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Δa* and Δb* of walnut wood (*Juglans nigra* L.) treated with acid and alkaline buffers and UV-A light irradiation

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Abstract: *Δa* and Δb* of walnut wood (Juglans nigra L.) treated with acid and alkaline buffers and UV-A light irradiation.* A study on parameters a* and b* of walnut wood (*Juglans nigra* L.) by buffer treatment and then by UV-A light irradiation has been carried out. Eight types of buffers were used in the tests. Four acid (pH = 2.0, 3.0, 4.0, 5.0), one neutral (pH = 7.0), and three alkaline (pH = 8.0, 9.0, 10.0). Two types of lamps were used in the tests, i.e. a UVA-340 lamp with a wavelength of 290 - 400 nm, emitting light resembling natural light, an a UVA-351 lamp with a wavelength of 300 – 400 nm, imitating light found indoors penetrating through window panes. The parameters a* and b* of the samples were measured using a Datacolour 600 spectrophotometer after buffer treatment which lasted 24h and then after light irradiation which lasted 100h. It was detected that the samples of walnut wood after treatment with the acid buffer and then exposed to the outdoor and indoor light irradiation became less red and after treatment with the alkaline buffer more red. Moreover, the parameter b* in the case of detected species of wood is more sensitive to indoor light irradiation in comparison to outdoor light irradiation.

Keywords: walnut wood *Juglans nigra* L., acid buffer treatment, alkaline buffer treatment, photodegradation color change,

INTRODUCTION

The wood, when exposed to sunlight, undergoes a photochemical degradation and becomes pale or grayish, yellowish or darkened, depending on the influence of its chemical composition, especially from the extractive compounds (Ayadi *et al*. 2003). Extractives can be regards as non-structural wood constituents. Although there are similarities in the occurrence of wood extractives within families, there are distinct differences in the composition even between closely related wood species. Furthermore, various parts of the same tree, e.g. stem, branches, roots, bark and needles, differ markedly with respect to both their amount and composition of extractives. This causes that colour of different wood species is varied and sometimes unexpected. Moreover intensity of observed changes is different also. One of exotic wood divisions includes range of colour change due to sun light. The first group covers those which change colour in minor range. The second group creates species which in average range change colour, the most often they darken. Those are species such as afrormosia, purpleheart, opepe, afzelia, kempas, ipe, merbau, padouk, sucupira. The third group, the most numerous one, includes species changing colour very visibly and fast mainly due to sun light. The following species are in this group: *Hymenaea courbaril,* walnut wood, teak, iroko, american cherry, wenge. Another wood division takes into consideration not intensity of observed changes but their kind. For example ipe wood darkens in the direction of red and jatoba - brown. Gaboon wood which at the beginning can be salmon pink becomes light brown due to atmospheric factors. In present work changes of two colour parameters were detected. It were parameter a* which indicates changes between green and red colour and b* which indicated changes between yellow and blue colour. The red hue of wood is commonly associated with extractive content, and correlations between redness values (a*) and the extractive contents of wood has been reported for blackbutt (*Eucalyptus pilularis*) and larch (*Larix* sp.) (Gierlinger et al., 2004). The yellowing of wood is mainly causes by the

photochemistry of lignin (Yazaki et al., 1994) and its derivatives such as quinones, quinone methides, and stilbenes Hon and Glasser (1979).

MATERIAL AND METHODS

Preparation of samples

The investigated materials were exotic eastern black walnut wood (*Juglans nigra* L.). Samples with dimension of 60 x 30 x 4 mm (±1 mm) (long. x tang. x red.) were prepared from the same boards. They were polished with sandpaper (400 P) prior investigation, after cutting. Then, they were divided into eight groups. The first group was the control sample. The next groups were dipped in acid (pH = 2.0, 3.0, 4.0, 5.0), neutral (pH = 7.0), alkaline (pH = 8.0, 9.0, 10.0) buffers, produced by Honeywell Burdick & Jackson. The investigation were performed using three samples from each variant. Three circle measuring points were marked on each sample (diameter 10 mm). The buffer treatment lasted 1h and 24h and was performed under laboratory conditions (23 °C, 45% RH). After dipping, the samples were dried at 40 °C for 24h. The samples humidity during experiment was constant and amounted 5.8%±0.1.

Irradiation

Irradiation was performed in an apparatus by ATLAS, equipped with two types of low pressure UV radiators with maximum emissions at 340 and 351 nm. The UVA-340 lamp emitted ultraviolet light resembling solar light found outdoors (with a wavelength range of 290 – 400 nm), while the UVA-351 lamp emitted light imitating daylight penetrating window panes and found indoors (with a wavelength range of 300 – 400 nm). The intensity of light projected onto the tested surfaces was 0.5 W/m^2 and the Black Panel temperature (BPT) was 38°C. The samples were irradiated for 100 h. Exposures were interrupted after 100 hours.

Colour measurements

All the colour measurements were taken from the surface of the samples. The samples were measured before and after treatment in acid or alkaline buffers. The colour coordinates in the CIE *L*a*b** system were recorded with a Datacolour 600 dual-beam d/8° spectrophotometer, using the D_{65} standard illuminant. The wavelength range of spectrophotometer was from 360 nm to 700 nm, reporting at 10 nm intervals. Reflectance of instrument was 0.15 (max), 0,008 (avg.).The sensor head diameter was 10 nm. The measurement of colour coordinate *L** was performed on three samples per each variant. Calibration of the instrument was performed before testing using the white tile, green tile and black trap standards provided with the spectrophotometer. Three points of fixed locations were measured on each sample.

Data listed in this work are the average of nine replicated measurements. The colour sphere is described as a tridimensional system of colour coordinates(axes *L**, *a** and *b**). Axis *a** depicts the share of green or red colour within the analysed colour; hues of green take on negative values and hues of red, positive values. Axis *b** depicts the share of blue or yellow colour within the analysed colour; hues of blue take on negative values and hues of yellow, positive values. Axis *L** describes colour brightness within the value from 0 to 100. *L** = 100 means that a given colour is close to white, and *L** = 0 that a colour is close to black. In this work color coordinates a* i b* were described.

RESULTS

Changes of the colour parameter a* of the walnut wood samples treated with buffers and then exposed to 340 and 351nm UV-A light irradiation are presented in Figure 1. It was observed that the samples after treatment with the acid buffers and then exposed to the outdoor and indoor light irradiation became less red. However, the observed changes were

minor and did not exceed 1 point. Only in the case of the samples treated with the weakest acid buffer (pH=5) samples showed minor tendency to reddening. The bigger change of the parameter a* was observed on the surface of the wood sample treated with the neutral buffer (pH=7) but only after exposure to outdoor irradiation (351 nm). The irradiation of this sample with 340nm UV-A light did not cause changes of red colour. Significantly the samples after treatment with the alkaline buffers were more prone to reddening due to light irradiation. However, the effect of irradiation with 340 and 351nm UV-A light is similar and it is difficult to indicate which range of the light is more affecting for walnut wood. Additionally there is a tendency that the higher value of buffer pH initiated the higher change of a* parameter.

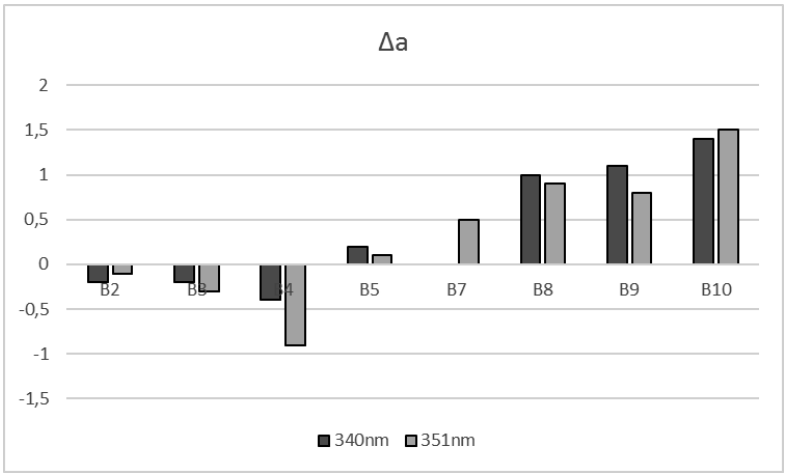

Figure 1. Changes of colour parameter Δa* of the walnut wood samples treated with buffers and then exposed to 340 and 351nm UV-A light irradiation

Changes of the colour parameter b* of the walnut wood samples treated with the buffers and then exposed to 340 and 351nm UV-A light irradiation are presented in Figure 2. It can be stated that the parameter b* is more sensitive to indoor light irradiation in comparison to outdoor light irradiation. Majority of the samples dipped in buffers used changed their parameter b* more significantly after exposure to 340 nm UV-A light than after exposure to 351nm UV-A light. Only in one case when the sample was treated with buffer B8 (alkaline buffer) changes of yellowing were higher after outdoor irradiation. Additionally it can be observed that for the samples from B3 to B9 changes of parameter b* were small and less than 1 unit. Significantly more prone to yellowing after 340nm light irradiation were samples which were previously treated with the strongest acid and alkaline buffers. Obtained results exceeded 2.5 units.

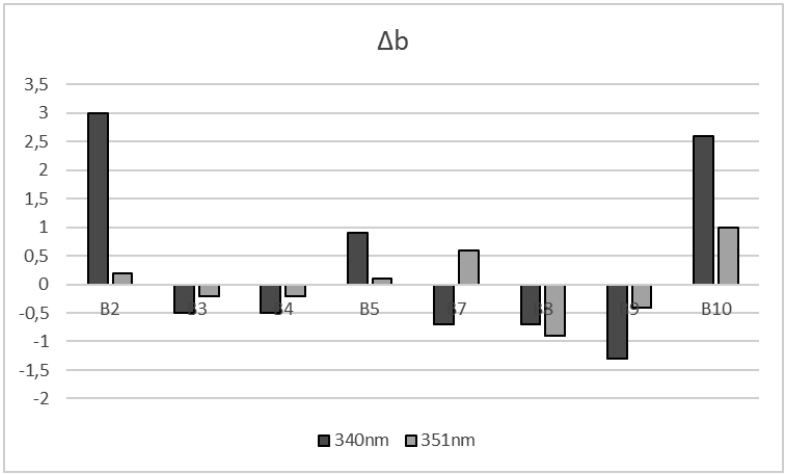

Figure 2. Changes of colour parameter Δb* of the walnut wood samples treated with buffers and then exposed to 340 and 351nm UV-A light irradiation

SUMMARY

On the basis of conducted research it may be stated that:
1. Walnut wood after treatment with the acid buffers and then exposed to the outdoor and indoor light irradiation became less red and after treatment with the alkaline buffer more red.
2. The light irradiation 340 and 351nm UV-A caused similar changes of parameter a* on the surface of walnut samples after treatment with the acid and alkaline buffers.
3. The parameter b* is more sensitive in the case of walnut wood to indoor light irradiation in comparison to outdoor light irradiation.
4. The highest changes of parameter b* were observed on the surface of walnut wood treated with the strongest buffers.

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Streszczenie: *Zmiana parametrów* a* i b* *drewna orzecha amerykańskiego* (*Juglans nigra* L.) *po działaniu kwaśnych i zasadowych buforów oraz naświetlaniu światłem UV-A.* Badaniom poddano drewno orzecha amerykańskiego (*Juglans nigra* L.), które przed naświetlaniem zanurzono w ośmiu buforach. Cztery bufory miały odczyn kwaśny (pH=2 - 5), jeden obojętny (pH=7), a pozostałe trzy zasadowy (pH=8 - 10). Próbki po obróbce buforami naświetlano światłem UV-A imitującym światło zewnętrzne i wewnętrzne (340 i 351nm). Interpretacji poddano zmianę parametrów a* i b*. Stwierdzono, że drewno badanego gatunku poddane obróbce buforami kwaśnymi a następnie naświetlanie promieniami imitującymi światło zewnętrze i wewnętrzne staje się mniej czerwone. Odwrotne zjawisko obserwowane jest w przypadku drewna poddanego działaniu buforów zasadowych. Po takiej obróbce i naświetlaniu światłe o długości fal 340 i 351nm drewno stawało się bardziej czerwone. Nie stwierdzono istotnych różnic między zmianą parametru a* próbek drewna badanego gatunku naświetlanych światłem zewnętrznym i zewnętrznym. Różnice stwierdzono jednak w przypadku parametru b*, który okazał się bardziej czuły na naświetlanie światłem wewnętrznym. Największe zmiany parametru b* stwierdzono w przypadku próbek orzecha poddanego działaniu najsilniejszego buforu kwaśnego i zasadowego (pH=2 i 10).

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