METHYLISOTHIOCYANATE FUMIGANT CONTENT OF DOUGLAS-FIR HEARTWOOD AT VARIOUS MOISTURE LEVELS AFTER TREATMENT WITH SOLID SODIUM N-METHYLDITHIOCARBAMATE[1]

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ABSTRACT

The relationship between moisture content and the presence of methylisothiocyanate (MITC) in wood following various applications of sodium n-methyldithiocarbamate (NaMDC) was investigated with small Douglas-fir heartwood blocks. While MITC levels were initially higher in wetter blocks, MITC levels in drier blocks remained more stable over the 8-week test period. The addition of water as well as NaMDC to blocks enhanced MITC levels only initially; this effect declined over the test period for blocks at 30% MC or greater. In comparing the effect on MITC levels of applying the NaMDC in powder or pellet form, no significant difference between the two application methods emerged.

Keywords: Sodium n-methyldithiocarbamate, methylisothiocyanate, moisture content, decomposition, fumigants, Douglas-fir heartwood.

INTRODUCTION

Internal decay of pressure-treated wood poles is of important concern with wood species that are characterized by thin sapwood shells surrounding heartwood cores. Internal decay in woods of this type can be arrested with internal application of fumigants. However, many of the chemicals currently used as fumigants are dangerously volatile or caustic during application and so their use is limited (Morrell and Corden 1986). Thus, there is a need to identify chemicals that, while able to move rapidly through wood to control decay, lack the handling problems of existing fumigants.

Of currently registered wood fumigants, metham-sodium (32.1% sodium n-methyldithiocarbamate) is the most widely used; when applied to wood, it decomposes to release fungitoxic methylisothiocyanate (MITC) (Elson 1966). Unfortunately, metham-sodium is a caustic liquid, and workers frequently incur skin burns from spills during application. As an alternative, the water can be removed from metham-sodium to produce powdered sodium n-methyldithiocarbamate (NaMDC), a stable salt. As with liquid metham-sodium, this salt decomposes to release MITC when applied to wood, and its ease of handling makes it more

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attractive than liquid metham-sodium for wood pole treatment. Another advantage of using the solid form of this fumigant for treating wood poles is that more active ingredient can be applied per treatment hole, which means fewer holes per pole are required.

Preliminary studies suggest that wood moisture content and the addition of water during NaMDC application both play an important role both in the decomposition of NaMDC and in MITC release (Sexton et al. 1991). The current study has investigated the importance of these factors in more detail. Wood moisture content varies widely in poles, both positionally and seasonally, and so widespread use of NaMDC as a fumigant will depend largely on the chemical's ability to decompose in wood over a wide range of moisture contents. Therefore, this study has attempted more clearly to determine the effects of wood moisture content on NaMDC decomposition and MITC release. The study has also compared the results of applying NaMDC in powder and pellet form in an exploration of different fumigant application strategies.

MATERIALS AND METHODS

One hundred thirty-five Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] heartwood blocks (2.5 cm by 2.5 cm by 10.0 cm) were conditioned to 30, 60, or 100% moisture content (MC) as follows: The blocks were oven-dried at 54 C for several days and weighed to the nearest 0.01 g. The blocks were then pressure treated with distilled water until the MC exceeded 100%. Blocks were then placed on a table subjected to a continuous air flow and were periodically reweighed to determine moisture content until 45 blocks for each of the three moisture levels were obtained. When the blocks reached a target moisture level, they were dipped 3 times in molten wax to retard further moisture loss and stored for an additional 2 weeks to achieve greater uniformity of moisture throughout the wood. An additional set of 45 blocks was conditioned to approximately 10% MC in a standard relative humidity/temperature room. These latter blocks were also wax-coated once their weight stabilized.

A 0.9-cm-diameter by 1.9-cm-deep hole was drilled halfway down the length of each block, and 50 or 150 mg of NaMDC, in either powder or pellet form, was added to each hole. (Pellets have major safety advantages in terms of reduced dust during application, but they reduce the initial area of chemical/wood contact. The NaMDC was applied in both powder and pellet form to determine whether the initial reduction in contact affected MITC levels.) The NaMDC was prepared from 40% concentrate (supplied by Buckman Laboratories Inc., Memphis, TN) by using previously described procedures (Miller and Morrell 1989). To manufacture the pellets, small amounts of water were added to the powdered chemical and the mixture was pressed into pellets that solidified upon drying. All blocks receiving the 50-mg NaMDC dosages or the 150-mg dosage of powder, and half the blocks receiving the 150-mg dosage of pellets, also received 5.0 ml of water, to expedite MITC release. The holes were then plugged with a rubber serum cap, and the blocks were stored at room temperature.

At 1, 4, and 8 weeks, three blocks per treatment were sampled for MITC distribution. Sections 0.5 cm thick were cut at four locations: at distances of 0.5 cm and 3.5 cm from each side of the treatment hole. The sections were cut into 16 equal-size cubes, and the inner 4 cubes were placed in 5.0-ml ethyl acetate for 48 hours to extract MITC from the wood. The MITC content was determined by injecting a sample of the ethyl acetate extract into a Varian 3700 Gas Chromatograph equipped with a flame photometric detector. Separation was achieved with a 2-m long (2-mm inner diameter) glass column packed with 10% Carbowax® 20M on 80/100 Supelcoport®. Operating conditions were as follows: nitrogen flow—50 ml/min; injector temperature—130 C; column temperature—100 C; and detector temperature—130 C. The extracted wood samples were then oven-dried at 54 C and

TABLE 1. *MITC content of Douglas-fir heartwood blocks at various moisture levels 1 to 8 weeks after treatment with 50 or 150 mg of solid NaMDC.*[1]

Moisture content (%)	Dosage (mg/block)	Water added[2]	MITC content (μg/g oven-dry wood)[3] Pellets 1 wk	Pellets 4 wk	Pellets 8 wk	Powder 1 wk	Powder 4 wk	Powder 8 wk
10	50	+	321	254	129	309	369	166
	150	+	3,628	1,472	980	2,293	1,253	1,180
	150	−	14	82	155	—	—	—
30	50	+	101	94	36	175	27	9
	150	+	2,023	297	111	755	676	200
	150	−	480	370	283	—	—	—
60	50	+	122	92	18	140	27	9
	150	+	2,319	453	38	1,465	588	88
	150	−	775	270	254	—	—	—
100	50	+	109	113	14	178	76	45
	150	+	2,403	924	281	1,473	1,259	221
	150	−	497	305	245	—	—	—

[1] Level reported is for outer zone, 3.5 cm from treatment site.
[2] Five ml of water was added (+) with some treatments to aid in MITC release.
[3] Values represent the means of 6 analyses per treatment.

weighed. The MITC content was calculated on a μg of MITC per oven-dry g of wood basis.

RESULTS AND DISCUSSION

MITC was detected in all treated blocks at every exposure period; however, the amount detected varied with NaMDC dosage and wood moisture content (Table 1). As expected, MITC levels were higher with the higher (150-mg) NaMDC dosage at each wood moisture level. However, the increases were out of proportion to the threefold difference in dosage amounts. For example, 1 week after treatment, MITC levels for the 150-mg dosages were 6 to 25 times higher than for the 50-mg dosages. This disproportionality, which appeared to decrease with time, may reflect the timing of the initial wave of MITC release. Although MITC levels at both dosage levels appeared to peak at or before 1 week, the higher chemical/water ratio at the 150-mg dosage may have delayed MITC release relative to the 50-mg dosage so that the 150-mg dosage reached its maximum level of MITC much closer to the first sampling date.

Wood moisture content had a variable effect on the levels of MITC detected. MITC levels were greatest in wood with high moisture contents 1 week after treatment, but these initially high levels often declined below levels found in drier blocks after 4 or 8 weeks. High wood moisture content enhances NaMDC decomposition, but the wetter the wood, the more rapidly MITC moves through the wood (presumably eliminating fungi as it does so) and is lost to the surrounding air (Zahora and Morrell 1989a). Drier wood, on the other hand, retains more MITC, which is then available for release as wood moisture content rises and conditions suitable for fungal decay develop. Thus, more rapid decomposition of the NaMDC pellets in the 10% MC blocks could be expected when the moisture content increased to levels suitable for decay activity.

In comparing the 150-mg pellet applications to which water was and was not added, the addition of water appeared to cause a marked increase in MITC levels 1 week after treatment, even in blocks with 100% MC. This effect gradually declined with increasing exposure; by 8 weeks, MITC levels at all moisture content levels except 10% were actually higher in the blocks to which water was not added. In the 10% MC blocks, ambient moisture levels apparently were too low to cause extensive NaMDC decomposition, so the addition of water and the tendency for drier wood to retain MITC resulted in a longer-lasting effect on chemical levels. Although the addition of water during application undoubtedly hastens pellet decomposition, no residual pellets were found at the 1-week point in the 30, 60, and 100% MC blocks to which no water was added. These results indicate that although adding water to NaMDC applications may improve fungal control in the short term, existing moisture content in poles is probably adequate for chemical decomposition and long-term MITC release. A similar effect has been noted with treatment of Douglas-fir utility poles with gelatin encapsulated MITC (Morrell et al. 1990).

MITC levels were expected to be highest near the treatment hole, particularly 1 week after treatment. However, between the two positions sampled, few consistent differences in MITC levels were noted at any time. These results appear consistent with preliminary data obtained with a computer prediction model (S. Smith, P. Humphrey, and J. Morrell unpublished) and suggest that longitudinal MITC movement is extremely rapid, producing fairly uniform chemical levels in the area around the treatment site within several days. This effect has important implications for the frequency of chemical treatment, because rapid MITC movement produces rapid fungal control (Zahora and Morrell 1989b) but also results in more rapid loss of chemical from the treatment site.

As Table 1 indicates, no consistent difference in the levels of MITC produced was found between powder and pellet formulations, despite the differences in exposed surface area. Both forms of NaMDC decomposed very quickly when sufficient moisture was present. This result suggests that pelletized formulations, which reduce the risk of inhalation of chemical dust, break down quickly after application and are feasible for internal decay control.

CONCLUSIONS

NaMDC application appears to be sensitive to a number of treatment variables including wood moisture content, the addition of water during application, and dosage. Wood moisture content of 30% or higher causes rapid NaMDC breakdown and MITC movement through wood. Adding water to NaMDC applications to expedite chemical breakdown probably is effective only in drier wood but may not be necessary if the moisture content is too low to support decay activity. Although only 2 NaMDC dosages were investigated, MITC levels in wood do not appear to be directly proportional to the amount of NaMDC applied, and this effect needs further investigation. These results suggest that NaMDC application represents a viable option for controlling internal decay of wood poles under a variety of wood moisture conditions.

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