CONTROLLING DECAY FUNGI IN DOUGLAS-FIR HEARTWOOD WITH PELLETIZED SODIUM N-METHYLDITHIOCARBAMATE[1]

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ABSTRACT

A small block test was used in assessing whether pelletized sodium n-methyldithiocarbamate (NaMDC) would decompose and produce methylisothiocyanate (MITC) and thereby eliminate *Antrodia carbonica* colonies from Douglas-fir heartwood. Also evaluated were the effects of wood moisture content, dosage, incubation period, pH level, and presence of copper sulfate on percentage of kill of the fungus and amount of MITC in the wood. Increasing moisture content produced the most dramatic increases in MITC production and fungal control. The effects of pH and the presence of copper ions were more variable. The results indicate that pelletized NaMDC can effectively control fungal infestations in Douglas-fir heartwood. Field studies are planned.

Keywords: Fumigants, sodium n-methyldithiocarbamate, wood decay, Douglas-fir, pH.

INTRODUCTION

Fumigants are important to utility companies in their efforts to control internal decay and extend service life of wood poles (Morrell and Corden 1986). Although such fumigants are widely used (Goodell and Graham 1983), the currently registered formulations have several drawbacks, including a risk of spills while in liquid form and high volatility. These drawbacks limit fumigant application to the groundline zone, despite the presence of internal decay at higher levels; they have also stimulated the search for safer fumigant formulations.

Previously, two solid fumigants, Mylone and Tridipam, have been evaluated for their efficacy against decay fungi in Douglas-fir heartwood (Morrell et al. 1988). While these fumigants appear promising for this purpose, a simpler approach to improving fumigant technology is to modify currently registered formulations. Vapam, the most commonly used wood fumigant, is an aqueous formulation containing 32.1% active ingredient (sodium n-methyldithiocarbamate or Na-

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MDC). Removing the water would increase applicator safety and maximize chemical dosage. To be effective, Vapam must decompose. Decomposition produces a variety of products, including methylisothiocyanate (MITC), the presumed primary fungitoxicant (Ashley et al. 1963; Turner and Corden 1963). The rate and character of Vapam decomposition vary with pH, temperature, oxygen level, and substrate. Previous studies suggest that anhydrous NaMDC is less effective as a wood fumigant than is the waterborne formulation (Graham and Corden 1980). Before solid NaMDC can be used as a wood fumigant, methods must be found for controlling and accelerating decomposition and thereby maximizing MITC production. In this report, solid NaMDC applied under various conditions and with various additives is assessed as a fungitoxicant.

MATERIALS AND METHODS

Anhydrous NaMDC was prepared by removing the water from a 40% concentrate (Buckman Laboratories, Inc., Memphis, TN) according to previously described procedures (Miller and Morrell 1989). The mixture was filtered, air-dried, and stored in sealed jars for subsequent use.

The powdered NaMDC was formulated into small 150-mg pellets by adding a small quantity of water and pressing the mixture into an aluminum mold in a specially adapted shotgun-shell-reloading press. In addition to those consisting of pure NaMDC, the pellets were formulated with either copper sulfate (1% by weight) or buffer salts (1% by weight) so that they had pH values of 4, 7, 10, or 12. A previous study suggested that pH has a strong influence on the effectiveness of Mylone and Tridipam (Morrell et al. 1988).

The pellets were evaluated with a small block test (Corden and Morrell 1988): 150, 300, or 450 mg (1, 2, or 3 pellets) of each chemical formulation were added to a hole drilled at the center of a Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] heartwood block (2.5 by 2.5 by 10.0 cm) colonized by *Antrodia carbonica*, an important decayer of Douglas-fir utility poles (Eslyn 1970; Graham and Corden 1980; Zabel et al. 1980). Each chemical formulation was evaluated on 12 blocks. On one-half of these blocks, wood moisture content was increased by pressure soaking (125 psi) the blocks for 4 hours prior to inoculation with the test fungus. These blocks had wood moisture contents ranging from 80% to 100% and are referred to as "wet," while those not pressure soaked attained moisture contents ranging from 30% to 50% and are referred to as "dry."

After chemical treatment, the blocks were incubated in plastic chambers connected to an air-flow system that ensured a steady flow of humidified air over the blocks and thus minimized any buildup of volatile fumigant vapors. The blocks were incubated in these chambers for 1 or 4 weeks.

Chemical effectiveness was assessed by cutting a series of three 0.5-cm-thick sections from the ends of each block. The outer sections were discarded and the next two sections were cut into 16 equally sized squares. The inner four squares from the middle section were placed on the surface of potato dextrose agar and observed for the test fungus, whose growth (or lack of it) was used as a measure of chemical effectiveness. The four center squares from the innermost section were placed in 5 ml of ethyl acetate and extracted for 24 hours. A small sample of the extract was examined by gas chromatography (Zahora and Morrell 1988) for MITC content.

TABLE 1. *Effect of pH, wood moisture content, and copper ions on the ability of NaMDC to eliminate* A. carbonica *from Douglas-fir heartwood blocks and to decompose to produce MITC 4 weeks after treatment.*

		pH of buffer additive[b]									
		None		4		7		10		12	
Dosage (mg)	Copper[a] (+/−)	Kill (%)	MITC (mg)	Kill (%)	MITC (mg)	Kill (%)	MITC (mg)	Kill (%)	MITC (mg)	Kill (%)	MITC (mg)
					Wet blocks[c]						
150	+	100	27 (11)	88	70 (41)	100	82 (53)	100	43 (21)	100	58 (57)
	−	69	9 (<1)	94	10 (<1)	72	9 (<1)	94	11 (<1)	59	11 (1)
450	+	100	513 (357)	100	107 (84)	100	190 (141)	100	676 (204)	100	348 (138)
	−	100	257 (181)	97	286 (40)	97	381 (196)	100	573 (210)	92	936 (456)
750	+	100	7,518 (12,535)	100	1,960 (813)	100	43,592 (23,040)	100	1,114 (1,554)	100	526 (690)
	−	100	1,095 (1,259)	100	1,840 (2,926)	100	267 (334)	100	2,811 (6,879)	100	437 (448)
					Dry blocks[c]						
150	+	80	19 (2)	92	9 (<1)	91	9 (<1)	100	9 (1)	100	9 (<1)
	−	91	9 (<1)	83	9 (<1)	88	8 (<1)	97	8 (<1)	100	9 (<1)
450	+	100	38 (51)	100	40 (22)	100	77 (57)	100	20 (18)	100	114 (102)
	−	100	10 (1)	100	16 (9)	100	9 (<1)	100	134 (116)	100	11 (5)
750	+	100	183 (143)	100	80 (123)	100	13 (5)	100	78 (106)	100	34 (23)
	−	100	150 (126)	100	91 (115)	100	129 (145)	100	70 (82)	100	54 (58)

[a] Copper sulfate was added to some treatments (+) at the level of 1% by weight.

[b] Buffer was added at 1% by weight of salt. Kill is expressed as percentage of test squares from which the test fungus was not isolated (24 were assayed per treatment), while MITC levels are expressed in mg/ovendry gram of wood. Values in parentheses represent one standard deviation.

[c] Wet blocks had MC of 80 to 100%, while dry blocks had MC of 30 to 50%.

RESULTS AND DISCUSSION

Culturing and gas chromatographic analysis indicated that pelletized NaMDC alone or in combination with various buffers or metal ions was capable of eliminating *A. carbonica* from the test blocks over a 4-week incubation period (Table 1). In general, chemical levels were higher after 1 than after 4 weeks, while fungal control was higher after 4 weeks (Fig. 1). Conversely, chemical levels declined after 4 weeks and the degree of fungal control was high. These differences reflect the delay between chemical decomposition and fungal control. They also suggest that a highly concentrated wave of MITC passes through the wood shortly after fumigant application. Although this chemical continues to diffuse through the wood thereafter, a high initial dosage probably improves the efficacy of the treatment.

As expected, increasing the number of pellets improved both the levels of MITC and the degree of fungal control after 4 weeks; however, increases in MITC content

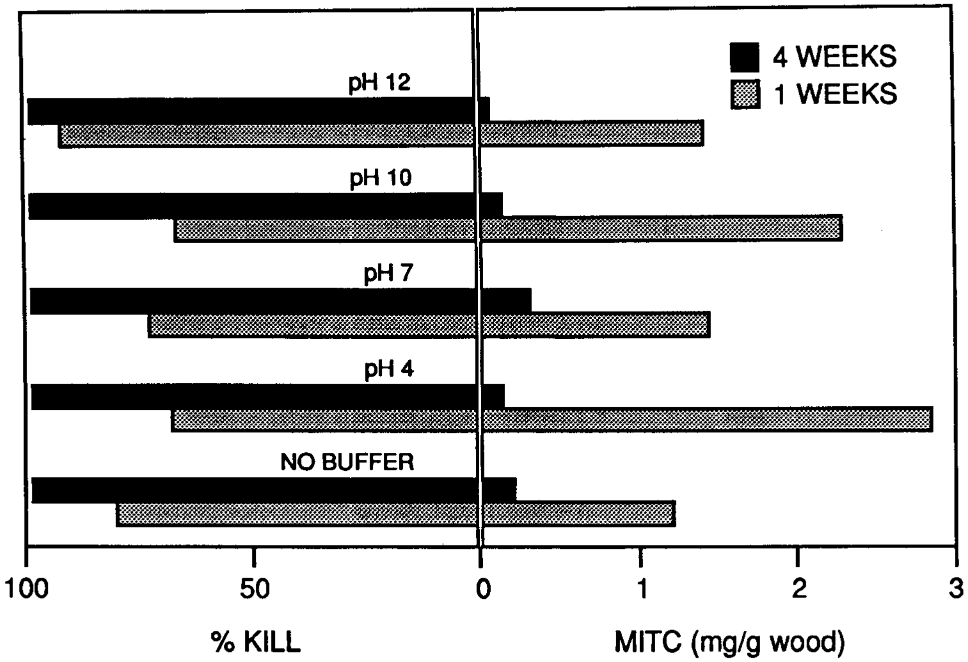

FIG. 1. Effect of adding five 150-mg pellets of NaMDC in combination with buffers at various pH levels on percentage of kill of *Antrodia carbonica* and decomposition of NaMDC to MITC 1 and 4 weeks after treatment.

were less consistent at the two higher dosages when the pH level was 7 and 12 (450 and 750 mg) (Fig. 2).

Increasing wood moisture content decidedly increased MITC content but did not markedly improve the degree of fungal control (Fig. 3). The MITC content and degree of fungal control were generally more variable in the "dry" blocks, probably because of a less uniform moisture distribution there. This effect confirms the results of previous tests of nonpelletized NaMDC (Graham and Corden 1980) and parallels soil studies that suggest that improved decomposition in the presence of increased moisture is actually due to improved oxygen exchange (Turner 1962). Results of the small block test suggest that pelletized NaMDC may be less effective in dry than in wet wood; also, previous studies show that MITC adsorbs more readily to dry than to wet wood and thus will be retained there at higher levels for a longer period (Zahora and Morrell 1989). However, dry wood has a low risk of decay and the chemical would still be present in the treatment holes if wood moisture content subsequently increased and became favorable to fungal growth.

While moisture had a substantial influence on NaMDC performance, the effect of various pH levels on decomposition to MITC and on fungal control was more variable (Figs. 1–3). Dilute NaMDC solutions have a pH of about 9.5, while the Douglas-fir heartwood used in these tests had a pH of 3.5. Higher pH (7.0) has been associated with increased decomposition of Vapam to MITC in soil (Turner 1962), suggesting that increasing the normally low pH of wood would improve NaMDC performance. In earlier tests, the addition of small amounts of buffer at pH 10 or 12 improved the effectiveness of powdered Mylone and Tridipam,

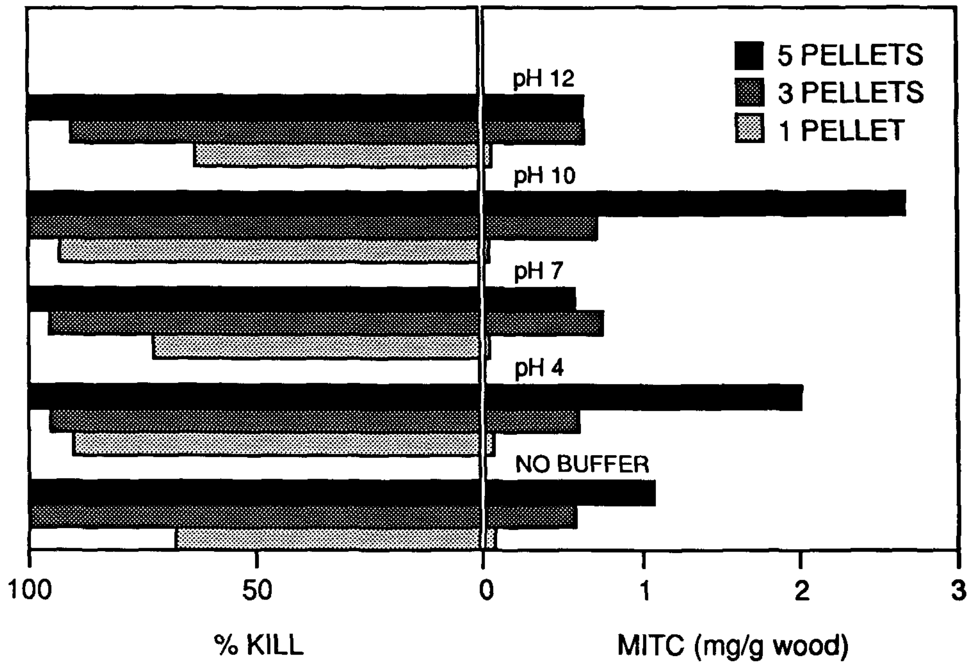

FIG. 2. Effect of pellet dosage of NaMDC on percentage of kill of *Antrodia carbonica* and decomposition of NaMDC to MITC 4 weeks after treatment.

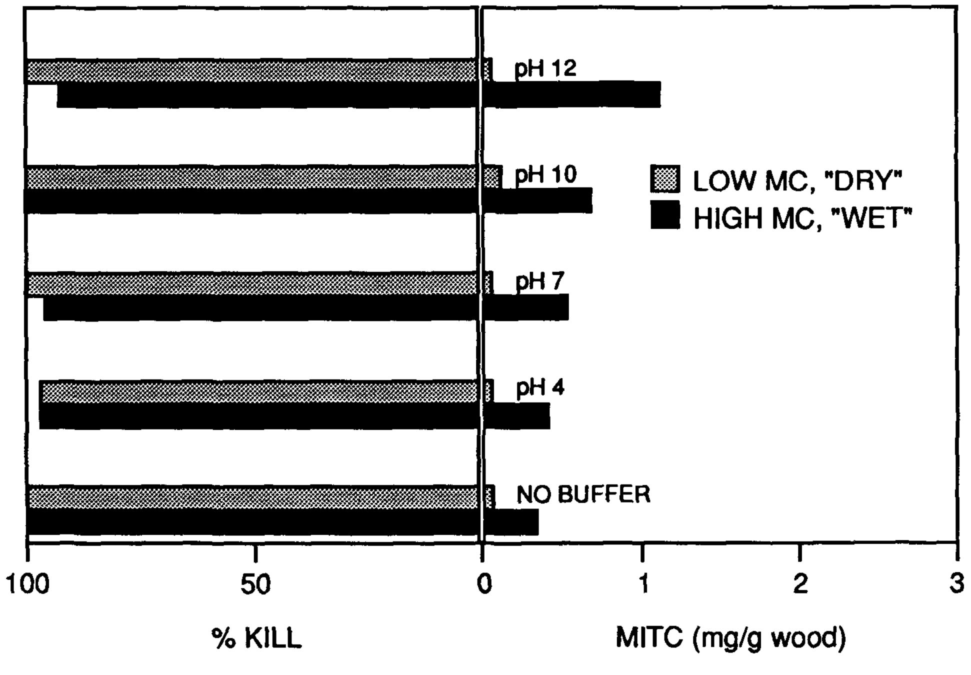

FIG. 3. Effect of wood moisture content (wet, 80–100%; dry, 30–50%) and pH on percentage of kill of *Antrodia carbonica* and decomposition of NaMDC to MITC 4 weeks after treatment.

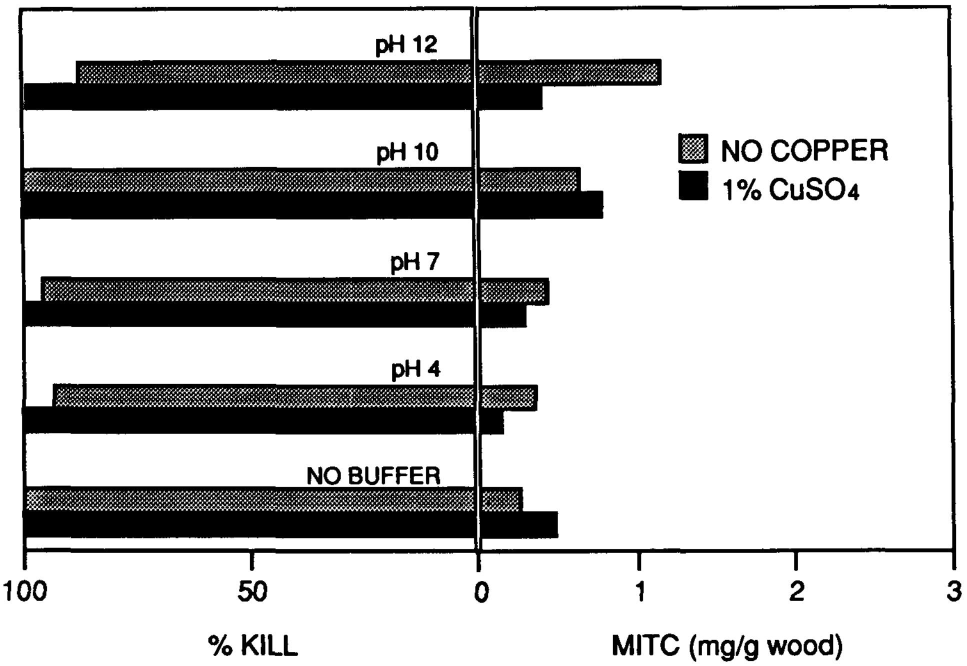

FIG. 4. Effect of copper sulfate on decomposition to MITC of three 150-mg NaMDC pellets at various pH levels and percentage of kill of *Antrodia carbonica* 4 weeks after treatment.

while the effects with NaMDC were variable (Morrell et al. 1988). In some of our experiments, increased pH was associated with a gradual increase in the levels of MITC detected (Fig. 3, wet samples), while little or no difference was noted between the effects of buffers at pH 7, 10, or 12 in other of our tests (Figs. 1 and 2). Since NaMDC decomposes more readily than does Mylone or Tridipam, its higher natural decomposition rate may have masked any increased decomposition caused by the buffer in this test.

One of the additives evaluated, copper sulfate, while not associated with higher MITC levels in all treatments, appeared to be associated with slight improvements in the degree of fungal control (Fig. 4). Earlier soil studies suggested that nontoxic levels of NaMDC reduced the fungitoxicity of copper sulfate but that dilute copper sulfate solutions enhanced the fungitoxicity of NaMDC (Domsch and Corden 1973). This effect was attributed to the production of higher levels of dimethylthiuram disulfide (DMTD). Although DMTD is 100 times more fungitoxic than NaMDC (Domsch and Corden 1973), it is not sufficiently volatile to improve fungal control away from the treatment site (Elson 1966). Copper ions, however, may alter the production of other volatile decomposition products such as hydrogen sulfide, carbon disulfide, methylamine, or carbonyl sulfide, all of which, though not highly fungitoxic, may act synergistically with MITC to improve fungal control (Turner 1962).

CONCLUSIONS

Our data suggest that the decomposition rate of pelletized NaMDC in Douglas-fir heartwood is sufficient for fungal control. While pH and the presence of copper ions affected the rate of decomposition, wood moisture content had the greatest influence on chemical performance. These results suggest that application of solid NaMDC should effectively control decay fungi established in Douglas-fir heartwood; however, further field tests are planned to confirm these results.

The substitution of NaMDC for aqueous Vapam could enhance safety during application and maximize chemical dosage. This formulation could also be safely applied above ground to control decay in areas where the application of currently registered chemicals is not permitted.

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