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Comparative studies of ipe (*Tabebuia* spp.) wood photodegradation cause by treatment with outdoor and indoor UV-A light irradiation

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Abstract: *Comparative studies of ipe (Tabebuia spp.) wood photodegradation cause by treatment with outdoor and indoor UV-A light irradiation.* A study on photodegradation of ipe (*Tabebuia* spp.) wood by UV A light has been carried out. 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. Colour of the samples was measured using a Datacolour 600 spectrophotometer prior and after 1, 5, 10, 25, 50 and 100-hour irradiation. Characterization of investigated material included determination of its chemical components. Despite the fact that ipe wood contains high concentrations of components playing an important role in the photodegradation process (e.g. 37.2% lignin) the detected changes are minor and do not exceed 1 point. The change in colour (ΔE) for ipe wood surface was mainly caused by changes in the chromatic coordinate (b*) and the lightness coordinate (L*). Greater changes occurred under the influence of a UV-340 lamp emitting the type of light resembling that found outdoors.

Keywords: ipe (*Tabebuia* spp.) wood, chemical composition, photodegradation, UV-A light

INTRODUCTION

Almost all chemical components of wood are sensitive to the action of UV irradiation, but their susceptibility to photodegradation depends on their structure. A potential absorber of UV irradiation includes chromophors such as aromatic rings or the carbonyl group. Lignin which comprises such groups absorbs relatively irradiation strongly in the UV/Visible region (80-95%), therefore it is the key structure in wood photodegradation. Other main constituents of wood, carbohydrates, being poor in chromophor structures, absorb 5-20% irradiation (Norrström 1969, Kuo 1991). High concentrations of chromophoric groups suggest that wood is prone to photodegradation (Chaochanchaikul et al. 2012, Garcia et al. 2014). Mitsui and Tsuchikawa (2005) proved that hardwoods are more resistant to colour change than softwoods due to their lower lignin content. According to Chang et al. (2009), extractives play an essential role in the photodegradation of wood and the rate of wood degradation was limited by the presence of extractives.

MATERIAL AND METHODS

Preparation of samples

Samples of 40 × 15 × 5 mm (±1 mm) (long. × tang. × rad.) were prepared from the same boards. They were polished with sandpaper (400 P) prior to the analyses after cutting. The samples were represented by three samples with 3-fix measurement points with a diameter of 10 mm in the cross section. The samples included both earlywood and latewood.

Chemical analysis of the wood main component

The chemical analysis of the ipe component included the determination of the extractive substances according to the T 204 cm-97 standard procedures (ethanol was used as an extractant). Lignin quantification of acid–insoluble lignin was conducted according to the T 222 om-02 standard. Pentosans were assayed according to the T 223 cm-01standard procedure. The analysis of cellulose content was conducted according to the Seifert method. Every determination was repeated three times for each sample.

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. Samples were irradiated for 100 h. Exposures were interrupted after 1, 5, 10, 25, 50 and 100 hours.

Colour change assessment

The colour of light irradiated surfaces of the test samples was measured with a Datacolour 600 ™ Spectrophotometer (by Datacolour Int.). The colour coefficients were measured before and after exposure to light.

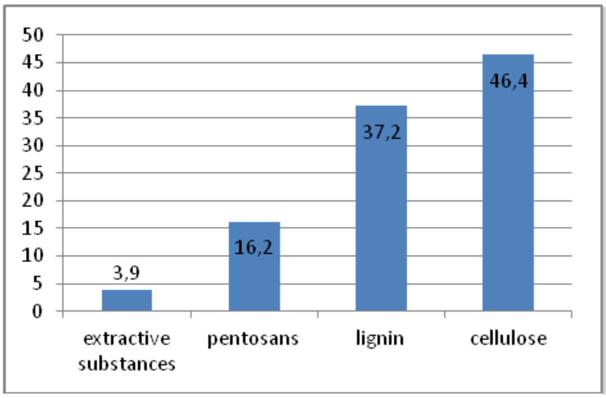
The three colour coordinates, L*, a* and b* of the CIE Lab system, were recorded after each irradiation and these parameters were used to calculate the total colour change (ΔE).

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

where:
ΔE – colour difference,
L* – achromatic coordinate of colour (lightness). Values of the lightness coordinate L* may range from 0 (black) to 100 (white).
a*, b* – chromatic coordinates of colour. The a* axis corresponds to green (–a) and red (+a), while the b* - to 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

The chemical composition of ipe wood is presented in Figure 1. Tested wood contained 3.9% extractive substances and 37.2% lignin. Both these components play the most important role during photodegradation of wood material. A high concentration of lignin indicates that a given wood species is prone to colour changes. On the other hand, extractives are assumed to be components which limit photodegradation. Figure 2 presents colour parameters of investigated ipe wood before UV-A light treatment in comparison to the white standard. The low value of lightness (L*) indicates that ipe wood has a dark hue.



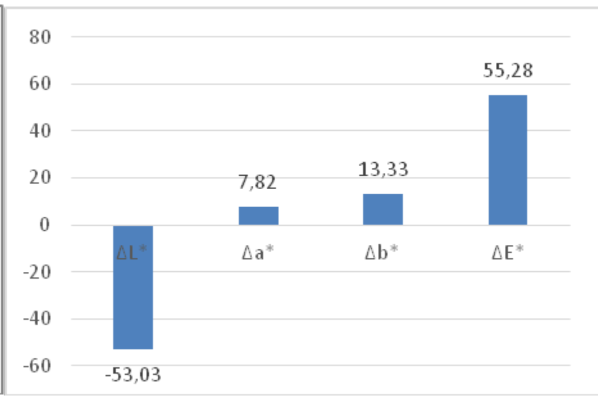


Figure 1. Percentages of main components of ipe

Figure 2. Colour parameters of ipe wood before light irradiation

Changes of colour (ΔE*) and colour parameters (ΔL*, Δa*, Δb*) in the ipe wood samples caused by outdoor and indoor UV light irradiation are presented in figure 3. Light irradiation using a UVA-340 lamp caused darkening, while irradiation using a UV-A 351 lamp resulted in insignificant lightening of ipe wood surface. These changes in both cases are minor, less than 1 point. Light resembling outdoor light irradiation caused a decrease of colour coordinate "a*", which means that ipe wood is less red after irradiation that the control. In the case of the sample treated with 351-nm light coordinate "a*" did not change after irradiation. The decrease of coordinate "b*", which was detected in the case of irradiation using a UV-A 340 lamp, suggested that wood is yellower. The exposure of wood surface to indoor light photodegradation caused a decrease of the "b*" value, which means that this surface is less yellow that the control. Total colour change (ΔE*) of ipe wood detected after irradiation with a UV-A 340 lamp was significantly greater in comparison to that which took place after irradiation with the UV-A 351 lamp.

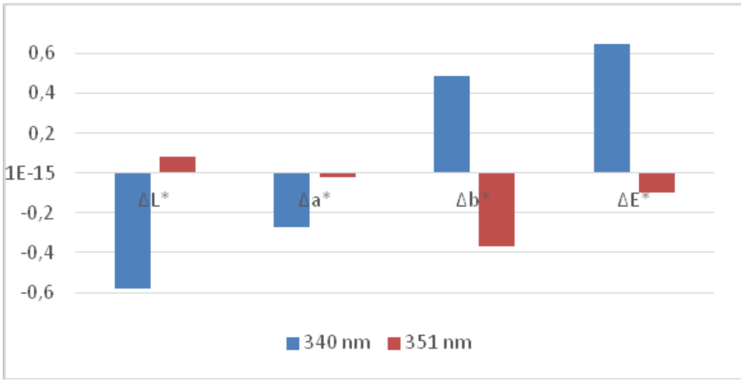


Figure 3. Changes of ipe wood colour after UV-A irradiation

CONCLUSION

1. Despite the fact that ipe wood includes high concentrations of components which play an important role in the photodegradation process, the detected changes are minor and do not exceed 1 point.
2. The change in colour (ΔE) for ipe wood surface was mainly caused by changes in the chromatic coordinate (b*) and the lightness coordinate (L*).
3. Greater changes occurred under the influence of a UV-340 lamp emitting the type of light resembling that found outdoors.

REFERENCES

1. CHANG, T-CH, CHANG, H-T, WU, C-L, CHANG S-T. 2010: Influences of extractives on the photodegradation of wood, Polymer, Degradation and Stability 95(4): 516-521
2. CHAOCHANCHAIKUL K., JAYARAMAN K., ROSARPITAK V., SOMBATSOMPOP N. 2012: Influence of lignin content on photodegradation in wood/HDPE composites under UV weathering, Photodegradation BioResources 7(1), 38-55
3. GARCIA R., A., OLIVEIRA LOPES J., NASCIMENTO A.M., FIGUEIREDO LATORRACA J. 2014: Color stability of weathered heat-treated teak wood. Maderas-Ciencia Tecnologia 16(4): Ahead of Print: Accepted Authors Version
4. KUO, M-L, N.HU. 1991: Ultrastructural changes of photodegradation of wood surfaces exposed to UV. Holzforschung 45: 347–53
5. NORRSTROM, H. 1969: Color of unbleached sulfate pulp, Svensk Papperstidn.72, 25-38
6. MITSUI K., TSUCHIKAWA S. 2005: Low atmospheric temperature dependence on photodegradation of wood, Journal of Photochemistry and Photobiology B: Biology 81: 84-88
7. SEIFERT V.K. 1956: Über ein neues verfahren zur schnellbestimmung der rein-cellulose, Papier 10

Standard procedures

T 204 cm-97 Solvent extractives of wood and pulp

T 222 om-02 Acid-insoluble lignin in wood and pulp

T 223 cm-01 Pentosans in wood and pulp

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Streszczenie: *Badania porównawcze fotodegradacji drewna ipe (Tabebuia spp.) po działanu buforów kwaśnych i zasadowych.* Badaniom poddano próbki drewna ipe (*Tabebuia* spp.). Charakterystyka materiału badawczego obejmowała oznaczenie składu chemicznego oraz wyznaczenie parametrów barwy badanego drewna. Badania kolorymetryczne prowadzono po 1 h, 5h, 10 h, 25 h, 50 h oraz 100 h naświetlania przy użyciu spektrofotometru Datacolor 600 rejestrując współrzędne barwy w układzie CIE Lab. Naświetlanie prowadzono w aparacie firmy Atlas wyposażonym w lampy UV. Długości fal padających na powierzchnię wynosiła 290-400 nm temperatura = 38°C, natężenie światła 0,5 W/m^2. Współrzędne kolorymetryczne badanych próbek odnoszono do białego wzorca. Analiza chemiczna wykazała, że badany materiał charakteryzował się wysoką zawartością substancji ekstrakcyjnych oraz ligniny, które zwierają grupy chromoforowe, uczestniczące w procesie fotodegradacji. Sugeruje to podatność drewna ipe na zmianę barwy pod wpływem naświetlania zarówno w warunkach zewnętrznych jak i wewnętrznych. Badania parametrów barwy drewna ipe w odniesieniu do białego wzorca wykazało, że drewno ipe cechuje się ciemną barwą (niski parametr L*). Naświetlanie drewna ipe spowodowało niewielkie, nie przekraczające 1 punktu, zmiany parametrów barwy. Całkowita zmiana barwy (ΔE*) jest spowodowana głownie zmianą parametru b* i L*. Stwierdzono, że większe zmiany barwy badanego drewna spowodowało naświetlanie lampą UV-A emitującą światło o długości fali 340 nm, imitującą światło zewnętrzne.

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