

Performance of antisapstain compounds on kiln-dried Douglas-fir and hem-fir lumber subjected to rewetting

Neil Melencion*

J.J. Morrell*

Abstract

Mold and stain fungi can be easily controlled by kiln-drying, but even this material can be rewetted during shipping and storage, allowing fungi to colonize the wood. The potential for using surface spray treatments with commercial formulations containing combinations of propiconazole, didecyldimethyl ammonium chloride, or 3-iodo-2-propynyl butylcarbamate to protect kiln-dried Douglas-fir and hem-fir lumber was evaluated over an 18-month storage period. Rewetted, untreated wood was readily colonized by fungi, while the treated boards experienced much lower levels of discoloration. Protection did appear to decline with storage time for hem-fir but not Douglas-fir. Chemical treatment of kiln-dried lumber may provide added protection against rewetting during transit and prior to installation in dry applications.

Mold and stain fungi have long been a problem in wood products (Davidson 1935, Scheffer and Lindgren 1940, Lindgren 1952, Kaarik 1980). The growth of fungi on wood is a function of moisture content (MC), oxygen levels, temperature, and the type of wood (Zabel and Morrell 1992). Freshly harvested wood is susceptible to fungal attack from the time it is cut until it dries below 20 percent MC. This attack can be limited by either kiln-drying or applying a topical fungicide shortly after sawing. While kiln-drying is often presumed to render the wood immune to attack, this material can become susceptible to fungal attack if it becomes wet during transport, storage, or use. The problem has generally been controlled on wet wood by application of prophylactic fungicides (Scheffer and Lindgren 1940, Anderson et al. 2002, Morrell et al. 2002). For decades, the primary concern with wet wood was the risk of decay. A series of high-profile lawsuits over the presence of mold fungi on wood- and paper-based materials have raised serious concerns among many consumers (Robbins and Morrell 2002). While the real risks of mold on wood-based materials in housing remain the subject of lively debate, the customers of these products are increasingly demanding mold-free wood. Furthermore, the ability to limit mold on lumber has inherent value to producers because it limits the potential for litigation. In response, the industry has either applied fungicides to green lumber or kiln-dried the wood. Intuitively, kiln-dried materials limit the availability of the moisture required for attack by mold and stain fungi; however, even this material can be wetted in the time between drying

and installation in a structure. Some suppliers of kiln-dried materials have begun supplementally treating their lumber with fungicides after planing to provide added protection in the time between production and installation. There is little data on the effectiveness of these treatments, both in the short time when the wood can be accidentally wetted prior to installation in a structure or afterward when leaks or condensation can produce moisture conditions suitable for fungal growth in a wall cavity.

In this report, we assess the ability of three antisapstain systems to limit fungal attack of kiln-dried Douglas-fir and hem-fir lumber.

Materials and methods

Kiln-dried Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and hem-fir (a mixture of *Abies* spp. and *Tsuga heterophylla* (Ref.) Sarg) lumber (nominal 5 by 10 mm by 2.4 m long) was obtained from area lumberyards. The Douglas-fir was selected so that it was primarily sapwood (>70%). Hem-fir does not produce distinguishable heartwood; however,

The authors are, respectively, Graduate Research Assistant and Professor, Dept. of Wood Sci. and Engineering, Oregon State Univ., Corvallis, Oregon (neil.melencion@oregonstate.edu, jeff.morrell@oregonstate.edu). This paper was received for publication in December 2006. Article No. 10283.

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Table 1. — Chemicals evaluated for protecting rewetted kiln-dried Douglas-fir and hem-fir lumber against fungal discoloration.

System	Active Ingredient(s)	Active ingredient (%)	Supplier
Mycostat P	Propiconazole (Propi) 1-[[2(2,4-Dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl]1-H-1,2,4-triazole	4.56	Diacon, Vancouver, BC
Brightwood XL	Propiconazole Didecyldimethyl ammonium chloride (Propi/DDAC)	4.94 46.25	Contechem, Inc., Portland, OR
NP-1	Dimethyldidecyl ammonium chloride 3-Iodo-2-propynyl butyl carbamate (DDAC/IPBC)	64.8 7.6	KopCoat Inc., Pittsburgh, PA

Table 2. — Degree of discoloration of kiln-dried Douglas-fir or hem-fir lumber rewetted 1 to 18 months after treatment with selected fungicides.

Treatment	Dilution rate	Degree of discoloration ^a					
		Douglas-fir			Hem-fir		
		No. of months					
		1	12	18	1	12	18
------(%)-----							
Control	--	30 (19)	27 (13)	3 (3)	26 (17)	92 (5)	83 (10)
Propiconazole	1:50	6 (7)	7 (7)	3 (6)	26 (17)	22 (19)	18 (15)
	1:100	1 (2)	10 (10)	2 (2)	<1 (1)	5 (4)	11 (3)
	1:200	2 (4)	12 (9)	6 (9)	<1 (1)	6 (8)	8 (4)
Prop/DDAC	1:50	2 (2)	12 (8)	2 (2)	0	10 (12)	35 (19)
	1:100	1 (1)	9 (9)	3 (4)	3 (6)	6 (8)	53 (16)
	1:200	1 (1)	4 (5)	4 (5)	0	8 (8)	29 (11)
IPBC/DDAC	1:50	1 (1)	8 (6)	8 (3)	<1 (1)	4 (7)	15 (5)
	1:100	3 (4)	14 (9)	1 (1)	11 (9)	3 (6)	27 (8)
	1:200	<1 (1)	10 (5)	5 (6)	1 (1)	2 (2)	24 (8)

^aValues represent means of 6 replicates per treatment/time while figures in parentheses represent one SD.

boards were selected with grain patterns suggestive of having been cut from the outer portion of the log. The materials were cut into defect free 150-mm-long sections that were conditioned to constant weight at 23 °C and 65 percent relative humidity (RH). The samples were then randomly allocated to 10 groups of 30 specimens of each species.

The specimens from a given group were sprayed to runoff with one of the three concentrations of each of the three chemicals tested (Table 1). All chemicals were diluted in water and controls were sprayed with water. Preliminary trials indicated that total liquid uptake on the sprayed samples ranged from 1 to 3 percent (wt/wt). Samples were then allowed to surface dry before being stored at 23 °C and 65 percent RH for 18 months. The long storage period was included to determine if the protective effect of a given treatment declined over time as a result of either wood/chemical interactions or migration of chemical away from the wood surface. One, 12 and 18 months after treatment, six samples per species/treatment combination were removed from the conditioning room, placed in a bucket with enough water to cover the wood and soaked for 1 hour for hem-fir or 3 hours for Douglas-fir. Preliminary trials had indicated that 1 hour of soaking produced 30 to 35 percent weight gain in the hem-fir samples, while a 3-hour soaking produced 12 to 16 percent weight increases in the Douglas-fir samples. The intent was to wet the wood surface and simulate a unit of lumber subjected to a continuous rainfall. The wetted boards were then sprayed with a mixture of spores and hyphal fragments of *Alternaria*

alternata, *Aspergillus niger*, *Trichoderma harzianum*, and *Ophiostoma piceae*. The blocks were then placed in plastic bags and incubated at 32 °C for 4 to 8 weeks until the water-treated controls had developed a moderate to heavy discoloration. In one case (Douglas-fir at 18 mo), the degree of discoloration remained low even after 8 weeks, but the samples were evaluated at that point because of concerns that prolonged incubation would introduce further variation into the test. All of the samples were visually assessed for the degree of discoloration on a scale from 0 (no discoloration) to 100 (completely discolored). The ratings combined the percentage of wood surface covered by fungal growth with intensity of the coverage (Morrill et al. 2002).

Results and discussion

Rewetting of untreated kiln-dried lumber generally resulted in substantial discoloration of both species, although discoloration was exceptionally low on the 18 month Douglas-fir samples (Table 2). The results highlight the importance of protecting kiln-dried lumber from wetting. Discoloration was consistently greater on untreated hem-fir than Douglas-fir. A portion of this lower discoloration on Douglas-fir can be attributed to the presence of some heartwood in this material; however, these samples did not differ materially from those assessed earlier in the test. The results suggest that some other factors such as poor inoculum potential may have affected discoloration results. As a result, discoloration ratings on Douglas-fir ranged from 3 to 30 percent, but the means were inconsistent over time.

Chemical treatment of hem-fir produced substantial reductions in discoloration at all treatment levels, but there appeared to be no consistent dose-response effect (Table 1). Discoloration of this species appeared to increase slightly 18 months after treatment, suggesting that the chemicals had either diffused inward or were more labile when soaked.

Treatment of Douglas-fir also produced substantial reductions in discoloration although the low degree of discoloration on the controls at 18 months made it difficult to determine if the chemical was effective at this time point. Once again, there was no consistent dose-response effect. Chemical treatment was clearly protective 1 and 12 months after treatment, although there was a slightly higher degree of

discoloration in the latter samples that might suggest declining protection.

Soaking created a major challenge to the antistain chemical because there was an excess of water available to solubilize chemical from the wood. This exposure was designed to replicate kiln-dried material exposed to continuous rainfall. Some of the solubilized chemical could diffuse further into the wood, but the bulk would leach into the surrounding liquid. The rate of loss would be a function of biocide solubility as well the presence of any residual cosolvents from the original formulation. Wrapping units to prevent wetting would clearly mitigate this risk; however, care would need to be taken to avoid moisture condensation in the units since this temporary free moisture can permit mold fungi to grow on the wood surfaces.

Despite the potential for leaching loss during the soaking, the results indicate that treatment of kiln-dried wood provided substantial supplemental protection and would be a viable approach to protecting wood from incidental wetting that can occur during the time between drying and installation in a structure.

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