ALKYLAMMONIUM COMPOUNDS AS ABOVE-GROUND WOOD PRESERVATIVES

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ABSTRACT

The fungicidal efficacy of a number of alkylammonium compounds has been compared in a simulated above-ground decay test against brown- and white-rot fungi. All the compounds tested were at least as active as copper-chrome-arsenate (CCA) against brown-rot fungi in softwood but only compounds of the dialkyldimethylammonium halide type proved to be highly active against white rot in hardwood. Over-all thresholds for the didecyldimethylammonium salts were less than 0.8 kg/m^3 compared with approximately 1.6 kg/m^3 (salt basis) for CCA.

Wood species had a marked effect on the efficacy of tertiary amine salts against **Gloeophyllum trabeum** (Pers. ex Fr.) Murr. With **Pinus radiata** D. Don (radiata pine) as substrate the threshold was approximately 1.6 kg/m^3, whereas with southern yellow pine† the threshold was greater than 3.2 kg/m^3. However, wood species had little effect on the threshold with didecyldimethylammonium chloride.

INTRODUCTION

The prospect of environmental and/or supply considerations affecting the availability of currently used wood preservatives has led to increased efforts to develop alternative treatment chemicals.

One class of compound that shows considerable promise for wood preservation is the alkylammonium compounds (AAC) (Nicholas & Preston 1980), particularly quaternary ammonium compounds and tertiary amine salts having long alkyl side chains. In conventional soil-jar tests against basidiomycete fungi AAC have performed well (Butcher, Preston & Drysdale 1977) though their efficacy against soft rot in unsterile soil is lower than against pure cultures of fungi (Butcher, Hedley & Drysdale 1977). In order to establish a realistic retention of one type of AAC for use in above-ground situations, Butcher (1979) compared the performance of a benzalkonium chloride with

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† Southern yellow pine is a collective term for an anatomically identical group of pine species, the most common of which are **Pinus taeda** L., **P. elliottii** Engelm., **P. echinata** Mill., and **P. palustris** Mill.

that of CCA in a laboratory above-ground test. This study suggested that the AAC used was approximately twice as effective as CCA (salt basis) in controlling brown rot in the softwood radiata pine. Further work (J. A. Butcher pers. comm.) showed that tertiary amine salts with alkyl chain lengths of 12 or 14 carbon atoms exhibit similar fungicidal activity to benzalkonium chloride and both are now approved by the New Zealand Timber Preservation Authority for the treatment of radiata pine used in above-ground situations (Butcher 1980).

Subsequently, considerable interest has been expressed in the use of other types of AAC as above-ground preservatives in hardwoods and softwoods. Preston & Nicholas (1982) have recently shown that there are marked differences between the fungicidal activity of the different generic types of AAC, particularly with respect to their ability to control white rot in ground-contact situations. In this investigation we have compared the effectiveness of a series of AAC against brown-rot and white-rot fungi in softwoods and a hardwood using the test method developed by Butcher (1979) to simulate a severe above-ground decay hazard.

METHOD

Square glass jars (500 ml) containing 3% malt agar were prepared so that the agar covered one side of the jars when they were placed horizontally. The jars were then inoculated with one of the test fungi *Gloeophyllum trabeum* – CSIRO DFP 7520; *Poria placenta* (Murr.) – ATCC No. 44197; *Coriolus versicolor* (L. ex Fr.) Quel. – FRI 715. After 2 weeks, during which the individual fungi became well established, two feeder strips of untreated sapwood (radiata pine for brown-rot fungi, *Betula pendula* Roth. (silver birch) for white-rot fungi) were placed above the fungi, supported at each end by a PVC rod. The feeder strips were 112 mm long, 20 mm wide, and 16 mm deep. Six slots (11 mm wide and 8 mm deep) were cut across each feeder strip, the slots being evenly distributed along them. The jars were incubated at 27°C for 8 weeks and at the end of this period the feeder strips were covered with mycelia and were in an advanced stage of decay.

Under aseptic conditions, the feeder strips were removed from the jars and the sterilised test blocks (20 × 20 × 10 mm) placed in the slots provided. Each jar contained two treatments (five replicates per treatment) and two untreated controls. The assembled feeder strips were then placed in freshly prepared decay jars above water agar which provided a reservoir of moisture. The jars were incubated for 10 weeks at 27°C after which time the blocks were removed, cleaned, reconditioned to 12% m.c., and weighed. Decay was expressed as a percentage loss of weight.

The test material comprised sapwood blocks (20 × 20 × 10 mm) of radiata pine and southern yellow pine (for brown-rot fungi) or silver birch (for white-rot fungi). The blocks were conditioned to 12% m.c., weighed, and then vacuum-pressure impregnated with the various treating solutions (*see* Table 1). Preservative retentions were calculated from solution uptakes, concentrations, and block volumes.

After treatment the blocks were weighed, wrapped in polyethylene for 2 weeks to allow fixation to occur, then air-dried. The samples were then impregnated with deionised water and subjected to a standard leaching procedure (blocks in nine times

TABLE 1—Weight loss of radiata pine blocks exposed to **G. trabeum** and **P. placenta**, and silver birch blocks exposed to **C. versicolor**

Treating chemical	Nominal retention (kg/m³)	Weight loss (%)		
		Radiata pine		Silver birch
		G. trabeum	**P. placenta**	**C. versicolor**
Alkyl(C12,14)-trimethylammonium chloride	0.8	1.0	0.5	9.7
	1.6	1.0	0.3	8.3
	3.2	0.2	0.0	9.2
Alkyl(C18,16)-trimethylammonium chloride	0.8	0.3	0.0	10.1
	1.6	1.1	0.1	9.0
	3.2	0.1	0.1	8.0
Dodecylbenzyl-trimethylammonium chloride	0.8	0.0	0.1	10.2
	1.6	0.4	0.1	5.2
	3.2	0.0	0.1	0.1
Alkyl(C14,12,16)-benzyldimethyl-ammonium chloride	0.8	0.1	4.3	7.5
	1.6	1.8	1.3	10.5
	3.2	0.1	0.1	4.0
Alkyl(C12,14)-dimethylammonium acetate	0.8	15.5	2.4	12.0
	1.6	0.1	0.0	10.2
	3.2	0.0	0.2	6.3
Alkyl(C12,14,16)-dimethylammonium acetate	0.8	9.9	11.0	7.3
	1.6	3.9	0.0	8.4
	3.2	0.0	0.0	2.1
Alkyl(C12,14)chloro-propenyldimethyl-ammonium chloride	0.8	0.9	0.0	7.2
	1.6	0.7	0.6	8.0
	3.2	0.3	0.1	5.8
Dialkyl(C12,14)-dimethylammonium chloride	0.8	0.4	0.4	5.2
	1.6	0.5	0.6	0.4
	3.2	0.5	0.3	1.0
Didecyldimethyl-ammonium chloride	0.8	0.6	0.1	1.8
	1.6	0.2	0.1	0.0
	3.2	0.4	0.0	0.0
Didecyldimethyl-ammonium bromide	0.8	0.2	0.6	0.6
	1.6	0.6	0.0	0.0
	3.2	0.6	0.5	0.0
Copper-chrome-arsenate (salt formulation)	0.8	8.5	10.8	3.8
	1.6	1.1	3.3	0.4
	3.2	1.1	1.1	0.9
Untreated		25.6	21.8	17.1

their own volume of deionised water which was changed every other day for 14 days). Before the biological tests were carried out the blocks were conditioned to 12% m.c., weighed, and sterilised by exposure to 1,2-epoxypropane vapour.

RESULTS AND DISCUSSION

The data presented in Table 1 show that all of the AAC tested were effective in controlling the brown-rot fungi *G. trabeum* and *P. placenta* in radiata pine. Only two types of AAC, the tertiary amine salts and benzalkonium chloride (alkylbenzyldimethylammonium chloride), failed to control brown rot at 0.8 kg/m^3, the tertiary amine salts having a threshold of approximately 1.6 kg/m^3 and the benzalkonium chloride between 0.8 and 1.6 kg/m^3. By comparison the CCA formulation tested (Tanalith NCA) had a threshold against the brown-rot fungi similar to that of the tertiary amine salts, i.e., 1.6 kg/m^3 (1.12 kg/m^3 oxide basis).

The activity of alkyldimethylammonium acetate against *G. trabeum* on southern yellow pine was markedly reduced (threshold approximately 1.6 kg/m^3 in radiata pine but >3.2 kg/m^3 in southern yellow pine). This decrease in activity was not apparent with didecyldimethylammonium chloride. This may possibly be because of distribution problems in the treatability of various *Pinus* spp. with AAC, particularly with tertiary amine salts (A. J. Bergervoet pers. comm.).

The generally high activity of the AAC against brown rot in pine was not evident against white rot (*C. versicolor*) in silver birch. Only the dialkyldimethylammonium halides proved to be highly effective against white rot, the C10, 10 salts (didecyldimethylammonium chloride and didecyldimethylammonium bromide) giving control at the lowest retention tested, i.e., 0.8 kg/m^3. Dialkyl(C12,14)dimethylammonium chloride was slightly less active with a threshold between 0.8 and 1.6 kg/m^3. Of the monoalkyl chain AAC, only dodecylbenzyltrimethylammonium chloride controlled white rot at the highest level (3.2 kg/m^3) used. White-rot fungi are usually not prevalent in the decay of softwood timber used in above-ground situations, but attack can occur when the softwood is adjacent to hardwood timber that has been decayed by white-rot fungi (Savory & Carey 1976).

Interestingly, the order of effectiveness of the AAC against white rot in this above-ground test closely parallels the relative effectiveness of these chemicals in ground-contact field tests (Butcher *et al.* 1979; A. F. Preston & P. A. McKaig unpubl. data). From a practical stand-point, this may mean that timber treated with those AAC which exhibit low activity against white rot in hardwoods is likely to decay rapidly should wood intended for above-ground use be mis-used and placed in contact with soil.

CONCLUSIONS

In simulated above-ground decay hazard conditions a range of alkylammonium compounds has been shown to be effective in preventing decay by brown-rot fungi in radiata pine. Of those tested, alkyltrimethylammonium salts and dialkyldimethylammonium salts proved to be the most effective, with tertiary amine salts and benzalkonium chloride less so. Only the dialkyldimethylammonium salts proved to be highly effective in controlling decay by white rot in silver birch.

The results of the test strongly suggest that didecyldimethylammonium salts are viable alternative preservatives for use above-ground and that a retention not greater than 50% of that recommended for CCA treatment (salt basis) would be adequate. Should such a retention ratio of didecyldimethylammonium chloride to CCA be adopted, then the present specified retentions for tertiary amine acetate and benzalkonium chloride may need to be re-evaluated.

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