Control of Stain and Mold Fungi on Red Alder Pallet Stock

Jeffrey J. Morrell
Dennis Sanders

Abstract

The potential for limiting fungal attack on red alder (*Alnus rubra* Bong.) pallet stock was evaluated in a small-scale field test. Alder is extremely susceptible to biological attack, as evidenced by the nearly complete colonization of nontreated materials within 18 days after cutting. Pallet stock was either dipped or sprayed with 11 different candidate fungicides. Dipping tended to produce better protection than spraying, reflecting the opportunity for greater uptake during the dipping process. Most treatments provided protection for 11 days when applied by dipping, while only four treatments were able to provide protection for the full 30-day test period. The results suggest that chemical protection of alder is possible, but the protective period is much shorter than that found with other wood species.

Pallets play a critical role in global trade, and wood plays a major role in pallets because it is strong, reliable, relatively inexpensive, and renewable. It can also be easily disposed of at the end of its useful life. Most wood pallets are constructed using freshly cut lumber that remains susceptible to fungal attack until the wood dries below the fiber saturation point (Zabel and Morrell 1992). For many years, fungal mold was considered a minor inconvenience, but public concerns about mold, coupled with the potential for these fungi to contaminate the materials being transported on the pallets, have heightened concerns about how to limit mold using chemical treatments without these same chemicals contaminating materials being transported on the pallets. Many wood species are used to produce pallets, and there is considerable variation in susceptibility of these woods to fungal attack (US Department of Agriculture 2010). Red alder (*Alnus rubra* Bong.) is among the most susceptible woods used for pallet construction in the Pacific Northwest (Resch 1980, Niemiec et al. 1995). The wood of this species contains high levels of carbohydrates, and mold fungi can develop on the wood surface in as little as 3 days after sawing. This creates a substantial logistical problem because alder pallet stock is often transported for long distances after sawing, and pallets are fabricated while the materials remain green. Transportation can occur on open flatbed trucks, which can allow for some surface drying, but pallet stock is also moved in closed trucks that limit the potential for moisture loss and encourage rapid fungal development. While kiln drying would virtually eliminate this risk, the cost would make these materials less competitive. Developing effective, economical methods for protecting freshly cut alder would help facilitate more efficient movement of these materials.

In previous tests, a variety of chemicals were shown to provide 2 months of protection to freshly cut alder, although there was considerable variation in the degree of protection afforded by the treatments (Miller and Morrell 1990). Although there is little direct evidence that mold on lumber constitutes a health risk, attitudes about the presence of any mold have changed considerably (Robbins and Morrell 2002). Mold is a particular problem on pallets that are often used without drying. Pallet users do not want mold, nor do they want harsh chemical treatment, because either might contaminate the materials being transported. In addition, there have been a number of changes in the formulations used for protecting freshly sawn lumber that suggest a need for updated evaluations of currently used antisapstain systems.

In this report, we describe tests of potential chemical systems for protecting freshly cut red alder pallet stock against fungal attack.

Materials and Methods

Freshly sawn red alder pallet stock (17 mm by 140 mm by 1 m) was obtained from a mill located near Eugene, Oregon. The 570 boards were allocated to one of 19 treatment groups

The authors are, respectively, Professor, Dept. of Wood Sci. and Engineering, Oregon State Univ., Corvallis (jeff.morrell@oregonstate.edu [corresponding author]); and Quality Control Manager, Northwest Hardwoods, Inc., Tacoma, Washington (Dennis.Sanders@northwesthardwoods.com). This paper was received for publication in October 2015. Article no. 15-00068.

Forest Prod. J. 66(7/8):467–471.
doi:10.13073/FPJ-D-15-00068

of 30. Fifteen boards from each group were allocated to be sprayed, while the other 15 were allocated to be dipped in a given system. One end of each board was marked to represent the nontreated half. This approach provided a direct comparison between treatments and controls on every board.

Eleven different formulations were obtained from various chemical companies (Table 1). All but two of the concentrates were diluted to two target concentrations on a weight basis with regular tap water according to manufacturers' recommendations. The levels were typically a concentration approaching the upper limit allowed by the label and the approximate midpoint of the label. One system was only tested at one concentration, while another was tested at a high concentration for the spray treatment and a lower concentration for the dip treatment.

Fifteen boards from a given treatment group were immersed for half their length for 30 seconds in the desired treatment solution, allowed to drain for several minutes, and then solid piled by treatment in stacks of 15 boards. The remaining 15 boards from a treatment group were sprayed to runoff on both sides for one-half their length with the desired treatment solution. This meant that each board had a nontreated and treated half. The boards were stacked in two layers of nontreated alder on the bottom (with all nontreated ends vertically aligned), and then the 15 boards of a given treatment were placed on top, followed by an additional nontreated board. Seven stacks were placed on a pallet, and then two additional stacks of nontreated boards were placed on either side of the treated pieces. The nontreated boards were used to limit drying of the treated samples and to create more stable, elevated moisture conditions. Many of these boards were also heavily colonized by mold and stain fungi and thus provided copious inoculum for the test boards. The entire unit was then wrapped in black polyethylene to retard drying, and the wood was then placed in a shaded area. The test occurred during the months of August and September when daytime temperatures ranged from 25°C to 33°C, creating ideal conditions for fungal growth.

The degree of fungal discoloration was visually assessed 11, 18, and 30 days after treatment on a scale from 0 (no mold or stain attack) to 100 (complete discoloration). The presence of fungal attack was counted in the rating regardless of color intensity. The results were tabulated by treatment to assess the ability of each chemical to limit fungal attack over the test period. There is no specific level of protection that would be considered adequate for performance because different wood users perceive mold to differing degrees. For the purposes of this test, treatments with ratings of 30 percent or less were considered to be providing acceptable protection to the wood.

The data for the 18- and 30-day assessments were also subjected to an analysis of variance, and the results were then compared using Tukey's pair-wise comparisons ($\alpha = 0.05$). This analysis must be viewed with some caution, because significant differences between treated and nontreated halves may be meaningless if the overall rating of the treated half exceeds the threshold for protection.

Results and Discussion

The discoloration ratings on nontreated control halves of boards ranged from 21 to 98 percent 11 days after treatment, illustrating the high degree of susceptibility to fungal attack of this wood species (Table 2). Only one of the 19 dip treatments (Britewood XL at the 1:50 dilution) had a rating greater than 30 percent 11 days after treatment, suggesting that most treatments were capable of providing short-term protection to the wood (Table 2). Spray treatments were far less effective, with only 9 of the 19 treatments providing the acceptable level of protection. Effective treatments included the two Mycostat IV dilutions, NexGen, Workhorse, both Britewood systems, and AntiBlu 64 system. Eleven days would be sufficient for transportation of freshly cut material

Table 1.—Components present in antifungal systems evaluated for the ability to protect freshly cut red alder.

Trade name	Concentrate content (%)	Supplier
Mycostat IV	2.7% propiconazole/5.4% fenpropimorph/9.0% boric acid	Diacon Technologies, Ltd., Richmond, BC, Canada
Mycostat BX-2	2.0 propiconazole/5.0% disodium tetraborate pentahydrate	
CelBrite FS1	50% potassium sorbate	Koppers Performance Chemicals, Griffin, GA
CelBrite Plus	45% potassium sorbate/0.8% 3-iodo-2-propynyl-butylcarbamate (IPBC)	
PQ-8	5.4% oxine copper	ISK Biocides, Inc., Memphis, TN
TuffBrite/PQ-8	40.4% chlorothalonil	
NexGen	14.5% chlorothalonil/14.7% methylbisthiocyanate Plus PQ-8	
Workhorse	1.1% IPBC/1.1% propiconazole/0.3% diiodomethylparatolylsulfone plus 6.9% WRS-15 & 27.0% penetrator	KopCoat Inc., Pittsburgh, PA
Britewood XL	46.5% dimethyl didecyl ammonium chloride/ 4.94% propiconazole	Contechem, Inc. Portland, OR
Britewood Special	1% IPBC/4% orthophenylphenate/4% propiconazole	
AntiBlu XP-64 plus Cellu-Treat DOT	25% alkyldimethylbenzylammonium chloride/6% IPBC/4.0% propiconazole plus 1% disodium octaborate tetrahydrate	Arch Wood Protection, Conley, GA, and Nisus Corporation, Rockford, TN

Table 2.—Discoloration of red alder 11 days after dip or spray treatment with different antimicrobial chemicals.[a]

		Degree of discoloration			
		Dip		Spray	
Trade name	Dilution	Control	Treated	Control	Treated
Mycostat IV	1:50	25 (16)	**1 (3)**	81 (13)	**27 (15)**
	1:75	27 (21)	**1 (3)**	74 (27)	**27 (17)**
Mycostat SP	1:20	63 (28)	**19 (26)**	88 (16)	36 (23)
	1:30	40 (27)	**7 (13)**	76 (26)	33 (17)
Cellbrite FS-1	1:5	47 (28)	**19 (22)**	89 (10)	43 (22)
	1:10	53 (21)	**23 (23)**	77 (22)	77 (22)
CellBrite Plus	1:10	66 (22)	**24 (14)**	61 (21)	**19 (16)**
	1:20	24 (14)	**3 (6)**	69 (29)	**27 (26)**
PQ-8	1:100	80 (21)	**29 (22)**	98 (4)	53 (26)
	1:150	77 (18)	**23 (18)**	100	82 (14)
Tuffbrite/PQ8	1:250	55 (26)	**18 (16)**	93 (12)	65 (29)
	1:350	77 (21)	**28 (22)**	100	59 (18)
NexGen	1:250	61 (9)	**9 (7)**	55 (15)	**17 (22)**
Workhorse		82 (23)	**11 (9)**	91 (13)	**15 (11)**
Britewood XL	1:50	95 (10)	36 (22)	83 (14)	**27 (14)**
	1:40	36 (21)	**5 (6)**	97 (5)	**13 (16)**
Britewood Special	1:50	95 (26)	**16 (26)**	99 (5)	**19 (8)**
	1:40	47 (10)	**5 (9)**	77 (14)	**11 (10)**
AntiBlu 64	1:50	34 (27)	**1 (3)**	—	—
	1:15	—	—	21 (17)	**4 (9)**

[a] Values represent means of 15 boards per treatment, where 0 signifies no stain or mold while 100 signifies complete fungal coverage. Values in parentheses represent one standard deviation. Values in bold text are at or below the minimum considered to provide acceptable protection.

from the mill to most pallet manufacturers, but would provide relatively little additional time for storage.

Discoloration ratings on nontreated control boards ranged from 74 to 100 percent 18 days after treatment, further illustrating the high susceptibility of red alder wood to fungal attack (Table 3). White-rot decay was observed on a number of boards. Almost all treatments had significantly lower degrees of discoloration than the nontreated controls, but only five dip treatments provided acceptable protection (<30% rating) to the alder over the

Table 3.—Discoloration of red alder 18 days after dip or spray treatment with different antimicrobial chemicals.[a]

		Degree of discoloration			
		Dip		Spray	
Trade name	Dilution	Control	Treated	Control	Treated
Mycostat IV	1:50	93 (12)	38 (30) CDEF	100	45 (18) EFG
	1:75	81 (16)	33 (13) DEF	99 (5)	63 (24) BCDE
Mycostat SP	1:20	99 (4)	57 (26) BCD	98 (6)	53 (25) DEF
	1:30	93 (11)	40 (25) CDEF	90 (14)	63 (26) BCDE
Cellbrite FS-1	1:5	92 (12)	61 (18) BC	95 (9)	82 (24) ABC
	1:10	86 (18)	59 (16) BCD	99 (3)	98 (4) A
CellBrite Plus	1:10	98 (4)	47 (28) BCDE	91 (16)	42 (21) EFG
	1:20	95 (10)	49 (12) BCDE	29 (25)	**23 (26) G**
PQ-8	1:100	100	74 (20) AB	84 (11)	43 (34) EFG
	1:150	95 (14)	63 (26) BC	95 (11)	77 (32) ABCD
Tuffbrite/PQ8	1:250	99 (3)	**27 (13) EF**	100	60 (31) CDE
	1:350	99 (3)	49 (26) BCDE	100	89 (15) AB
NexGen	1:250	95 (5)	48 (27) BCDE	95 (7)	42 (16) G
Workhorse		100	**17 (19) F**	99 (4)	**23 (12) FG**
Britewood XL	1:50	100	44 (19) CDEF	95 (11)	**27 (18) FG**
	1:40	91 (18)	**22 (15) EF**	100	**22 (19) G**
Britewood Special	1:50	98 (8)	47 (31) BCDE	99 (3)	61 (26) CDE
	1:40	100	**27 (29) EF**	100	38 (15) EFG
AntiBlu 64	1:50	81 (23)	31 (18) DEF	—	—
	1:15	—	—	75 (12)	**30 (9) FG**

[a] Values represent means of 15 boards per treatment, where 0 signifies no stain or mold while 100 signifies complete fungal coverage. Values in parentheses represent one standard deviation. Values in bold text are at or below the minimum considered to provide acceptable protection. Values followed by the same letter(s) do not differ significantly from one another using Tukey's pair-wise comparisons ($\alpha = 0.05$).

Table 4.—Discoloration of red alder 30 days after dip or spray treatment with different antimicrobial chemicals.[a]

		Degree of discoloration			
		Dip		Spray	
Trade name	Dilution	Control	Treated	Control	Treated
Mycostat IV	1:50	100	**29 (26) GH**	100	43 (20) EFG
	1:75	100	**26 (16) GH**	100	**23 (10) G**
Mycostat SP	1:20	100	39 (26) EFGH	100	61 (28) DE
	1:30	100	**29 (20) GH**	100	68 (25) CD
Cellbrite FS-1	1:5	100	90 (9) AB	100	84 (20) ABC
	1:10	99 (4)	67 (24) BCD	100	95 (10) AB
CellBrite Plus	1:10	89 (12)	43 (21) DEFGH	97 (7)	59 (27) DE
	1:20	100	65 (24) BCDE	99 (3)	86 (22) ABC
PQ-8	1:100	100	59 (35) CDEF	100	89 (10) ABC
	1:150	100	77 (20) ABC	100	99 (3) A
Tuffbrite/PQ8	1:250	100	39 (11) EFGH	100	93 (11) AB
	1:350	100	52 (30) CDEFGH	100	95 (11) AB
NexGen	1:250	100	70 (19) BC	100	37 (22) FG
Workhorse		100	**30 (26) GH**	100	**23 (16) G**
Britewood XL	1:50	100	58 (13) CDEF	100	33 (14) G
	1:40	99 (4)	**24 (10) H**	100	31 (9) G
Britewood Special	1:50	100	71 (14) BC	100	73 (20) BCD
	1:40	100	32 (25) FGH	100	78 (13) ABCD
AntiBlu 64	1:50	100	**24 (11) H**	—	—
	1:15	—	—	94 (18)	57 (19) DEF

[a] Values represent means of 15 boards per treatment, where 0 signifies no stain or mold while 100 signifies complete fungal coverage. Values in parentheses represent one standard deviation. Values in bold text are at or below the minimum considered to provide acceptable protection. Values followed by the same letter(s) do not differ significantly from one another using Tukey's pair-wise comparisons ($\alpha = 0.05$).

18-day test period (TuffBrite 1:250, Workhorse, Britewood XL 1:40, Britewood Special 1:40, and AntiBlu 64). Five of the spray treatments also provided acceptable protection over the 18-day period (CellBrite Plus 1:20, TuffBrite 1:250, Workhorse, Britewood XL, and AntiBlu 64). Interestingly, the CellBrite system was less effective when used as a dip system, although it is important to understand that the nontreated control halves of boards sprayed with this chemical also had much lower levels of discoloration, suggesting that the conditions for fungal growth were less suitable on this set of boards. The results illustrate the difficulty of protecting alder from fungal attack.

Fungal discoloration was nearly complete on the nontreated halves of both the dipped and sprayed boards 30 days after treatment (Table 4). Eleven of 19 treatments had stain ratings that were significantly better than those for the controls, but only four treatments provided acceptable protection (<30% rating) to the boards, including both Mycostat IV treatments, Mycostat BX-2 (1:30 dilution), Workhorse, Britewood XL (1:40 dilution), and AntiBlu 64. Mycostat IV (1:75) and Workhorse were the only spray treatments that provided acceptable protection over the same period. The two Britewood XL treatments were nearly at the acceptable level, while the remaining treatments were unable to provide adequate protection. All of these treatments contained propiconazole as one of their ingredients. This chemical was not in use when the earlier alder trials were performed, but it is a common component in formulations used in the Western United States (Morrell et al. 2002, Schauwecker and Morrell 2008).

The results clearly illustrate both the inherent susceptibility of alder to fungal attack as well as the difficulty of using chemical treatments to protect the wood. A number of treatments were somewhat effective, but relatively few boards in these treatments were free of fungal attack. These tests were performed during the hot summer months in Oregon, creating extreme pressure on any treatment. Many mills vary the concentrations of chemicals they use to protect lumber with time of year to take advantage of conditions less conducive to fungal growth, and it might be possible to use much lower concentrations of these active ingredients to provide short-term protection (Miller and Morrell 1990).

Mold on pallets is a major concern, and the use of chemicals may be one approach for protecting these materials. However, there have also been concerns about the use of chemicals on pallets. Some pallet companies ban the use of any chemicals for this application because of concerns that the chemicals would inadvertently contaminate materials being transported. However, many of these same companies restrict the presence of mold, creating a conundrum for suppliers. It will be important to examine the willingness of potential users to accept chemical treatment. Fungicides provide one reasonable approach for protecting these materials prior to pallet fabrication.

Conclusions

Alder stained rapidly and was virtually completely colonized within 30 days after cutting. Almost all systems provided adequate protection over an 11-day period when applied by dipping, while five provided protection over the entire 30-day test. The results illustrate the difficulty of protecting red alder from fungal attack but suggest that chemical treatments can effectively limit this damage.

Literature Cited

Miller, D. J. and J. J. Morrell. 1990. Controlling hardwood sapstain: Trials of stain-preventative products on red alder lumber. Research

Bulletin 68. Forest Research Laboratory, Oregon State University, Corvallis. 8 pp.
Morrell, J. J., C. S. Love, and C. M. Freitag. 2002. Preventing discoloration of unseasoned hem-fir and Douglas-fir lumber with selected fungicide formulations. *Forest Prod. J.* 52(2):53–61.
Niemiec, S. S., G. R. Ahrens, S. Willits, and D. E. Hibbs. 1995. Hardwoods of the Pacific Northwest. Research Contribution 8. Forest Research Laboratory, Oregon State University, Corvallis. 114 pp.
Resch, H. R. 1980. Utilization of red alder in the Pacific Northwest. *Forest Prod. J.* 30(4):21–26.
Robbins, C. and J. Morrell. 2002. Mold, housing and wood. Western Wood Products Association, Portland, Oregon. 11 pp.
Schauwecker, C. F. and J. J. Morrell. 2008. Use of antistain chemicals by softwood lumber producers in the Western United States during 2006—A survey. *Forest Prod. J.* 58(10):52–55.
US Department of Agriculture (USDA). 2010. Wood handbook: Wood as an engineering material. General Technical Publication FPL-GTR-190. USDA Forest Products Laboratory, Madison, Wisconsin. 509 pp.
Zabel, R. A. and J. J. Morrell. 1992. Wood Microbiology. Academic Press, San Diego, California. 474 pp.