Protecting Aspen Oriented Strand Board Panels from Biodegradation with White Cedar Extracts and Coatings

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Abstract

Eastern white cedar (*Thuja occidentalis* L.) is a naturally durable wood species due to toxic compounds present in the heartwood. These compounds may serve as natural fungicides to protect nondurable wood products from biodegradation. This study was intended to improve the effectiveness of posttreating aspen oriented strand board (OSB) panels with white cedar heartwood extracts against mold and decay by co-applying a protective coating. The results showed that aspen OSB samples treated with the white cedar water-soluble heartwood extracts had little mold infection. No mold growth was detected on any samples that were dip treated with the extracts and then brushed with a coating. The decay test showed that most samples treated with both white cedar heartwood extracts and a coating had significantly less weight loss than untreated control samples. Using coating products alone also reduced mold and decay growth on OSB samples; however, adding cedar extracts to the treatment significantly improved the performance of one of the three coating products tested against mold and decay.

Eastern white cedar (*Thuja occidentalis* L.) is indigenous to eastern North America and is found from the southern portion of eastern Canada to the adjacent northern portion of the United States (Johnston 1990). It is recognized as a naturally and highly durable wood species (Williams and Feist 1999, Laks et al. 2008). The durability of cedar species is mostly due to toxic compounds (thujaplicin and thujic acid) present in the heartwood (Taylor et al. 2002). Compared with western red cedar (*Thuja plicata* Donn ex D. Don), eastern white cedar contains a high percentage of α-thujaplicin, relatively low percentages of β-thujaplicin and γ-thujaplicin, and very little thujic acid in its heartwood extracts (Gripenberg 1949).

Use of eastern white cedar wood to make composite panels that are durable against decay and termites has been studied for many years (Behr and Wittrup 1969, Behr 1972, Haataja and Laks 1995, Yang et al. 2010). Extensive studies on extracts of this wood species are mostly focused on pharmaceutical use of essential oils coming from leaves and twigs in the form of the ''mother tincture'' (Naser et al. 2005). However, heartwood extracts of this wood species are poorly documented and underutilized. Wan et al. (2007) reported using hot-water extracts of eastern white cedar heartwood to protect aspen oriented strand board (OSB) against mold and decay. The study involved pretreatment of aspen strands with the extracts during blending, surface pretreatment of aspen strands after mat formation, and posttreatment of aspen panels after hot pressing. The results of that study showed that these treatments slightly reduced fungal infection on panels by mold but not by decay fungi and was not more effective due to leaching of extracts from the panels.

Coating wood can prevent loss of water-soluble extracts from treated wood by preventing water penetration and blocking ultraviolet radiation. The coatings can be either

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oil- or water-based, but they often contain water repellent, moldicide, and pigment to prevent fungal growth and ultraviolet degradation (Morrell et al. 2001). Finishing western red cedar heartwood with selected coatings is reported to significantly reduce extractive bleeding by weathering (Stirling et al. 2006). The present research was performed to improve the effectiveness of posttreating OSB panels with white cedar heartwood extracts against mold and decay by co-applying a coating.

Materials and Methods

Preparation of white cedar extracts

Eastern white cedar logs were obtained from a local forest farm and debarked upon arrival at the Québec Laboratory of FPInnovations. The sapwood of the logs was trimmed away, and the heartwood was sawn into 100-mm (4-in.)-long blocks. The blocks were then ground into fine particles (5 to 10 by 1 by 1 mm) with a laboratory grinding machine (Wiley mill) and passed through a 5-mesh screen. The moisture content (MC) of the particles was 19.7 percent. For the extraction, the heartwood particles were weighed and placed in a container filled with distilled water (250 g of particles per liter of water). The containers were heated at 121°C for 20 minutes, and then cooled to 50°C to 60°C. The extracts in the container were filtered through three layers of cheesecloth. The remaining wood particles were further extracted by the same method with half the amount of distilled water. The two extracts were mixed together and then poured into trays, each containing 2 liters. The filled trays were placed in a freezer room at −30°C for 48 hours. The extracts were freeze-dried into powder with an industrial-scale lyophilizer. The yield of the final powder product was 4.12 g/liter of extracts.

Treatment of aspen panel with extracts and coatings

Aspen OSB panels (10 mm thick) were purchased from a retail store and cut into sample sizes of 50 by 50 mm. Three commercial coatings were obtained from a retail store. They were (1) DuraCote Clear Lacquer Coating (Mohawk, Hickory, North Carolina), (2) Natural Deck Oil (water-based, Bio-Wash, Cincinnati, Ohio), and (3) Wolman Clear Wood Preservative (oil-based, Wolman, Vernon Hills, Illinois). Two sets of aspen OSB samples were prepared: one set of samples (50 by 50 mm) was used for mold testing and another set (19 by 19 mm) for decay testing. For treatment, OSB samples were dipped for 5 seconds in one of the white cedar heartwood extract solutions at concentrations of 5, 10, or 15 percent in water, left at room temperature for 6 hours to complete dryness of dip-treated samples, and then painted with one of the coatings. Each treatment included 10 sample replicates for the mold test and 18 samples for the decay test. Additional sets of untreated aspen OSB samples with the same replicate numbers as treated groups served as the control groups for mold and decay tests. All treated and untreated samples were conditioned in a chamber at 20°C and 65% relative humidity (RH) for at least 3 weeks to reach equilibrium MC before testing.

Evaluation of panel fungal resistance

The mold resistance of panels was tested according to American Wood Protection Association Standard E24-06 (AWPA 2007). Treated and untreated OSB samples were randomly placed in a mold incubation container. The container was maintained at 25°C and 100% RH. Panel samples in the container were inspected for mold colonization after 12 weeks of incubation. Mold growth on each panel sample was visually rated using a scale of 0 to 5, where 0 = no mold growth, 1 = <5 percent mold coverage on sample surfaces, 2 = 5 to <25 percent mold coverage, 3 = 25 to <50 percent mold coverage, 4 = 50 to <75 percent mold coverage, and 5 = ≥75 percent mold coverage. Average scores, which measured the general severity of the quantity of mold growth on each sample, were obtained by averaging infection rates from all samples of a treatment.

The decay resistance of panels was tested according to AWPA Standard E10-09 (AWPA 2009). Soil jars were prepared in the same way as described in the standard. Jack pine (*Pinus banksiana* Lamb.) sapwood was used for feeders in jars, and the feeders were inoculated with one white-rot fungus, *Irpex lacteus* (ATCC 11245), and two brown-rot fungi, *Gloeophylum trabeum* (ATCC 11539) and *Postia placenta* (FTK-120E), respectively. The jars were incubated in a chamber at 25°C for 2 weeks before being used for the test. Treated and untreated test samples were conditioned in a forced-draft oven set at 40°C to constant MC and were weighed just before the test. The samples were then wrapped with aluminum foil and disinfected at 100°C for 20 minutes. After cooling, the samples were aseptically placed on the mycelium-covered feeders in soil jars, and the jars were incubated at 25°C for 16 weeks. At the end of the incubation period, samples were removed from the bottles, attached fungal mycelia were removed, and the samples were oven dried to a constant weight at 40°C and weighed to determine weight losses. The average weight loss from six replicates of each type of sample served as an index of the severity of wood decay caused by a particular fungus.

The data from mold and decay resistance tests were analyzed statistically by univariate analysis of variance together with a Duncan multiple range test for significance ranking among different treatments.

Results and Discussion

The mold growth on the samples treated with extracts of white cedar heartwood and the three coating products is shown in Table 1. After a 12-week testing period at 25°C and 100% RH, untreated OSB samples had an MC of 30.5 percent; whereas, those samples treated with white cedar heartwood extracts alone had MCs ranging from 26.8 to 28.1 percent. OSB samples treated with one of the three coatings alone or with both the cedar extract and a coating had similar MCs ranging between 25.7 and 27.6 percent. The amount of mold growth on untreated control OSB samples was significant, with an average mold growth rating of 3.7, which was significantly different from all treated groups. The average mold growth ratings on OSB samples dip treated with the extracts alone at concentrations of 5, 10, and 15 percent were 1.7, 1.5, and 0.7, respectively. OSB samples brushed with DuraCote Clear Lacquer Coating (Coating A), Natural Deck Oil (Coating B), or Wolman Clear Wood Preservative (Coating C) alone had average mold growth ratings of 0.17, 0.3, and 1.0, respectively. No mold growth was detected on any sample dip treated with the cedar extracts at concentrations of 5, 10, or 15 percent, and then brushed with Coating A or B. Samples dip treated with the cedar extracts at a concentration of 5 or 10 percent,

Table 1.—Mold growth on OSB samples treated with white cedar extracts and coated with a finish.

Treatment[a]	Sample MC at the end (%)[b]	Mold growth rating[b,c]	SD	Mold growth reduction (%)
A-0	26.3 AB	0.17 A	0.15	95
A-5	26.5 ABC	0 A	0	100
A-10	26.2 AB	0 A	0	100
A-15	26.7 ABC	0 A	0	100
B-0	25.7 A	0.3 AB	0.3	92
B-5	26.4 ABC	0 A	0	100
B-10	27.6 BC	0 A	0	100
B-15	26.5 ABC	0 A	0	100
C-0	25.9 AB	1 CD	0.3	73
C-5	27.2 ABC	0.07 A	0.12	98
C-10	26.1 AB	0.03 A	0.06	99
C-15	27.4 ABC	0 A	0	100
E-5	26.8 ABC	1.73 E	0.57	54
E-10	28.1 C	1.47 DE	0.4	61
E-15	28.1 C	0.67 BC	0.4	82
Control	30.5 D	3.73 F	0.4	0

[a] A = DuraCote Clear Lacquer Coating; B = Natural Deck Oil; C = Wolman Clear Wood Preservative; E = extract alone; 0, 5, 10, and 15 = 0, 5, 10, and 15 percent cedar extract, respectively.

[b] Within each column, values with the same letter are not significantly different at the 5 percent significance level.

[c] Values are the means of 10 replicates. Mold growth rating: 0 = no mold growth; 1 = <5 percent mold coverage; 2 = 5 to <25 percent mold coverage; 3 = 25 to <50 percent mold coverage; 4 = 50 to <75 percent mold coverage; and 5 = ≥75 percent mold coverage.

and then brushed with Coating C had a slight mold growth (rating <1), while those samples treated with 15 percent extract and brushed with this coating were free of growth. Compared with untreated OSB samples, mold growth was reduced by 95, 92, and 73 percent on those samples brushed with Coating A, B, or C alone, respectively. Mold growth was totally prevented on those OSB samples by the treatment with 5 percent cedar extract and Coating A or B, or with 15 percent cedar extract and Coating C.

The weight losses of posttreated and untreated OSB samples caused by the three decay fungi are presented in Table 2. Two decay fungi, *I. lacteus* and *G. trabeum,* colonized all untreated control samples and caused weight losses of 75.2 and 64.4 percent, respectively. The other brown-rot fungus, *P. placenta,* grew well on most untreated samples but showed a large amount of variation. In most cases, the least amount of weight loss was associated with the higher concentrations of cedar extracts used. For example, the untreated control samples lost an average weight of 64.4 percent with *G. trabeum,* whereas the samples treated with 5, 10, and 15 percent cedar extract had weight losses of 60.5, 59.9, and 40.5 percent, respectively. *Postia placenta* was more sensitive to white cedar heartwood extracts than the other decay fungi, and little weight loss was caused by this fungus on samples treated with 10 and 15 percent cedar extract alone.

Of the three coatings used, Coating A was highly resistant to decay in the absence of cedar extract. OSB samples with this coating alone had weight losses of only 9.8, 0.7, and 0.5 percent caused by *I. lacteus, G. trabeum,* and *P. placenta,* respectively. The treatment of OSB samples with white cedar heartwood extracts before coating application did not significantly reduce weight losses of samples compared with those brushed with Coating A alone. Coating B was not resistant to decay, and pretreating OSB samples with white

Table 2.—Weight losses of OSB samples treated with white cedar extracts and coated with a finish.[a]

Treatment[b]	*I. lacteus*	*G. trabeum*	*P. placenta*
A-0	9.83 ± 14.24 A	0.66 ± 0.29 A	0.47 ± 0.33 A
A-5	14.27 ± 14.6 A	0.79 ± 0.18 A	0.72 ± 0.29 A
A-10	13.77 ± 13.91 A	1.29 ± 0.51 A	0.86 ± 0.33 A
A-15	11.52 ± 15.91 A	1.07 ± 0.26 A	1.13 ± 0.27 A
B-0	50.66 ± 2.1 CD	56.17 ± 11.1 E	52.82 ± 6.18 E
B-5	42.84 ± 13.27 BC	51.79 ± 3.68 DE	20.03 ± 29.44 BC
B-10	66.75 ± 3.45 EF	32.84 ± 20.75 BC	12.78 ± 19.18 AB
B-15	36.15 ± 17.94 B	25.69 ± 27.19 B	0.83 ± 0.37 A
C-0	38.19 ± 8.5 B	12.8 ± 18.2 AB	1.67 ± 0.32 A
C-5	32.81 ± 5.78 B	1.6 ± 0.32 A	1.48 ± 0.31 A
C-10	29.75 ± 3.92 B	1.86 ± 0.34 A	1.68 ± 0.22 A
C-15	32.36 ± 11.44 B	1.72 ± 0.73 A	1.94 ± 0.55 A
E-5	70.74 ± 6.16 EF	60.48 ± 3.05 E	40.32 ± 30.44 DE
E-10	71.78 ± 2.66 EF	59.9 ± 3.64 E	0.54 ± 0.17 A
E-15	60.71 ± 4.92 DE	40.45 ± 18.69 CD	1.36 ± 1.3 A
Control	75.21 ± 1.98 F	64.38 ± 4.62 E	30.73 ± 30.79 CD

[a] Values are the means ± standard deviations of six replicates presented in percentages. Within a column, values with the same letter are not significantly different at the 5 percent significance level.

[b] A = DuraCote Clear Lacquer Coating; B = Natural Deck Oil; C = Wolman Clear Wood Preservative; E = extract alone; 0, 5, 10 and 15 = 0, 5, 10, and 15 percent cedar extract, respectively.

cedar heartwood extracts before surface treatment with Coating B significantly increased panel resistance to decay. For example, the samples coated with Coating B alone lost an average weight of 52.8 percent with *P. placenta,* whereas samples treated with 5, 10, and 15 percent cedar extracts and Coating B showed weight losses of 20, 12.8, and 0.8 percent, respectively. Coating C was highly resistant to *P. placenta* and showed moderate resistance to *I. lacteus* and *G. trabeum*. Pretreating OSB samples with white cedar heartwood extracts before applying Coating C reduced average weight losses of the samples caused by *G. trabeum* and *I. lacteus,* but the difference was not statistically significant compared with samples treated with Coating C alone.

Conclusions

The mold test on the posttreated aspen OSB samples with the extracts of white cedar heartwood and three coating products showed that after a 12-week testing period at 25°C and 100 percent RH, mold growth was serious on untreated control OSB samples, while only slight to moderate mold growth was detected on panel samples dip treated with the cedar extracts alone at concentrations of 5, 10, or 15 percent or with the coatings alone. No mold growth was detected on any sample dip treated with the extracts at concentrations of 5, 10, or 15 percent, and then brushed with a selected coating. The decay test on these posttreated OSB samples showed that after a 16-week exposure to three decay fungi in soil jars, most treated samples had much less weight loss than untreated control samples. For a coating product without fungicide, pretreating panels with extracts of white cedar heartwood before applying the coating significantly increased the mold and decay resistance of the panels.

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