Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 84, 2013: 335-338
(Ann. WULS - SGGW, For. and Wood Technol. 84, 2013)

Color changes of pine wood under impact of UV light after treatment with acid and alkali buffers

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Abstract: *Color changes of pine wood under impact of UV light after treatment with acid and alkali buffers.* The objective of the present study was to investigate colorimetric parameters of pine wood surface after treatment with water and different pH solutions and after UV light irradiation. The color coordinates of pine wood were measured prior to treatment, after treatment with water and buffers and then consecutively after 5, 10, 25, 50 and 100 hours of irradiation. Results demonstrated that all samples were susceptible to photo-irradiation and surface color changed more or less from light to dark as indicated by a decrease in lightness (L*) with exposure time. The biggest changes were observed in samples after alkali treatment. The samples after treatment with water and acid displayed a similar pattern of discoloration.

Keywords: colorimetry, changes color, pine, acid, alkali buffer

INTRODUCTION

Wood color changes caused by light are observed in its external layer and the extent of that change depends on wood species. The change of wood color is thought to be due mainly to the ultraviolet (UV) as well as fractions of the visible (VIS) spectrum of solar radiation, which acts in combination with moisture, temperature and oxidative agents such as oxygen and/or ozone to depolymerize lignin and cellulose in wood cell walls. The photo-discoloration process involves very complex physical and chemical reactions. There have been many studies attempting to clarify the mechanism of wood discoloration (Müller 2003, Rosu 2010, Zborowska et al. 2011, etc.). In order to improve aesthetic features, wood surface used in furniture industry is lacquered with transparent lacquers highlighting in this way both hue and wood drawing. However, they do not guarantee stability of wood color. Numerous investigations are known to improve durability of used lacquer (Schaller and Rogez 2007, Nowaczyk–Organista 2011, Weichelt at al. 2011, etc.).

The objective of the present study was to investigate colorimetric parameters of pine wood surface after treatment with water, acid and alkali buffers and after UV light irradiation.

MATERIALS AND METHODS

Pine wood samples before light exposure were dipped in water and two buffers (pH = 10.0 and pH = 4.0). Treatment lasted 24 hours and was performed under laboratory conditions. After dipping, samples were dried at 40°C for 24 hours.

Pine wood samples prepared in that way were exposed to light. In the experiment an Atlas Company apparatus equipped with UV lamps was used. Trial conditions were as follows: UV lamp 340 nm, length of waves falling onto the surface 290 – 400nm, temperature BST = 38°C, light intensity - 0.5 W/m^2.

The color coordinates (Lab) of tested samples were recorded before and after treatment and also before and after 1, 5, 10, 25, 50 and 100 hours of irradiation using a Datacolor 600 spectrophotometer. Color change in the CIE Lab system was calculated according to the following formula:

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

where:

ΔE – color difference,

L – achromatic coordinate of color – brightness, L=100 white, L=0 black,

a, b – chromatic coordinates of color.

Because pine wood is classified as a clear wood species (brightness coordinate "L" about 88 units), color coordinates of pine surface before and after 24 h treatment with water and acid and alkaline buffers, as well as before and after irradiation were referred to the white standard (L = 96.29, a = - 0.34, b = 1.25).

RESULTS

Table 1 shows the change of colour (ΔE*, ΔL*, Δa*, Δb*) of pine wood samples before and after treatment with water, acid and alkali buffers referred to the white standard.

It was stated that treatment with water, acid and alkali buffer caused reddening and yellowing of surface compared to the sample before treatment (pine control). The greatest change of colour and colour coordinates was observed in the case of pine wood treated with the alkali buffer. The difference between ΔE* of the control and the alkali treated surface amounted to 2.83 units and was caused mainly by the change of the brightness coordinate. Wood treatment with water and acid buffer gives no significant change of colour (ΔE*) when compared to the control. The difference between ΔE* amounted to 1.38 and 0.52 units, respectively.

Tab. 1 The change of colour and colour coordinates of pine samples before and after treatment with water, acid and alkali buffers.

Sample/ 24h treatment	**ΔL***	**Δa***	**Δb***	**ΔE***
Pine/control	-12.97	4.25	21.05	25.10
Pine/water	-14.11	4.83	21.88	26.48
Pine/acid	-13.42	4.43	21.36	25.62
Pine/alkali	-15.00	5.50	22.87	27.93

Analysis of the changes in colour and colour coordinates (ΔE*, ΔL*, Δa* and Δb*) of wood treated with water, acid and alkali buffer during irradiation (fig.1) leads to an observation that the values of coordinate ΔL* for pine wood treated with alkali buffer are lower when compared to the change of coordinate ΔL* for samples dipped in water and acid buffer. The greatest change in lightness, from 15.0 to 22.04, was observed in samples treated with alkali buffer after 1 hour of irradiation. Successive hours of light exposure are not so effective and the course of brightness coordinate change was quite regular. After 100 hours of light exposure lightness of these samples amounted to 27.71 units. Pine wood after water and acid treatment was characterized by a similar course of brightness coordinate changes and after 100 hours of irradiations it decreased to around 23 units. The analysis of the changes of chromatic coordinate a* indicates that wood treated with water and alkali and acid buffer demonstrated a similar course of changes over the irradiation time and it finally amounted to approx. 8 units. Analyses of changes in chromatic coordinate "b" during light exposure of 3 test samples showed that wood after treatment with water and acid is slightly less resistant (a higher DB* value) to light when compared to wood dipped in alkali buffer. Based on the progress curve of the color coordinate ΔE* it may be stated that the color in all samples changes rapidly and constantly throughout the experiment. The changes in samples treated

with water, acid and alkali buffer and after 100 hours of irradiation were similar and amounted to approx. 14 units.

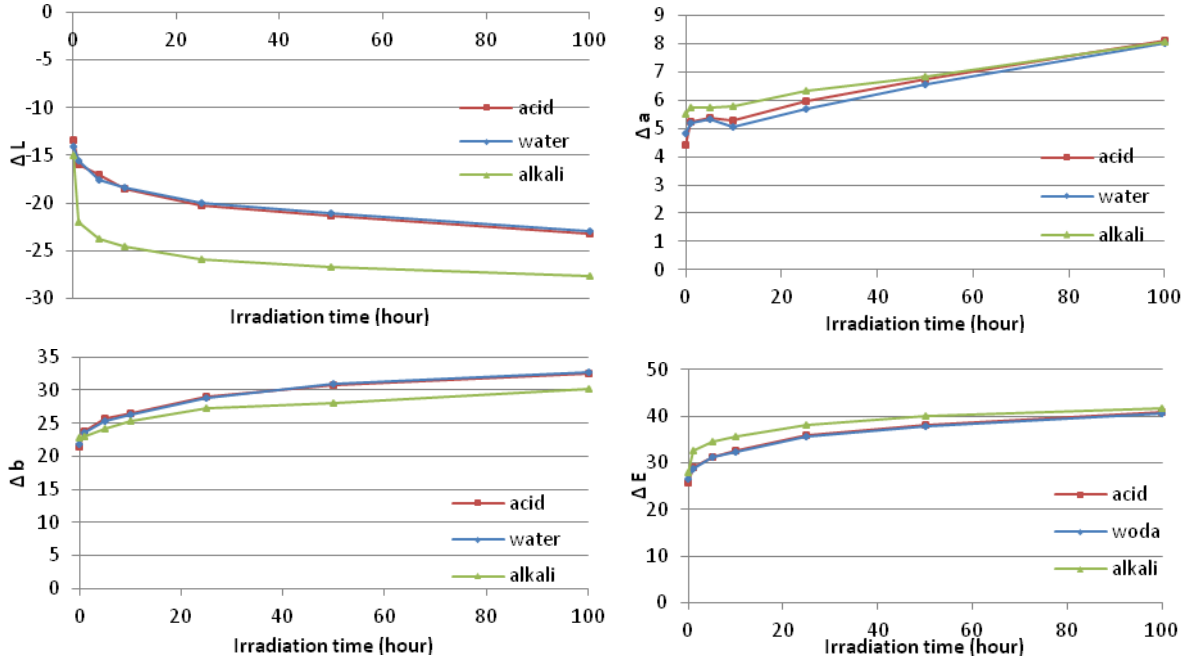

Fig. 1 Changes in colour and colour coordinates (ΔE*, ΔL*, Δa* and Δb*) of pine wood samples caused by UV light irradiation.

SUMMARY

Tested samples were susceptible to photo-irradiation and surface color changed more or less from light to dark, as indicated by a decrease of brightness (L*) with exposure time. The greatest changes were observed in samples after alkali treatment, after a 1-hour irradiation. What is more, the irradiated surface showed a tendency to turn reddish and yellowish. The samples after treatment with water and acid displayed a similar pattern of discoloration, as they were more susceptible to changes in the range of blue-yellow than wood after alkali treatment. The changes in color (ΔE*) were similar in the case of all samples.

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Streszczenie: *Zmiany barwy drewna sosny pod wpływem światła UV po działaniu buforów kwaśnego i zasadowego.* Badaniom poddano próbki drewna sosny przed i po działaniu wodą, buforem kwaśnym (pH = 4) i zasadowym (pH = 10) oraz po 1 h, 5h, 10 h, 25 h, 50 h oraz 100 h naświetlaniu. 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. Barwę badanych próbek mierzono przed namaczaniem, po namaczaniu oraz kolejno po naświetlaniu przy użyciu spektrofotometru Datacolor 600 rejestrując współrzędne barwy w układzie CIE Lab. Współrzędne kolorymetryczne badanych próbek odnoszono do białego wzorca. Na podstawie przeprowadzonych analiz stwierdzono, że wszystkie badane próbki, niezależnie od sposobu obróbki wstępnej są mniej lub bardziej podatne na zmianę jasności (L*) i ich jasność obniża się wraz z upływem czasu naświetlania. Największe zmiany zanotowano po godzinie naświetlania w przypadku próbek drewna poddanych wcześniejszemu działaniu buforem zasadowym. Zaobserwowano ponadto tendencje to zmiany barwy powierzchni próbek w kierunku czerwonym (a*) i żółtym (b*) we wszystkich badanych wariantach, niezależnie od obróbki wstępnej, przy czym próbki po działaniu kwasu i wody były mniej odporne na zmiany w kierunku barwy żółtej. Generalnie zmiany zachodzące w próbkach poddanych wcześniejszemu działaniu wody i kwasu miały podobny przebieg. Zmiany barwy (ΔE*) odnotowane po 100 godzinnym naświetlaniu próbek poddanych działaniu wody, buforu kwaśnego i zasadowego były podobne.

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