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Colour change caused by UV light in wenge wood after impregnation with water, acid and alkaline buffers

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Abstract: *Colour change caused by UV light in wenge wood after impregnation with water, acid and alkaline buffers.* The paper presents colour change in wenge wood caused by the treatment of water, acid and alkaline buffers as well as 100-hour irradiation with UV light with a wavelength of 300 – 400 nm, resembling that found indoors. It was found that the tested samples were characterized by a varied sensitivity to UV light. Samples subjected to water and alkaline buffer treatment changed their colour both under the influence of the solutions, in which they were soaked, and UV light irradiation. Acid buffer did not cause sample discolouration and it may be found that it also enhanced their resistance to the action of UV light. After 100-hour irradiation no colour change was observed.

Keywords: exotic wood, colour change, UV irradiation, CIE Lab system,

INTRODUCTION

For several years we have been observing increased interest in wood of exotic species. Exotic wood is used most frequently in the production of floor boards, but it is also used in the manufacture of furniture and interior finishings. Under the influence of external conditions products made from exotic wood, similarly as those produced from European species, change in colour. Literature on the subject contains limited information describing changes in colour of exotic wood, caused by different factors as well as naturally occurring ageing processes (Jankowska et al. 2011).

Sunlight is a significant factor causing discolouration of wood. Wood is lacquered in order to enhance its stability and resistance to light, as well as reveal its decorative value. Lacquer manufacturers offer refining products protecting wood against photochemical reactions. However, studies conducted by Jankowska and Szczęsna (2011) showed that lacquering, waxing and varnishing did not protect wood surface against changes in its colour and that the rate of these changes was dependent on the type of the applied finishing agent. A greater colour changeability was found for coated wood than unprotected wood. Studies on increasing wood surface resistance against the destructive effect of light were presented e.g. by Nowaczyk-Organista (2009a, 2009b) and Weichelt et al. (2011).

The aim of the study was to determine colour change in wenge wood samples, caused by their treatment with water, acid and alkaline buffers, followed by UV light.

MATERIALS AND METHODS

It was decided to choose wenge wood, which is a species commonly used both by furniture and parquet manufacturers. It is wood with a very dark colour and characteristic drawing (Jankowska et al. 2012).
Samples were cut so that their greatest surface originated from the tangential or radial section.

After measuring colour of control samples, wenge wood samples were dipped for 24 h in water, acid buffer (pH = 4) and alkaline buffer (pH = 10). Next they were dried at 40°C for 24 h. After drying they were subjected to 100-hour UV irradiation. Irradiation was performed

in an apparatus by Atlas, equipped with a UVA-351 lamp (with a wavelength range of 300-400 nm). The applied lamp emitted ultraviolet light resembling that found indoors, penetrating through window panes. The intensity of light projected onto the tested surfaces was 0.5 W/m^2, and the Black Panel temperature (BPT) was 38°C.

Colour of tested samples was measured before and after soaking in selected solutions and after 1, 5, 10, 25, 50 and 100-hour irradiation using a Datacolour 600 spectrophotometer. Colour change was analyzed on the basis of a CIE Lab mathematical model of colour space, developed by the International Commission on Illumination, according to the following formula:

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

where:

ΔE – colour difference,

L* – achromatic coordinate of colour (brightness). The values of the brightness coordinate L* may range from 0 (black) to 100 (white).

a*, b* – chromatic coordinates of colour. The axis a* corresponds with green (–a) and red (+a), while the axis b* with blue (-b) and yellow (+b).

Colour coordinates were measured before and after irradiation of samples in identical sites. Colourimetric coordinates of tested samples were referred to the white standard of L = 96.29, a = -0.34 and b = 1.25.

RESULTS AND DISCUSSION

Table 1 presents values of colour (ΔE*) and parameters describing colour (ΔL*, Δa*, Δb*) in wenge wood before and after treatment with water, acid buffer and alkaline buffer. Colour of control samples (ΔE*) was 56.52 units. Sample exposure to the action of water and alkaline buffer caused an increase in the value of (ΔE*) by 2.93 and 6.13 units. Dipping of wenge wood in acid buffer did not cause its discolouration.

Tab. 1 Changes of colour and colour coordinates in wenge samples before and after treatment with water, acid buffer and alkaline buffer

Sample	ΔL*	Δa*	Δb*	ΔE*
Wenge/control	-55.93	4.99	6.25	56.52
Wenge/water	-58.33	7.05	9.00	59.45
Wenge/acid buffer	-55.90	6.63	8.25	56.90
Wenge/alkali buffer	-62.17	4.34	6.31	62.65

When analyzing changes in parameters describing colour, i.e. the parameter of lightness (ΔL*) and chromatic coordinates (Δa*, Δb*), it may be stated that the occurring colour changes in wood subjected to the action of alkaline buffer were mainly caused by changes in the parameter of lightness (ΔL*). As a result of sample soaking in the alkaline solution the value of the lightness parameter increased by 6.24 units in relation to that determined for the control samples, i.e. treatment of wenge wood samples with alkaline buffer caused their darkening. Lightness of samples did not change after soaking in acid buffer, similarly as it was with the value of (ΔE*). Colour change observed under the influence of water was caused by comparable changes in values of all colour parameters showing an upward trend (ΔL* = 2.4, Δa* = 2.06, Δb* = 2.75).

Recorded changes in parameter (Δa*) indicate that the action of water and acid buffer caused colour changes on the surface of tested samples towards more red colour, while the action of the alkaline buffer to a limited extent changed it towards less red. In turn, change in the values of coordinate (Δb*) indicate that all samples became yellower. The greatest surface discolouration towards yellow was recorded for wood subjected to water extraction, while it was lowest for soaking in alkaline buffer.

In turn, Figure 1 presents changes in colour and colour parameters in sample surface under the influence of their 100-hour irradiation with UV light with a wavelength of 300 – 400 nm.

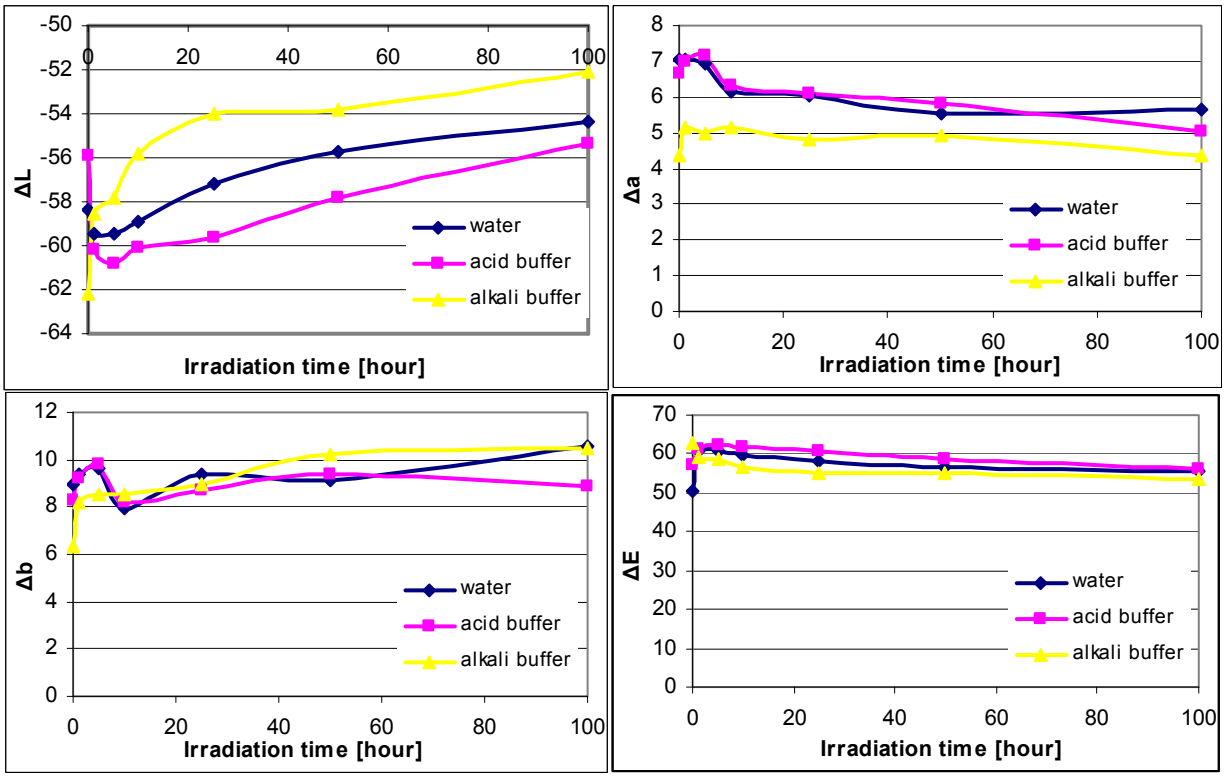

Fig. 1 Change of colour (ΔE*) and colour parameters (ΔL*, Δa*, Δb*) of wenge wood samples caused by UV light irradiation

Based on the progression curve for change in colour (ΔE*) it may be stated that 100-hour irradiation of samples caused change in its colour only in the case of samples subjected to the action of water and alkaline buffer. Samples, which had been dipped in acid buffer, did not undergo discolouration under the influence of UV irradiation. Value of their parameter (ΔE*) changed slightly from 56.90 units (after acid buffer treatment) to 56.33 units (after 100-hour irradiation), while in the course of the first 5 hours of irradiation the values of (ΔE*) increased (to 61.31 after 1h and to 62.06 units after 5h), followed by a decrease.

The action of UV light with a wavelength of 300 – 400 nm caused greatest changes in colour (ΔE*) for samples treated with alkaline buffer, amounting to 9.23 units. In the case of samples subjected to water extraction they were markedly lower (3.74 units). Testing results indicate that as a result of 100-hour irradiation among parameters describing colour it was the values of the parameter of lightness (ΔL*) that changed most markedly. Samples, for which significant changes in colour (ΔE*) were observed, were also characterized by significant changes in the parameter of lightness. Differences in the values of (ΔL*) for wood subjected to UV light treatment, amounted to 10.04 units for samples subjected to the action of alkaline buffer and 3.94 units for samples following water extraction. In the case of samples after acid

buffer treatment eventually this parameter did not change. Its value after 100-hour UV exposure was comparable to that recorded in the control samples and samples after dipping in the solution. During the first 5 hours of irradiation values of this parameter decreased (to -60.20 after 1h and to -60.86 units after 5h), followed by an increase (to -55.34 units after 100h).

Changes in values of parameter (Δa*) in samples irradiated with UV light were not considerable. Surface colouring of samples subjected to the action of water and acid buffer changed towards less red. A different sensitivity to UV light was found in samples after alkaline buffer treatment. In their case the value of parameter (Δa*) increased slightly, which indicates subtle changes in the hue towards more red. When analyzing changes in parameter (Δb*) it may be stated that the surface of all samples was discoloured towards more yellow. While the value of (Δb*) in samples subjected to water and acid treatment (after a 100h irradiation) increased by 1.54 and 0.65 units, for samples subjected to alkaline solution treatment it increased by 4.16 units.

CONCLUSIONS

Based on the recorded testing results it may be stated that the samples exhibited a varied sensitivity to UV light. Samples exposed to the action of water and alkaline buffer changed in colour both under the influence of the solutions in which they had been dipped and under UV irradiation. Wood samples treated with alkaline buffer turned out to be more susceptible to changes. This buffer caused their darkening, subtle colour changes towards less red and more yellow. Their UV irradiation caused changes consisting in their lightening, subtle reddening and yellowing.

Lesser changes were found in values of parameters describing colour of samples subjected to water extraction. The action of water caused an increase in values of all colour parameters, while irradiation caused a decrease in values of (ΔL* and Δa*) and an increase in values of index (Δb*).

Acid solution treatment did not cause change in colour (ΔE*) in sample surface and it may be stated that it enhanced their resistance to the action of UV light. After 100-hour irradiation values of parameter of lightness did not change, remaining at the level comparable to that for samples after impregnation and for the control. Only slight changes were recorded in the chromatic coordinates Δa* and Δb*. After soaking of samples in acid buffer slight transition of colour hue towards red and yellow was observed. After 100-hour irradiation the value of parameter (a*) decreased slightly, reaching a value lower than after the impregnation test and comparable to that determined for the control, while the value of parameter (Δb*) increased slightly, which indicates slight discolouration of samples towards yellow.

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Streszczenie: *Zmiana barwy drewna wenge po impregnacji wodą, buforem kwaśnym i zasadowym spowodowana działaniem światła UV*. W pracy przedstawiono zmiany barwy drewna wenge spowodowane działaniem (obróbką) wody, buforu kwasowego i zasadowego oraz 100-godzinnym naświetlaniem światłem UV o długości fali 300 – 400 nm, podobnym do występującego w pomieszczeniach. Stwierdzono, że badane próbki charakteryzowały się zróżnicowaną wrażliwością na działanie światła UV. Próbki poddane działaniu wody i buforu alkalicznego zmieniły swoje zabarwienie zarówno pod wpływem roztworów, w których zostały zamoczone jak i naświetlania światłem UV. Działanie buforem kwaśnym nie spowodowało przebarwienia próbek i można stwierdzić, że zwiększyło także ich odporność na działanie światła UV. Po 100-godzinnym naświetlaniu nie odnotowano zmian ich barwy.

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