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날짜 2014. 5. 30.(Fri.) 13:00 - 18:00

장소 강원대학교 춘천캠퍼스 아산관

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주관 강원대학교 조형예술연구소, 산림과학연구소

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2014 한국가구학회 춘계 국제학술대회 연구논문 발표 / Thesis Presentation

좌장 | Chairs	시간 | Time	제목 | Title	발표자 | Researcher
Room A **김명태**	15:40 - 16:00	UV Printing을 이용한 스툴(Stool)디자인에 관한 연구 A Study on Stool Design Using UV Printing	노예지 (홍익대)
	16:00 - 16:20	색동우드 단판의 퇴색시험에 따른 색차 특성 Characteristics of color differences of rainbow-colored veneer by fading test	서진석 (국립산림과학원)
	16:20 - 16:40	스마트워크 환경에 따른 스마트체어 디자인에 관한 연구 A Study on Smart Chair Design for the Smart Work Environment	이효진 (홍익대)
	16:40 - 17:00	와이어로프(Wire rope)를 이용한 캔틸레버 의자디자인 연구 A Study on Cantilever Chair Design Using Wire Rope	황인환 (홍익대)
Room B **변희섭**	15:40 - 16:00	합판 단면 적층(積層)을 활용한 목쟁반 디자인에 관한 연구 A Study on Wood Tray Design Assembled with Cross Section of Plywood	박관우 (홍익대)
	16:00 - 16:20	신 탄화법을 이용한 무할렬 대나무 숯잔의 제조 Manufacturing of crack-free charcoal cup from bamboo by new carbonization method	박상범 (국립산림과학원)
	16:20 - 16:40	실내건축재료와 황토처리 탄화보드의 흡방습 특성 연구 Study on humidity control characteristic of indoor finishing materials and nano-loess treated carbonized board	이 민 (국립산림과학원)
	16:40 - 17:00	평철(平鐵)의 탄성을 활용한 안락의자 디자인 연구 A Study on Lounge Chair Design Using Metal Resiliency	조환수 (홍익대)
Room C **김정호**	15:40 - 16:00	황장목의 해부 및 물리적 특성 Anatomical and physical characteristics of Hwangjang-mok (Pinus densiflora for. Erecta Uyeki)	이애희 (강원대)
	16:00 - 16:20	Physical and Colorimetric Changes in Okan (Cylicodiscus gabunensis) Wood After Heat-Treated at different Temperature	장재혁 (강원대)
	16:20 - 16:40	화재로부터 안전한 목재가구 방염처리 Flame retardant treatment for wooden furniture	손동원 (국립산림과학원)
	16:40 - 17:00	Effects of wood main components on feeding activity of termite	이한솔 (국립산림과학원)
	17:00 - 17:20	Graphite 개질 방법에 따른 난연 성능 발현에 대한 연구	서현정 (숭실대, 국립산림과학원)

Physical and Colorimetric Changes in Okan (Cylicodiscus Gabunensis) Wood After Heat-Treated at Different Temperature

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1. Introduction

Thermal modification is a treatment performed at elevated temperatures (160-260°C) during a short time in an environment free from oxygen or with low oxygen content using steam, inert gas (nitrogen), or oil (Boonstra *et al.*, 1998; Sailer *et al.*, 2000; Kocaefe *et al.*, 2008). Heat-treated wood has a growing market in outdoor applications like exterior cladding, window and door joinery, garden furniture and decking. There are also many indoor applications for heat-treated wood such as flooring, panelling, kitchen furnishing and interiors of bathrooms and saunas (Viitaniemi, 2000). Many researches have reported the effect of heat treatment on properties of temperate wood species which are mainly use for industrial-scale heat treatment in Europe such as scots pine, norway spruce birch, aspen, and alder (Yildiz, 2002; Bekhta and Niemz, 2003; Johansson and Moren, 2006; Esteves *et al.*, 2007; Kocaefe *et al.*, 2008; Pena and Hale, 2009).

Their studies revealed that heat treatment can reduce wood hygroscopy, improve wood dimensional stability and durability without any toxic chemicals. Previous researches were also stated that one of the important effect of wood heat treatment is the change in wood color. However, up to now there is limited or no information on properties of heat-treated wood from tropical species. Therefore the objective of this study is to evaluate the physical properties and color changes of Okan wood *(Cylicodiscus gabunensis)* which belong to tropical wood species after heat-treated at different temperature.

2. Materials and Methods

2.1. Materials

Heat-treated wood were prepared from sapwood and heartwood part of Okan (*Cylicodiscus gabunensis* (Taub.) Harms) wood obtained from Africa tropical rainforest. The samples dimensions were 300 mm x 90 mm x 20 mm in length, width and thicknes respectively.

In this experiment only sample with good orientation, small variation in density, and absence of defects were prepared. The samples were heat-treated in a modified electric kiln (L-Series, JEIO TECH Ltd., Korea) in low presence of oxygen by using inert gas (nitrogen). The samples were heat-treated at 160°C, 180°C, 200°C, and 220°C for 2 hours, and one untreated sample was used as control. After the treatments, the samples were placed in conditioning room at temperature of 25°C and 40% of relative humidity until the physical properties and colorimetric evaluation.

2.2. Methods

The weight and dimension of samples before and after heat treatment were measured to determine the weight and and density reduction according to KS F 2198 as a standar for determining the density and specific gravity of wood (Korean Industrial Standards, 2011). The colorimetric evaluation was performed by using CIE-L*a*b* system as method to determine wood color (Commission International de L'Éclairage). Four measurements of each sample images before and after heat treatment were taken by using Photoshop CS4 (Adobe Systems Incorporated USA, 2008) to obtain L*, a* and b* color values. The Δ E* (color difference between heat-treated and control samples was measured through following equation:

$$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

Where: Δ E = color difference between heat-treated and control samples; Δ L*, Δ a*, Δ b* = lightness, red-green coordinate and yellow-blue coordinate variation, respectively; L* = lightness; a* = red (+) – green (-) color coordinate; b* = yellow (+) – blue (-) color coordinate.

The anatomical structure of the samples were also examined using scanning electron microscope (JEOL, JSM-5510). Micrographs were taken from the cross section of the control and heat-treated samples with size of 0.5 cm by 0.5 cm to detect the changes in the wood cell structures. The samples were put under vacuum chamber and coated with a thin layer of gold by an ion sputter coater for 2 minutes.

3. Results and Discussion

3.1. Physical Properties

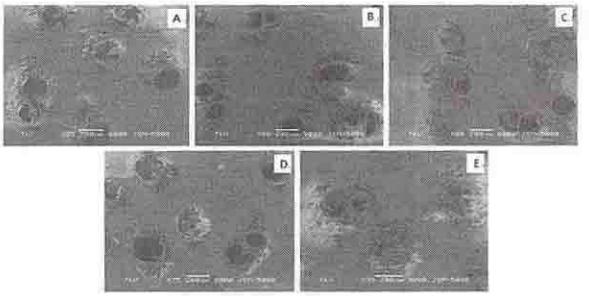
Wood Region	Treatment	Weight (g)	Weight loss (%)	Density (g/cm^3)	Density reduction (%)
Sapwood	Control	201.29	7.84	0.76	3.62
	160°C	185.50		0.74	
	Control	188.45	8.03	0.71	3.33
	180°C	173.32		0.69	
	Control	197.87	9.12	0.75	3.87
	200°C	179.83		0.72	
	Control	197.06	15.69	0.77	6.92
	220°C	166.14		0.71	
Heartwood	Control	295.20	7.95	1.10	1.97
	160°C	271.78		1.07	
	Control	287.12	9.88	1.09	3.05
	180°C	258.79		1.05	
	Control	293.29	10.37	1.10	2.73
	200°C	262.87		1.07	
	Control	290.91	13.08	1.09	4.04
	220°C	252.86		1.05	

<Table 1.> Physical properties of *Cylicodiscus gabunensis* before and after heat-treated at different temperatures for 2 hours

Table 1 displays some physical properties of the samples. The results showed that heat-treatment significantly reduced weight and density of samples. Weight loss was significantly increased with increasing temperature. However, density reduction between different temperature was not significantly different.

Weight and density reduction can be explained by typical micrographs taken from the cross sections of control samples and heat-treated samples presented in Figure 2. It is clear that high temperature treatment caused shrinkage and certain damage on cell wall of samples. Esteves and Pereira (2009) stated that during the heat treatment process, extractives, hemicellulose and a part of cellulose molecules in the amorphous regions are degraded due to high temperature. This causes the chemical changes of the wood; or in other words, the basic components of the wood cell wall structure are changed in their number and

dimension, leading to the reduction in dimension and weight of the wood after heat-treated.



<Fig 2.> SEM images of sapwood part of *Cylicodiscus gabunensis* samples heat-treated at different temperatures:
(A) Control; (B) 160oC; (C) 180oC; (D) 200oC; (E) 220oC

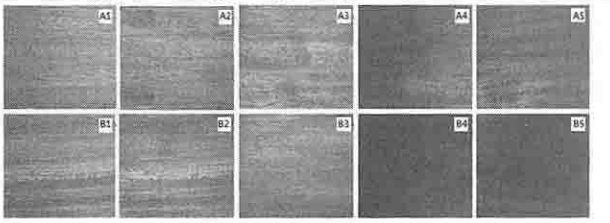
3.2. Color changes

Table 2 summarizes the color parameters of *Cylicodiscus gabunensis* before and after heat-treated at different temperatures for 2 hours. It appears that wood species significantly influenced lightness (L*) and yellow-blue color coordinate (b*) properties. All the wood samples showed a darker tone for all heat-treatment temperature, with the maximum lightness reduction (Δ L*) and yellow-blue color coordinate (b*) obtained on sapwood samples heat-treated at 220°C. Darkening as a result of heat treatment was clearly visible and it increased with increasing temperature as seen in Figure 2.

The highest color difference (Δ E) value was 49.70 for sapwood and 39.30 for heartwood after heat-treated at 220°C for 2 hours. Results of this study are compatible with the other researchs results. Shi *et al.* (2011) stated that heat treatment resulted in a darkening of wood tissues and the color became dark with temperature increase. Their study also revealed that the effect of treatment temperature on color change in sapwood is more obvious than that in heartwood as occured in this study. According to Ishiguri *et al.*, (2003), the discoloration is related to the migration and volatilization of color extract in the heating process, or the rapid oxidation of lignin and some chemical element in high temperature.

<Table 2.> Color parameters of *Cylicodiscus gabunensis* before and after heat-treated at different temperatures for 2 hours

Wood Region	Treatment	L	a	b	DL	Da	Db	DE
Sapwood	Control	65.25	3.75	37.75	7.50	-1.50	3.00	8.22
	160°C	57.75	5.25	34.75				
	Control	75.75	0.25	40.25	18.50	-8.00	7.50	21.51
	180 °C	57.25	8.25	32.75				
	Control	68.50	0.75	36.25	16.75	-5.50	24.75	30.39
	200 °C	51.75	6.25	11.50				
	Control	70.00	2.50	45.75	24.00	1.50	43.50	49.70
	220 °C	46.00	1.00	2.25				
Heartwood	Control	54.25	11.25	28.63	16.13	5.25	6.63	18.21
	160	38.13	6.00	22.00				
	Control	55.75	6.63	23.50	7.75	5.00	19.00	21.12
	180 °C	48.00	1.63	4.50				
	Control	61.63	9.75	31.38	23.13	8.25	26.25	35.94
	200 °C	38.50	1.50	5.13				
	Control	60.38	8.88	33.25	21.00	9.75	31.75	39.30
	220 °C	39.38	-0.88	1.50				



<Fig 1.> Color change of sapwood part (A) and heartwood part (B) of *Cylicodiscus gabunensis* before and after heat-treated at different temperatures: (1) Control; (2) 160℃; (3) 180℃; (4) 200℃; (5) 220℃

4. Conclusion

This work investigated the effect of heat treatment on physical properties and color change of sapwood and heartwood part of Okan wood (*Cylicodiscus gabunensis*). Based on the findings in this work, weight loss increased by increasing heat temperature. Density of samples after heat treated were also decreased as compared to control. Color changes was significantly affected by heat treatment, higher treatment temperatures result in darker wood color. Furthermore the effect of treatment temperature on color change in sapwood is more obvious than that in heartwood.

Acknowledgement

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