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HIZLI YAŞLANDIRILMIŞ ISIL İŞLEM GÖRMÜŞ ODUNUN BAZI YÜZEY KARAKTERİSTİKLERİ

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Özet-Isıl işlem görmüş odun dış mekân uygulamalarında geniş bir kullanıma sahiptir. Bu çalışmanın amacı 190 ve 212 °C sıcaklıkta ısıl işlem görmüş ve hızlı yaşlandırmaya maruz bırakılmış Sarıçam (*Pinus sylvestris* L.), Uludağ göknarı (*Abies bornmülleriana* mattf.), Kızılağaç (*Alnus glutinosa* subsp. Barbata (C. A. Mey.)), ve Kayın (*Fagus orientalis* Lipsky) odunun renklerindeki değişimlerin belirlemektir. Bu çalışmada hızlı yaşlandırma testleri 288 saat süre ile ASTM G154 standart metoduna uygun olarak gerçekleştirilmiştir. Isıl işlem görmüş ve görmemiş odunların ultraviyole ışınlarıyla fotodedgradasyonu renk açısından değerlendirilmiştir. Isıl işlem görmüş odunun hızlı yaşlandırma sonrası renginin işlem görmemiş odundan daha stabil olduğu sonucuna ulaşılmıştır. Isıl işlem renk stabilizasyonunu geliştirmede etkili bir metottur.
Anahtar Kelimeler- ısıl işlem, hızlı yaşlandırma, renk, odun.

SOME SURFACE CHARACTERISTIC OF ARTIFICIALLY WEATHERED HEAT-TREATED WOOD

Abstract- Heat-treated wood has a wide usage in outdoor applications. The objective of this research was to determine changes in the color of heat-treated Scots pine (*Pinus sylvestris* L.), Turkish fir (*Abies bornmülleriana* mattf.), Black alder (*Alnus glutinosa* subsp. Barbata (C. A. Mey.)), Oriental beech (*Fagus orientalis* Lipsky) wood at temperature 190 °C and 212 °C that was exposed to artificial weathering. In this study, accelerated weathering tests (UV and moisture) were executed according to the standard method of ASTM G154 for a period of 288 h. Photodegradation by ultra-violet radiation of both heat-treated and untreated wood was evaluated in terms of color. The degradation of lignin and extractives of wood is resulted in an immediate color change of the wood. It was obvious that the heat-treated wood resulted in more color stability than untreated wood during weathering. Heat-treatment is an effective method to improve color stability.
Key Words- Heat-treatment, weathering, color, wood.

Bu makale, 4. Uluslararası Mobilya ve Dekorasyon Kongresi'nde sunulmuş ve İleri Teknoloji Bilimleri Dergisi'nde yayınlanmak üzere seçilmiştir.

1. GİRİŞ (INTRODUCTION)

Woody material has been made use of engineering and structural works in many purposes for indoor and outdoor construction/furniture materials. The exposure of wood to especially outdoors condition which is a combination of factors such as solar irradiation, moisture, wind, heat/cold, oxygen and atmospheric pollutants, degrades the components and changes its color. The most dangerous ones are ultraviolet (UV) light, the component of sunlight, to depolymerize of lignin in the wood cell walls and after depolymerization reactions, water removes degradation products and it results in surface erosion (Williams 2005; Hon,1991; Evans et al., 1992; Hon, 2001).

Wood exposed to sunlight absorbs solar radiation. The UV (75 µm) penetrates a lower depth in the wood than the visible light (200 µm). But visible light has not enough energy to break the chemical bonds. However, withal the photochemical degradation begins due to UV, which changes its aesthetic appearance (Hon, 2001). Wood becomes pale or grayish, yellowish or darkened mostly depending on the extractive compounds (Feist 1983, Ayadi et al. 2003). To minimize the effects of weathering deterioration, it is necessary to identify the causative factors and to improve wood properties against to weathering deterioration. Heat treatment is an effective method to develop some physical properties of wood but while it is improving the dimensional stability of wood, it makes wood susceptible against to photodegradation. Many researchs have shown that weathering causes poor aesthetics surface for heat-treated wood hence of the discoloration and surface checking when exposed to UV radiation (Sivonen et al., 2002; Syrjänen et al., 2000; Mayes et al., 2002).

Studies which are about surface characteristics of heat-treated wood after exposure to artificial weathering are limited and it is not well known how weathering effects the surface characteristic of heat-treated wood. The aim of this study was to investigate color property of heat treated wood during artificial weathering exposure of 288 h. Results of two hardwood species (Black alder and beech) and two softwood species (Scots pine and Turkish fir) could serve as the basis for the performance of heat treated wood in outdoor conditions.

2. YÖNTEM (METHOD)

2.1. Odun Türü (Wood species)

In this research we have studied four wood species: beech wood (*Fagus orientalis* Lipsky), Black alder (*Alnus glutinosa* subsp. Barbata (C.A. Mey)), Scots pine (*Pinus sylvestris* L.), Turkish fir (*Abies bornmülleriana* Mattf.). These species are known to have a low natural durability resistance. Therefore, heat treatment is thus a suitable means to gain it an added value. The sample trees used for the present research were obtained from the Bolu Forestry Departments.

Table 1. Örnek alınan ağaçların bölgeleri ve karakteristikleri **(**The locations and characteristics of the sampled trees)

Tree species	Region		Year	Diameter at 1,30m (cm)	Height of growing place (m)
Scots pine	Bolu	Düzce	78	45	870
Beech	Bolu	Düzce	83	47	870
Black alder	Giresun	Tirebolu	77	34	6
Turkish fir	Bolu	Düzce	72	43	870

2.2. Isıl İşlem (Heat Treatment)

The thermal treatment has been performed with the ThermoWood® technology (Finnish ThermoWood Association, 2003) by the Turkish company Nova Wood. During the heat treatment, the oven temperature was held at 190 and 212°C for 1,5 and 2 hours, respectively.

2.3. Hızlı Yaşlandırma (Artificial Weathering)

Heat treated and control samples were subjected to an artificial weathering by exposing to 310 nm fluorescent UV lamps in the QUV accelerated weathering tester during the periods of 288 h which is suitable natural climatic condition for west black sea area. The weathering cycle involved a continuous light irradiation of 1 h followed by a water spray for 10 min and conditioning for 4 h. The average irradiance was 0.67 W/m^2 at 310 nm wavelengths with a constant chamber temperature of 60 °C.

2.4. Renk Ölçümü (Color Measurement)

The colors of samples were measured by an 8 mm in diameter with 10° observer angle using with a spectrophotometer according to the CIE L* a* b* system to express the color change (Figure 1).

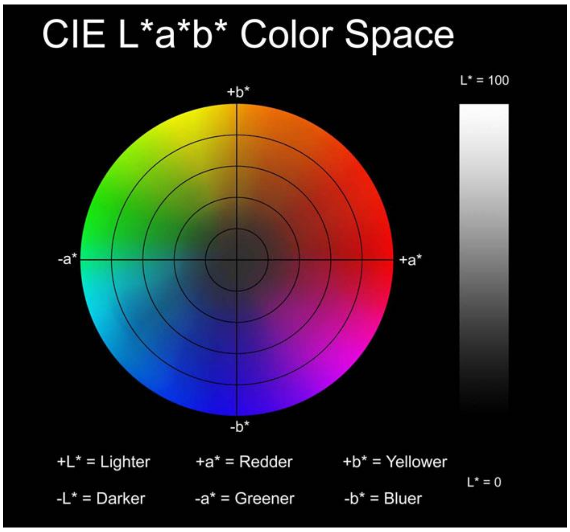

Figure 1. CIE Lab renk alanı: L her zaman pozitiftir ve beyazlığı temsil eder; a>0 kırmızı bileşeni temsil eder; a<0 yeşil bileşeni temsil eder; b>0 sarı bileşeni temsil eder; b<0 mavi bileşeni temsil

eder. (CIE Lab color space: L is always positive and represents lightness; a> 0 represents red component, a<0 represents green component; b>0 represents yellow component, b<0 represents blue component.

The measurements were recorded at the same points on surface of each sample before and after weathering. Initially, to determine the effect of heat treatment on color change, before and after heat treatment the color of samples was measured. Then, to determine the effect of artificial weathering on color change, before and after the weathering test, L*, a* and b* values were measured.

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

The differences in parameters *ΔL*, Δa**, and *Δb** and the total color differences *ΔE** were calculated using the following formulas;

$$\Delta L^* = L_{ut/ht} - L_{ht/wht} \quad (1)$$

$$\Delta a^* = a_{ut/ht} - a_{ht/wht} \quad (2)$$

$$\Delta b^* = b_{ut/ht} - b_{wht} \quad (3)$$

(4)

where *ΔE** is total color change; *ΔL** is lightness difference, $L_{ut/ht}$ is untreated/heat treated lightness; $L_{ht/wht}$ is heat-treated/heat treated and weathered lightness; *Δa** is green/red coloration difference; $a_{ut/ht}$ is untreated/heat treated green/red coloration; $a_{ht/wht}$ is heat-treated/heat treated and weathered green/red coloration; *Δb** is yellow/blue coloration difference; $b_{ut/ht}$ is untreated/heat treated yellow/blue coloration; $b_{ht/wht}$ is heat-treated/heat treated and weathered yellow/blue coloration.

3. BULGULAR (FINDINGS)

Table 2 shows the changes of L*, a*, b*, and E* according to the temperature of treatment and weathering. While the decrease in ΔL* indicates that the samples become darker, positive values of Δa* and Δb* indicate a tendency of wood surface to become red hue and yellow hue.

Table 2. Odun örneklerinin renk değişimleri (Color change of wood samples)

Wood species	Treatment	Color change			
		*ΔL**	*Δa**	*Δb**	*ΔE**
BLACK ALDER	HT (190°C)	-2,95 (2,06)	-1,46 (0,95)	4,34 (1,25)	5,45
	HT-W (190°C)	-2,67 (2,49)	1,35 (0,75)	3,97 (1,96)	4,97
	HT (212 °C)	-16,20 (1,29)	-1,30 (0,90)	0,61 (1,94)	16,26
	HT-W (212°C)	6,02 (2,54)	-0,28 (0,84)	-1,49 (2,70)	6,21
	W	6,45(3,71)	-1,55 (0,99)	0,70 (1,55)	6,67
ORIENTAL BEECH	HT (190°C)	-8,15 (3,02)	-2,94 (0,78)	-6,41 (1,05)	10,78
	HT-W (190°C)	-0,16 (3,07)	0,54 (1,41)	-3,40 (1,18)	3,45
	HT (212 °C)	-22,65 (3,69)	-6,10 (1,08)	-7,35 (1,49)	24,58
	HT-W (212°C)	7,43 (2,96)	-1,80 (0,82)	-5,25 (1,47)	9,27
	W	5,90 (2,37)	-3,78 (1,01)	-6,56 (1,42)	9,60
TURKISH FIR	HT (190°C)	-10,26 (2,16)	2,11 (0,55)	2,59 (0,78)	10,79

	HT-W (190°C)	-2,51 (2,07)	2,39 (1,03)	-4,66 (1,14)	5,81
	HT (212 °C)	-24,62 (2,95)	2,84 (0,75)	2,97 (0,70)	24,96
	HT-W (212°C)	3,40 (0,91)	-1,02 (0,56)	-6,22 (1,04)	7,16
	W	-5,59 (2,42)	2,50 (0,75)	4,52 (1,99)	7,62
SCOTS PINE	HT (190°C)	-15,81 (2,48)	3,50 (0,85)	2,42 (2,08)	16,37
	HT-W (190°C)	-0,36 (1,19)	0,54 (0,20)	-3,47 (1,40)	3,53
	HT (212 °C)	-28,27 (2,92)	4,64 (0,93)	2,62 (1,07)	28,77
	HT-W (212°C)	4,64 (1,31)	-1,12 (0,93)	-8,19 (1,67)	9,48
	W	-8,81 (2,23)	2,98 (0,65)	2,92 (1,09)	9,75

3.1. Color Change After Heat Treatment

The decrease in L* for all wood species and temperatures indicates that the specimens became darker (Figure 3). By increasing treatment intensity, ΔL* increased depending on decrease of L*. This result corresponds to the increase in ΔE*, which is mostly affected from L* variations (Figure 2). By increasing treatment temperature, the minimum total color change was obtained in Black alder wood species. According to Δa* values red hue was dominant in the softwood species and green hue was dominant in the hardwood species after heat treatment. Δb* was changeable depends on the wood species and heat treatment conditions.

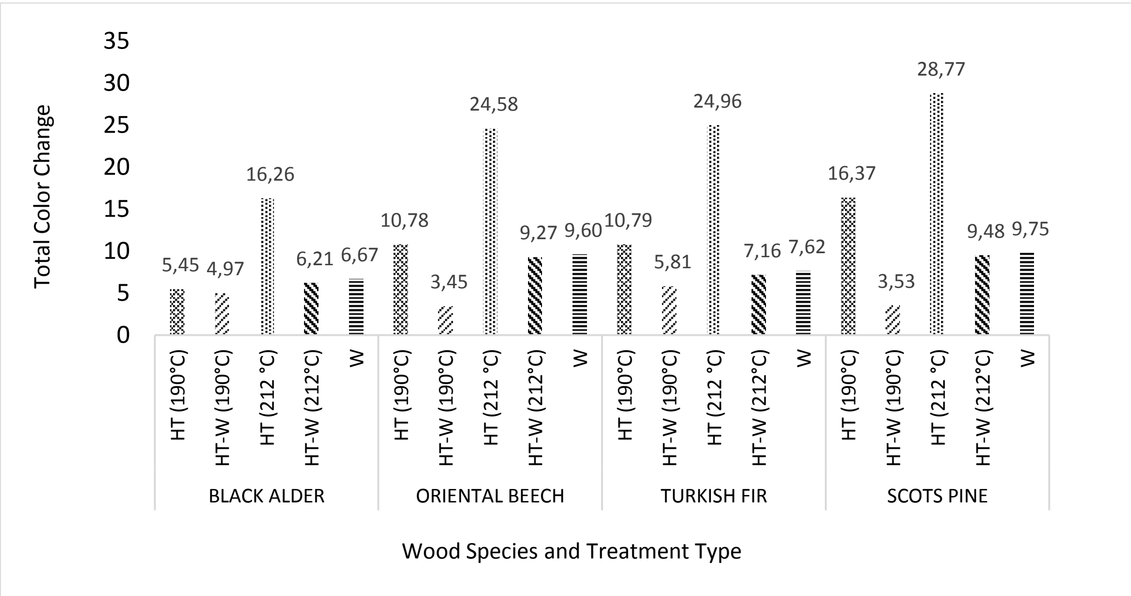

Figure 2 Isıl işlem görmüş-ısıl işlem görmemiş yaşlandırılmış-ısıl işlem görmüş yaşlandırılmış odun türlerinin toplam renk değişimi (The total color changes of heat treated (HT)– untreated weathered (W) – heat treated weathered (HT-W) wood species).

3.2.Color Change After Weathering

The original color of wood samples was noticeably changed by weathering and the lightness values increased (Figure 3). The total color change of heat treated samples after weathering decreased in comparison with the untreated wood samples at the end of the 288 hours (Figure 2). Generally, intensive heat treatment conditions caused green and blue hue after artificial weathering. The maximum total color change was obtained in Scots pine wood species.

Figure 3. Yaşlandırma öncesi ve sonrası örneklerin renk değişimleri (The color changes of the samples according to before and after weathering).

4. SONUÇ VE TARTIŞMA (CONCULUSION AND DISCUSSION)

The original color of wood samples was markedly altered by intensity of heat treatment conditions. This could be apparently seen from the negative ΔL^* values of samples. Different oxidative and/or hydrolytic discoloring reaction causes the color change during heat treatment (Sundqvist, 2002).

By the weathering the increase of ΔL^* indicated that the almost all heat-treated at temperature 212 °C and then weathered wood samples were getting darker. With the effect of weathering, the total color change decreased for heat-treated at temperature 190 °C weathered Oriental beech wood samples while it increased for heat-treated at temperature 212 °C weathered ones.

Heat treatment gives a uniform color stability to wood and this property is desirable. By the weathering the color of heat treated at temperature 190 and 212 °C samples changed less than untreated and weathered samples for all wood samples. There are several studies which are agree with this results on the color change of heat-treated and untreated wood (Ayadi et al., 2003; Temiz et al., 2006; Dubey et al., 2010).

Mostly the softwood species were affected more than the hardwood species from weathering. Because the amount of lignin is greater in the soft wood species than the hardwood species. Likewise, Kocaefe et al. (2013) indicated that with weathering a cyclic damage of heat-treated wood surface takes place process. Because lignin is more sensitive to irradiation than the other wood components.

Discoloration of wood surface was depending on combination of the photodegradation of lignin and extractives during UV irradiation. Moreover, color changes of heat treated wood species caused by irradiation were predicted to be due to increase in the amount of cellulose and decrease in amount of lignin and extractives content on wood surfaces (Ayadi et al., 2003).

These results of two hardwood species (Black alder and Beech) and two softwood species (Scots pine and Turkish fir) could serve as the basis for the performance of heat treated wood in outdoor conditions.

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