The Alleviation of Discoloration in Teak (*Tectona grandis*) 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 moulder, 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.

INTRODUCTION

Teak wood (*Tectona grandis*) has long been known as one of the primary important wood species. In Indonesia, the trees mostly grow in Java, particularly in the Central Java and East Java provinces. Teak wood has a good combination of wood properties. Its physical-mechanical properties and its durability from bio-deterioration are quite good. Many people are also interested in its color and feature. Some end products from teak wood are high class furniture. These products are currently exported to the East Asian countries, European and the United States. One problem usually found in the processing of teak wood is discoloration on its surface. This problem has been reported that caused financial losses in the teak wood products.

Normally, fresh teak wood has a uniform light-brown color. The sapwood is white color 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 this 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 moulder, 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. Therefore, Forest Products Technology Research and Development Center (FPTRD), Bogor-Indonesia made a study and experiment to improve the quality of color and feature of processed teak wood. This research consisted of two steps. The first step was studying the mechanism of discoloration on teak wood. The second step was the color equalization of the wood surface. The color equalization was done by combining drying technique and chemical treatments. This experiment used two technical methods. The first method was equalizing wood color after drying, while in the second method, the chemical treatments were conducted before drying to prevent discoloration during drying.

DISCOLORATION ON SOME SPECIES OF WOODS AND ITS ALLEVIATION EFFORTS

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*) dan white pine (*Pinus strobus* L.). The types and characteristics of wood discolorations 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 all 1985). In oak, brown discoloration developed at the beginning of kiln drying (Bauch et all 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 all 1992). The case of discoloration that occurred in oak wood as reported by Dujesiefken et all (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 fibre saturation point) and using higher temperatures thereafter diminishing discoloration (Tarvainen 1994 in Tarvainen et all 2001, Basri et all 2001); steaming treatment before drying on red wood (Elwood et all 1960) and kumia wood (Basri et all 1998); chemical treatment on Eastern white pine wood before kiln drying (Shields et all 1973); manipulation of kiln drying schedules on the drying of hem-fir (Avramidis et all 1993); and vacuum process on European oak wood (Charrier & Haluk 1992).

MATERIALS AND METHODS

Materials

This research used teak woods from the border region between Central Java and East Java. Teak woods from this region often experience discoloration during drying. Some wood samples were made from fresh teak wood. The samples were used for moisture content determination (2.0 x 10.0 x 2.0) cm, drying schedule determination (2.0 x 10.0 x 20.0) cm, and for the alleviation experiment of discoloration (2.0 x 10.0 x 40) cm.

Methods

Firstly, the determination of moisture content (MC) was conducted according to the standard procedure. Some wood samples were oven-dried at (103 ± 2) ^oC until their weight was constant. The MC of wood samples were calculated based on their weight before and after oven-drying. In addition, an optimum drying schedule of wood samples was determined according to the method made by Shin Terazawa (Terazawa 1965), to minimize drying defects during kiln drying.

In this experiment, some wood treatments were experimented 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 to reach 8% moisture content. After the discoloration occurred, all wood were treated with 1% H_2O_2 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 color of the samples were recorded and evaluated regularly.

The 2nd Treatment

Thirty-two fresh teak wood samples were dried in a kiln to 8% moisture content. Afterwards, all samples were 1 mm-planned. The surface part that experienced discoloration were grouped into four. Three group were treated with 5% Na_2SO_3, 5% Na_2CO_3, and 5% natrium borat respectively, 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 color of the samples were recorded regularly.

The 3nd Treatment

Twenty-four fresh teak wood samples were dried in a kiln to 8% moisture content. Afterwards, all samples were 1 mm-planned. The surface part that experienced discoloration were grouped into three and then were treated with 3% Na_2SO_3, 3% Na_2CO_3, and 3% natrium borat respectively. All samples divided into two groups to be dried in air dried without shed and under shed. The physical appearance and color of the samples were recorded regularly.

The 4rd Treatment

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

The 5th Treatment

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

Result and Discussion

The MC of teak wood samples before drying were between 50% and 60%. The drying temperatures used in this experiment were between 50 ºC - 77 ºC (**Table 1**). These temperatures were still under allowable temperature limit (55 ºC – 85 ºC). 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 (%)	DB 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 kiln drying, extractives from the inside of wood moved the wood surface. The color of extractives was greenish. Under heat influence, the extractives were oxidized and their color became dark brown to black marks/ stains which spread on the surface and inside of the wood. **Figure 1**. shows the dried teak wood samples without treatments (control).

As a consequence of discoloration, the export price of teak products could drop to 50%; some of them could even be rejected. Presteaming treatment before drying on red wood (Elwood et all 1960) and kumia wood (*Manilkara sp*) successfully prevented discoloration. But, this technique did not cause satisfied result on teak wood. Discoloration of kumia wood was only on its surface. This defect could be eliminated by planning wood surface (Basri et all 1998). Discoloration on teak wood still existed even though the wood surface was planned.

In the trial of 1st treatment method, the discoloration on the wood samples after drying was cleaned with technical 1% H_2O_2 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 yellow 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 less bright yellow color.

Figure 1.Teak wood after kiln drying

In the trial of 2nd treatment method, the discolored surface was still existing after 1 mm-planning. Then after chemical treatments 5% Na_2SO_3, 5% Na_2CO_3 and 5% natrium borat respectively for a few hours air drying without shed and 3-5 days air drying under shed, the color of wood surfaces became uniformly darker without brown streaks/ marks compared to that before chemical treatments.

In the trial of 3rd and 4th treatment methods, the brown streaks were cleaned after chemical treatments. The treatments with 3% Na_2SO_3, 3% Na_2CO_3 and 3% natrium borat respectively for a few hours air drying without shed and 3-5 days air drying under shed resulted in brighter surface color compared to that 2nd treatment method. But, when the samples were re-dried in a kiln or re-planned the discoloration reoccurred.

In the trial of 5th treatment method, the discoloration on wood surface after drying were cleaned by chemical treatments with (Na_2SO_3, Na_2CO_3 and natrium borat) less than 3%, followed with air drying under shed for ± 5 days. The color quality was better and more uniform compared to the other treatment methods (1st, 2nd, 3rd, 4th 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 (**Figure 2**).

Figure 2. Teak wood after 5th treatment method.

When these treated wood samples were re-dried in a kiln, the discoloration reoccurred. So, the temperature or the drying condition in the kiln seemed to be the dominant factor in the discoloration on teak wood.

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

Chemical treatment effectively eliminated only the surface discoloration. 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 diluting the H_2O_2 solution to be less than 1% concentration.

CONCLUSSIONS

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 solution is the best chemical used in this experiment. The color of treated teak wood was light and bright brown 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 be used to equalize the surface color of teak 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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