The Alleviation of Discoloration in Teak (*Tectona grandis* L.f.) Wood Through Drying and Chemical Treatments

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Abstract

Teak wood is well known as one of the important wood species from Indonesia. The properties of this wood are quite good and delighted by many people. However, the wood processing may cause discoloration on some pieces or boards of this wood. This degrades the wood performance. The wood surface is slightly darkened. Dark-brown streaks often arise distinctly on the brown color of wood surface. Moreover, when the kiln-dried wood is re-exposed in the further process with a planner or a molder, the discoloration may still exist. The aim of this study was to find out an appropriate technique to alleviate discoloration on teak wood. The result showed that drying temperature was the most important factor in the discoloration of teak wood. Among chemical treatments in this experiment, the use of 3% Na_2SO_3 solution was the most effective way to alleviate discoloration on teak wood.

Key words: Teak, discoloration

Introduction

Discoloration problem due to drying was found in some commercial wood species, for example, ilomba (*Pycnanthus angolensis* Exell), oak (*Quercus robur*), hem-fir, redwood (*Sequoia sempervirens*) and white pine (*Pinus strobus* L.). The type and characteristics of wood discoloration vary among wood species. Millet (1952) reported that factors influencing brown stains (discoloration) of wood were age of wood, drying conditions, and extractives. In ilomba wood, discoloration was characterized by a reddish-brown color which was developed during drying, particularly at the area in contact with other sapwood, was caused by chemical reactions of extraneous compounds in the parenchyma cells (Bauch *et al.* 1985). In oak, brown discoloration developed at the beginning of kiln drying (Bauch *et al*. 1991), but in European oak, brown discoloration developed during kiln drying, particularly in a kiln schedule which applied high moisture content and high temperature (Charrier *et al*. 1992). The case of discoloration that occurred in oak wood as reported by Dujesiefken *et al*. (1984) might be explained as the result of chemical reactions in the xylem, including the formation of phenols and other components, followed by oxidation process as the wood tissue exposed to the air.

To prevent or alleviate the discoloration on woods could be done by some treatments, such as using low temperature (above the fiber saturation point) and using higher temperatures thereafter diminishing discoloration (Tarvainen 1994 in Tarvainen *et al*. 2001; Basri *et al*. 2001), steaming treatment before drying on red wood (Anderson *et al*. 1960) and kumia wood (Basri *et al*. 1998), chemical treatment on Eastern white pine wood before kiln drying (Shields *et al*. 1973), manipulation of kiln drying schedules on the drying of hem-fir (Avramidis *et al*. 1993), and vacuum process on European oak wood (Charrier and Haluk 1992).

Normally, fresh teak (*Tectona grandis* L.f.) wood has a uniform light-brown color. The sapwood is light and can clearly be distinguished from the brown heartwood. The discolored wood, on the other hand, is characterized by blotchy orange and dark-brown marks, which degrade the color uniformity of the wood surface. Sometimes these blotchy marks appear in green or black colors. Unless the wood is kiln dried, the blotchy marks will remain within one or two months.

In the drying of some teak wood pieces or boards, however, dark-brown streaks often arise in contrast to the brown color of the wood surface. Moreover, when the surface of kiln dried wood is re-exposed in further process with a planner or a molder, all discolorations reappear on the wood surface.

Various efforts in alleviating discoloration of teak wood have been done. But, the results have not been satisfied yet. Furthermore, though discoloration problem has been studying by many researchers, related problem to discoloration in teak wood especially the main influencing factors and efforts to minimize the problem are still unclear and limited. Therefore, to share the knowledge relating to this matter, we report our study on quality improvement of discolored teak wood.

Materials and Methods

Materials

Teak wood of 55 years old from Cepu, Central Java, Indonesia was used in this research since the woods from this region often produce discoloration during drying. The sample size (thickness, width, and length) for moisture content determination was 2 cm x 2 cm x 10 cm; for drying schedule determination was 2 cm x 10 cm x 20 cm; and for the alleviation experiment of discoloration was 2 cm x 10 cm x 40 cm.

Methods

Determination of moisture content (MC) was conducted following gravimetric procedure. The wood samples were oven-dried at (103 ± 2)°C until their weight was constant. The MC was then calculated based on their weight before and after oven-drying. To minimize drying defects during kiln drying, an optimum drying schedule by Terazawa (1965) was applied.

This research consisted of two steps. The first step was studying the mechanism of discoloration on teak wood, and the second one was the color equalization of the wood surface.

Presteaming treatment before drying could successfully prevent discoloration (Anderson *et al*. 1960). But, this technique does not work on teak since it still exists even though the wood surface was planned. Therefore, the equalization in this study was done by combining drying technique and chemical treatments; after and before drying. Physical appearance and the color were evaluated qualitatively using naked eye.

In this experiment, five treatments were applied and compared in terms of their effectiveness in the alleviation of discoloration on teak wood:

1st treatment: Eight fresh teak wood samples were dried in a kiln with a suitable drying schedule to reach 8% MC. After the discoloration occurred, all wood were soaked in 1% H_2O_2 an hour and then divided into two groups of drying treatment. One group was dried under direct sunshine (without shade), while the other group was air dried under shed at room temperature. The physical appearance and their color were recorded and evaluated regularly.

2nd treatment: Thirty-two fresh teak wood samples were dried in a kiln to 8% MC. Afterwards, all samples were 1 mm-planned. The surface part that experienced discoloration was grouped into four. Three groups were soaked in 5% Na_2SO_3, 5% Na_2CO_3, and 5% sodium borate respectively an hour each, and the remaining group was as control. After the treatments, all samples divided into two groups to be dried. One group was air dried without shed. The other group was air dried under shed. The physical appearance and their color were recorded regularly.

3rd treatment: Twenty-four fresh teak wood samples were dried in a kiln to 8% MC. Afterwards, all samples were 1 mm-planned. The surface part that experienced discoloration was grouped into three and then was soaked in 3% Na_2SO_3, 3% Na_2CO_3, and 3% sodium borate respectively, an hour each. All samples divided into two groups to be dried in air dried without shed and under shed. The physical appearance and their color were recorded regularly.

4th treatment: Twelve fresh teak wood samples were used. Their initial MC was determined. Then they were grouped into three. The 1st group was soaked in 3% sodium borate, the 2nd with 3% Na_2CO_3, while the 3rd was soaked in 3% Na_2SO_3. Each treatment was done several times until the wood could not absorb the chemical solution. The samples then were dried to 8% MC. The observation of MC was done with moisture meter and weight measurement. After the drying process, the physical quality and the color were evaluated. Then they were planned about 1 mm before being evaluated again.

5th treatment: Twenty-four fresh teak wood samples were dried to 8% MC. After the discoloration occurred, all samples divided into three groups, which were treated separately with different chemical solution (diluted of 3% Na_2CO_3, 3% Na_2SO_3, and 3% sodium borate). After that, all samples were divided into two groups to be air dried with and without the shed respectively. The physical appearance and the color were recorded regularly.

Results and Discussion

The MC of teak wood samples before drying was between 50% and 60%. The drying temperatures used in this experiment were between 50ºC and 77ºC according to the drying schedule in Table 1. These temperatures were still under allowable temperature limit (55ºC ~ 85ºC). Drying with this schedule did not cause physical drying defects, except, their color became darker. In average, drying all wood samples from fresh to ± 8 % MC took 4 days.

Table 1. Drying schedule of teak wood

Moisture Content (%)	Dry Bulb Temperature (ºC)	Relative Humidity (%)
Initial ~ 40	50	71
40 ~ 35	50	66
35 ~ 30	50	50
30 ~ 25	60	48
25 ~ 20	60	43
20 ~ 15	70	40
≤ 15	77	30

During drying, some extractives from inside of wood were moving out to wood surface. It was found that wood surface became greenish at the beginning, and then turned to dark brown or black at the end of drying process. It showed that due to heat influences, the greenish color of extractives was oxidized. This phenomenon produced discoloration in teak.

Figure 1 shows the dried teak wood samples without chemical treatment (control). It showed that the

wood color is uneven where blotchy orange and dark brown marks present at some parts, as a consequence of discoloration.

Figure 1.Teak Wood After Kiln Drying

It could be deduced that the color of extractive in teak was greenish since the wood color surface at the beginning of drying process turned from brown to greenish. And under heat influence, the extractives became dark brown to black. This result similar to that in mangium (Basri *et al*. 2001).

In the trial of 1st treatment, the discoloration on the wood samples after drying was cleaned with 1% H_2O_2 technical solution followed by open air drying (under direct sunshine) for 6 ~ 8 hours. The discolored wood surface with brown marks changed uniformly to a bright yellowish brown color. On the other hand, the samples that air dried under shed at room temperature after treated with 1% H_2O_2 solution changed to a pale brown color.

It probably related to the H_2O_2 effect as bleaching agent and oxidation by sunshine.

In the trial of 2nd treatment, the discolored surface was still present after 1 mm-planning. Then after chemical treatments of 5% Na_2SO_3, 5% Na_2CO_3 and 5% sodium borate respectively for a few hours air drying without shed and 3-5 days air drying under shed, the color of wood surfaces became uniformly brighter without brown streaks/marks compared to that before chemical treatments. This phenomenon probably also relating to the chemicals effect as bleaching agent.

In the trial of 3rd and 4th treatments, the brown streaks were cleaned after chemical treatments. The treatments with 3% Na_2SO_3, 3% Na_2CO_3 and 3% sodium borate respectively for a few hour air drying without shed and 3 ~ 5 days air drying under shed resulted in brighter surface color compared to that of the 2nd treatment method. But, when the samples were re-dried in a kiln or re-planned, the discoloration reoccurred. It showed that lower concentration of the chemicals will lower the reaction during bleaching.

Figure 2. Teak Wood After 5th Treatment Method.

In the trial of 5th treatment, the discoloration on wood surface after drying were cleaned by chemical treatments (with Na_2SO_3, Na_2CO_3 and sodium borate less than 3% respectively), followed with air drying under shed for ± 5 days. The color quality was better and more uniform compared to the other treatments. The treatment with diluted 3% Na_2SO_3 solution resulted in the best result, which fulfilled required color quality standard. The color was light and bright brown with oily surface that was specific character of teak wood (Fig. 2).

When these treated wood samples were re-dried in a kiln, the discoloration reoccurred. So, the temperature

in the kiln seemed to be the dominant factor in the discoloration on teak wood.

Based on the above results, the best treatment for improving the color quality of teak wood was the 5th treatment. There were several steps done in this treatment; drying the fresh wood, planning and treating them with diluted 3 % Na_2SO_3 solution before air drying at room temperature for 5 days. The condition of air drying room should be dry and clean since wet condition could reduce the process of treatment.

Chemical treatment effectively eliminated the surface discoloration only. The discoloration might reappear when the wood was planned. Therefore, it was suggested that the treated wood should not be planned or the chemical treatment should be applied after planning.

The use of 1% H_2O_2 could also improve the color quality of teak wood. But, it caused the reduction of oil content on the wood surface. This might be solved by reducing the concentration of H_2O_2 solution to be less than 1%.

Conclusions

This research concluded that discoloration on teak wood could be alleviated by the combination of chemical treatment and preliminary kiln drying on fresh teak wood.

Diluted 3% Na_2SO_3 is the best solution used in this experiment. Using this solution, the color of treated wood was light brown and bright with oily surface.

Chemical treatment equalized only the color of wood surface. Therefore the treatment should be applied after planning.

H_2O_2 solution could also be used to equalize the surface color of wood. But, the concentration should be less than 1%. So the surface color was not too yellow and the surface was still oily.

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