USDA

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Note
FPL–RN–0311

Factors Affecting Oxidative Stain in Soft Maple (*Acer rubrum* L.)

Michael C. Wiemann
Mark Knaebe

Abstract

A preliminary study to determine possible treatments that might be used to eliminate or limit value reducing stain in soft maple suggests that rapid processing and treatment with sulfur dioxide gas decreases discoloration, high-temperature drying increases discoloration, and freezing in dry ice prior to processing has no effect.

Keywords: discoloration, oxidative stain, sulfur dioxide

Acknowledgments

The authors thank the U.S. Agency for International Development and Andrea von der Ohe of the U.S. Forest Service International Programs for funding this study. Kretz Lumber Co., Inc., Antigo, Wisconsin, donated the soft maple. Sam Zelinka (Forest Products Laboratory), Regis Miller (Forest Products Laboratory, retired), Terry Mace (Wisconsin Department of Natural Resources), and Robert White (Forest Products Laboratory) gave critical reviews that improved the manuscript.

October 2008

Wiemann, Michael C.; Knaebe, Mark. 2008. Factors affecting oxidative stain in soft maple (*Acer rubrum* L.). Research Note FPL-RN-0311. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 4 p.

A limited number of free copies of this publication are available to the public from the Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53726–2398. This publication is also available online at www.fpl.fs.fed.us. Laboratory publications are sent to hundreds of libraries in the United States and elsewhere.

The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin.

Factors Affecting Oxidative Stain in Soft Maple (*Acer rubrum* L.)

Michael C. Wiemann, Botanist
Mark Knaebe, Forest Products Technologist
Forest Products Laboratory, Madison, Wisconsin

Introduction

To discover possible treatments to eliminate gray oxidative stain that often develops in soft maple (*Acer rubrum* L.) and the tropical species ochoó (*Hura crepitans* L.), we subjected a large number of wood samples of soft maple to treatments, dried them, and evaluated the effects of the treatments on wood color. This was an exploratory study only and does not lend itself to statistical analysis. Its purpose is to provide information to use in the design of a controlled research study.

When present, the stain typically affects all the sapwood. A board surface may occasionally be unstained for a depth of a millimeter or two, but planing or sawing will expose the stained wood.

Our previous research (Wiemann and others 2007, Wiemann and others in press) showed that treatment with sulfur dioxide as a gas or in aqueous solution reduced or eliminated stain and that storage time and drying temperature affected the amount of discoloration. Using low temperature to retard the reactions causing discoloration might also be a mechanism to prevent stain. Because boards of ochoó that were hit with a hammer prior to other treatments left a white hammerhead mark after drying, but similarly treated soft maple boards left a dark mark, we decided to explore this very interesting contradiction by hitting every board at least once with a hammer.

Methods

We obtained 128 test boards from 1-in.- (25-mm-) thick sapwood planks freshly sawn from soft maple logs. Their initial moisture contents were calculated from 1-in. (25-mm) moisture content samples that were weighed green, oven-dried, and weighed after oven-drying. Each test board was also weighed prior to treatment so that its calculated ovendry weight could be determined and used to monitor drying.

Test boards were divided into three approximately equal groups. One of these groups was treated immediately. The other two groups were stored at a temperature of 27°C and a relative humidity (RH) of at least 90% for either 5 or 10 weeks before treatments. Treatments are described in Table 1.

The sequence of sulfur dioxide exposure, freezing, and hammering was varied among samples. Boards were dried in a constant temperature and humidity room (23°C, 50% RH, 9% equilibrium moisture content) or in a conditioning chamber (46°C, 75% RH, 13% equilibrium moisture content).

Table 1. Treatments applied to test boards

Treatment	Application	No. of boards
Exposure to sulfur dioxide gas in sealed plastic bags	No exposure	21
	Exposure for 1 h	107
Freezing at –73°C	No freezing	96
	Freezing for 20 h	32
Hammering board surfaces with 16-ounce (450-g) carpenter's hammer		All
Drying	23°C, 50% RH	53
	46°C, 75% RH	75

The samples equilibrated until their calculated weights indicated that they had reached an average moisture content of 20% or less. They were then cut open to evaluate type and amount of discoloration and effects of hammer impacts. They were re-evaluated after 1 month.

Results and Discussion

The initial moisture content of all sample boards was greater than 50%. Results of evaluations are shown in Table 2. Freezing had no effect, and hammering had a limited effect on only a few boards, so these treatments are not included in the table.

Rapid processing had a profound effect on discoloration. Table 2 shows that stain became more severe as storage time increased, regardless of treatment with sulfur dioxide.

The color of the wood was white (i.e., no discoloration) (Fig. 1), gray (the typical oxidative stain) (Fig. 2), or blotchy red or pink (Fig. 3). Samples that were not treated with sulfur dioxide developed gray stain. Those treated immediately after sawing were either white (no storage or storage for only 5 weeks) or pink (storage for 10 weeks). Samples that were treated after storage and conditioning had pink stain (5 weeks storage) or a mixture of gray and pink stain (10 weeks storage), with more gray in the samples conditioned at higher temperature (Table 2). We had not previously seen the pink color, and we do not know if the sulfur dioxide treatment prevents or removes discoloration.

Table 2. Effects of treatments on wood color[a]

Board storage	Board conditioning	Wood color following indicated sulfur dioxide treatment		
		No treatment	Treated immediately after sawing	Treated after storage
None	23°C, 50% RH	Light gray	White	—
	46°C, 75% RH	Gray	White	—
5 weeks, 27°C, >90% RH	23°C, 50% RH	—[b]	White	Blotchy red or pink
	46°C, 75% RH	Gray	White	Blotchy red or pink
10 weeks, 27°C, >90% RH	23°C, 50% RH	Gray	Blotchy red or pink	Mostly pink, some gray
	46°C, 75% RH	—[b]	Blotchy red or pink	Mostly gray, some pink

[a] Color ranges from white (completely unstained) to gray. RH, relative humidity.
[b] No samples.

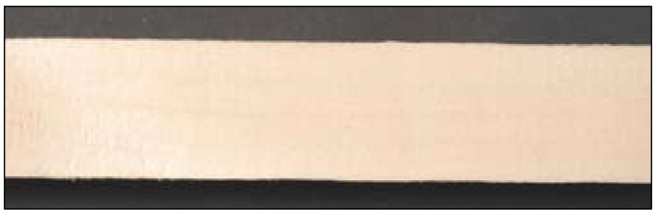

Figure 1. Edge view of pure white soft maple board treated with sulfur dioxide.

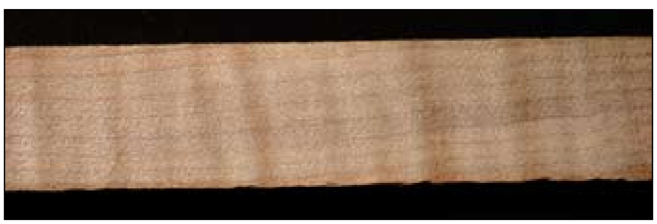

Figure 2. Edge view of board showing severe gray discoloration in untreated soft maple board.

Figure 3. Edge view of board showing blotchy red discoloration in soft maple board treated with sulfur dioxide.

In stained samples that were treated immediately, surfaces were white for a depth of a few millimeters (Fig. 4), as is normally the case for gray stain in maple. The stained samples that were treated after 5 or 10 weeks storage were stained throughout their cross sections with no white surfaces (Fig. 2).

With time, the pink color decreased and the boards appeared less stained. After a month, many of the boards were completely unstained, and others were only slightly pink. Although the previously unseen pink color surprised us, it seems that it is only temporary and that sulfur dioxide will produce unstained wood, at least in the boards stored for 5 weeks.

The pink color may be present with, but masked by, the gray, and treatment with sulfur dioxide may be more effective at preventing or eliminating gray than pink. Samples untreated by sulfur dioxide appear gray, those treated immediately after sawing and stored for 5 weeks or less appear white, and those treated immediately after sawing but stored for 10 weeks appear pink. If samples are not treated until after storage, stain will develop and cannot be removed. Sulfur dioxide treatment is adequate to prevent the gray but not the pink from boards stored only 5 weeks but cannot prevent all the gray from the boards stored for 10 weeks. Higher temperature and humidity increase the severity of the gray stain (Table 2).

Although we believed that lower temperature could eliminate stain, preliminary results from this experiment show that board storage time and drying temperature are interactive. We thought that drying below a unique critical temperature might be sufficient to control stain, but it seems that the drying temperature must be lower if boards are stored longer. Stain may also occur even at ambient temperature (as in air-drying) if the drying time is very long.

Although we hit all the boards with the hammer, the effects were visible in only four of them (Fig. 5). None of these four had been treated with sulfur dioxide. These results further confuse the already ambiguous results obtained from previous studies. Figure 6 shows the *unstained* areas produced in every board of ochoó that was hit with a hammer; Figure 7 shows the *stained* area produced in every board of soft maple that was similarly hit. We have no explanation for why only a few of the soft maple boards of this study developed dark hammer marks. One possible factor could be harvest season. The trees of our previous study were harvested in autumn; hammering left dark marks. The trees of this study were harvested in late winter; hammering did not leave dark marks in most boards.

Figure 4. Edge view of board with white surfaces but with interior gray discoloration.

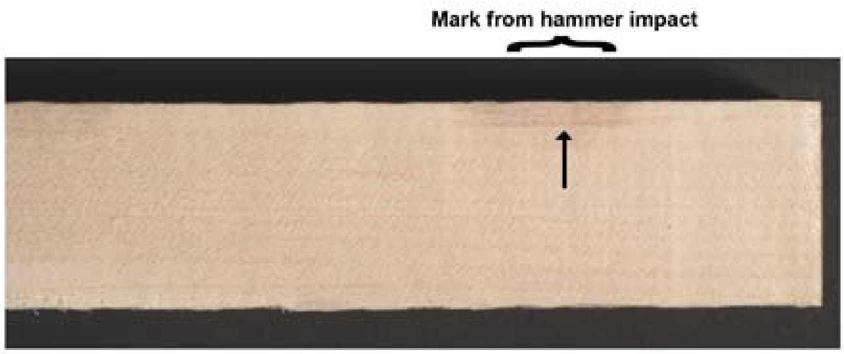

Figure 5. Edge view of soft maple board showing hammer impact marked by discolored wood.

Figure 6. Hammer impact in ochoó board marked by *unstained* (white) wood.

Figure 7. Hammer impacts in soft maple board marked by *stained* wood.

Conclusions and Recommendations

1. Log storage time affects the amount of discoloration, so the ability of rapid processing to decrease or eliminate stain requires further study.
2. Unstained surfaces in otherwise stained boards may result from rapid surface drying, or they may result from saw blade trauma. Not all samples had unstained surfaces, and the hammer tests gave results that differed from previous tests. Therefore, the effects of impact need to be assessed in a more controlled study.
3. Low-temperature freezing does not affect the amount of discoloration.
4. Treatment of boards with sulfur dioxide can reduce or eliminate stain, although in some cases this treatment produced a pink stain, which faded over time. The feasibility of using this treatment will depend on cost, facilities, and noxiousness of the chemical.
5. High drying temperatures increase the amount of discoloration regardless of other treatments. Discoloration is probably a function of both temperature and time.

References

Wiemann, M.C.; Bergman, R.D.; Knaebe, M.; Bowe, S. In press. Exploring methods for prevention of oxidative stain in soft maple (*Acer rubrum* L.). Research Paper. Madison, WI: U.S. Forest Service, Forest Products Laboratory.

Wiemann, M.C.; Knaebe, M.; Harriague, F. 2007. Reduction of oxidative stain in ochoó (*Hura crepitans* L.). Research Note FPL-RN-0306. Madison, WI: U.S. Forest Service, Forest Products Laboratory. 23 p.