Holz als Roh- und Werkstoff (2005) 63: 392–393
DOI 10.1007/s00107-005-0022-7

KURZORIGINALIA · BRIEF ORIGINALS

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Color changes in acetylated wood by the combined treatment of light and heat

Published online: 29 Juli 2005

Abstract This study investigated the change in color of acetylated wood by the combined treatment of light and heat. The color of acetylated wood was stable against light, however, heat treatment after light-irradiation made it change greater. Furthermore, the acetylated wood discolored greater than unacetylated one by light-irradiation after heat treatment. These results show that the acetylated wood is not stable when it is exposed under special condition.

Verfärbung von acetyliertem Holz bei einer kombinierten Behandlung mit Wärme und Licht

Zusammenfassung In dieser Arbeit wurde die Farbänderung von acetyliertem Holz bei einer kombinierten Behandlung mit Licht und Wärme untersucht. Die Farbe von acetyliertem Holz war zwar lichtstabil, eine auf die Lichtbestrahlung folgende Wärmebehandlung verursachte jedoch eine größere Farbveränderung. Darüber hinaus verfärbte sich acetyliertes Holz stärker als unacetyliertes bei Lichtbestrahlung nach einer Wärmebehandlung. Diese Ergebnisse zeigen, dass acetyliertes Holz unter besonderen Bedingungen nicht farbstabil bleibt.

1 Introduction

There are many reports on the acetylation of wood for improving the color stability. Feist et al. (1991) reported that acetylation was effective to prevent the degradation of lignin and hemicellulose of wood during accelerated weathering. Plackett et al. (1992) reported that the color of the acetylated wood was more stable than that of untreated one in weathering using water spraying. Ota et al. (1996, 1997) stated that the color of acetylated kiri (*Paulownia tomentosa* Steud.) changed to bright pale brown after light-irradiation. Furthermore, Ohkoshi (2002) showed that the color of acetylated softwood changed less than that of untreated one by exposure to light up to 1000 hours.

On the other hand, we reported the color change by heat treatment after light-irradiation (Mitsui et al. 2001, Mitsui 2004). The color changes in the heated wood after exposure to light was greater than those in unirradiated one. Furthermore, the color of specimens irradiated for long time changed greater than that for short time. This method is effective for coloration of wood because of no VOC emission such as toluene and xylene from paint, and less damage such as cracking and bending by treatment. However, it is questionable whether the color obtained by this combined treatment is stable against light or not.

For improvement in the color of the surface of the wood treated by this method, acetylation was applied. There are three occasions to apply acetylation; before light-irradiation, after light-irradiation (i.e. before heat treatment), or after heat treatment. This paper deals with the application before light-irradiation.

2 Materials and methods

This study examined the sapwood of Japanese cypress (*Chamaecyparis obtusa*) and beech (*Fagus crenata*). The samples were stored, before and between treatments, in a desiccator, in total darkness, over P_2O_5, at room temperature.

The dried specimens were treated with acetic anhydride in the liquid phase without a catalyst for 6 hours at 120 °C. At the end of the reaction, the specimens were fully washed with water and dried over P_2O_5, at room temperature. The weight percent gains of Japanese cypress and beech were 23.4% and 21.6%, respectively.

Specimens were irradiated for 50 hours with artificial sunlight from a xenon lamp in a commercial chamber (SX-75: Suga Test Instruments Co. Ltd., Tokyo, Japan) as described in a previous paper (Mitsui et al. 2003). After light-irradiation, specimens were treated in humid conditions at 90 °C and 90% RH

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Table 1 Color parameter of wood before treatment
Tabelle 1 Farbparameter des verwendeten Holzes vor der Behandlung

Species	L^*	a^*	b^*
Japanese cypress	83.09 ± 1.56	2.34 ± 0.13	20.01 ± 0.32
Beech	67.10 ± 0.64	6.46 ± 0.10	19.98 ± 0.35

Note: Mean ± s.d.

for 50 hours. After heat treatment, specimens were irradiated for 50 hours again.

The color of the surface of specimens was measured with a colorimeter (SE-2000: Nippon Denshoku Industries Co., Ltd., Tokyo, Japan) as described in previous papers (Mitsui et al. 2001, Mitsui 2004). Table 1 shows the color parameter of specimens before treatment.

3 Results and discussion

Figure 1 shows the changes in color of Japanese cypress by treatments. The ΔL^* of unacetylated wood decreased with light-irradiation, and remarkably decreased by heat treatment after exposure to light. When the specimens were exposed to light again, it increased. The Δa^* increased slightly by light-irradiation and increased sharply by heat treatment. After heat treatment, Δa^* decreased with light-irradiation. The Δb^* increased with light-irradiation, followed by decreasing during heat treatment and increased again slightly by the second exposure to light. The changes in color by the treatment of process up to heat treatment concur with previous results (Mitsui et al. 2001, Mitsui 2004). The change in color resulting from light-irradiation after heat treatment (i.e. the second light-irradiation) shows that the wood heated after light-irradiation discolors by exposure to light.

On the other hand, neglected changes in ΔL^* and Δb^* were observed with acetylation, only Δa^* decreased slightly. With acetylated wood, the ΔL^* changed to the positive, the Δa^* decreased, and Δb^* increased by light-irradiation. These results show that acetylation is effective to reduce the color changes by light, compared with unacetylated wood, as many researchers mentioned (Feist et al. 1991, Plackett et al. 1992, Ota et al. 1996, Ota et al. 1997, Ohkoshi 2002). However, heat treatment after light-irradiation made the color of acetylated wood change greater, and its color was almost same as unacetylated one heated after exposure to light. Furthermore, the color of acetylated wood changed remarkably by the second light-irradiation after heat treatment. The degree of its change in color was more pronounced than that of unacetylated one, and the acetylated wood discolored greater than unacetylated one. The changes in beech were similar to those in Japanese cypress. These results show that the acetylated wood is not stable when it is exposed under special condition, that is, heat treatment after light-irradiation. Moreover, the color of the acetylated wood browned by the combined treatment of light-irradiation and heat treatment is more changeable than that of unacetylated one by exposure to light.

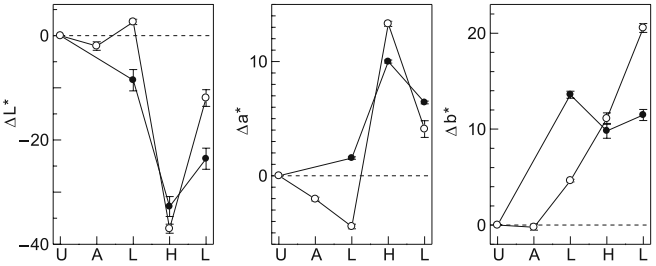

Fig. 1 Changes in the color of Japanese cypress by treatments. U, A, L, and H mean untreatment, acetylation, light-irradiation, and heat treatment, respectively. ○: Acetylated wood, ●: Unacetylated wood
Abb. 1 Veränderungen der Farbe von japanischer Zypresse durch verschiedene Behandlungen. U, A, L und H bedeuten jeweils unbehandelt, acetyliert, lichtbestrahlt und wärmebehandelt. ○: acetyliertes Holz, ●: unacetyliertes Holz

In a future study, we will report on the changes in color and IR spectra of the wood acetylated in another occasion (i.e. after the first light-irradiation or after heat treatment).

Acknowledgement This research was supported by the Industrial Technology Research Grant Program in 2003 of the New Energy and Industrial Technology Development organization of Japan.

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