ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 11 N° 4 2015
pp. 373-376

WETTABILITY CHARACTERISTICS OF *WILD CHERRY WOOD* MODIFIED BY THERMOWOOD TECHNOLOGY

Ayhan AYTIN
Duzce University, Duzce Vocational School
Program of Furniture and Decoration, 81100 Duzce, Turkey
Tel: 0090 380 5240100, Fax: 0090 380 5240097, E-mail: ayhanaytin@hotmail.com

Suleyman KORKUT
Duzce University, Faculty of Forestry
Department of Forest Industry Engineering, 81620 Duzce, Turkey
E-mail: suleymankorkut@hotmail.com

Oner UNSAL
Istanbul University, Faculty of Forestry
Department of Forest Products Engineering, 34473 Istanbul, Turkey
E-mail: onsal44@hotmail.com

Zeki CANDAN
Istanbul University, Faculty of Forestry
Department of Forest Products Engineering, 34473 Istanbul, Turkey
E-mail: zekic@istanbul.edu.tr

Hızır Volkan GÖRGÜN
Istanbul University, Faculty of Forestry
Department of Forest Products Engineering, 34473 Istanbul, Turkey
E-mail: volkan.gorgun@istanbul.edu.tr

Abstract

It is well known that there are various thermal modification methods in the world and some of those methods have been registered such as ThermoWood, Perdure, Plato, and Menz Holz. All these methods have some major differences such as process conditions, wet or dry process, steering schedules, process steps, atmosphere (oxygen or nitrogen), steaming, and use of oil. Major aims of the thermal modification methods are to improve dimensional stability, durability, equilibrium moisture content, permeability, and surface quality. The main objective of this research was to investigate the effects of the thermal modification process by ThermoWood technology on the wettability characteristics of the wood. The experimental wood materials were cut from wild cherry wood (Cerasus avium (L.) Monench). The wood specimens were subjected to thermal modification at temperature of 190°C or 212°C for 60, 90, 120, or 150min. Contact angle measurements were obtained using a goniometer system connected to a digital camera and computer system. The results clearly showed that the surface wettability properties of the thermally modified wood materials by ThermoWood technology were significantly affected by the process temperature or time. The wettability measurements indicated that the contact angle values of the wood materials increased with the thermal modification. The results acquired in this work provide important information for future research and utilization of the thermally modified wood materials.

Key words: *ThermoWood technology; surface wettability; contact angle; thermal modification; wood.*

INTRODUCTION

The environmental impact caused by biocides and preservatives, as well as by cumulative disposal of treated and waste woods, is one of the reasons why researchers around the world have been investigating alternative methods of wood management and preservation (Barnes and Murphy 1995). One of these approaches is to study how the thermal treatment used in the wood manufacturing industry affects some of the natural characteristics of woods, including durability, shape stability, and discoloration, which are mainly caused by loss of extractives and/or effects of chemical degradation. In the heat-treatment process, wood is heated to temperatures of 160-250^{0}C, usually above 200^{0}C depending on the species used and the desired material properties (de Oliveira et al. 2010).

Understanding the surface modification of wood that takes place by heating is extremely important, in particular for industrial application, since properties such as surface quality, dimensional stability and/ or anisotropy factor may change drastically. The temperature induces various changes in the surface of wood, thus decreasing its hydrophilic characteristics and, consequently, wettability, an important characteristic to be evaluated when water-based color coatings are intended to be used to protect and recover surfaces (de Oliveira et al. 2010).

The wood is expected to become more hydrophobic with increasing heat-treatment temperature; consequently, the contact angle will increase due to the chemical changes taking place (Kocaefe et al. 2008). Hakkou et al. (2005) suggest that the change in wettability might be due to the modification of conformational arrangement of wood biopolymers as a result of residual water or plasticization of lignin. Gérardin et al. (2007) used contact angles to evaluate the surface energies of heat-treated pine and beech wood and related hydrophobic behavior of wood to hemicelluloses degradation.

Wild cherry *(Cerasus avium* (L.) Monench*)* is a deciduous tree that grows to a height of 15-30m, with a trunk diameter up to 1.5m. *C. avium* is native to Europe, western Turkey, and northwestern Africa. Its wood is hard, reddish brown, and widely used for wood turning, manufacturing cabinet, veneer, and musical instruments (Esen et al. 2005). Recently, the use of wild cherry wood has grown in popularity in Turkey and surrounding countries due to high demand for this species (Korkut and Aytin 2015).

Various techniques exist for the measurement of wood wettability. In this work we study the wettability of heat-treated wild cherry wood using a goniometer system. Contact angle measurements by the contact angle goniometer before and after treatment allow us to measure the wettability. The results are compared with these of the untreated species.

OBJECTIVE

The main objective of the present research was to evaluate the effects of the thermal modification process by ThermoWood technology on the wettability characteristics of the wild cherry wood.

MATERIAL, METHOD, EQUIPMENT

The two sample trees of wild cherry wood (*Cerasus avium* (L.) Monench) used for the present study were harvested from a mixed oak-hornbeam wild cherry stand in the Duzce Forest Enterprises, western part of Turkey.

Ten Boards which are 80mm in thickness sawn and sawdust immediately removed from surfaces. Then, boards were heat-treated. Small and defect-free specimens (10 x 50 x 50mm) were cut from the boards to determine wettability.

Thermal Modification

Heat treatment was carried out under steam atmosphere with a laboratory kiln from Nova ThermoWood in Gerede, Turkey. Steam is used during the drying and heat treatment as a protective vapor. The heat treatment was applied according to the method described in the Finnish ThermoWood Handbook (ThermoWood Handbook 2003). Experimental design of the samples was shown in Table 1.

Table 1

Thermal modification process parameters for experimental groups

Sample types	Temperature (^{0}C)	Time (min.)
Control		
A	190	60
B	190	120
C	212	60
D	212	90
E	212	120
F	212	150

Determination of Wettability

Contact angle tests were carried out to determine wettability characteristics of the thermally modified or unmodified wild cherry wood. The contact angle values were defined as the angle through

the liquid phase formed between the surface of a solid and the line tangent to the droplet radius from the point of contact with the solid. The contact angle values were obtained by using a goniometer system connected with a digital camera and computer system (KSV Instrument, Finland) (Fig. 1). The liquid employed for the measurements was 5µL of distilled water at 20°C with a surface tension of 72.80mN/m. The contact angle value was determined for each image by digital image analysis software. The image was captured immediately after the droplet of distilled water was placed on the thermally modified or unmodified wild cherry wood surface, and then every 1 second for duration of 60 seconds. The mean contact angle value and the standard deviation for each sample were calculated from 60 photo images. A total of 98 test samples, 14 samples for each treatment, were used for the contact angle tests.

Fig. 1.
Wetting measurements

Statistical Analyses

For the wettability, all multiple comparisons were first subjected to an analysis of variance (ANOVA) at $p<0.05$ and significant differences between mean values of the treated and untreated groups were determined using Duncan's multiple range test.

RESULTS AND DISCUSSION

The contact angle values of the thermally modified wild cherry wood at each exposure condition are presented in Table 2. Significant differences ($p<0.05$) between all groups were found to exist as determined by Duncan‘s multiple-comparison tests. Not only the average values changed significantly but also the changes were significant in ANOVA and Duncan’s multiple range test results.

Table 2

Wettability results of the wood samples

Sample types	Wettability CA (°)	Duncan's grouping
Control	51.675 (16.473)	d
A	62.673 (12.124)	bdef
B	66.229 (10.827)	adef
C	50.542 (9.805)	e
D	44.030 (10.824)	f
E	74.442 (12.302)	a
F	60.613 (12.895)	cef

Values in parentheses are standard deviation.

The results acquired in this study indicated that the wettability property of the wood samples decreased with increasing thermal treatment temperature. The contact angle values all of treated wood samples were higher than those of the untreated wood samples except group C.

The highest contact angle values were around 74.442 for wild cherry wood heat-treated at 212ºC for 120min. while the contact angle values of control specimens for wild cherry wood were around 51.675. The average contact angle values of the panels treated with temperature of 190 C for 60min. were 2% higher than those of the control samples, followed by the wood samples treated with temperature of 190 C for 120min. (28% higher) and 212 C for 120min. (44% higher).

The contact angle measurements showed that thermal treatment had a significant influence on the surface wettability of the treated wood samples. The increase in contact angle for the wood samples could be due to as a decrease in hydrophilicity. The surface of wood modified with thermal treatment is less polar and thus repels water, resulting in a lower wettability than in the case of unmodified wood (Christiansen 1990; Christiansen 1994). It is well known that surface wettability is a function of surface roughness, and surfaces for which wetting is nearly zero are said to exhibit super-hydrophobicity (Mittal 2008).

These properties can be compared with the results of other studies (Unsal et al. 2010; Candan et al. 2012) in literature which are related to the effects of different durations on wettability of wood-based composites and panel products. Unsal *et al.* 2010 reported that the thermally modified OSB panels had greater contact angle values than those of the unmodified panels. It was concluded that the modification resulted in a poorer wettability.

CONCLUSIONS

The results obtained within the present research demonstrated that the contact angle values of the wild cherry increased for the heat treatment times studied compared to the contact angle values of their untreated counterparts. Therefore, the wettability properties of the treated wood samples were lower than those of the untreated wood samples. Using the thermal modification method, the wood samples could be obtained which have more hydrophobic characteristics for outdoor application.

REFERENCES

Barnes HM, Murphy RJ (1995) Wood preservation: the classics and the new age, Forest Products Journal, 45:16-23.

Candan Z, Buyuksari U, Korkut S, Unsal O, Cakicier N (2012) Wettability and surface roughness of thermally modified plywood panels, Industrial Crops and Products, 36(1):434-436.

Christiansen AW (1990) How overdrying wood reduces its bonding to phenol formaldehyde adhesives: a critical review of the literature. Part I. Physical responses, Wood Fiber Sci., 22:441-459.

Christiansen AW (1990) Effect of overdrying of yellow-poplar veneer on physical properties of and bonding, Holz als Roh- und Werkstoff, 52:139–149.

De Oliveira RM, Brisolaria A, Sales A, Gonçalves D (2010) Wettability, Shrinkage and Color Changes of Araucaria angustifolia After Heating Treatment, Materials Research, 13(3):351-354.

Esen D, Yildiz O, Kulaç S, Sarginci M (2005) Neglected valuable leafy type of Turkey's forests: Wild cherry, (*Cerasus avium* (L.) Monench) or syn. *Prunus avium* L.). J Chamber of Forest Engineer (TBMMO), 2:18-22.

Gérardin P, Petric M, Petrissans M, Lambert J, Ehrhrardt JJ (2007) Evolution of Wood Surface Free Energy after Heat Treatment. Polym. Degrad. Stabil. 92:653-657

Hakkou M, Petrissans M, Zoulalian A, Gérardin P (2005) Investigation of Wood Wettability Changes During Heat Treatment on the Basis of Chemical Analysis. Polym. Degrad. Stabil. 89:1–5.

Kocaefe D, Poncsak S, Doré G, Younsi R (2008) Effect of heat treatment on the wettability ofwhite ash and softmaple by water, Holz als Roh- und Werkstoff, 66:355–361.

Korkut S, Aytin A (2015) Evaluation of physical and mechanical properties of wild cherry wood heat-treated using the ThermoWood process, MADERAS: Ciencia y tecnología, 17(1):171-178.

Mittal K (2008) Contact Angle, Wettability, and Adhesion, vol. 5Brill Publications, Leiden-Netherlands, 308 p.

Unsal U, Candan Z, Buyuksari U, Korkut S, Babiak M (2010) Effects of thermal modification on surface characteristics of OSB panels, Wood Res., 55(4):51–57.

ThermoWood Handbook (2003) Finnish Thermowood Association c/o Wood Focus Oy, P.O. Bo284 (Snellmaninkatu 13), FIN-00171 Helsinki, FINLAND.