.84
L	V	0.12	0.28	0.76	1.12	0.34	1.22	0.96	0.31	1.01	0.57
	Min.	19.6	37	31.9	26.4	36.6	13.6	37.7	35.32	30.1	39
	Max.	20.6	38.6	34.28	29.5	38.4	16.4	40.4	36.78	32.7	41

IM: impregnation material, SV: statistical values, x: mean, Min.: minimum, Max.: maximum, S: standard deviation, v: variance; Uv: unvarnished, Sv: synthetic varnish, Ac: acrylic varnish, Wb: waterborne varnish, Pu: polyurethane varnish

YCT in wood decreased as dipping period increased. The rate of decrease was greater in oak than in Oriental beech. This may have been due to tannin in oak wood. Results of multiple variance analysis for the effect of wood type, varnish type, and impregnation period on YCT are given Table 8.

The difference between the groups was important for the effect of variance sources on YCT for a = 0.05. Duncan's test results are given in Table 9 and indicate the importance of differences between the groups.

YCT in unimpregnated woods was the highest in oak and the lowest in Oriental beech. YCT was the highest in oak impregnated by medium-term dipping and the lowest in oak impregnated by long-term dipping. In impregnated and varnished test specimens, YCT was the highest in short-term dipping and synthetic varnished oak, and was the lowest in short-term dipping and waterborne varnished Oriental beech.

Table 8. Multiple variance analysis for the effect of wood type, varnish type, and period of impregnation on YCT.

Source	Degrees of freedom	Sum of squares	Mean square	F Value	Probable 5% (SIG)
Factor A	1	386.948	386.948	380.2449	0.0000
Factor B	4	7960.643	1990.161	1955.6835	0.0000
AB	4	95.357	23.839	23.4262	0.0000
Factor C	3	379.962	126.654	124.4598	0.0000
AC	3	47.369	15.790	15.5163	0.0000
BC	12	301.070	25.089	24.6545	0.0000
ABC	12	149.952	12.496	12.2795	0.0000
Error	160	162.821	1.018		
Total	199	9484.122			

Factor A: wood type, Factor B: varnish type, Factor C: impregnation period

Table 9. Duncan's test results (N mm^{-2}).

Material	x	* HG	Material	x	*HG
II+S+Sv	41.77	A	II+S+Wb	33.06	KLM
II+L+Pu	40.04	B	II+Ac	33.02	KLM
II+M+Pu	40.01	B	I+S+Ac	32.7	LM
II+M+Sv	39.95	B	II+M+Wb	32.66	LM
I+M+Sv	39.5	BC	II+L+Wb	32	MN
II+L+Sv	39.29	BC	I+Pu	31.72	MN
I+S+Sv	38.55	CD	I+Ac	31.16	N
II+S+Pu	38.34	CDE	II+Wb	27.84	O
I+L+Sv	37.63	DEF	I+L+Wb	27.68	OP
I+L+Pu	37.49	DEF	I+M+Wb	26.78	OPQ
I+M+Pu	37.16	DEF	I+S+Wb	26.43	PQR
II+M+Ac	37.09	EFG	II+M	25.63	QR
II+Sv	36.68	FG	II+S	25.12	RS
II+L+Ac	36.43	FGH	I+Wb	23.94	S
II+Pu	36.18	FGHI	II+Co	22.51	T
I+Sv	35.69	GHIJ	I+S	22.01	TU
II+S+Ac	35.08	HIJ	I+M	21.04	UV
I+S+Pu	35.03	IJ	I+L	20.21	VW
I+M+Ac	34.37	JK	I+Co	19.08	E
I+L+Ac	33.47	KL	II+L	14.57	X

I: Oriental Beech, II: Oak, S: short-term dipping, M: medium-term dipping, L: long-term dipping, x: mean, HG: degrees of homogeneity, *LSD: 1.258, Sv: synthetic varnish, Ac: acrylic varnish, Wb: waterborne varnish, Pu: polyurethane varnish

Discussion

Air-dry and full-dry densities of Oriental beech and oak test specimens impregnated by different methods increased as compared to control specimens. This may have been due to increased absorption of impregnation material as the impregnation period increased.

Retention was greater in the long-term dipping than in short-term dipping method. It was reported that in impregnation of Scotch pine and Oriental beech woods with Imersol-WR, retention increased along with the period of impregnation (Örs et al., 2000). In this study, retention was higher in long-term dipping than in medium and short-term dipping impregnation of Oriental beech and oak. On the other hand, retention was high in Oriental beech and lower than expected in oak. This may have been due to tyloses in oak.

YCT was the highest in oak, synthetic varnish, and medium-term dipping and was the lowest in oak, long-term dipping, and waterborne varnish. YCT was 9% higher in oak than Oriental beech. YCT was 10% higher than the control specimen in short-term, 11% higher in medium-term, and 7% higher in long-term dipping; therefore, it can be concluded that the impregnation material increased YCT.

YCT was 45% higher in synthetic varnish specimens than in control specimens, 38% higher in acrylic varnish, 27% higher in waterborne varnish, and 43% higher in polyurethane varnish. Hence, varnishing increased YCT of wood.

For the combination of wood and varnish, YCT was the highest in oak and synthetic varnish (39.42) and the lowest in Oriental beech and waterborne varnish (26.21).

Efficacy of varnishes to increase YCT as compared to control specimens of Oriental beech and oak was 46% and 44% for synthetic varnish, 37.5% and 48.7% for acrylic varnish, 21.5% and 30% for waterborne varnish, and 42% and 43% for polyurethane varnish, respectively. In varnishing after the impregnation, YCT was lowest for waterborne varnish for both types of wood. This result may, therefore, be taken into consideration when YCT is important and varnishing will be done after impregnation.

For the combination of wood and impregnation material, YCT was the highest in oak and medium-term dipping (35.07), and the lowest in Oriental beech and short-term dipping (30.94). As YCT increased in oak wood with the period of dipping, a dark-gray color was observed in long-term dipping. In Oriental beech wood, approximately the same values were measured. This result must be taken into consideration in the impregnation of oak and similar types of wood.

For the combination of impregnation material and varnish, YCT was the highest in short-term dipping and acrylic varnish (40.16), and the lowest in medium-term dipping and waterborne varnish (29.72). Impregnation material and impregnation period are effective in increasing YCT of varnishes; therefore, YCT of varnished specimens was lower in unimpregnated specimens than in impregnated specimens. The lowest change in YCT was measured in acrylic varnish and the lowest value was measured in waterborne varnish.

For the combination of wood + impregnation material + varnish, YCT was the highest in oak + short-term dipping + synthetic varnish (41.77), and the lowest in Oriental beech + shot-term dipping + waterborne varnish (26.43). Impregnation material, impregnation period, type of varnish, and type of wood are important to YCT, but the efficacy of varnish type and impregnation material are more important. YCT of Oriental beech and oak varnished with waterborne varnish was lower than other varnishes. The change in YCT was the lowest with acrylic varnish.

Color change was reported in varnished and bleached Oriental beech and oak wood (Uysal et al., 1999). It was also reported that YCT increased in chestnut and Scotch pine impregnated with T-CBC and varnished with synthetic and polyurethane varnishes (Uysal et al., 1998).

YCT values were determined after varnishing Oriental beech and oak impregnated with Tanalith-CBC and Imersol–WR 2000. YCT was 30.0 in Oriental beech + synthetic varnish, but 36.6 in this study, 27.0 in beech + waterborne varnish, but 23.5 in this study, 30.5 in oak + synthetic varnish, but 37 in this study, and 26.9 in oak + waterborne varnish, but 26 in this study (Atar, 1999).

Additionally, T-CBC decreased YCT, while no considerable changes were observed in I-WR 2000. The compared values were approximately equal (Atar, 1999).

Color change was measured after varnishing Oriental beech and oak woods processed with different paints. Wood paints showed an increasing effect in YCT of oak, and polyurethane and synthetic varnishes, and a decreasing effect in Oriental beech (Çakıcıer, 1996).

In this study, the impact of varnish type, impregnation material, and duration of impregnation on YCT of wood was determined. For low YCT of wood, waterborne varnish and a short-term dipping must be applied; but, for high YCT of wood, synthetic varnish and short-term dipping method must be applied.

In conclusion, the type of varnish has a first degree effect, but impregnation material and impregnation period have second degree effects on YCT 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 YCT of wood is important.

References

Anderson, E.L., Z. Pawlak, N.L. Owen and W.C. Feist. 1991. Infra yellow studies of wood weathering. Appl. Spectroscopy. 45: 641-647.

ASTM D 358, 1983. Wood to be used as panels in weathering test of coating. ASTM Standards. West Conshohocken. PA. USA.

ASTM D 1413-99, 1999. Standard test method for wood preservatives by laboratory soil-block cultures. ASTM Standards. West Conshohocken. PA. USA.

ASTM D 2244-02, 2003. Standard practice for calculation of color tolerances and color differences from instrumentally measured color coordinates. ASTM Standards. West Conshohocken. PA. USA.

ASTM D 3023, 1981. Practical for determination of resistance of factory applied coating on wood product of stain and reagents. ASTM Standards. West Conshohocken. PA. USA.

Atar, M. 1999. Renk Açıcı Kimyasal Maddelerin Ağaç Malzemede Üst Yüzey İşlemlerine Etkileri. Doktora Tezi. Gazi Üniversitesi, Fen Bilimleri Enstitüsü. p.120-121.

Cassens, D.L. and W.C. Feist. 1999. Exterior wood in the south: selection, application and finishes. USDA Forest Service. Fpl-Gtr-69: 55.

Çakıcıer, N. and A. Sönmez. 1996. Ahşap yüzeylerde kullanılan verniklerin su ile eritilen önemli ağaç boyaları ile boyanmış yüzeylerde yaptığı renk değişiklikleri. Endüstriyel Teknoloji. 2: 34-40.

DYO, 1996. Dewilux Teknik Bülten. Dewilux Fabrikaları. A.Ş. İzmir.

Evans, P.D., A.J. Michell and K. Schmalzl. 1992. Studies of the degradation and protection of wood surfaces. Wood Sci. Technol. 26: 151-163.

Hickson's Timber Impregnation Co. Ltd., 2000. Into the 21st century Imersol-Aqua brochure. Datasheet no: 6214, 2.0.0, P.1-4, USA.

Örs, Y., M. Atar and A. Özçiftci. 2000. Bonding strength of polyvinyl acetate based adhesive in some wood materials treated with impregnation. Journal of Applied Polymer Science. 76: 1472-1479.

Shigo, A.L. and W.E. Hills. 1973. Heartwood, discolor yellow wood and microorganism in living trees. Annual Review Phytopathol. 11: 197-222.

TS 2472, 1976. Odunda fiziksel ve mekanik deneyler için hacim ağırlığı tayini. Türk Standartları Enstitüsü. Ankara.

TS 2471, 1976. Odunda fiziksel ve mekanik deneyler için rutubet miktarı tayini. Türk Standartları Enstitüsü. Ankara.

TS 344, 1981. Ahşap koruma genel kuralları. Türk Standartları Enstitüsü. Ankara.

TS 345,1974. Ahşap emprenye maddeleri etkilerinin muayene metotları. Türk Standartları Enstitüsü. Ankara.

Uysal, B., A. Sönmez, M. Atar and A. Özçifçi. 1999. Ağaç malzemede renk açma işlemleri ve verniklerin renk değiştirici etkileri. Turk J. Agric. For. 23: 849-854.

Uysal, B., H. Peker and M. Atar. 1998. Açık hava Şartlarının emprenyelenmiş ve verniklenmiş ağaç malzeme yüzeyinde renk değişimine etkileri. Teknoloji Dergisi. 1: 66-77.