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Photostability of surface coatings on beech wood

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Abstract: *Photostability of surface coatings on beech wood.* The paper evaluates the light resistance of transparent coatings, based on colour change in the Q-SUN test, on beech wood. It also monitors the influence of four examined factors on the colour change of surface treatments; the four factors are: exposure to xenon light in the Q-SUN test, the length of exposure to xenon light and its influence on the surface treatment, the types of wood surface treatment, and parts of wood – sapwood, false heartwood. The submitted article deals primarily with colour changes occurring on sapwood and on false heartwood of beech.

Keywords: beech wood, CIELAB system, colour changes, interior, paints, photostability

INTRODUCTION

The term the surface treatment means a process, in which the surface of the product, or the surface of the component, is modified by fluid or solid material. The task of the surface finish is to protect the product and to enhance its aesthetic value. One of the aesthetic properties of the surface treatment of wood is the colour. Wood products are often modified by transparent coatings which produce transparent films and thus colour and texture of wood remain accorded.

Beech is classified as a no-heartwood plant, but its wood often has typical false heartwood. False heartwood is characterized by darker staining wood. In the case of a transparent coating on beech wood with false heartwood, it is important to know how the colour on the surface is changing in the process of aging by light. Light stability of acrylic paints has been dealt by DECKER, BIRA (1996) and MAMOŇOVÁ, REINPRECHT (2008).

Colour deviation after simulated radiation on tropical wood species has been analysed by BAAR, GRYC (2010). ZAHRA *et al.* (2007) dealt with colour variation in two European species of oak, during exposure to natural light.

Various transparent finishes cause colour variations on wood surface. The impact of transparent finish on the possibility to emphasize the aesthetic properties of root textures has been dealt by MAMOŇOVÁ (2009). Discoloured wood finishes after exposure to radiation was evaluated by TESAŘOVÁ (2009), REINPRECHT *et al.* (2011), and SLABEJOVÁ (2013), organic light-finishes were evaluated by RUŽINSKÁ *et al.* (2009).

In the experiment, we monitored the chromatic aberration of transparent finishes on beech wood, in sapwood and false heartwood parts, in accelerated test in xenotest (Q-SUN test). The selected coatings are used for refinishing furniture in small or medium-large furniture firms and joinery firms.

MATERIALS AND METHODS

In the experiment, we used beech specimens (*Fagus sylvatica L.*) with dimensions of 30 mm × 35 mm × 3 mm, with tangential-radial surfaces, with moisture content of 8% ± 2%, and the average density in absolutely dry state $\rho 0 = 676$ kg / m^3 .

The specimens of sapwood as well as the specimens of false heartwood were modified by coating with pneumatic spray, with following materials:

1. Waterborne coating material: **Milesi Hydrocrom – XHT**
2. Oil coating material: **SirColor: Sirca - OOJ 77 G 12-54**

3. Acrylic coating material: **SirColor: Sirca - OPU 79 G 30**
4. Polyurethane coating materials: **SirColor: Sirca - OPU 77 G 30-50**
   Lazurol – S1119 (Lodný lak)
   ICLA - PO266.3
   Chemolak – Parketopur N U 1053

Coated specimens and also uncoated ones have been stored in the dark place for six months and then exposed to the xenon lamp in the Q-SUN test for 96 hours. Change of the surface colour was determined after 24, 48, 72, and 96 hours in the Q-SUN test.

Colour of finish was measured with spectral photometer BYK-Gardner GmbH 6834, with perimeter lighting. Spectral photometer was equipped with optics to measure the colour tint in the specification of 45 ° light incidence / 0 ° measurement, and integrated optics for gloss measurement with 60 ° geometry. Parameters were measured in the CIELAB system, values L * a * b *. From the measured values of L * a * b *, the colour deviation was calculated ΔE * – the Euclidean distance, according to the following equation (CIE 1986):

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

where: L^* – the lightness or brightness of the colour,
a* – is the coordinate with tint between red and green,
b* – is the coordinate with tint between yellow and blue.

Measured values of deviations of the colour after exposure to the xenon lamp in the Q-SUN test were evaluated colorimetrically according to table 1.

Table 1 Colorimetric evaluation (ALLEGRETTO *et al*., 2009)

0.2>ΔE	Invisible difference
0.2<ΔE<2	Little difference
2<ΔE<3	Colour change visible with high quality filter
3<ΔE<6	Colour change visible with medium-quality filter
6<ΔE<12	High colour changes
ΔE>12	Different colour

RESULTS AND DISCUSSION

Calculated values of colour deviations ΔE * were evaluated by three-factor analysis of variance. We evaluated the effect of wood part (false heartwood or sapwood) (2 levels of factor 1), the effect of the length of xenon radiation on the surface of the specimens (5 levels of factor 2), and the type of coating material (7 levels of factor 3). It was confirmed that the observed factors were statistically highly significant, but only two interactions were not statistically significant (type of paint - duration of xenon radiation, the type of paint - duration of xenon radiation - wood part).

Figure 1 shows that the surface of beech specimens from sapwood, covered with polyurethane varnish Lazurol S1119 (LL), after 96 h in Q-SUN test reached the greatest deviation in colour ΔE = 7.4 (the interval "high colour changes").

Test specimens from beech wood with false heartwood, with coatings Lazurol S1119 (LL), after 96 h in Q-SUN test reached ΔE = 3.9 (the interval " colour changes visible with medium quality filter").

In Figure 1 we can see that on the monitored finishes, the smallest variations in colour after 96 hours in the Q-SUN test were on sapwood specimens with waterborne coatings Miles Hydrocrom XHT (MH). The value of colour change was ΔE = 2.8 (the interval "colour changes visible with high quality filter").

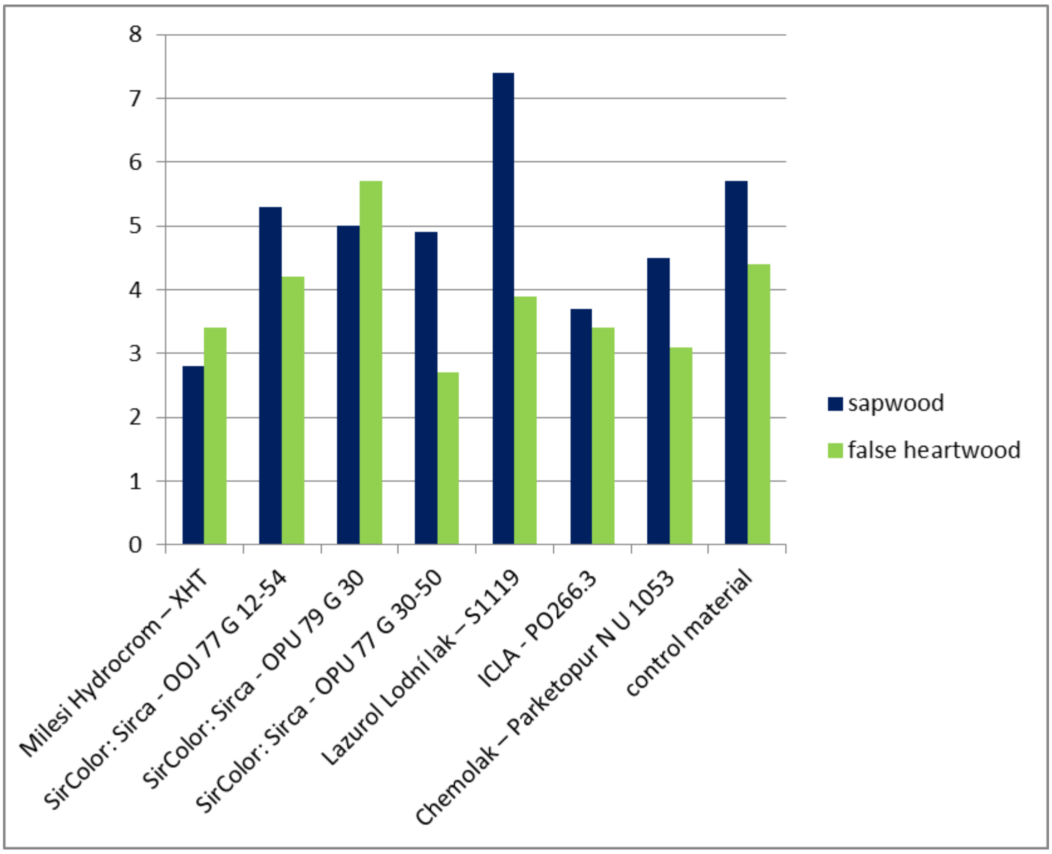

Figure 1 Dependence of colour variation (ΔE) on transparent finishes in the Q-SUN test, for sapwood and for false heartwood

Test specimens from beech wood with false heartwood, with waterborne coatings Milesi Hydrocrom XHT (MH), after 96 h in Q-SUN test reached the value of ΔE = 3.4 (the interval "colour changes visible with medium quality filter"). It was the third lowest colour deviation on samples with false heartwood from all the monitored finishes.

After the analysis of the spectra of individual axes L *, a *, b * (Table 2, 3), we found that the colour changes, occurring on the sapwood and false heartwood of beech wood, are antithetically moved to different axes. Reference specimens confirmed that a shift in the values on the axes L *, a * under the action of radiation for false heartwood, is completely opposite when compared to sapwood. This can lead to standardization of colour, as in SLABEJOVÁ (2013), or to change the contrast into the negative image.

The best lightfastness of finish, in an accelerated test in Q-SUN test, was reached by water-borne coating material Milesi Hydrocrom XHT (MH). After 96 h exposure under xenon lamp it had the smallest ΔE value from all the monitored surfaces on specimens from sapwood. Also it had the smallest difference in variation in surface colour on sapwood when compared with surface colour on false heartwood (Fig. 1).

The greatest colour variations, in interface CIE colorimetric L * a * b *, were observed on the lightness value L*, which is in accordance with REINPRECHT et al. (2011) and BAAR, GRYC (2010). Lightness value L* in sapwood, for all the evaluated paints, excluding the varnish Lazurol S1119, and including the control specimens without surface treatment, was changed to white.

The specimens made from false heartwood were the opposite. All monitored finishes, including control specimens without surface treatment, directed towards black.

Table 2 Direction of change of the color spectrum in the Q-SUN test on sapwood.

	COATING MATERIALS							Control material
	Lazurol lak S1119	Milesi Hydrocrom	SirColor OOJ	SirColor OPU 77	SirColor OPU 79	ICLA PO266.3	Chemolak-Parketopur N	
L*								
a*								
b*								

Table 3 Direction of change of the color spectrum in the Q-SUN test on hartwood.

	COATING MATERIALS							Control material
	Lazurol lak S1119	Milesi Hydrocrom	SirColor OOJ	SirColor OPU 77	SirColor OPU 79	ICLA PO266.3	Chemolak-Parketopur N	
L*								
a*								
b*								

The values of the colour spectrum a* varied depending on the part of wood. On sapwood, all the examined finishes, except Miles Hydrocrom XHT (MH), changed toward green tints, which are consistent with the work by BAAR, GRYC (2010). Changes in the colour spectrum on the axis a * on false heartwood specimens, in all the monitored finishes including control specimens changed toward red tints.

Regardless of the part of wood, the values b * changed toward blue tint on specimens with paint materials: SirColor: Sirca OOJ 77, SirColor: Sirca OPU 77, ICLA - PO266.3, Chemolak – Parketopur N U 1053, and on the control specimens in accordance with the work by BAAR, GRYC (2010). Paint materials SirColor: Sirca OPU 79 and Lazurol S1119 also changed the values for the two parts of wood (sapwood, heartwood), but toward yellow tint.

CONCLUSION

Based on the measured values, we can conclude that the largest colour deviation on all the examined transparent finishes, on sapwood, occurred after the first 24 hours under radiation of xenon lamp in the Q-SUN test. On False heartwood, these changes were almost the same intensity after each cycle of action of xenon lamp.

From all the monitored finishes, the best colour stability, when exposed to xenon lamp, reached Milesi Hydrocrom - XHT (water soluble coating material). While also the actual difference between colour changes on sapwood and false heartwood is relatively small.

When compared with control specimens without surface treatment, surface treatment Lazurol Lodný lak – S1119 (polyurethane coating material), after 96 hours in the xenotest, reached considerably greater colour changes on sapwood than on untreated samples. Finish SirColor: Sirca - OPU 79 G 30 (acrylic paint) reached larger colour changes on heartwood than on untreated specimens.

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Streszczenie: Światłotrwałość powłok na drewnie buka. Praca ocenia światłotrwałość transparentnych powłok na drewnie bukowym na bazie testu Q-SUN. Dodatkowo, sprawdzany jest wpływ wybranych czynników na zmianę koloru powłok, czynnikami są: ekspozycja na światło ksenonowe w teście Q-SUN, czas ekspozycji na światło ksenonowe, rodzaj powłok oraz części drewna – biel oraz fałszywa twardziel. Szczególną uwagę zwrócono na zmiany barwowe na bielu i fałszywej twardzieli buka.

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