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Surface Wettability of Wood Species from Tropical and Temperate Zones by Polar and Dispersive Liquids

Kvašenje površine drva iz tropskih i umjerenih zona polarnim i disperzivnim tekućinama

Original scientific paper • Izvorni znanstveni rad
Received – prispjelo: 20. 1. 2017.
Accepted – prihvaćeno: 1. 12. 2017.
*UDK: 630*812.24*
doi:10.5552/drind.2017.1704

ABSTRACT • *Wood species from Africa, South America and Europe, primarily used as a flooring and construction material, were acquired for the study. Wettability was determined using the measurement of the contact angle of wood with the reference liquids (water, diiodomethane) based on the sessile drop method. Surface free energy of wood on tangential sections within first 60 s after applying a drop was determined. Among the species from the tropical zone, the greatest hydrophobicity, similar to oak wood, was characteristic for courbaril wood. After 60 s, the value of the surface free energy for the heartwood of the studied species was between 60 and 70 mJ·m*$^{-2}$*, while for the sapwood of pine and birch, it was about 80 mJ·m*$^{-2}$*. The biggest changes in the work of adhesion, within 60 s after the application of a drop of water on the surface of the wood, was stated for pine sapwood, and the smallest one for tauari and courbaril wood.*

Keywords: *contact angle, diiodomethane, surface free energy, water, wettability*

SAŽETAK • *Istraživanje je provedeno na vrstama drva rasprostranjenima u Africi, Južnoj Americi i Europi, ponajprije na onima koje se upotrebljavaju kao materijal za podove i za gradnju. Kvašenje drva određeno je mjerenjem kontaktnog kuta drva s referentnim tekućinama (vodom, dijodometanom) postupkom kapanja. Utvrđena je površinska slobodna energija na tangencijalnom presjeku drva unutar prvih 60 s nakon nanošenja kapi. Među vrstama drva iz tropske zone najveću je hidrofobnost, sličnu onoj koju ima hrastovo drvo, pokazalo drvo jatobe. Vrijednost slobodne površinske energije za srževinu ispitivanih vrsta drva nakon 60 s bila je između 60 i 70 mJ·m*$^{-2}$*, dok je za borovinu i brezovinu bila oko 80 mJ·m*$^{-2}$*. Najveće promjene zbog djelovanja adhezije unutar 60 s od nanošenja kapljice vode na površinu drva zabilježene su za borovinu, a najmanje za drvo brazilskog hrasta i drvo jatobe.*

Ključne riječi: *kontaktni kut, dijodometan, slobodna površinska energija, voda, kvašenje*

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1 INTRODUCTION
1. UVOD

Wood, as an organic material, is built of carbohydrates (ca. 70 %), i.e. cellulose and hemicelluloses, which are compounds with a relatively large quantity of polar hydroxyl groups -OH in their structure (Požgaj *et al*., 1993; Gindl *et al*., 2004). For that reason, wood shows high affinity for water. This property of wood is described by a number of parameters including adsorption, desorption, swelling, water absorption, wettability expressed by the measurement of the contact angle (Mantanis *et al*., 1994; Wolkenhauer *et al*., 2009; Buyuksari *et al*., 2011; Dündar *et al*., 2012; Hill *et al*., 2012).

An important variable that allows the determination of the ability of wood to interact with liquids is the measurement of the wettability expressed through the contact angles for different types of reference liquids (De Meijer *et al*., 2000; Gindl *et al*., 2001; Wolkenhauer *et al*., 2009). The difficulties associated with it result from the fact that wood, as porous material, varies in terms of morphological and chemical structure, having different properties within and between species. Studies carried out so far (Zhang *et al*., 1997; Kúdela, 2014; Rolleri *et al*., 2016) show that the wettability of wood shows a significant differentiation depending on the chemical composition, roughness, polarity of the wetting liquid, processing method and air parameters. Wood wettability is also significantly affected by thermal treatment (Gérardin *et al*., 2007; Kocaefe *et al*., 2008) or fungicide protection, among others (Fuczek *et al*., 2010).

Liptáková and Kúdela (1994) and Kúdela (2014) determined the contact angle after the separation of a drop of liquid from the needle (t = 0 s) and in the equilibrium state at the phase boundary wood-liquid. Huang *et al.* (2012) varied the time of determining the contact angle of jack pine wood (*Pinus banksiana* Lamb.) depending on the type of the reference liquid. Authors studied the contact angle of wood with water for 50 s, with ethylene glycol for 10 s and with formamide for 1 s, while maintaining the appropriate intervals between the measurements. Santoni and Pizzo (2011) studied the contact angle of Mediterranean wood species with water at intervals of 0.3 s for 150 s. Kocaefe *et al*. (2008) marked the contact angle of white ash (*Fraxinus americana*) and soft maple (*Acer rubrum*) before and after heat treatment within 30 s. Due to the dynamics of changes, the more rational solution is to define the contact angle of wood with water for a specified period of time. This makes it possible to determine more complete wettability characteristics of wood. Wettability of wood is described by a number of parameters, of which the most studied and analysed are contact angle and surface free energy. Only a few authors examine wetting energy, spreading coefficient of reference liquid, work of adhesion for the phase boundary wood-liquid, surface tension of the liquid (Zhang *et al*., 1997; Kocaefe *et al*., 2008; Wolkenhauer *et al*., 2009; Gonzalez de Cademartori *et al*., 2015).

The aim of this study was to determine the wettability of wood species from Africa, South America and Europe used mainly as flooring and construction materials. Important aspect of the study was to determine the dynamics of changes in parameters describing the phenomenon of wood wettability.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

Wood species selected for the study are used to manufacture flooring materials and construction elements according to EN 1912:2012+AC (2013). Table 1 summarizes the basic information about the studied species of wood. Surfaces of wood samples were finished by planing. After conditioning the samples to an air-dry condition in accordance with the recommendations of ISO 13061-1 (2014), wood density was determined using a stereometric method in accordance with the requirements of ISO 13061-2 (2014). Wood moisture content was determined according to ISO 13061-1 (2014).

Contact angles of wood with reference liquids were studied in a goniometer Phoenix 300 of Surface

Table 1 Investigated species of wood
Tablica 1. Istraživane vrste drva

Latin name *Latinski naziv*	**Trade name of wood (and code) according to EN-13556 (2003)** *Trgovački naziv (i kôd) prema EN-13556 (2003)*	**Occurrence** *Podrijetlo vrste*	**Structure of wood** *Građa drva*
Afzelia africana Smith ex. Pers.	afzelia (AFXX) / *afzelija*	Africa / *Afrika*	deciduous *listača* diffuse-porous *difuzno porozno drvo*
Betula pendula Roth	European birch (BTXX) *obična breza*	Europe / *Europa*	
Couratari multiflora (J.E. Smith) Eyma	tauari (CIXX) / *brazilski hrast*	South America *Južna Amerika*	
Hymenea courbaril L.	courbaril (HYCB) / *jatoba*	South America *Južna Amerika*	
Khaya ivorensis A. Chev.	African mahogany (KHXX) *afrički mahagonij*	Africa / *Afrika*	
Pinus sylvestris L.	Scots pine (PNSY) / *obični bor*	Europe / *Europa*	coniferous / *četinjača* sapwood / *bjeljika*
Quercus robur L.	European oak (QCXE) *hrast lužnjak*	Europe / *Europa*	deciduous / *listača* ring-porous *prstenasto porozno drvo*

Table 2 Surface tension components of reference liquids (Gindl *et al.*, 2001)
Tablica 2. Komponente površinske napetosti referentnih tekućina (Gindl *et al*., 2001.)

Liquid *Tekućina*	**Property** / *Svojstvo*		
	Surface tension / *Površinska napetost* mJ·m^{-2}	Dispersive / *Disperzivnost* mJ·m^{-2}	Polar / *Polarnost* mJ·m^{-2}
water (H_2O) / *voda*	72.80	21.90	51.00
diiodomethane (CH_2I_2) *dijodometan*	50.80	50.80	0.00

Electro Optics company (Suwon City, Korea), based on a "sessile" drop method. The volume of the drop applied to the surface of wood (tangential section) was 3 µl. Two reference liquids were used for the study: water and diiodomethane (Table 2).

Based on the conducted studies, work of adhesion for the phase boundary wood-water was determined. Surface free energy of wood species selected for the study was determined using the Owens-Wendt method (Owens and Wendt, 1969) based on Young's equation:

$$\sigma_S = \gamma_{SL} + \sigma_L \cdot \cos\theta \tag{1}$$

where: σ_S is the total surface free energy of the solid (mJ·m^{-2}), γ_{SL} is the interfacial tension between solid and liquid, σ_L is the surface tension of the liquid, and θ is the contact angle (°).

The total surface energy (σ_S) is divided into a dispersive part (σ^D) and a polar part (σ^P) according to the equation:

$$\sigma_S = \sigma^D + \sigma^P \tag{2}$$

The interfacial tension between solid and liquid is described by the equation:

$$\gamma_{SL} = \sigma_S + \sigma_L - 2 \cdot \left(\sqrt{\sigma_S^D \cdot \sigma_L^D} + \sqrt{\sigma_S^P \cdot \sigma_L^P}\right) \tag{3}$$

where: σ_L^D and σ_L^P are dispersive and polar parts of liquid, respectively; σ_S^D and σ_S^P are dispersive and polar parts of solid, respectively.

The work of adhesion (W_{SL}) is determined by the equation:

$$W_{SL} = \sigma_S + \sigma_L - \gamma_{SL} \tag{4}$$

In order to obtain an optimal adhesion, the work of adhesion must achieve the maximum value. This occurs when the interfacial tension (γ_{SL}) is 0. Good adhesion is obtained if the dispersive and polar parts of the solid and liquid phases are in the right ratio, because only dispersive - dispersive and polar - polar interactions occur (Wolkenhauer *et al*., 2009). Therefore, the work of adhesion can be divided into a dispersive and a polar part according to the equation:

$$W_{SL} = W_{SL}^D + W_{SL}^P \tag{5}$$

where:

$$W_{SL}^D = 2\sqrt{\sigma_L^D \cdot \sigma_S^D} \tag{6}$$

$$W_{SL}^P = 2\sqrt{\sigma_L^P \cdot \sigma_S^P} \tag{7}$$

Values of the contact angle were determined 1, 2, 3, 10, 20, 30, 40, 50 and 60 s after the application of a liquid drop on the surface of the wood and by extrapolating within 0 s. Surface free energy of investigated wood species and components of the surface free energy - polar, dispersive, work of adhesion were determined after 60 s. Studies were performed after 24 h from the sample preparation. Statistical analysis was performed using STATISTICA version-12 software of StatSoft, Inc. Statistical analysis of the test results was carried out at the significance level of 0.050. For other studied parameters, trend lines were determined, and the parameters for the equation of the curve (y) and the coefficients of determination R^2 were provided.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

According to ISO 13061-2 (2014), the density of wood from the tropical zone was as follows: African mahogany 562 kg·m^{-3} (±24), afzelia 717 kg·m^{-3} (±21), courbaril 847 kg·m^{-3} (±5), tauari 844 kg·m^{-3} (±16), and the density of wood from the temperate zone was as follows: European birch 635 kg·m^{-3} (±21), Scots pine (sapwood) 495 kg·m^{-3} (±9), European oak (heartwood) 758 kg·m^{-3} (±84). The wood moisture content ranged from 6.53 % (±0.12) to 6.82 % (±0.25) in case of all tested wood species. The density of the tested wood species was typical, showing at the same time the typical variability of the property. For example, according to the study of Sekhar and Negi (1960), carried out on 250 logs from 50 different wood species, density variation coefficient within a single species of wood in an air-dry condition averaged to about 6 %. In the standard ISO 3129 (1979), an average value of 10 % was assumed for a typical variation coefficient of wood density.

A statistically significant correlation was established between density and contact angle for wood-water relations and between density and contact angle for wood-diiodomethane relations ($p = 0.00001$). However, if we tried to describe these relationships by the linear regression model, the values of the coefficient of determination would be low. The R^2 value for the relationship between density and contact angle for wood-water was 0.517, and for the relationship between density and contact angle for wood-diiodomethane, it was 0.394 (Figure 1).

The difference between the wettability of softwood (Scots pine) and hardwood (African mahogany, afzelia, birch, courbaril, European oak, tauari) species was demonstrated. This difference was statistically significant (Table 3). The variability of contact angle is most likely the result of different anatomical structure and chemical composition (non-structural compounds

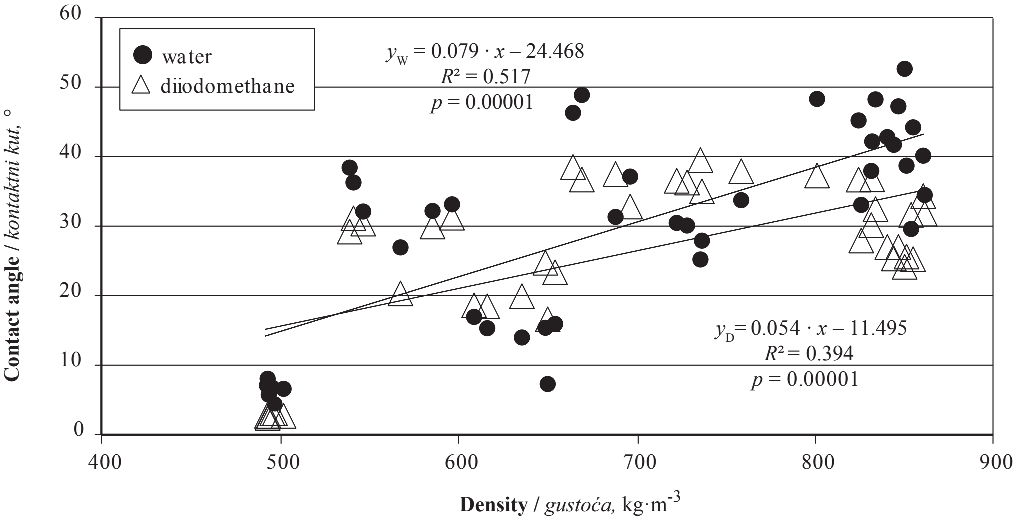
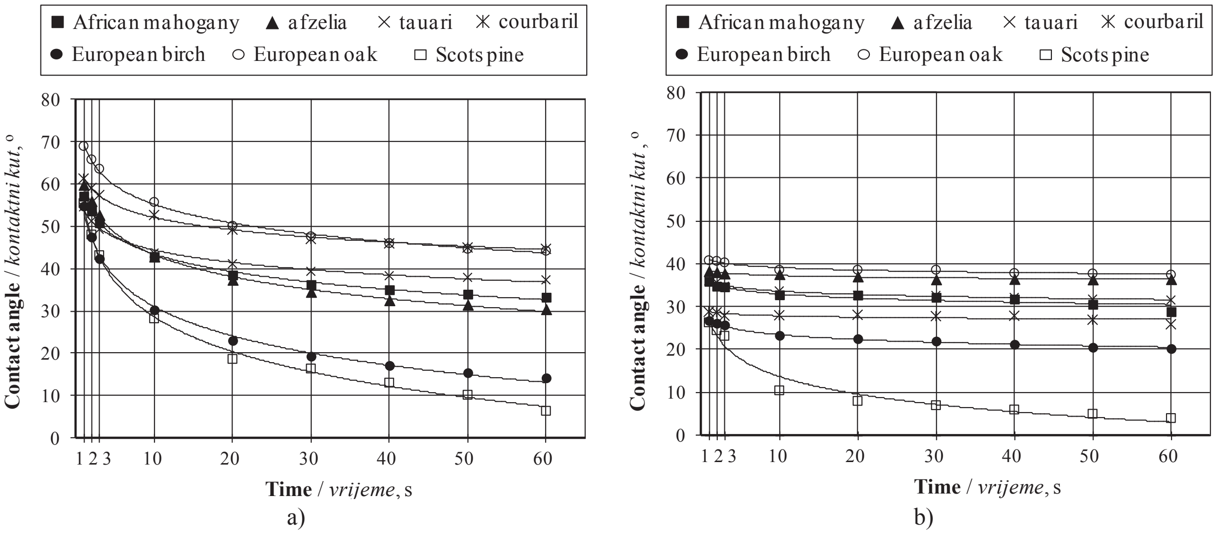


Figure 1 Relationship between density and contact angle determined 60 s after application of a liquid drop on wood surface
Slika 1. Odnos između gustoće i kontaktnoga kuta određen 60 s nakon nanošenja kapi tekućine na površinu drva

Table 3 Results of statistical analysis (t - test) for contact angle and surface free energy determined 60 s after application of a liquid drop on wood surface
Tablica 3. Rezultati statističke analize (*t*-test) za kontaktni kut i slobodnu površinsku energiju utvrđeni 60 s nakon nanošenja kapi tekućine na površinu drva

Wood species *Vrsta drva*	**Contact angle** / *Kontaktni kut*				**Surface free energy** *Slobodna površinska energija*	
	wood - water *Drvo - voda*		wood - diiodomethane *Drvo - dijodometan*			
	Statistical measures					
	t	*p*	*t*	*p*	*t*	*p*
softwood vs. hardwood *drvo četinjača vs. drvo listača*	-4.384760	0.000097	-10.099300	0.000000	3.634960	0.008343
Wood area / *dio drva*						
sapwood vs. heartwood *bjeljika vs. srževina*	-11.825300	0.000000	-9.151830	0.000000	7.778898	0.000109

content), different surface structure and thus different roughness of particular wood species (Liptáková *et al.*, 1995; Wolkenhauer *et al.*, 2009). The value of the contact angle depends primarily on whether it takes place through the heartwood (African mahogany, afzelia, courbaril, European oak, tauari) or sapwood (birch and pine) (Table 3). This was due to the fact that sapwood has an open structure for conducting water. In the cell walls of sapwood, the pits are open. Furthermore, the increased wettability of this area is determined by the presence of living unlignified parenchyma cells of wood and wood rays. The results obtained for pine sapwood and heartwood of hardwood species were confirmed in previous research. Santoni and Pizzo (2011),



a) b)

Figure 2 Contact angles at phase boundary wood-water (a), wood-diiodomethane (b)
Slika 2. Kontaktni kutovi na granici drva i vode (a), drva i dijodometana (b)

Table 4 Parameters of curve equation $y = a \cdot \ln(t) + (b)$ describing the changes of contact angle for phase boundary wood-water, wood-diiodomethane (*a* - direction coefficient, *b* - free term, R^2 - coefficient of determination, *t* - time)
Tablica 4. Parametri jednadžbe krivulje $y = a \cdot \ln(t) + (b)$ koja opisuje promjene kontaktnog kuta na granici drva i vode te drva i dijodometana (*a* – koeficijent smjera, *b* – odsječak na osi *y*, R^2 – koeficijent determinacije, *t* – vrijeme)

Wood species *Vrsta drva*	**Parameters of curve equation y = *a*·ln(*t*) + *b*** *Parametri jednadžbe krivulje y = a·ln (t) + b*					
	Contact angle wood-water *Kontaktni kut drvo - voda*			Contact angle wood-diiodomethane *Kontaktni kut drvo - dijodometan*		
	a	*b*	R^2	*a*	*b*	R^2
African mahogany / *afrički mahagonij*	-6.04	57.34	0.997	-1.36	36.05	0.883
Afzelia / *afzelija*	-7.48	60.48	0.998	-0.50	38.40	0.944
Tauari / *brazilski hrast*	-4.24	54.16	0.996	-1.10	36.13	0.990
Courbaril / *jatoba*	-4.24	61.86	0.997	-0.45	28.86	0.590
European birch / *obična breza*	-10.01	54.08	0.997	-1.62	27.17	0.987
European oak / *hrast lužnjak*	-6.40	69.93	0.996	-0.84	41.02	0.955
Scots pine / *obični bor*	-11.84	55.86	0.998	-5.93	27.34	0.966

who examined the Mediterranean species of wood, stated that in general softwoods showed higher contact angles than hardwoods due to different anatomy and presence of resins and terpenes in addition to fatty acids and phenolic components, also presents in hardwoods.

The surface of pine sapwood was the most hydrophilic among all studied wood species. Comparable changes of the contact angle of wood with water were reported for birch wood (Figure 2a). Within the conducted studies, the contact angle of pine and birch, 3 s after the application of a drop of water on the wood surface, was 46.25° (±6.22) and 42.44° (±3.58), respectively, and after 60 s, 6.45° (±1.83) and 14.29° (±3.91), respectively. The presented data show that, over time, the hydrophobicity of pine sapwood decreased significantly and was lower than in case of birch wood. Pine sapwood was characterized by considerably lower density, i.e. higher porosity (67 %) than other wood species under research (from 44 to 62 %). The process of water and diiodomethane penetration into the porous structure of pine sapwood was quicker than into other wood species tested. This resulted in the biggest changes in contact angle in time. Bekhta *et al*. (2015) stated that pine wood was the most hydrophobic among the studied wood species (pine, alder, beech, birch). The authors state that the contact angle of the pine and birch wood, 5 s after applying a drop of water on the wood surface, was 54.19° and 45.34°, respectively. These differences may be due to, among others, the type of the studied wood (pine sapwood or heartwood) and the resin content in the wood, which is a component significantly affecting wood hydrophobicity (Fengel and Wegener, 1989). Kúdela (2014) stated that the contact angle for the phase boundary beech-water at the beginning of the wetting process (t = 0 s) was 63.9°, while the contact angle at the time necessary to reach the equilibrium state at the phase boundary wood-water (at the moment when the drop started to contract) was 20.8°.

The surface of oak wood was the most hydrophobic one. The contact angle of oak wood, 60 s after the application of a drop of water on the wood surface, was 44.28° (±5.63). It is worth noting that the contact angle of European oak with the ring-porous structure was higher than the contact angle of tropical species i.e. afzelia, tauari, courbaril with diffuse-porous structure. Among the species from the tropical zone, the greatest hydrophobicity, similar to oak wood, was characteristic for courbaril wood. These interdependencies are mainly due to the fact that, generally, the species from the tropical zone have a much larger diameter of vessels compared to species of the temperate zone (Wagenführ, 2007).

Contact angles with a polar liquid (water) significantly changed over time. The dynamics of changes of the contact angle was significantly greater in the case of wetting wood with water than with diiodomethane (Figure 2 a, b). Contact angles of wood with water were the highest at the time of the drop application (at 0 s time of 70°), and then within 60 s decreased logarithmically (curve equations presented in Table 4). In case of heartwood, the dynamics of changes was lower and the terminal value of the angle (60 s after applying a drop) ranged from 35 to 40°. In case of sapwood, the terminal values of contact angle were only about 10°. In case of a nonpolar liquid (diiodomethane), the angles changed to a lesser extent. The initial values of contact angles of the tested wood species were in the range from about 30° to 40°. The biggest changes of the contact angle were noted for pine sapwood, for which the contact angle with diiodomethane, 60 s after applying a drop, was only about 5° (change at the level of 85 %). In case of European birch and African mahogany, the changes of the contact angle within 60 s were about 20 %. For the remaining species of wood, comparable changes of the contact angle with diiodomethane were observed. Within 60 s after applying a drop of liquid on the surface of the wood, the contact angle decreased by about 10 %. Gérardin *et al*. (2007), who studied the contact wetting angle based on the Wilhelmy method (based on the procedure indicated in Gardner *et al*., 1991; Wålinder and Johansson, 2001; Wålinder and Ström, 2001; Pétrissans *et al*., 2003), obtained the contact angle for water-pine sapwood at 55.4°, and for the diiodomethane-pine sapwood at 27.1°. The studies carried out by the authors, despite the implementation of different testing method for determining the contact angle of wood, confirm the dif-

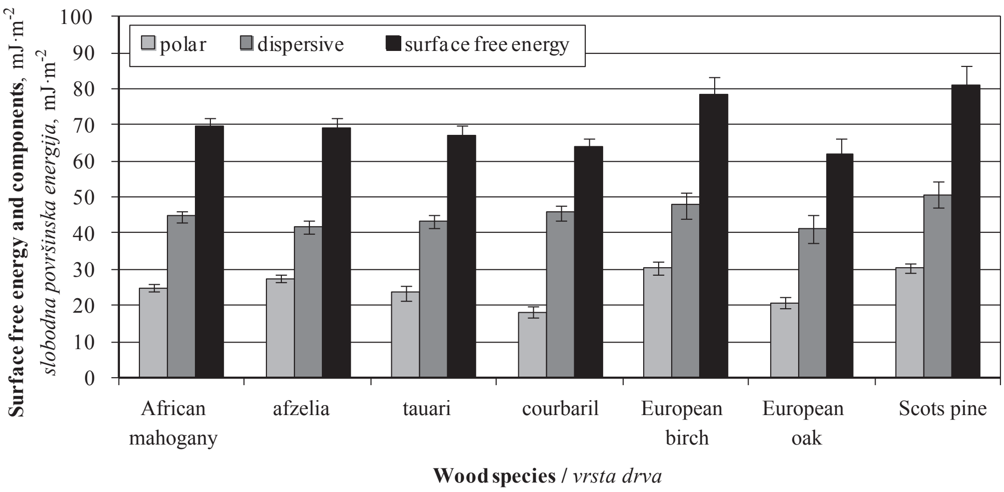


Figure 3 Surface free energy of investigated wood species and components of surface free energy – polar, dispersive
Slika 3. Slobodna površinska energija istraživanih vrsta drva i komponente slobodne površinske energije – polarna i disperzivna

ferences in the wettability of pine wood with polar and dispersive liquids, obtained in this work.

Surface free energy of wood was also dependent on wood species and, above all, on whether it was sapwood or heartwood (Table 3). After 60 s, the value of surface free energy for heartwood of the studied species was in the range of 60 to 70 mJ·m^{-2}, while for pine and birch sapwood, it was about 80 mJ·m^{-2} (Figure 3). The dispersive component was the dominant component of the surface free energy. This is a typical feature characteristic for polymers of which the wood is composed (Mohan *et al*., 2011; Shen *et al*., 1998). According to Li *et al*. (2014), the high value of the dispersive component is the result of high interaction ability of the dispersive part of available carbon-oxygen and carbon-carbon bonds within the wood. On the other hand, the polar component refers to the interaction between hydroxyl groups of wood and functional groups of adhesive by forming the hydrogen bond. The research carried out in the field of surface free energy is confirmed by literature data. Kúdela (2014) stated that the surface free energy of beech wood, determined based on the study of the contact angles of wood wetted with water and α-bromonaphthalene, was 84.7 mJ·m^{-2}. Gérardin *et al*. (2007) stated that the total surface free energy (calculated based on the examination of the contact angle of wood with three reference liquids i.e. water, diiodomethane, formamide) obtained for untreated pine sapwood and beech was relatively close. The authors stated that the surface free energy of pine sapwood and beech was 58.6 mJ·m^{-2} and 54.8 mJ·m^{-2}, respectively.

Table 5 Results of statistical analysis (*t*-test) for work of adhesion determined 60 s after application of a liquid drop on wood surface
Tablica 5. Rezultati statističke analize (*t*-test) za adhezijski rad određen 60 s nakon nanošenja kapi tekućine na površinu drva

Wood species *Vrsta drva*	**Work of adhesion** *Adhezijski rad*	
	Statistical measures *Statističke mjere*	
	t	*p*
African mahogany *afrički mahagonij*	-2.0059	0.072670
Afzelia / *afzelija*	2.9958	0.013439
Tauari / *brazilski hrast*	-2.0194	0.071049
Courbaril / *jatoba*	-7.5945	0.000019
European birch / *obična breza*	2.8456	0.019226
European oak / *hrast lužnjak*	-3.0288	0.012703
Scots pine / *obični bor*	1.9063	0.098288

Statistically significant differences were identified in the work of adhesion for wood-water and wood-diiodomethane phase boundaries (Table 5). Exceptions were African mahogany, tauari and pine wood ($p > 0.05$). The average work of adhesion values for wood-water phase boundaries for tropical zone wood species ranged from 124 to 135 mN·m^{-1} (Figure 4). The work of adhesion value observed for oak wood was similar (125 mN·m^{-1}), whereas the average work of adhesion value for birch and pine wood amounted to 143 and 145 mN·m^{-1}, respectively. Similar dependencies were noted in investigating the work of adhesion for wood-diiodomethane phase boundaries. In this case, the work of adhesion values, observed for oak wood, was likewise comparable to those of the tropical zone wood species. Li *et al*. (2014) stated that low values of the work of adhesion may be attributed to the air trapped in the rough and porous structure of the wood surface, which can decrease the wood-liquid contact area. Investigated wood species from tropical zone have large vessels, with average diameter above 150 μm, but without thyloses (Richter and Dallwitz, 2000). Oak wood has large diameter vessels as well (average diameter 160 μm), but only in earlywood, and they are filled with thyloses (Wagenführ, 2007), which mechanically block the penetration of water.

Investigated hygroscopic properties of wood largely depend on changes due to chemical and mechanical processes occurring in the wood structure in the process of creating heartwood. Mechanical closing of pits, presence of thyloses and over saturation with non-structural compounds affect the reduction of sur-

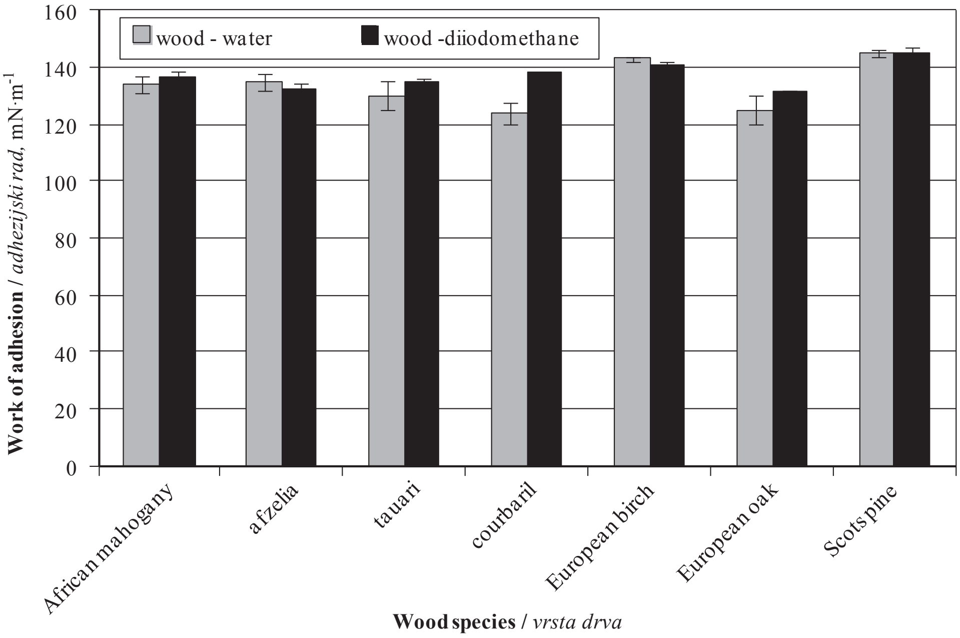


Figure 4 Work of adhesion for phase boundary wood-water and wood-diiodomethane
Slika 4. Adhezijski rad za granicu drvo – voda i drvo – dijodometan

face wettability and wood absorptivity. The result of this was the high value of contact angles for European oak and courbaril, and a low one for the sapwood of pine and birch. The essential relationship between wood wettability and surface chemical composition as well as surface morphology was noticed by, among others, Shen *et al*. (1998) and Li *et al*. (2014). The results of the research have shown that, among the tested wood species, oak wood was characterized by the lowest susceptibility to wetting with polar and dispersive liquids, expressed by the highest contact angle values. Among the wood species from tropical zones, courbaril wood showed the lowest polar liquid wetting susceptibility, whereas afzelia wood had the lowest dispersive liquid wetting susceptibility. In view of the above, these wood species ought to be regarded as particularly suitable for use as flooring material.

4 CONCLUSIONS
4. ZAKLJUČAK

The biggest changes of contact angles in the case of polar liquid (water) were recorded for pine and birch sapwood (changes at the level of 24 - 84 % during 60 s). In the case of dispersive liquid (diiodomethane) for the first 60 s after applying a drop, the angles changed in a much smaller range (changes at the level of 3 - 10 %). Wettability of oak wood with ring-porous structure was lower than wettability of tropical wood species with diffuse-porous structure. Surface free energy of wood depended on the wood species and, above all, on whether it was heartwood or sapwood. After 60 s, the value of the surface free energy for the heartwood of tested species was in the range of 60 to 70 mJ·m^{-2}, while for the sapwood of pine and birch, it was about 80 mJ·m^{-2}. The biggest changes of the work of adhesion, within 60 s after applying a drop of water on the wood surface, was recorded for pine sapwood (increase of 28 %) and the smallest one (increase of 15 %) for tauari and courbaril wood.

5 REFERENCES
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