

COMPARISONS OF PENTACHLOROPHENOL FORMULATIONS IN SOIL-BLOCK TESTS^{1,2}

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ABSTRACT

Sapwood blocks of southern yellow pine, pressure treated with waterborne emulsions of pentachlorophenol, a solution of pentachlorophenol in water, and a solution of pentachlorophenol in oil diluted with toluene, were incubated for 12 weeks in soil bottles with either *Gloeophyllum trabeum* or *Coniophora puteana*. *Coniophora puteana* was more tolerant of pentachlorophenol in some formulations than was *G. trabeum*, and was less sensitive to differences between formulations than was *G. trabeum* as evidenced by threshold values for pentachlorophenol in the different formulations.

Keywords: Pentachlorophenol, *Gloeophyllum trabeum*, *Coniophora puteana*, preservatives, wood decay, brown-rot.

INTRODUCTION

Pentachlorophenol is a major wood preservative in the United States. In 1978, about 40 million pounds of pentachlorophenol were used as a wood preservative. Ninety-three percent of this was applied as a pressure treatment (USDA 1980). Almost all of these pressure treatments plus a majority of the nonpressure treatments with pentachlorophenol were accomplished with petroleum carriers, but there currently is interest in the development of water-based formulations for pentachlorophenol. In evaluating these water-based formulations, potentials for formulation-dependent differences in efficacy of pentachlorophenol must be considered. Past research has demonstrated that petroleum carriers for pentachlorophenol can contribute to the effectiveness of the preservative solution (Baechler and Roth 1962; Duncan and Richards 1950). In general, the effectiveness of an oil carrier is correlated with the boiling point, the higher boiling petroleum carriers being the more effective carriers (Duncan 1957). A recent report indicates that significant differences in threshold values may also occur between formulations of water emulsifiable pentachlorophenol (Amburgey et al. 1985).

Laboratory studies with soil-block experiments utilizing red pine (*Pinus resinosa* Ait.) sapwood, treated with a waterborne solution of sodium pentachlorophenate, have shown that when petroleum carriers are not used, several wood-inhabiting fungi are able to deplete wood partially or entirely of their penta content, depending on retention levels of penta in the experimental blocks (Unligil 1968). Unligil suggested that *Coniophora puteana*, which can degrade pentachlorophenol, be

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used as a bioassay organism in evaluating penta-containing wood preservatives.

The standard American Society for Testing and Materials (ASTM 1980) soil-block method provides conditions that are near optimum for brown-rot fungi (Highley and Scheffer 1970), and higher retentions of preservatives are needed to prevent decay in soil-block tests than are needed to prevent decay in blocks incubated over agar (Duncan 1953; Leutritz 1946). The two brown-rot fungi currently used with ASTM D 1413 are *Gloeophyllum trabeum* (Pers. ex Fr.) Murr., a fungus known to be tolerant of arsenic (Kaufert and Schmitz 1937) and of phenolic compounds; and *Lentinus lepideus* Fr., a fungus known to be tolerant of creosote.

OBJECTIVES

This study was conducted to determine if threshold levels for pentachlorophenol would be comparable for *C. puteana* and for *G. trabeum* with each formulation, and whether the different pentachlorophenol formulations were equally effective in preventing brown rot in soil block tests.

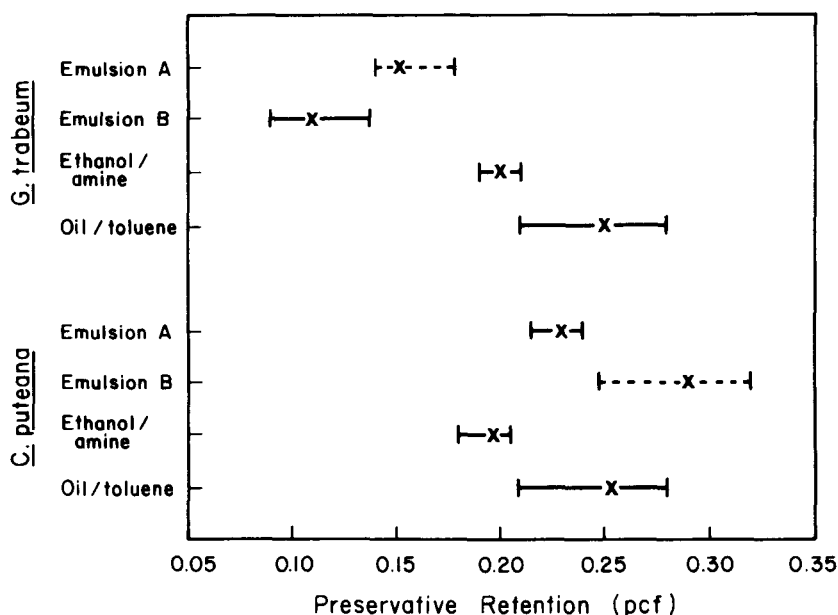
METHODS

The experimental approach followed ASTM D 1413, with several important exceptions.

Two brown-rot fungi were used. One was the ASTM standard *G. trabeum* (Pers. ex Fr.) Murr. (Madison isolate 617). The other was an isolate of *C. puteana* (Schum. ex Fr.) Karst. (Madison isolate ME-667).

Three-fourths-inch cubes of southern pine sapwood were used for the wood substrate. Two proprietary, waterborne emulsions, a solution of pentachlorophenol dissolved in oil and subsequently diluted with toluene, were each tested at retentions of 0.05, 0.077, 0.10, 0.14, 0.196, 0.274, 0.384, 0.538, 0.753, and 1.05 pounds per cubic foot (pcf). An additional series of blocks were treated to retentions of 0.05, 0.08, 0.09, 0.14, 0.19, 0.28, 0.40, 0.55, and 1.03 pcf water-soluble pentachlorophenol in N, N, N', N', 2-pentamethyl-1, 2-propanediamine plus ethanol diluted in water. Emulsions were prepared by diluting concentrates with distilled water. A 7% concentrate of pentachlorophenol in oil was diluted with toluene to achieve target concentrations of pentachlorophenol in oil. Information by the supplier indicated that the oil of the 7% solution had the following characteristics:

API gravity	15.6
Color, NPA	2
Viscosity, SUS at 100°F, second	37.5
Flashpoint, PM, °F	200+
Solvency, grams penta in 90 grams oil	10+
Sediment and water, %	Trace
Distillation range, °F	
Initial boiling point	400
50%	520
90%	596
End point	662



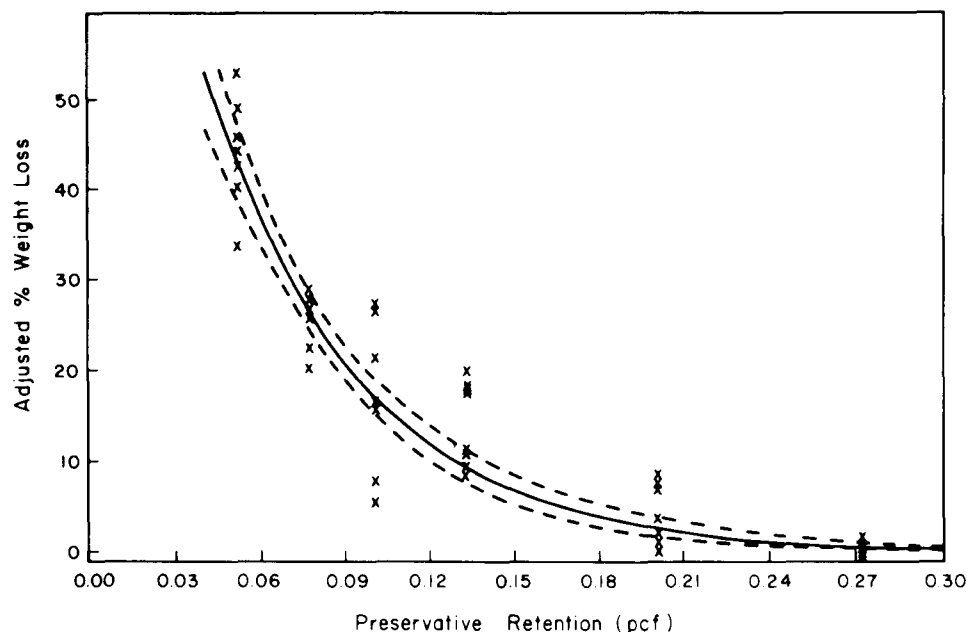
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FIG. 1. Threshold values for pentachlorophenol.³ The 95% confidence interval about each respective value is indicated with a solid line. Confidence intervals indicated by dashed line are not exact for those two sets of data because there was a lack of fit in the regression models for percent weight loss.

It was recognized that subtle differences of concentrations of oil, in the series of decay tests in which the 7% concentrate was diluted with toluene, could have an interactive effect in the estimate of threshold values for pentachlorophenol in oil.

Seven replicate southern pine sapwood blocks for each preservative-retention combination were tested against each fungus. Blocks were conditioned to constant weight, evacuated in a desiccator, and flooded with preservative while under vacuum as prescribed in ASTM D 1413. After the vacuum was released, but while still submerged in the preservative, the blocks were given an additional pressure treatment of 150 pounds per square inch (psi) for 5 minutes. Pressure treatment was used to maximize potential formulation-dependent differences that might affect the degree of penetration by pentachlorophenol into the wood cell walls.

After treatment, blocks were reequilibrated to constant weight, and amount of preservative uptake was determined from gains in weight. Then, treated blocks were gas sterilized with propylene oxide, and the sterile blocks were loaded into 8-ounce French square soil-block jars. Treated blocks were not put through a weathering cycle prior to incubation. After 12 weeks' incubation, blocks were reequilibrated to constant weight, and the percent weight loss due to decay was determined. A statistical approach that allows tests for lack of fit of data to assumed model (Link and DeGroot 1987) was used to estimate threshold values.



ML87 5305

FIG. 2. Weight loss for southern yellow pine sapwood blocks treated with pentachlorophenol in oil diluted with toluene, and incubated for 12 weeks in soil block jars with *G. trabeum* (Madison 617) (weight loss values have been adjusted to compensate for operational loss not due to decay).

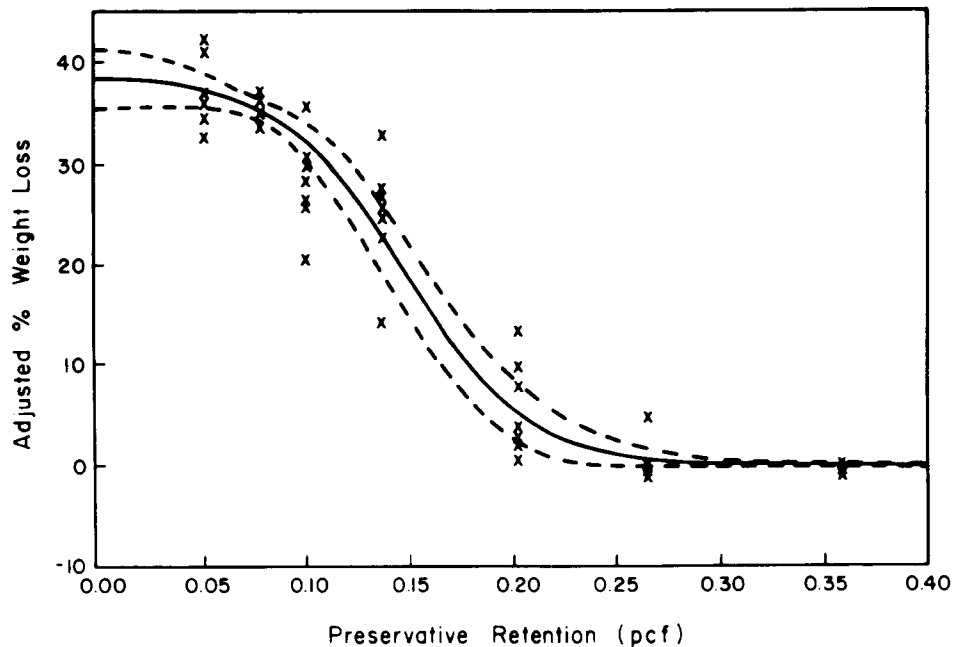
RESULTS AND DISCUSSION

The threshold values, for pentachlorophenol, achieved in this study (Fig. 1) cover a broader range of values than Duncan (1958) observed in past studies with pentachlorophenol in soil block studies. It is presumed that this difference, in part, reflects procedural departures from standardized ASTM methodology, e.g., gas versus steam sterilization. It may also be, in part, a reflection of the statistical modeling approach used to derive threshold values.

The two decay fungi differed in their tolerance of emulsified pentachlorophenol formulations, but not of other formulations (Fig. 1). Threshold values for pentachlorophenol in waterborne emulsions were generally higher for *C. puteana* than for *G. trabeum*.

Comparison of weight loss profiles for the two fungi in the series of blocks treated with pentachlorophenol in oil diluted in toluene (Figs. 2 and 3) suggests that *G. trabeum* is affected more by low concentrations of pentachlorophenol than is *C. puteana*. One can speculate that the practical significance of this would be that the rate at which penta-treated products failed, once failure began, would be faster in nature with decay caused by *C. puteana* than with decay due to *G. trabeum*.

In previous tests by Duncan and Richards (1950) and Baechler and Roth (1962), the effect of the petroleum carriers was noticed when dilution series were run within each of the carriers that were compared. In these tests, the oilborne solution of pentachlorophenol was diluted with toluene, while the emulsions and the amine solution were diluted with water. Results of these tests suggest that the efficacy



ML87 5306

FIG. 3. Weight loss for southern yellow pine sapwood blocks treated with pentachlorophenol in oil diluted in toluene, and incubated for 12 weeks in soil block jars with *C. puteana* (ME-667) (weight loss values are adjusted to compensate for operational loss not due to decay).

of pentachlorophenol, per se, in preventing decay by *G. trabeum* or by *C. puteana* was not adversely affected by formulating it into these two emulsions and subsequently diluting it with water (Fig. 1). In fact, emulsions in this test had lower threshold values against *G. trabeum* than did the solutions of pentachlorophenol in oil.

With both fungi, there was an important difference between emulsions as has previously been reported (Amburgey et al. 1985), and with *G. trabeum*, between both emulsions and penta-in-oil, as diluted, in threshold values for pentachlorophenol. This did not occur with *C. puteana*. Thus, formulation-dependent differences in soil block tests may, to some degree, be a reflection of the sensitivity of the assay organism to pentachlorophenol. The inclusion of *C. puteana* as a bioassay fungus in evaluating penta-containing wood, as suggested by Unligil (1968), seems to have merit.

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