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Controlling Sapstain: Trial of Strong Stain-Preventive Solutions on Selected Western Softwoods in Storage Prolonged For 12 Months

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Abstract

Environmental restrictions have induced many sawmills to seek alternatives to pentachlorophenol (penta) and similar chlorinated phenols for controlling mold and fungal stains on green lumber during storage and shipment. For that purpose, ten alternative stain preventives were evaluated against a traditional penta product (Permatox 101) on studs of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], hem-fir [*Tsuga heterophylla* (Raf.) Sarg.; *Abies* sp.], and sugar pine [*Pinus lambertiana* (Dougl.)] in field trials over a 12-month period. Strong solutions of most preventives provided good to excellent protection for 2 months. Efficacy decreased substantially after the studs were stored 6 months through warm weather. Hem-fir, and to a lesser degree, Douglas-fir, were adequately protected for 12 months only by Permatox 101. None of the treatments protected sugar pine for 1 year.

Introduction

Increasingly stringent environmental restrictions have induced many sawmills to seek less hazardous alternatives to pentachlorophenol and similar chlorinated phenols for control of fungal stains that otherwise degrade valuable lumber. Stain-preventive treatments that protect green lumber for as long as 6 months have generally satisfied the requirements of mills in the Pacific Northwest. Canadian producers now require 12-month protection for lumber to be exported overseas and have sought to prolong the 6-month period by monitoring the amount of fungicide deposited on the surface of lumber treated with very concentrated solutions.

This Paper reports the effectiveness of strong stain-preventive solutions for protecting Douglas-fir, hem-fir, and sugar pine lumber stored 12 months under severe field conditions at Oregon State University. Strong solutions should protect lumber for at least 6 months under hazardous storage conditions. Results after 2 and 6 months have been previously reported (Miller and Morrell 1989; Miller, Morrell, and Mitchoff 1989).

Procedure

Freshly sawn, rough green studs of Douglas-fir, hem-fir, and sugar pine were selected for high sapwood content, soundness, and freedom from fungal stains. Material sawn from old, partially dried logs was avoided.

Table 1. Chemicals tested in strong solutions as sapstain preventives.

Trade name	Preventives: Chemical name	Preventives: a.i. (%)	Concentrations tested: Dilution	Concentrations tested: Total a.i. (%)
GROUP 1				
BUSAN® 1030	2-(thiocyanomethylthio) benzothiazole	30	1:33	0.94
NP-1	Didecyl dimethyl ammonium chloride	64.8	1:100[1]	0.67
	3-iodo-2-propynyl butyl carbamate	7.6		
NYTEK™-GD	Copper-8-quinolinolate	10	1:40	0.046[2]
PQ-8	Copper-8-quinolinolate	5.4	1:50	0.020[2]
	Copper + borax			1.47[3]
Permatox 101	Sodium tetrachlorophenate	2.4	1:33	0.90
	Sodium pentachlorophenate	20.4		
	Sodium metaborate anhydrous	3.1		
	Phenylmercuric acetate	0.4		
GROUP 2				
BUSAN® 1009	Methylene bis thiocyanate	10	1:50	0.42
	2-(thiocyanomethyl) thiobenzothiazole	10		
MBT (Saptol-7)	Methylene bis thiocyanate	10	1:12.5	0.75
NYTEK™-GD	Copper-8-quinolinolate	10	1:40	0.046[2]
+ 4160 conditioner	(4160 added to solution)			
QUINDEX® N-10	Copper-8-quinolinolate	10	1:50	0.038[2]
RODEWOD® 200EC	Azaconazole	18.5	1:100	0.30[4]
+ DF50[5]	DF50	50.0		
RODEWOD® 2280-40400	Azaconazole	4.3	1:99	0.44
	Didecyl dimethyl ammonium chloride	43.0		
Permatox 101	Sodium tetrachlorophenate	2.4	1:33	0.90
	Sodium pentachlorophenate	20.4		
	Sodium metaborate anhydrous	3.1		
	Phenylmercuric acetate	0.4		

[1] Used solution, after dipping pine, was analyzed by Koppers at 1:144.

[2] % copper as metal.

[3] % copper + borax. Solution mix: 1 gal. PQ–8 + 50 gal. water + 12 lbs borax.

[4] Includes 0.10% DF50.

[5] DF50 added to solution used only on pine. DF50 is proprietary.

Two groups of chemicals were used in the trials (Table 1). Studs treated with stain preventives of group 1 were collected during April 1987, and those treated with preventives of group 2 during the succeeding May and June. Each group was regarded as a separate experiment and was evaluated against a standard treatment, Permatox 101.

Studs were treated within 24 to 36 hours of being sawn. Each was dipped to half-length for 15 seconds in a strong solution (the concentration recommended by vendors) of one of the preventives listed in Table 1. The undipped end of each stud served as the control. Each preventive was applied to 15 studs of the same species. The sets of 15 were assembled side by side into a bundle representing one wood species and all stain preventives of either trial group 1 or 2. Bundled studs were tightly strapped, end-coated, wrapped in black plastic sheeting to promote uniformly favorable conditions for staining throughout the bundle, and stored outdoors at Corvallis, Oregon.

After 2, 6, and 12 months, each stud having fungal stain or growth over at least 50% of the untreated, upturned face of the control end was evaluated according to procedures described by Miller and Morrell (1989). Stain damage was considered to be areas bleached or overgrown by fungi as well as those discolored by fungal stains and mold. Studs that had dried to <27% moisture content about 1/8 inch below the surface were not evaluated unless staining was already well advanced. Full details of the field trials and the earlier evaluations are given in Miller and Morrell (1989) and in Miller, Morrell, and Mitchoff (1989).

Results and Discussion

Stain

Discolorations and fungal growth had usually spread over at least 85% of the untreated surface of the control end of studs during the first 2 months of storage (Table 2). After 1 year, most control ends were nearly or completely discolored or overrun by fungi. These results confirm that there was strong potential for staining under the storage conditions of the trials.

Discolorations tended to be darker and to develop more rapidly on sapwood of Douglas-fir and sugar pine than on hem-fir, in which sapwood and heartwood were not readily distinguishable. Some sugar

Table 2. Mean percentage of untreated (control) areas of studs stained or overgrown by fungi after 2, 6, and 12 months of outdoor storage (see Figure 1 for dates). The number of studs evaluated is in parentheses.[1]

Preventive (treated end of stud)[2]	Douglas-fir			Hem-fir			Sugar-pine		
	2 mo	6 mo	12 mo	2 mo	6 mo	12 mo	2 mo	6 mo	12 mo
GROUP 1									
BUSAN® 1030	100 (15)	100 (14)	100 (14)	86 (12)	96 (14)	99 (15)	89 (8)	98 (9)	100 (9)
NP-1	99 (15)	100 (13)	100 (13)	86 (9)	89 (14)	95 (14)	97 (9)	99 (10)	100 (10)
NYTEK™-GD	100 (15)	100 (14)	100 (14)	79 (8)	88 (11)	98 (13)	100 (9)	98 (10)	100 (10)
PQ-8	100 (15)	100 (14)	100 (14)	87 (12)	94 (14)	99 (15)	97 (11)	99 (11)	100 (10)
Permatox 101	98 (15)	100 (12)	100 (12)	87 (6)	82 (12)	93 (13)	94 (11)	99 (12)	100 (12)
GROUP 2									
BUSAN® 1009	99 (15)	100 (14)	100 (13)	93 (12)	91 (15)	99 (15)	95 (13)	100 (13)	100 (11)
MBT	100 (15)	100 (14)	100 (14)	92 (13)	96 (15)	99 (15)	88 (12)	100 (12)	100 (9)
NYTEK™-GD + 4160	100 (15)	100 (14)	100 (14)	87 (12)	99 (15)	100 (15)	87 (14)	91 (15)	100 (13)
QUINDEX® N-10	100 (15)	100 (14)	100 (14)	85 (12)	99 (15)	100 (15)	83 (10)	99 (11)	100 (11)
RODEWOD® 2280-40400	100 (15)	100 (14)	99 (13)	93 (7)	85 (15)	97 (14)		No test	
RODEWOD® 200EC + DF50		No test			No test		83 (11)	89 (11)	100 (11)
Permatox 101	100 (15)	100 (14)	100 (12)	74 (9)	91 (14)	99 (14)	92 (13)	99 (13)	100 (14)

[1] Includes only those studs at least 50% stained on the untreated face area of the control end (sapwood only of Douglas-fir and pine).

[2] Names of stain-preventives are listed only to identify controls. No treatment effect on the control ends is implied.

pine heartwood later developed orange, dark-gray or black discolorations as well as surface growths; Douglas-fir heartwood normally did not. The results for Douglas-fir and sugar pine that follow refer only to the sapwood of those woods.

Douglas-fir

All preventives provided good to excellent protection during the first 2 months of storage (Table 3). After 6 months and the peak temperatures of August (Figure 1), efficacy of the treatments had declined; the percentage of studs that remained bright had fallen sharply, and staining over 70 to 100% of the treated surface of the studs was generally common. Best protection was provided by Permatox 101, especially if brown mold was disregarded, and by MBT.

Most treatments had failed after 12 months of storage, and many or all of the studs were extensively discolored or overrun by fungi. Permatox 101 and MBT provided the longest protection. The cause of the large discrepancy between the percentages of studs that remained bright in group 1 (8%) and group 2 (75%) 12 months after treatment with Permatox 101 is unknown.

Strong solutions of MBT at 0.8% a.i. and of TCMTB (i.e. Busan 1030) at 1.2% a.i. have provided "acceptable performance" against stain, mold, and decay fungi for16 months in Canadian tests with Douglas-fir, hem-fir, and spruce-pine-fir lumber under somewhat less severe storage conditions (Cserjesi *et al.* 1984).

Hem-fir

Most preventives provided 2 months of fairly good to excellent protection (Table 3). Permatox 101 and PQ–8 extended protection through 6 months of storage, but other treatments were less effective, and a few included large percentages of extensively stained studs.

Permatox 101 continued to provide very good protection through 12 months of storage. Other treatments were less effective and usually included more badly stained studs than bright studs. Under the less severe conditions of Canadian tests, NP–1 (0.5% a.i.) effectively protected hem-fir lumber for 12 months (Byrne and Johnson 1987), and strong solutions of TCMTB (i.e., Busan 1030) at 1.2% a.i. and of MBT at 0.8% a.i. provided "acceptable" efficacy for 16 months (Cserjesi *et al.* 1984).

TABLE 3. Percentage of studs that remained bright (<5% stained) or were extensively stained (70-100%) on the treated ends after 2, 6, and 12 months of outdoor storage (see Figure 1 for dates).

Preventive applied to treated end	Douglas-fir			Hem-fir			Sugar pine		
	n[1]	Bright	Extensively stained	n[1]	Bright	Extensively stained	n[1]	Bright	Extensively stained
GROUP 1									
BUSAN® 1030									
2 mo	15	93	0	12	100	0	8	100	0
6 mo	14	7	57	14	50	21	9	22	11
12 mo	14	0	71	15	33	53	10	20	40
NP-1									
2 mo	15	100	0	9	100	0	9	10	50
6 mo	13	0	84	14	50	0	11	18	82
12 mo	13	0	92	14	36	29	9	0	89
NYTEK™-GD									
2 mo	15	87	7	8	75	12	13	54	23
6 mo	14	7	79	11	18	18	13	15	69
12 mo	14	0	100	13	8	54	12	8	83
PQ-8									
2 mo	15	100	0	12	83	8	12	83	0
6 mo	14	14	64	14	79	0	12	33	8
12 mo	14	0	100	15	27	27	11	9	36
Permatox 101									
2 mo	15	80	0	6	100	0	12	75	0
6 mo	12	50	0	12	100	0	13	31	23
12 mo	12	8	30	13	85	8	13	8	69
Permatox 101[2]									
2 mo	15	(100)	—	—	—	—	—	—	—
6 mo	12	(92)	—	—	—	—	—	—	—
12 mo	12	(8)	—	—	—	—	—	—	—
GROUP 2									
BUSAN® 1009									
2 mo	15	100	0	12	75	0	13	85	0
6 mo	14	7	50	15	7	87	13	0	61
12 mo	13	0	100	15	0	93	11	0	100
MBT									
2 mo	15	100	0	13	100	0	12	92	0
6 mo	14	64	7	15	7	60	12	8	58
12 mo	14	29	14	15	0	100	9	0	100
NYTEK™-GD+4160									
2 mo	15	73	0	12	75	0	14	29	14
6 mo	14	7	71	15	13	33	15	0	93
12 mo	14	0	93	15	0	73	14	0	100
Quindex®N-10									
2 mo	15	93	0	12	42	17	10	20	40
6 mo	14	0	50	15	0	80	11	0	91
12 mo	14	0	100	15	0	100	11	0	100
RODEWOD® 2280-40400									
2 mo	15	100	0	7	71	14	No test		
6 mo	14	14	43	15	7	40	No test		
12 mo	13	0	77	14	0	100	No test		
RODEWOD® 200EC + DF50									
2 mo	No test			No test			11	72	0
6 mo	No test			No test			11	18	27
12 mo	No test			No test			11	0	91
Permatox 101									
2 mo	15	100	0	9	100	0	13	92	0
6 mo	14	79	7	14	93	0	13	8	0
12 mo	12	75	8	14	93	0	14	0	71
Permatox 101[2]									
2 mo	15	—	—	9	—	—	13	(100)	—
6 mo	14	(93)	(0)	14	(100)	—	13	(23)	—
12 mo	12	(92)	—	14	(100)	—	14	(0)	(64)

[1] Includes only studs at least 50% stained on the face area of the untreated end (sapwood area only of Douglas-fir and pine, and pine studs having sapwood on treated end only).

[2] Percentages in parentheses disregard brown mold. Double dash (—) indicates no brown mold present.

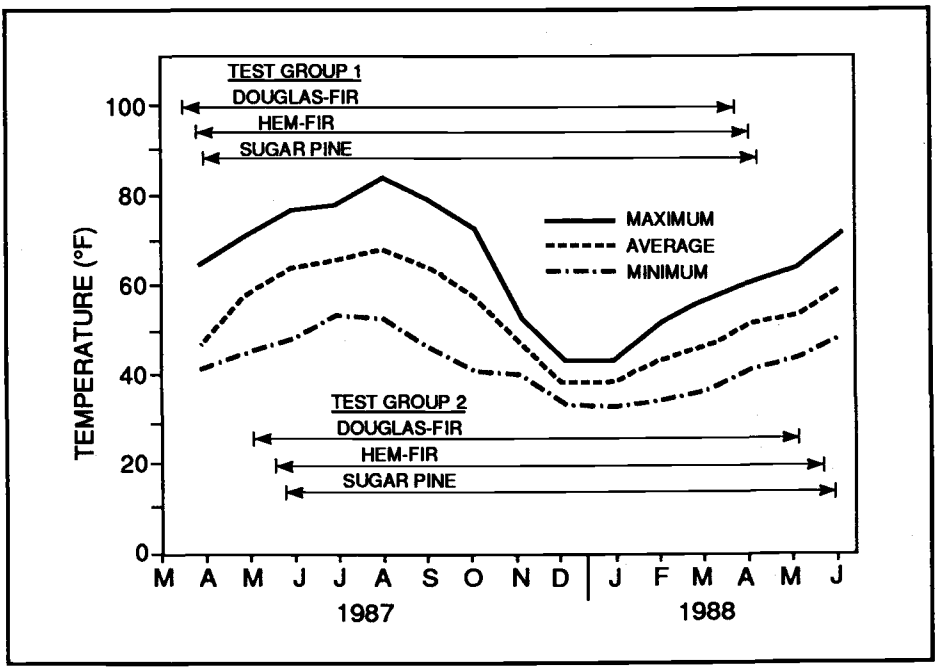

Figure 1. Average monthly temperatures during outdoor sapstain-control trials at Corvallis, Oregon.

Sugar pine

Five of 10 preventives tested provided good to excellent protection during the first 2 months of storage: Busan 1030, Busan 1009, PQ–8, MBT, and Permatox 101 (Table 3). Rodewod 200 EC + DF50 performed fairly well. After 6 months, the percentages of bright studs in most treatments were sharply reduced, and extensively stained studs were common. Bright studs were rare after 12 months, there being none in most treatments. Extensive staining was common in all treatments and prevalent in most.

Decay

Surface growth of decay fungi, indicated by bleaching of stained or molded wood and confirmed microscopically, was common on sapwood controls after 6 months, but rarely occurred on treated ends except on studs of pine sapwood. After 12 months, bleaching was generally common on treated ends of all studs except those treated

Table 4. Percentage of studs bleached by decay fungi on treated and untreated (control) ends after 12 months of outdoor storage (see Figure 1 for dates).

Preventive applied to treated end of stud	Douglas-fir			Hem-fir			Sugar pine		
	n[1]	Treated	Control	n[1]	Treated	Control	n[1]	Treated	Control
GROUP 1									
BUSAN® 1030	14	86	100	15	27	87	9	11	89
NP-1	13	62	100	14	0	86	10	20	40
NYTEK™-GD	14	93	86	13	38	85	10	40	10
PQ-8	14	14	100	15	0	80	10	10	20
Permatox 101	12	0	83	13	0	46	12	17	42
GROUP 2									
BUSAN® 1009	13	23	92	15	47	67	11	82	91
MBT	14	29	100	15	53	93	9	56	89
NYTEK™-GD + 4160	14	36	86	15	47	87	13	70	85
QUINDEX® N-10	14	71	93	15	60	80	11	73	82
RODEWOD® 2280-40400	13	8	77	14	7	21		No test	
RODEWOD® 200EC + DF50		No test			No test		11	45	91
Permatox 101	12	0	92	14	0	67	14	0	71

[1] Includes all studs at least 50% stained on the untreated face area of the control end (sapwood only of Douglas-fir and pine).

with Permatox 101 and, to a lesser degree, PQ–8 and Rodewod 2280-40400. It was also infrequent on pine studs treated with Busan 1030 (Table 4). Some other treatments could not be evaluated for decay because few studs (<50%) were bleached on the control ends. Bleaching was usually less prevalent on treated than on control ends.

The bleaching action of wood-rotting fungi has been noted previously by Cserjesi *et al.* (1984) and Scheffer (personal communication). In the trials reported here, it appeared to be associated with shallow surface decay, mostly in zones of soft springwood. Obvious and deep decay damage was rare.

Conclusions

The following conclusions are derived from trial conditions intended to stress the preventive treatments, and therefore from worse conditions than would normally be encountered in commerce. The strong solutions used are those recommended for protecting lumber under severe storage conditions for periods that typically last as long as 6 months and that include warm weather.

- Most preventives should provide 2 months of good to excellent protection for Douglas-fir and hem-fir lumber; some should also perform well with sugar pine.
- Efficacy of most preventives may decrease substantially or fail during 6 months of storage prolonged through warm weather. Under such conditions, none are likely to protect sugar pine adequately.
- Permatox 101 is generally the treatment most likely to protect stored lumber adequately for 1 year. It should provide good protection for hem-fir, but is less reliable for Douglas-fir sapwood. None of the treatments are likely to protect sugar pine sapwood for 1 year.

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