Alternative species and preservatives for wood roofing: laboratory decay studies

Rodney C. De Groot
Bessie M. Woodward
Susan LeVan

Abstract

Western hemlock, Pacific silver fir, and western white pine are being considered for the production of shakes and shingles. These species lack natural durability, thus preservative treatment is required. Using decay test procedures as described in ASTM D 2017, it was demonstrated that these species could be treated with several preservatives to achieve a level of decay resistance that is equivalent to that exihited by species with natural decay resistance categorized as either resistant or highly resistant.

Western hemlock *(Tsuga heterophylla* (Raf.) Sarg), Pacific silver fir *(Abies amabilis* Dougl. ex Forbes), and western white pine *(Pinus monticola* Dougl. ex D. Don) are being considered as source materials for the manufacture of shakes and Shingles. These woods lack natural durability, hence additional protection is required to achieve the degree of durability that is expected of wood roofing materials. The merits of preservative treatments for wood roofing materials manufactured from nondurable species have been recognized with the acceptance of CCA-treated southern pine shakes. The study reported here is one in a series of laboratory and field investigations that we are conducting to determine potential species for the manufacture of wood roofing. These investigations are addressing an array of considerations such as marlufacturing economics, weatherability, stability, treatability, and durability. The objective of this study was to evaluate the decay resistance of three candidate wood species treated with preservatives.

Materials and methods

Procedures described in ASTM D 2017[1] were followed in this study, with the exception that treated wood materials, rather than naturally durable wood species, were evaluated. This particular protocol was followed because Model Building Codes utilize ASTM D 2017 as a test to evaluate the durability of wood roofing materials. According to evaluation criteria defined in ASTM D 2017, naturally durable woods that have less than 10 percent weight loss in this test would be rated *highly resistant.* Those with 11 to 24 percent weight loss would be rated *resistant.* These classes of decay resistance have been related to service experience with naturally durable woods. For example, redwood, western redcedar, black locust, and white oak are classed, by this test, as either highly resistant or resistant. We presumed that treated materials would be similarly rated for use in wood roofing.

Only waterborne preservatives were used in this study (Table 1). Chromated copper arsenate (CCA) Type C was used as a reference preservative. A quaternary ammonium compound (DDAC) was used because it is accepted by the American Wood-Preservers' Association (AWPA) as a presmvative[2]. One formulation, identified as DDAC+, also contained a quaternary ammonium and is used commercially as an antistain treatment[3]. The remaining preservative was a water-

[1] American Society for Testing and Materials, 1986. Standard method of accelerated laboratory test of natural decay resistance of wood. D 2017. *In:* Annual Book of ASTM Standards. Vol. 04.09. ASTM, Philadelphia, Pa.

[2] American Wood-Preservers' Association. 1989. Standards for waterborne preservatives. *In:* Book of Standards. AWPA, Stevensville, Md.

[3] Ward, H.A. 1990. U.S. patent 4,950,685.

The authors are, respectively, Research Plant Pathologist, Microbiologist, andSupervisory Chemical Engineer, USDA Forest Serv., Forest Prod. Lab., One Gifford Pinchot Dr., Madison, WI 53705-2398. **This paper was received for publication in December 1991.**
Forest Products Research Society 1992.
Forest Prod. J. 42(11/12):57-60.

TABLE 1. — *Waterborne preservatives evaluated in this study.*

Preservative	Code[a]	Description
Didecyl dimethyl ammonium chloride (DDAC)		A commercial product[b]
Didecyl dimethyl ammonium chloride plus 3-Iodo-2-propynyl butyl carbamate (DDAC+)	3	A proprietary quaternary ammonium-based formulation[c]
Chromated copper arsenate (CCA)	1	Industrial reference; acidic preservative
Zinc naphthenate (ZnN)	11	Proprietary emulsion, with water repellent

[a] Identical codes were used for each preservative in a series of experiments. Codes are included here to aid the reader in comparing results from this investigation with results that will be reported in the future.
[b] Bardac 22 (100% $C_{10}C_{10}$).
[c] Ward, H.A. 1990. U.S. patent 4,950,685.

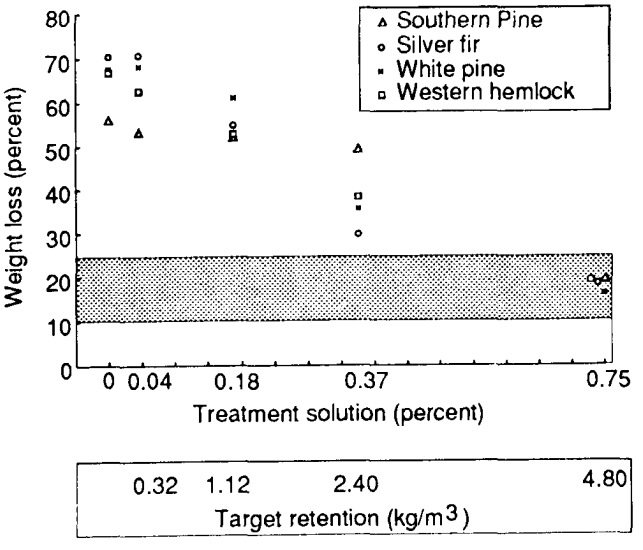

Figure 1. — Average weight loss in 25- by 25- by 9-mm blocks treated with CCA, after 16-week incubation with *G. trabeum.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

based formulation of zinc naphthenate (ZnN], which is used in nonpressure treatments of wood packaging.

Specimen blocks were cut to 25 by 25 by 9 mm as required by ASTM D 2017. Blocks of southern pine and western white pine were sapwood. Blocks from western hemlock and Pacific silver fir were not segregated according to heartwood or sapwood.

Treatment of specimen blocks with preservattves followed procedures described in ASTM D 1413.[4] Retentions for all preservatives were computed on the basis of weight gain resulting from uptake of treating solution. Preservative retentions are expressed as

[4] American Society for Testing and Materials. 1986. Standard method of testing wood preservatives by laboratory soilblock cultures. D 1413. *In:* Annual Book of ASTM Standards. Vol. 04.09. ASTM, Philadelphia, Pa.

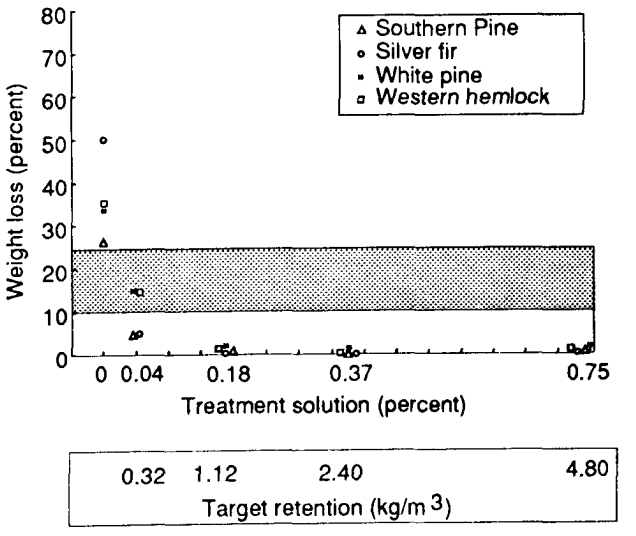

Figure 2. — Average weight loss in 25- by 25- by 9-mm blocks treated with CCA, after 16-week incubation with *C. versicolor.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

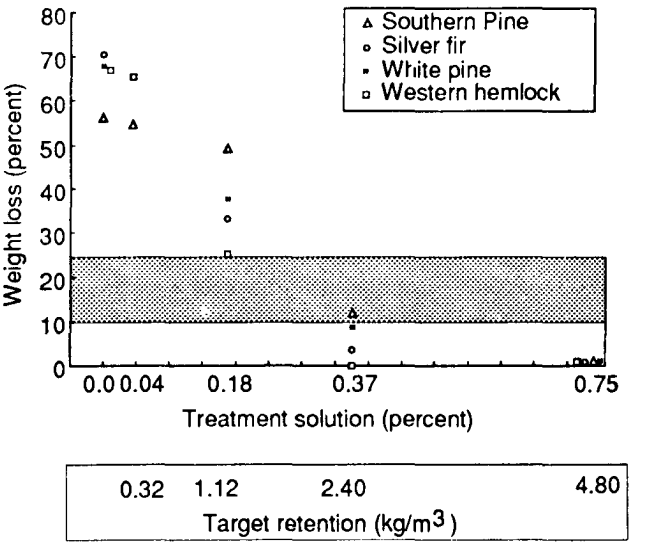

Figure 3. — Average weight loss in 25- by 25- by 9-mm blocks treated with DDAC+, after 16-week incubation with *G. trabeum.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

follows: for CCA, amount of Cu, Cr, and As as *oxide;* for quaternary ammonium compounds, amount of DDAC; and for ZnN, amount of metallic zinc per volume of wood.

Six replications were used for each treatment. Decay blocks were incubated in the dark, except for examinations when an incandescent llght was turned on within the controlled environment chamber. Gloeo-

phyllum trabeum (Pers. ex. Fr.) Murr. (Madison isolate 617) was used as the brown-rot fungus, and *Coriolus uersicolor* (L.) Quel. (Madison isolate 697) was used as the white-rot fungus. All soil-block jars were incubated for 16 weeks.

Results and discussion

The average percentage of weight loss resulting from these treatments is given in Figures 1 to 8.

Weight losses greater than 60 percent resulted in western hemlock, western white pine, and Pacific silver fir control blocks that were incubated with G. *trabeum*. *G. trabeum* caused an average weight loss of 56 percent in southern pine control blocks. Average weight losses of untreated control blocks incubated with *C. versicolor* ranged from 26 to 50 percent. With both fungi, the percentage weight loss was least in the southern pine blocks and greatest in the silver fir blocks. In untreated blocks of western hemlock, western white pine, and Pacific silver fir decayed by *G. trabeum,* average weight losses were not significantly different, but the average weight loss for untreated southern pine blocks was significantly different from the rest. In blocks decayed by C. *versicolor,* weight losses for western hemlock and western white pine were not significantly different. Average weight losses for silver fir and southern pine were significantly different from that of western white pine and western hemlock and from each other.

The actual preservative retentions achieved with test blocks approximated the target retentions, but actual species differences in wood density contributed to resultant differences in actual retentions. At each target level, preservative retentions were generally lower in southern pine than in the other species.

Protection (less than 24% weight loss) of all wood species from both decay fungi was achieved at the higher retentions for all preservatives except the ZnN formulation (Figs. 1 to 8). All retentions employed for ZnN were too low to provide adequate protection against *G. trabeum,* although some efficacy against C. *versicolor* was demonstrated at the higher loadings.

The amount of decay caused by *G. trabeum* in

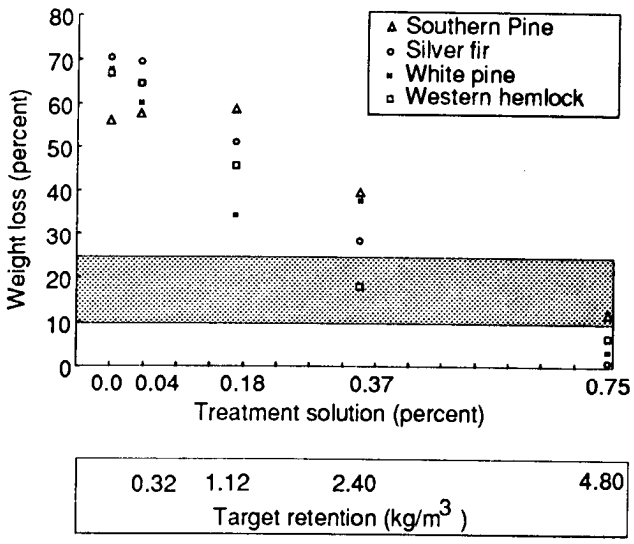

Figure 5. — Average weight loss in 25- by 25- by 9-mm blocks treated with DDAC, after 16-week incubation with *G. trabeum.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

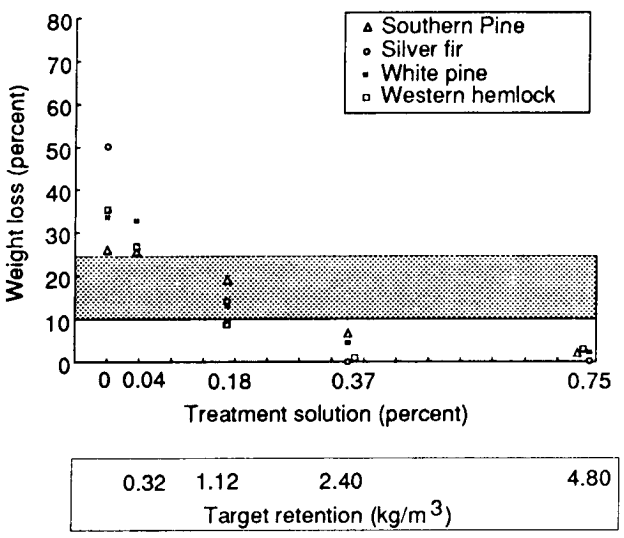

Figure 4. — Average weight loss in 25- by 25- by 9-mm blocks treated with DDAC+, after 16-week incubation with *C. versicolor.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

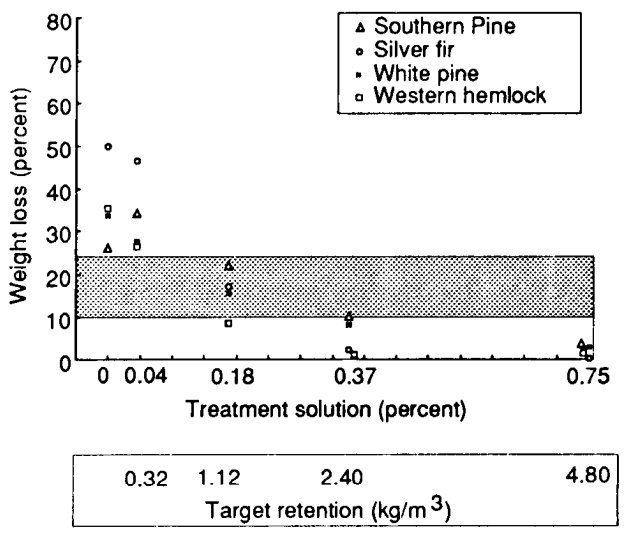

Figure 6. — Average weight loss in 25- by 25- by 9-mm blocks treated with DDAC, after 16-week incubation with *C. versicolor.* (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

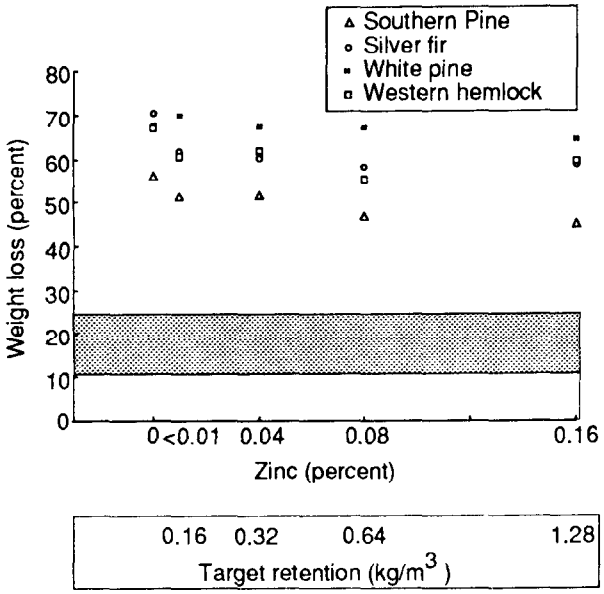

Figure 7. — Average weight loss in 25- by 25- by 9-mm blocks treated with ZnN, after 16-week incubation with *G. trabeum*. (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

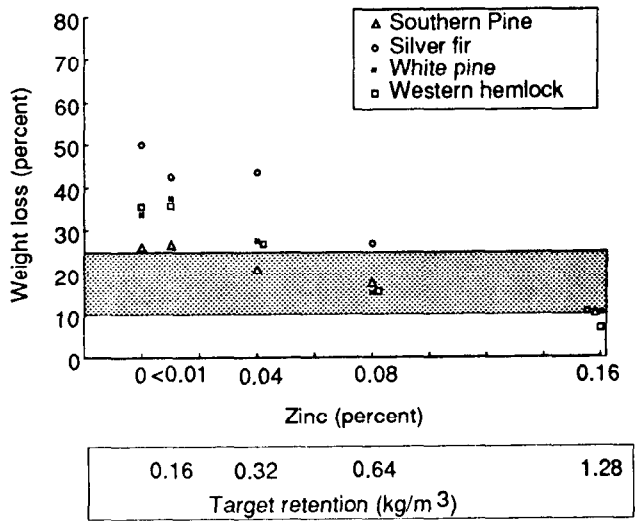

Figure 8. — Average weight loss in 25- by 25- by 9-mm blocks treated with ZnN, after 16-week incubation with *C. versicolor*. (0% to 10% weight loss = highly resistant; 11% to 24% weight loss (shaded area) = resistant; >24% weight loss = lesser degrees of resistance or nonresistant.)

CCA-treated blocks was greater than we anticipated. Analysis of the treating solution indicated that the composition of the stock solutions was within the limits prescribed by AWPA. We assumed that the procedural details of this test, such as thin specimen blocks and a 16-week incubation compared to a 12-week incubation, contributed to the high weight losses. The greater efficacy of didecyl dimethyl ammonium compared to CCA against brown- and white-rot decay fungi, as observed here, has previously been reported.[5]

The DDAC+ formulation performed better than did DDAC alone (Figs. 3-6).

At the respective lower retentions of DDAC and DDAC+, *G. trabeum* (Figs. 3 and 5) caused greater weight losses than did C. versicolor (Figs. 4 and 6). AIthough not shown, the range in weight losses for each target retention in all species was broader with DDAC alone than it was with DDAC+. With DDAC+, data were generally tightly grouped about each respective mean. At a target retention of 0.3 pcf (4.8 kg/m^3), the small weight losses in all wood species treated with quaterna~ ammonium compounds were significantly different from weight losses that occurred in blocks treated with CCA.

Differences between wood species in severity of decay at specific, low retentions were more pronounced in tests with G. *trabeum* than with C. *versfcolor. No* consistent, species-dependent pattern in relative performance was observed.

Conclusions

This study demonstrated that treatment of southern pine sapwood and several western softwoods with preservatives other than CCA induced a resistance to two decay fungi that would be classified highly resistant according to the criteria of ASTM standard D 2017.

Our results suggest that wood shakes and shingles made from the species utilized in this test and treated to 0.3 pcf (4.8 kg/m^3) of DDAC+ should be categorized as highly resistant to wood decay fungi. Slightly higher retentions of DDAC would be required to achieve that degree of protection in all the wood species used in this study.

[5] Hedley, M., K. Tsunoda, and K. Nishimoto. 1982. Evaluation of alkykammonium compounds for usc as low toxicity wood preservations in Japan. Wood Research 68:37-46.