Thermally Modified Wood Protection Against UV Radiation and Water

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ABSTRACT

Thermally modified beech, ash and oak wood was used for the tests. The wood was modified in industrial conditions in a chamber filled with overheat steam. The samples were covered with ten different types of a wood surface finishing in accordance with the finish manufacturer's technical guidelines. A laboratory lamp was used as a source of UV radiation. Colour changes of finished and unfinished wood were measured with a spectrophotometer. The test allowed to find the most effective wood finishing in the set of the tested finishing materials. Overall properties of the modified wood surface were examined and described by its wettability, time-dependent contact angle and surface free energy calculations. The data enabled the assessment and comparison of the hydrophobic effect of the investigated modifications and prediction of the material susceptibility towards finishing processes (*e.g.* coating).

INTRODUCTION

Thermally modified wood is a new material on the Polish market. At present a few producers have chamber for modification process in an overheated steam environment. They use mainly oak, ash, beech and birch wood for the process. Thermally modified wood is used for floor materials, stairs steps, balusters and for top panels in furniture. The main aim of wood modification in Poland is a change of the wood colour. Dark wood, looking like exotic wood is obtained from domestically grown light colour species without any chemical additives or special finishing. Thermally modified wood has different mechanical an physical properties compared with wood that has not been thermally treated A possible change in the colour of wood is its darkening. Changes of the colour of the wooden products, a result of UV exposure are observed, leading to customer dissatisfaction. Some types of wood finishing are more effective from the point of view of wood protection against UV radiation. In this paper the comparison of colour changes for chosen finishing materials used for floor finishing is presented.

EXPERIMENTAL PROCEDURE

Test specimens

Three species of wood from Polish forest were tested: oak (*Quercus robur* L.) ash (*Fraxinus excelsior* L.), beech (*Fagus silvatica* L.). Semi products for parquet were used as wood samples. Thermal modification was carried out in industrial conditions. The wood was heated with overheat steam at the temperature of 190 ^{0}C in the case of oak and ash wood and at the temperature of 170 ^{0}C in the case of beech wood. For each species twenty samples were made, ten from non-modified wood and ten from modified wood. They were covered with ten kinds of wood finish, typically used for parquet finishing, consistently with the manufacturer's technical guidelines. The list of the applied types of finish is presented in Table 1.

Table 1: Types of wood finishing

No.	Undercoat	Top layer
1	BONA PRIME (acrylic)	BONA TRAFFIC (2 comp. polyurethane)
2	OLI NATURA/HS (modified wax)	OLI NATURA Pflegewachs (wax)
3	Deva Egzofond Alckohol	Deva Aqua Transit (polyurethane)
4	OLI –Universalgrund 1.50	OLI-AQUA TOP 2K Parkettsiegel 51.20 + AQUA HARTER 13.1 (water dispersion of polyurethane)
5		OLI PUR (polyurethane)
6		Berger-Seidle UNO (polyurethane)
7		SCALA 2 komp. ParkettLack
8	Deva Egzofond Alckohol	Deva Quick Plus (polyurethane)
9		AQUA TOP 3 layers (water dispersion of polyurethane)
10	Berger-Seidle Spezial Exotengrund	Berger-Seidle UNO (polyurethane)

UV exposure

A laboratory lamp was used as a source of UV radiation, with the wattage characteristic from 90 to 140 W/m^2, on the table level where the samples were placed. The power of UV radiation was determined by Multimeter UV M100 with a 295-400 nm detector head. Time of the exposure was 24 hours.

Colour measurements

The colour of the samples was measured after UV exposure in different 12 locations in an 8 mm zone. The measurements were carried out with an X-Rite spectrophotometer, model SP-60. The device allows to determine the colour parameters: x; y; z; L; a; b; c and h. The colour change ΔE was determined according to PN EN 7224-3: 2003. Paints and varnishes-Colorimetry-Part3: Calculation of colour differences (Eqn. 1), using the following formula;

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

where: ΔE – denotes colour changes, L – denotes lightness, a - denotes red/green value, b – denotes yellow/blue.

Contact angle and free surface energy

Contact angles were measured on a Phoenix 300 (SEO, Korea) instrument. Free surface energies were determined based on the sessile drop method. A droplet of 5 μL of a reference liquid was placed on the surface of each sample of thermally modified wood and non-modified and unfinished wood. Ten measurements were taken for each liquid,. Since wetting is a time-dependent process, the contact angle was traced for 5 s. The initial contact angle was determined by extrapolation of the contact angle-time curve to *t=0 (Jinzhen and Kamdem 2007)*. Respective total surface energies (γ^{tot}) as well as their dispersive and polar components (γ^{P} , γ^{D}) were calculated using the Owens-Wendt method (based on water and diodomethane).

RESULTS

The results of colour changes for finished ash, oak and beech wood and for wood without coating are presented in Table 2.

Table 2: Colour changes of tested wood samples

Type of wood finishing (see table1)	Wood species - oak/ash/beech			
	Non modified		Thermal modified	
	Unfinished wood	Finished wood	Unfinished wood	Finished wood
	ΔE colour difference oak / ash / beech			
1	9.8 / 17.1 / 9.5	8.2 / 12.2 / 7.5	2.1 / 5.3 / 1.8	9.0 / 8.5 / 4.3
2	9.5 / 18.4 / 10.3	4.9 / 14.7 / 6.6	3.7 / 4.4/ 3.0	1.5 / 6.2 /1.8
3	8.3 / 13.4 / 10.1	5.6 / 6.0 / 8.4	4.5 / 6.8 / 3.7	2.5 / 5.9 / 4.8
4	10.1 / 12.7 / 9.7	6.9 / 13.4/ 9.1	3.1 / 5.6 / 2.9	1.8 / 7.1 / 3.2
5	10.4 / 18.7 / 11.4	11.7 / 9.7 / 9.5	3.6 / 8.1 / 2.3	2.9 / 7.5 / 4.1
6	10.4 / 10.1 / 11.0	6.9 / 11.6 / 8.7	3.2 / 5.6 / 2.1	9.8 / 5.8 / 3.0
7	8.8 / 19.2 / 14.3	6.6 / 4.6 / 7.3	1.8 / 7.3 / 3.0	0.4 / 1.4 / 5.5
8	11.1 / 13.6 / 11.3	10.4 / 18.3 / 2.0	5.2 / 7.4 / 3.1	2.9 / 8.5 / 5.2
9	10.0 / 18.3 / 12.3	3.9 / 12.7 / 3.2	3.0 / 5.4 / 3.1	2.8 / 1.9 / 5.3
10	9.9 / 15.5 / 11.1	7.0 / 9.2/ 12.0	4.3 / 8.0 / 3.3	6.8 / 6.0 / 3.1

The results of the surface energy determination were shown in Figs. 1 and 2. They show that the surface energy of beech and ash decreased after thermal treatment while that of oak. unexpectedly. slightly increased. However. in all cases a decrease in dispersive components γ^{tot} after treatment as well as a decrease in polar components γ^{P} can be observed and attributed to the reduction of the overall hydrophilicity of the surface. Consequently. it can be expected that glueability of the thermally treated material with water based adhesives is affected.

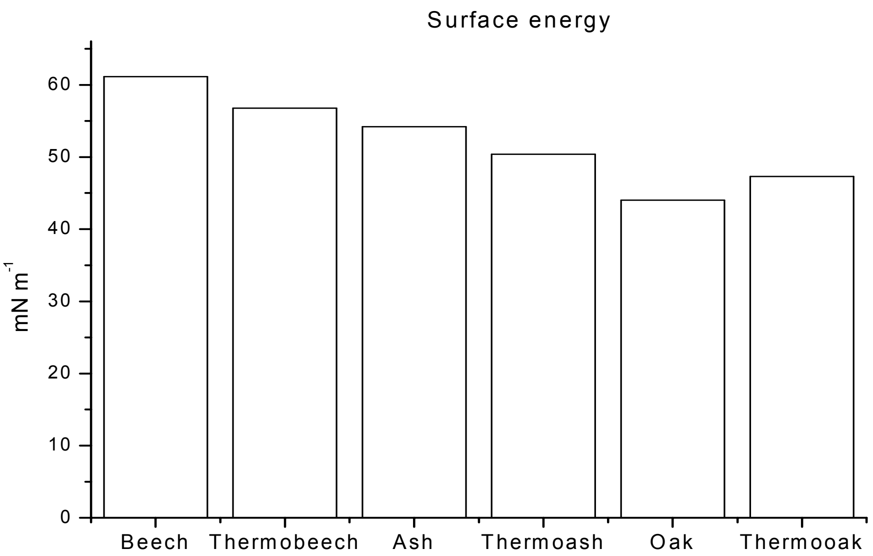

Figure 1: Total surface energies of the tested species

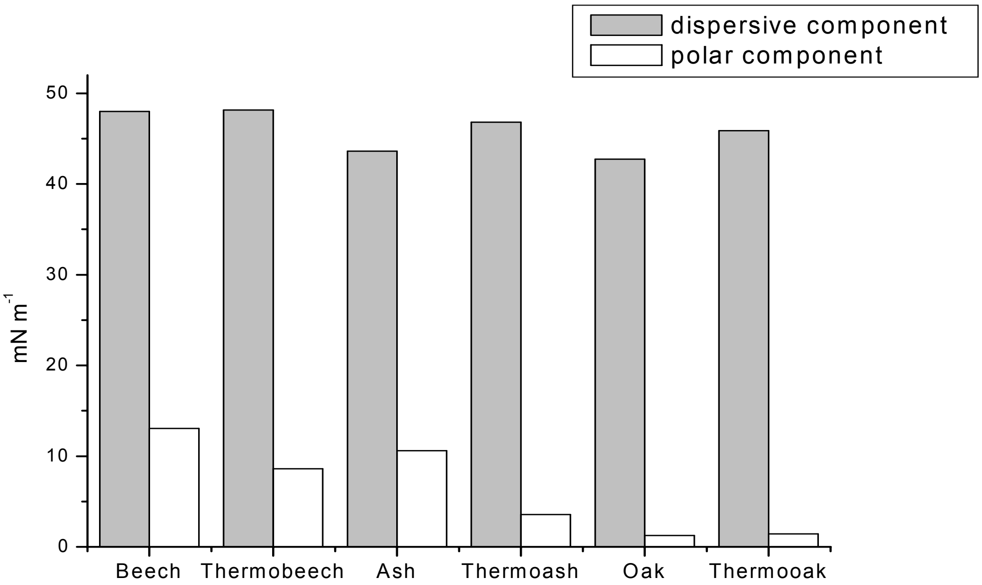

Figure 1: Dispersive and polar components of the measured surface energies

CONCLUSION

Colour changes in non-modified wood are greater then in thermally modified wood. Colour changes in finished thermally modified beech wood are greater then in unfinished thermally modified beech wood for eight tested types of finishing. Thermal modification of ash. oak and beech wood reduces hydrophilicity of the surface.

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REFERENCES

Jinzhen C.A.O. and Kamdem P.D. (2007). Surface energy of preservative treated southern yellow pine (*Pinus* spp.) by contact angle measurements. *Front. For. China*. **2**. 99-103