CWPA Proceedings, 2006, pp 68-76

CHARACTERISING THE PERMEABILITY OF BEETLE-KILLED WOOD

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Summary

The major defining characteristic of lumber cut from mountain pine beetle-killed trees is the extent of fungal bluestain. Bluestained wood has been reported to show increased permeability, which may make treatment with liquids such as wood preservatives easier. However, no data is available on the impact of the degree of bluestain resulting from the beetle attack. We therefore identified the need to generate data on the permeability characteristics of bluestained beetle-killed wood compared with non-stained wood.

The permeability of the wood was determined by weighing end-matched specimens before, and after 1-, 4-, and 24-hour dip or after a pressure treatment cycle with chromated copper arsenate preservative and then calculating the uptake and preservative retention.

The increase in permeability was confirmed by enhanced CCA uptake and penetration. Treatment with CCA also masked the bluestain by coloring it green, thereby disguising the less desirable stained wood. Given the high volume of bluestained lumber in the sawmill pipeline for the foreseeable future, it is possible that a significant amount of beetle-killed wood can be diverted into products such as treated decking. The fine micro-checking on the stained wood gave a superior appearance over non-stained sapwood. This would be an advantage for pressure treated decking when the sapwood is uppermost.

Further work on the drying and wetting properties of bluestained beetle-killed wood, as well as treatment studies and field tests with other wood preservatives are recommended.

Objective

To determine if commercially available mountain-pine beetle-killed (bluestained) lumber permeability properties differ from non-bluestained lodgepole pine sapwood.

Introduction

The major defining characteristic of lumber cut from mountain pine beetle-(MPB) killed trees is the extent of stain caused by bluestain fungi. Bluestained wood has been reported to show increased permeability, which may make treatment with liquids such as wood preservatives easier (Scheffer, 1969). However, no data was available on the impact on this property of the specific bluestain resulting from MPB attack.

We therefore have identified the immediate need to generate data on the permeability characteristics of bluestained wood compared with non-stained wood. Such work was undertaken and is reported here, together with some of the work's implications.

Materials and Methods

Sample Preparation

Ten bluestained and ten non-stained 2 x 4 in. lumber pieces from 14 mills across British Columbia were randomly selected for this study. For each stain type (stained and non-stained) 35 eight ft lengths were prepared, and divided as much as possible evenly across the source mills. All test specimens were conditioned at ambient pilot plant temperature (20°C) and relative humidity (~45%) for a minimum of 5 days, achieving a moisture content of about 8%.

Wood Permeability

The test described here was designed to measure permeability by determining whether bluestained wood absorbs more liquid than non-stained wood either during simple soaking or pressure treatment. Chromated copper arsenate (CCA) was used as a tracer wood preservative chemical because it reacts with the wood and stops moving at the end of the dip or pressure process. Twin, end-matched (labeled A and B) test specimens of full cross section, approximately 6 in. long and free of major defects were cut, numbered by mill source (1-14) and lumber piece (1-5), and end sealed with three coats of epoxy resin. All test specimens were further conditioned at ambient pilot plant temperature (21°C) and relative humidity (45% RH) for a minimum of 5 days. Each specimen was weighed and, after drawing the heartwood sapwood boundary on each end with a fine felt tip pen, the amount of sapwood was measured using a clear template divided into 20 squares. This enabled an estimate of the sapwood: heartwood ratio (±5%).

"A" specimens were soaked in a 1.8% CCA wood preservative solution for 1, 4 and 24 hours and reweighed at each interval. Test specimens were wrapped in a polyethylene sheet to retard drying and, to promote fixation, placed in an oven at approximately 75°C for 24 hours. Following fixation the specimens were unwrapped and oven dried at 50°C for 24 hours. For preservative penetration determinations, a 50 mm sample slice was cut from the center of each specimen. Each sample slice was sprayed with Chrome Azurol S and the penetration of preservative, as revealed by the blue color of the reagent, was measured at the center of the sapwood and heartwood faces. The percentage of cross-sectional area penetrated was also measured with the clear template for both sapwood and heartwood. Chemical retention based on uptake and sapwood content data were entered into a spreadsheet for analysis.

"B" specimens, both stained and unstained, were treated, in a retort with the following short pressure treatment schedule:

- 30 min full vacuum 740mm Hg
- Fill retort under vacuum with 1.8% CCA solution
- 2 minutes to full pressure
- 35 minutes at full pressure - 1035 kPa
- 10 min pressure relief
- Empty retort
- 15 minute final vacuum 740 mm Hg

This schedule had been pre-determined by experimentation to give a treatment which would just fully treat the stained portion of the specimens. Following treatment each specimen was reweighed. Fixation, drying and sampling of the specimens for penetration determinations were done as previously described for the soaked samples. Uptake, retention and sapwood content data were entered into a spreadsheet for analysis and reporting.

Results and Discussion

Preservative Uptake

During the soaking test both the stained and non-stained wood showed an initial rapid wetting during the first hour and further increase in uptake was roughly linear up to 24 hours. Stained wood absorbed more liquid, 400%, 400% and 300% higher uptake than the non-stained specimens over 1, 4 and 24 hour soaking periods respectively (Table 1). A 1-hour soaking of stained specimens resulted in twice the uptake of that from a 24 hour soaking of non-stained specimens. This difference is not accounted for by the higher proportion of sapwood in the stained specimens and thus shows that the stained wood was significantly more permeable than the non-stained wood. Liquid uptake data were converted to preservative retentions for reporting in Table 1 and Figure 1. The pressure treated stained specimens had a mean retention of 7.0 kg/m^3, more than twice the 3.2 kg/m^3 retention of the non-stained wood (Table 1).

Table 1: Average Retentions of Soaked and Pressure Treated Stained and Non-stained Wood

Treatment	**Stained**	**Non-stained**
Soak - 1 Hour (kg/m^3)	1.4 (1.1)[1]	0.3 (0.1)
Soak - 4 Hours (kg/m^3)	1.6 (1.2)	0.4 (0.1)
Soak - 24 Hours (kg/m^3)	2.1 (1.3)	0.7 (0.2)
Pressure – 35 min.(kg/m^3)	7.0 (3.5)	3.2 (2.4)

[1] Numbers in parentheses are standard deviations (n = 70)

Preservative Penetration

Penetration data is given in Table 2 as the mean percentage of sapwood or heartwood penetrated by the preservative as well as the mean penetration and percent over 10 mm on the sapwood and heartwood faces (see also Figures 2 – 4). Following a 24 hour soak the stained specimens had 61% of the available sapwood treated compared to only 8% of the sapwood treated in the non-stained specimens. As might be expected, heartwood was basically unpenetrated; both stained and non-stained specimens had only 1% of the heartwood treated, with a 24 hour soaking treatment. Almost all of the sapwood (99%) in the pressure treated stained specimens was penetrated, compared to 81% for the non-stained specimens. The pressure treated stained specimens had 25% of the heartwood treated, compared to 14% for the non-stained. As indicated by penetration data, stained material therefore had greater sapwood permeability in both treatments and a slight improvement in the adjacent heartwood permeability was indicated with the pressure treatment. The higher permeability of the stained wood is well-illustrated by Figures 5 and 6.

Table 2: Penetration Data Summary

	Dip Treatment		**Pressure Treatment**	
	Stained	**Non-stained**	**Stained**	**Non-stained**
Avg. sapwood treated (%)	61 (27)[1]	8 (15)	99 (3)	81 (25)
Avg. heartwood treated (%)	1 (1)	1 (1)	25 (25)	14 (16)
Centre sapwood face Avg. penetration[2](mm)	6.6 (5.5)	0.5 (0.7)	12.1 (5.0)	4.6 (4.9)
Centre heartwood face Avg. penetration[2] (mm)	1.2 (4.0)	0.0 (0.1)	2.9 (4.6)	2.3 (2.9)
Centre sapwood face [2] (% ≥ 10 mm)	24	0	71	20
Centre heartwood face[2] (% ≥ 10 mm)	7	0	10	6

[1] Numbers in parentheses are standard deviations (n = 70)
[2] Max. penetration measured = 16 mm

To highlight any differences, for this study the penetration measurements were taken from the center of both sapwood and heartwood faces. (Industry core borings to determine conformity to standards are taken randomly from the lumber edges.) The mean penetration into the sapwood face was over 12 times higher for the soaked stained specimens (mean = 6.6 mm) than for the non-stained specimens (mean = 0.5 mm). The pressure treated stained specimens had a 160% higher mean sapwood penetration than non-stained specimens. Following pressure treatment the center heartwood penetration measurements showed virtually no difference between stained and non-stained wood but there was higher heartwood mean penetration in the stained vs. the non-stained wood after 24 hours of soaking.

Heartwood/Sapwood Ratio

The data collected enabled the determination of the relative amount of sapwood and heartwood for the wood in test. The summary data show an average of 50% sapwood (standard deviation 29.2) in the bluestained pieces and 31% sapwood (standard deviation

30.5) in the non-bluestained pieces. Despite this difference in the amount of sapwood between stained and non-stained samples, we believe the 250 cross sections measured (to the nearest 5%) in collecting these data were a representative sample of the whole of the material tested.

General Discussion and Implications

The work reported here clearly shows that bluestained beetle-killed, wood is more permeable to water than non-stained sapwood. The anticipated increase in permeability was confirmed in our research in terms of CCA uptake and penetration data. One implication of the stained sapwood treating more readily than non-stained wood is that in batches of preservative treated wood the stained wood is liable to be over treated or the non-stained wood undertreated. As might be anticipated there was virtually no effect of bluestain in the sapwood on the penetration of preservative into the heartwood, the most refractory part of the wood. The micro-checking biologically mimics incising, a mechanical process used on refractory wood to increase preservative penetration and enable standards to be met. Unfortunately the micro-checking is in the wrong place because the sapwood is already treatable. Because pieces of lodgepole pine lumber are hardly ever pure sapwood, it is hard to take advantage of the increased permeability. Attempting to do so by shorter press time will exacerbate the sapwood:heartwood preservative retention ratio even more heavily towards the sapwood. From the standpoint of the treater more preservative would be used, along with higher cost, to achieve the same level of protection of the non-durable heartwood. CSA standards require treatment of both heartwood and sapwood, and the heartwood is the limiting factor in achieving compliance with CSA standards. Consequently, improved sapwood permeability is not a great advantage to the pressure treating industry.

Treatment with CCA masked the bluestain by coloring it green, thereby disguising the less desirable stained wood. Preservatives now commercialized as replacements for CCA in the domestic market have a similar color and the results obtained here with CCA are likely applicable also to those preservatives. Given the high volume in the sawmill pipeline for the foreseeable future it is possible that a significant amount of beetle-killed wood can be diverted into products such as treated decking. The fine micro-checking on the stained wood gave a superior appearance over non-stained sapwood. This would be an advantage for pressure treated decking when the sapwood is uppermost.

Increased permeability also means that dried bluestained wood will wet up more readily in the presence of liquid water. We have previously observed this in bluestained lumber left unprotected in the weather. Preservative treated bluestained wood would also wet up more under similar circumstances. End uses such as decking will be subjected to wetting/drying cycles, simulated in this testing. This may increase the leachability of less fixed preservatives such as the ones being commercialized to replace CCA. Reducing the wetting of treated wood by water repellents or sealants might be a useful strategy.

Conclusions

- Bluestained beetle-killed wood is more permeable than non-stained sapwood and absorbs water-based wood preservative more readily.

References

Scheffer, T.C. 1969. Protecting stored logs and pulpwood in North America. Mat. u Org. 4(3): 167-199.

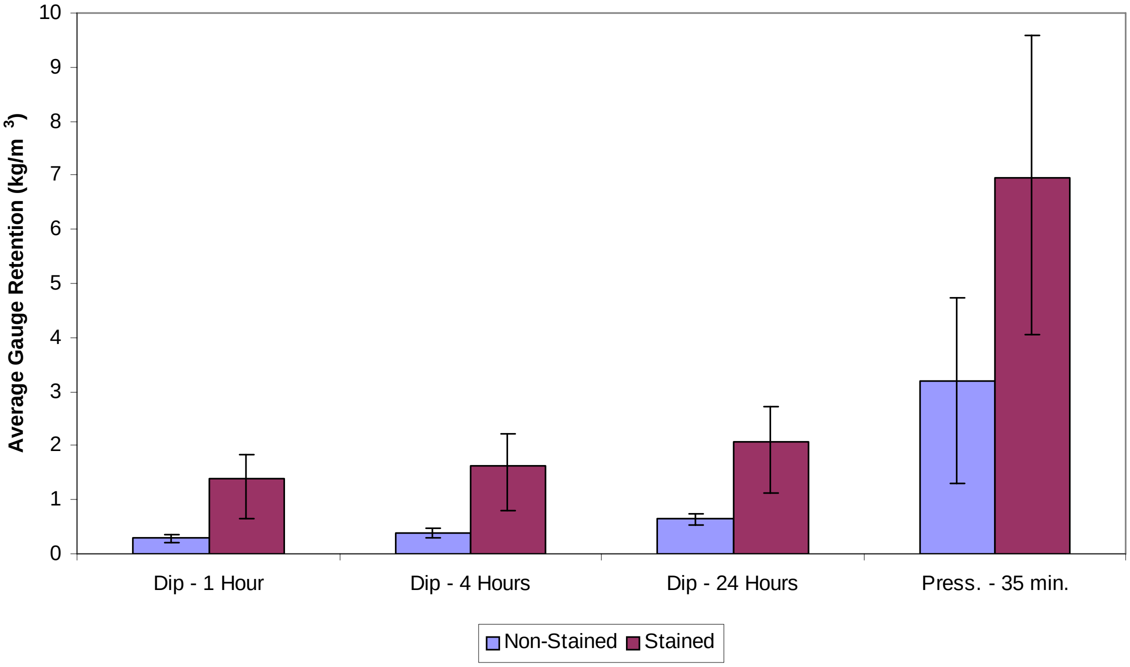

Figure 1: Average Retention – Dip vs. Pressure Treatments (Bars indicate 25th and 75th percentiles)

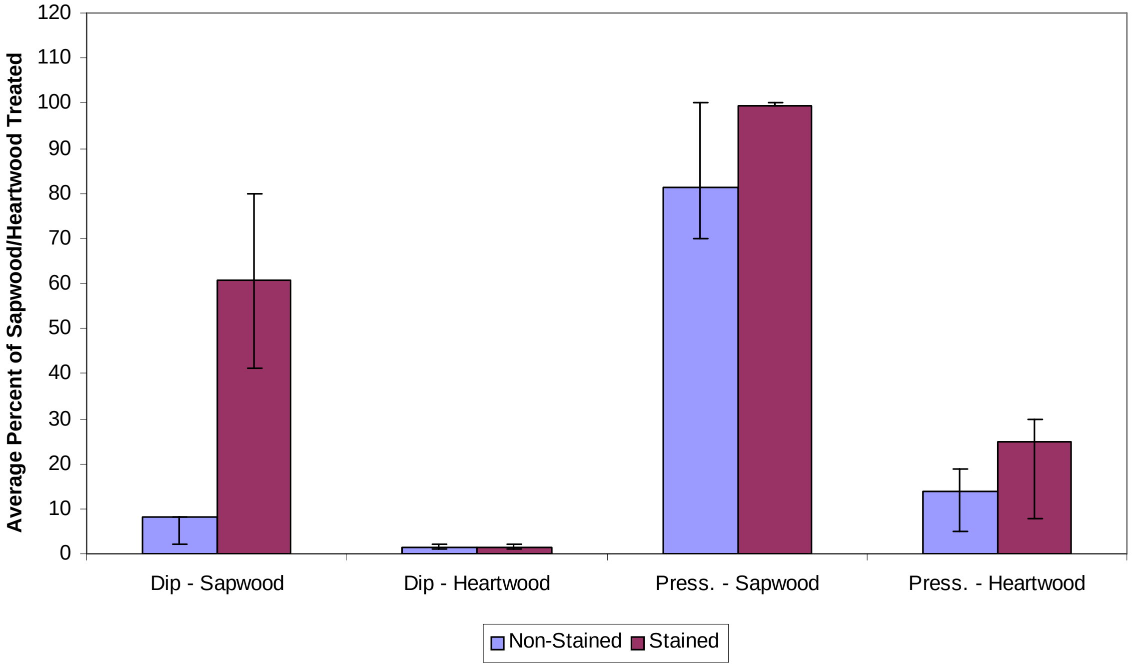

Figure 2: Average Percent of Heartwood/Sapwood Treated in Dip and Pressure Treatments (Bars indicate 25th and 75th percentiles)

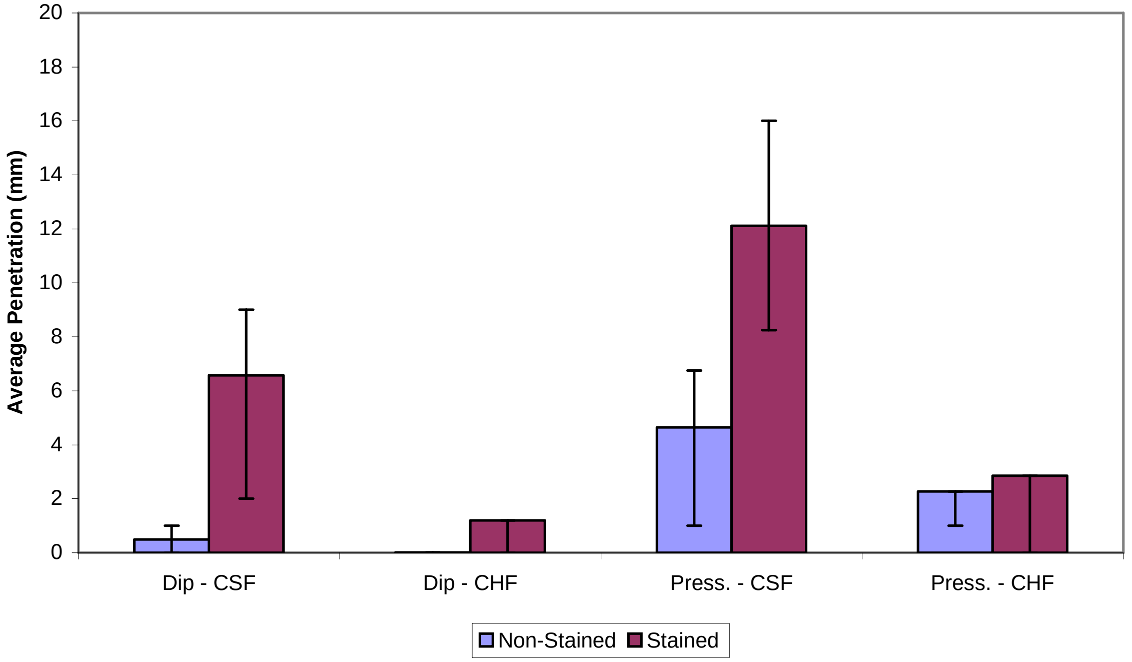

Figure 3: ***Mean Penetration of CCA in Dip and Pressure Treatments (Bars indicate 25th and 75th percentiles)***

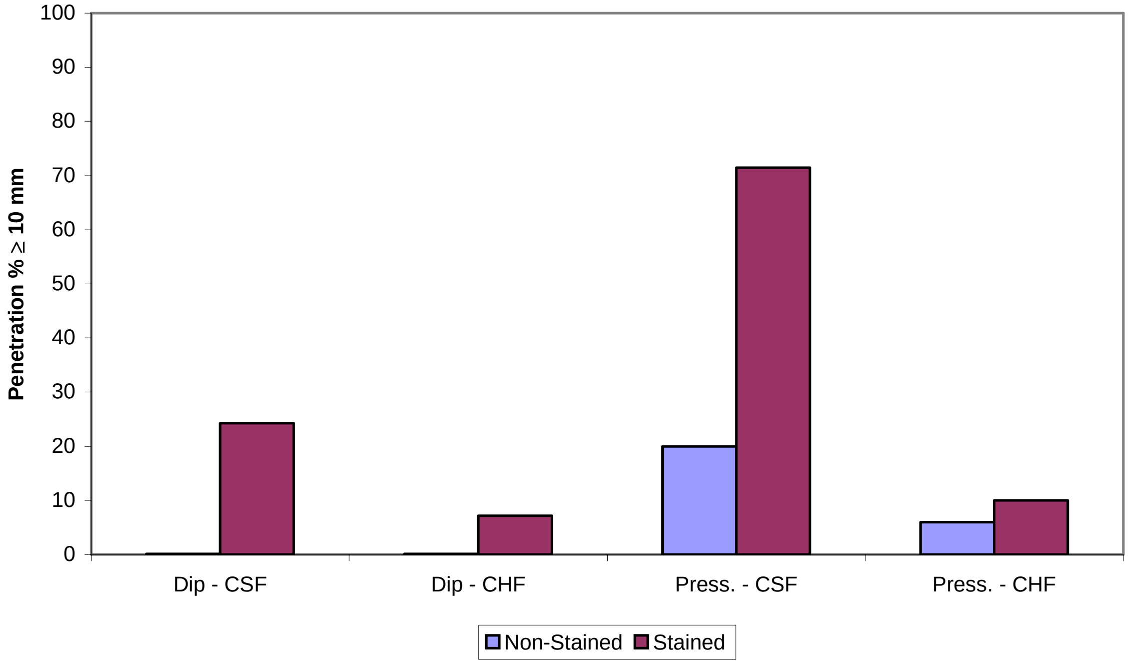

Figure 4: ***Percent Penetration ≥ 10 mm on Centre Sapwood and Heartwood Faces***

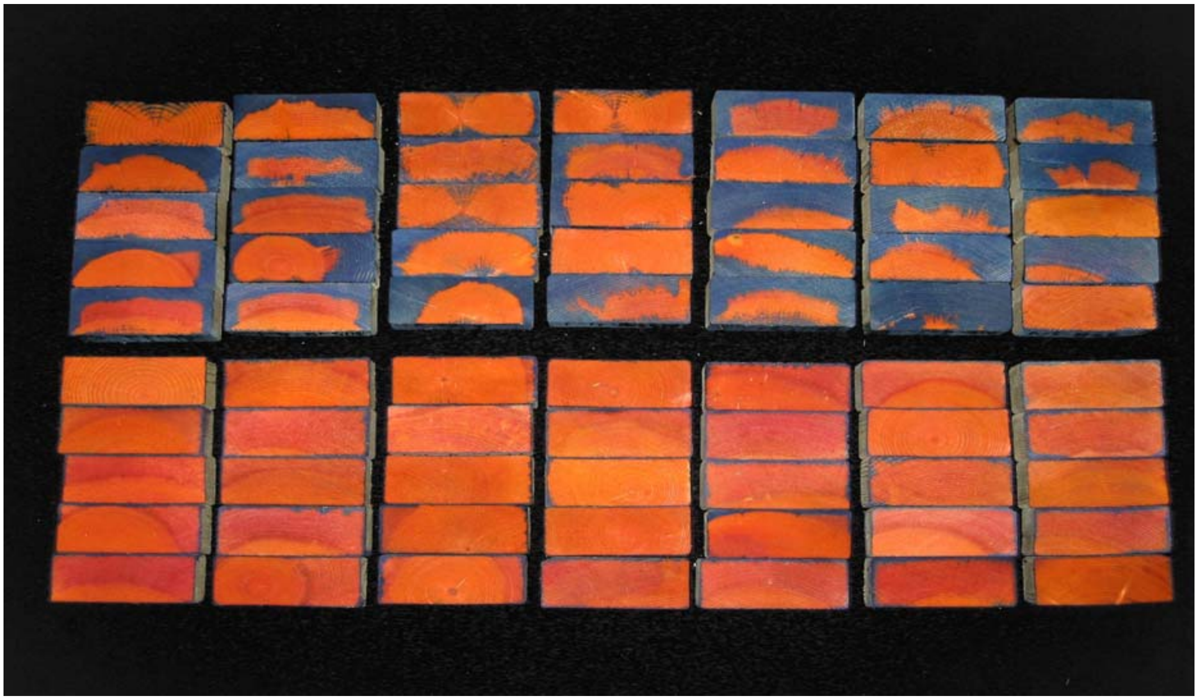

Figure 5: Non-stained Specimens – Pressure (top) vs. Dip Treated (24 hours soak)

Figure 6: Stained Specimens – Pressure (top) vs. Dip Treated (24 hours soak)