ALTERNATIVE WOOD PRESERVATIVES FOR USE IN INDONESIA

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ABSTRACT

In Indonesia, the wood preservative chromated copper arsenate (CCA) was recently banned. Within the United States and Indonesia, a search for alternative wood preservatives is underway. Collaborative research was initiated to evaluate alternative preservatives for protection of several temperate and tropical wood species. Soil-block decay tests were conducted on southern yellow pine 19-mm cubes. Results would be indicative of the probable performance of preservatives in *Pinus merkusii* Jungh and de Vriese, which in Indonesia, is an important species used for cooling towers. This study showed that preservatives other than CCA can be used to protect pine sapwood from decay fungi of importance in Indonesia. Furthermore, it is possible to achieve with other preservatives a level of protection that is equivalent to that achieved by treatment with CCA to a target retention of 8.0 kg/m^3.

Indonesia has about 4,000 timber species but only 15 to 20 percent are classified as having durable heartwood. Therefore, treatment with wood preservatives is needed for many species to prolong the service life of wood in use. In Indonesia, chromated copper arsenate (CCA) had been the only preservative used to treat timber for use in cooling towers and CCA was also the most common preservative used for housing purposes, but it was banned in 1994. The need to identify alternative preservatives for use in Indonesia is particularly important for pine *(Pinus merkusii)* timbers and lumber used for these purposes.

This paper describes results from laboratory experiments in which alternative preservatives were evaluated in soil-block decay tests using southern yellow pine *(P. elliottii* Engelm. or *P. palustris* Miller) sapwood. These studies were conducted at the USDA Forest Service, Forest Products Laboratory, Madison, Wis. Results of these tests should be indicative of the likely performance of preservatives in sapwood of *P. merkusii.* This work is part of a larger, collaborative investigation of alternative preservatives for protection of several temperate and tropical wood species. To contribute to the understanding of relationships among preservative performance profiles in temperate and tropical field sites and to evaluate the relationship between results from laboratory decay tests and performance in the field, matched field plots were also established in a tropical Indonesian site and a temperate site in the United States (5).

MATERIALS AND METHODS

Decay studies were conducted following the guidelines in the AWPA E10-91 Standard Method of Testing Wood Preservatives by Laboratory Soil-block Cultures (1). The efficacy of the following alternative preservatives[1] was evaluated against wood-degrading fungi that are important in either the United States or Indonesia **(Table 1):** acid copper chromate (ACC); chromated copper arsenate (CCA); ammoniacal copper quat (ACQ-B); oxine copper (CuOx); and diesel/toluene.

Southern yellow pine blocks (19-mm cubes) were used in all tests. Pine sapwood was used because the principal wood for construction of cooling towers in Indonesia is *P. merkusii.* Treated pine is also an export commodity for the United States and fundamental information on this wood species will contribute to that trade.

With each preservative, except CuOx, test blocks were impregnated with solutions at concentrations of 0.075, 0.15, 0.30, 0.60, and 1.20 percent active ingredient. Only the lowest three concentra-

[1] When this study started, the waterborne preservatives were already included within AWPA standards. CuOx was being proposed for inclusion within AWPA standards.

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Forest Prod. J. 48(11/12):98-101.

tions of active ingredient were used with CuOx. With the oilbome treatment of CuOx and the diesel/toluene control, the concentration of diesel was held at a constant proportion of 33 percent of the total weight of the treating solution. This allowed us to simulate an empty cell treatment of preservative in oil while using the treating procedure described in AWPA E10-91 (1), which is essentially a full-cell process.

Thirty-five replicate blocks were treated per retention with each preservative. All treated blocks were leached following guidelines used in AWPA E11-87 (2) for waterborne preservatives, except that blocks of the same treatment and retention were leached in two, 1000-mL flasks. This reduced the overall time schedule for leaching the entire lot of treated and reference blocks.

In the soil bottles, pine *(P. elliottii* Engelm. or *P. palustris* Miller) feeder strips were inoculated with the brown-rot fungi and sweet gum *(Liquidambar styraciflua* L.) feeder strips were inoculated with white-rot fungi **(Table 1).** All test blocks were equilibrated to a constant weight at 27°C (80°F)/30 percent relative humidity (RH), then steam sterilized for 30 minutes prior to insertion into the inoculated bottles. Blocks were incubated in soil bottles for 12 weeks at 27°C (80°F)/70 percent RH. At the end of the 12-week incubation, blocks were reequilibrated to a constant weight at 27°C (80°F)/30 percent RH, then weighed again. The amount of wood that was destroyed in each block by the respective fungus during the incubation period was determined on the basis of weight lost by the block during incubation. That weight loss is expressed as a percentage of the original equilibrium weight.

The percentage weight loss caused by the individual species of decay fungi **(Table 3)** differed significantly; therefore, the performance of preservative treatments was compared with each fungus separately. With each fungus, the variation about means for individual treatments was heterogeneous. Therefore, the relative performance of the preservative was evaluated using a nonparametric linear analysis of variance and a Tukey test for significant differences (8) to rank median weight losses **(Tables 3** to **5).**

For each fungus, median percentage weight loss obtained from each retention level of preservative treatment was compared with the median percentage weight loss from 0.60 and 1.20 percent CCA **(Tables 4** and **5).** These comparisons provide reference to current or past preservative-treating practices **(Table 6)** in Indonesia and the United States.

Results

In the controls and at almost all treatment levels, the most decay was caused by *P. placenta* **(Table 2).** *G. trabeum* and *T. versicolor* caused an equivalent amount of weight loss in the controls, but *G. trabeum* was far more tolerant of the waterborne, copper-based preservatives (CCA, ACQ-B, ACC) at low retention levels than was *T. versicolor.* Treatments at relatively low retention levels of CuOx produced results against the brown-rot fungi *G. trabeum* and *P. placenta* that were equivalent to that produced by the

TABLE 1. – Wood-degrading fungi important in the United States and Indonesia that were used in this study.

United States	Indonesia
Gloeophyllum trabeum (Pers. ex Fr.) Murr.; M617; brown-rot fungus	*Pycnoporus sanguineus* (L. ex. Fr.) Murr.; 12328CR92; white-rot fungus
Postia placenta (Fr.) M. Lars. & Lomb.; M698 brown-rot fungus	*Dacryopinax spathularia* (Schw.) Fr.; 12389CR54; brown-rot fungus
Trametes versicolor (L.:Fr.) Pila't; M697; white-rot fungus	

TABLE 2. – Average percentage weight loss in control and treated blocks.

Preservative	Actual retention		Average weight loss				
			G. trabeum	*P. placenta*	*T. versicolor*	*P. sanguineus*	*D. spathularia*
	(kg/m^3)	(pcf)	(%)				
Control	0.00	0.00	38.4	61.7	40.4	10.2	7.9
Diesel/toluene	0.00	0.00	10.6	50.0	5.5	4.1	4.5
CCA-C	0.55	0.03	47.6	44.9	3.9	1.8	13.1
	1.13	0.06	46.7	40.1	2.1	1.7	2.6
	2.08	0.13	22.3	20.8	1.8	1.7	2.5
	4.11	0.25	12.2	7.8	1.5	1.8	2.6
	8.35	0.51	4.2	2.8	1.7	1.7	2.4
ACQ-B	0.51	0.03	33.4	34.4	2.7	1.0	2.5
	1.01	0.08	5.1	39.4	0.7	0.9	2.3
	2.08	0.13	1.5	29.0	0.6	0.8	2.4
	4.17	0.26	0.7	11.2	0.6	0.7	2.4
	8.29	0.51	0.5	0.4	0.6	0.7	2.4
ACC	0.50	0.03	35.6	56.2	2.8	3.9	3.9
	1.03	0.06	34.2	55.3	2.3	2.3	2.7
	2.06	0.13	22.5	52.1	1.7	1.8	2.3
	4.08	0.25	16.7	49.4	1.8	1.9	2.5
	8.51	0.53	10.5	47.9	2.3	2.1	2.5
CuOx	0.34	0.02	5.0	50.7	4.9	5.6	4.4
	0.72	0.04	4.8	6.2	5.4	5.1	6.3
	1.37	0.08	4.6	6.2	4.6	6.5	4.9

TABLE 3. – For each fungus, preservatives (by retention combination) that were not significantly different (X) from the treatment had the least amount of weight loss (i.e., provided the best protection).

Preservative	Actual retention		Decay fungi				
			G. trabeum	*P. placenta*	*T. versicolor*	*P. sanguineus*	*D. spathularia*
	(kg/m^3)	(pcf)					
Control	0.00	0.00					
Diesel/toluene	0.00	0.00					
CCA-C	0.55	0.03					X
	1.13	0.06					
	2.08	0.13					X
	4.11	0.25		X	X		
	8.35	0.51		X	X		X
ACQ-B	0.51	0.03				X	
	1.01	0.08			X	X	X
	2.08	0.13	X		X	X	X
	4.17	0.26	X		X	X	X
	8.29	0.51	X	X	X	X	X
ACC	0.50	0.03					
	1.03	0.06					
	2.06	0.13					X
	4.08	0.25					X
	8.51	0.53					X
CuOx	0.34	0.02					
	0.72	0.04		X			
	1.37	0.08		X			

TABLE 4. – Treatments where performance was significantly better (#) (i.e., less weight loss) or was not significantly different (X) from performance of treatment with CCA at 0.60 percent active ingredient (a.i.) (4.0 kg/m^3 target retention).

Preservative	Treating solution	Actual retention		Decay fungi				
				G. trabeum	*P. placenta*	*T. versicolor*	*P. sanguineus*	*D. spathularia*
	(% a.i.)	(kg/m^3)	(pcf)					
Control	0.00	0.00	0.00					
Diesel/toluene	0.00	0.00	0.00	X				X
CCA-C	0.60	4.11	0.25			Reference treatment		
ACQ-B	0.07	0.51	0.03			X	#	X
	0.15	1.01	0.08	#		X	#	#
	0.30	2.08	0.13	#	X	X	#	X
	0.60	4.17	0.26	#	X	X	#	X
	1.20	8.29	0.51	#	X	X	#	X
ACC	0.07	0.50	0.03					X
	0.15	1.03	0.06			X		X
	0.30	2.06	0.13	X			X	X
	0.60	4.08	0.25	X		X	X	X
	1.20	8.51	0.53	X		X	X	X
CuOx	0.07	0.34	0.02	#				X
	0.15	0.72	0.04	#	X			
	0.30	1.37	0.08	#	X			X

highest retention levels of CCA **(Tables 4** and **5).** This probably reflects the interactive effects of the oilbome carrier and preservative. Except for *P. placenta,* treatment of blocks with the diesel/toluene control substantially reduced the average amount of decay in comparison to that which occurred in the untreated controls **(Table 2).**

Treatment with ACQ-B at a retention of 8.29 kg/m^3 yielded maximum protection (least weight loss) for all fungi tested **(Tables 2** and **3).** Compared with P. *placenta, T. versicolor*, and *D. spathularia,* this preservative protection was not significantly different from that produced by CCA at the same retention level. Against *G. trabeum* and *P. sanguineus,* the preservative protection provided by ACQ-B ranked significantly better than that provided by CCA at retention levels of either 4.17 or 8.29 kg/m^3 **(Tables 4** and **5).**

DISCUSSION AND CONCLUSIONS

These laboratory results indicate that preservatives other than CCA can be used to protect pine sapwood from decay fungi. Furthermore, it is possible to

TABLE 5. – Treatments where performance was significantly better (#) (i.e., less weight loss) or was not significantly different (X) from performance of treatment with CCA at 1.20 percent active ingredient (a.i.) (8.0 kg/m^3 target retention).

Preservative	Treating solution	Actual retention		Decay fungi				
				G. trabeum	*P. placenta*	*T. versicolor*	*P. sanguineus*	*D. spathularia*
	(% a.i.)	(kp/m^3)	(pcf)					
Control	0.00	0.00	0.00					
Diesel/toluene	0.00	0.00	0.00					
CCA-C	1.20	8.35	0.51	---------------------Referencetreahnent----------------------				
ACQ-B	0.07	0.51	0.03			X	X	X
	0.15	1.01	0.08	X		X	#	X
	0.30	2.08	0.13	X		X	#	X
	0.60	4.17	0.26	#	X	X	#	X
	1.20	8.29	0.51	#	X	X	#	X
ACC	0.07	0.50	0.03					
	0.15	1.03	0.06					X
	0.30	2.06	0.13			X	X	X
	0.60	4.08	0.25			X	X	X
	1.20	8.51	0.53				X	X
CuOx	0.07	0.34	0.02	X				
	0.15	0.72	0.04	X	X			
	0.30	1.37	0.08	X	X			

achieve with other preservatives a level of protection that is equivalent to that achieved with CCA to a target retention of 8.0 kg/m^3.

The lowest percentage of weight loss ranged between 4.0 and 6.5 percent in blocks treated with diesel/toluene alone or with CuOx. With CuOx, this weight loss occurred in blocks exposed to all fungi. This may reflect a loss of volatile organic carrier alone, but our experiment omitted that treatment as an uninoculated reference.

We recognize that there is no universal agreement on the merits of the soil-block test procedures as a predictor of actual field performance. The AWPA-type soil-block tests are generally more severe than agar-block tests (3). Some researchers (6) consider results from soil-block tests with oilborne preservatives to be indicative of threshold values that occur in the field; however, others (7) remain to be convinced. The severity of challenge posed by soil-block tests is greater than that which occurs within 5 years of above-ground exposure in the southern United States (4) but longer relationships are not yet identified. The fungi *P. sangaiueus* and *D. spathularia* caused little weight loss in this experiment. The isolates used were from the United States. Whether this attributed to this result or those fungi did not thrive on pine sapwood is not known. In any event, these fungi did not pose as severe a challenge as did the other three decay fungi. For these reasons, we initiated parallel, matching field trials in both Indonesia and the United States. In time, these trials should allow us to assess the predictive capacity of these laboratory methods. Currently, we accept the results from the study reported herein as one indication that alternatives to CCA are available to successfully treat pine dimension materials for use in cooling towers and housing in Indonesia. Additional investigation on the effectiveness of the more promising alternatives against soft-rot fungi would be warranted prior to their use in cooling tower fill materials.

TABLE 6. – Preservative-treating practices.

Treating solution	Target retention in pine	Application of treatment
0.60% CCA	4.00 kg/m^3 (0.25 pcf)	Target retention currently used for above-ground construction in the United States and formerly used for above-ground construction in Indonesia.
1.20% CCA	8.00 kg/m^3 (0.50 pcf)	Target retention formerly used in Indonesia for wood treated with CCA and used in ground contact.

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