THE INFLUENCE OF WOOD MOISTURE CONTENT ON THE FUNGITOXICITY OF METHYLISOTHIOCYANATE IN DOUGLAS-FIR HEARTWOOD[1]

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ABSTRACT

High concentrations of the fumigant methylisothiocyanate (MITC) will effectively control decay fungi in large wood structures, but the fungitoxicity of low MITC concentrations and the influence of wood moisture content (MC) on its performance are not well understood. The MC of Douglas-fir heartwood greatly influenced the susceptibility of the decay fungus *Poria carbonica* to MITC vapors and the amount of MITC adsorbed by the wood. At constant, low MITC vapor concentrations (less than 1μg/cc air), wood at 10% MC adsorbed 5 times more MITC, but required 4 times the exposure period to control *P. carbonica,* than wood above the fiber saturation point. Adsorption of MITC to wood was not substantially influenced by the amount of wood decay. When wood MC was raised from 10% to 30% during fumigation, previously adsorbed MITC rapidly volatilized and fumigant fungitoxicity increased.

Keywords: Methylisothiocyanate, moisture content.

INTRODUCTION

Volatile fumigants can control internal decay in large, wooden structural members and thus extend their service lives (Graham 1973; Goodell et al. 1980; Zabel et al. 1982; Helsing et al. 1984). Methylisothiocyanate (MITC) is a volatile, fungitoxic component of the fumigant Vorlex® (20% MITC, 80% chlorinated C-3

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hydrocarbons) and is produced as the fumigant Vapam® (32% water solution of sodium N-methyldithiocarbamate) and several solid fumigants decompose in wood (Zahora and Corden 1985a, Morrell and Corden 1986). Of these fumigants, only Vorlex® and Vapam® are registered with the U.S. Environmental Protection Agency for application to wood.

MITC controls wood decay effectively, and residual MITC vapors can be detected in wood poles and pilings at least 5 years after initial fumigant treatments (Helsing et al. 1984). Over short periods (<32 h) at high MITC concentrations (>2 μg/cc air), wood moisture content (MC) greatly influences the fungitoxicity and sorption of MITC (Zahora and Corden 1985b). However, only limited information is available on MITC/wood interactions and fungitoxicity of MITC in wood after long exposures at low concentrations. This information may be important in determining the overall effectiveness of fumigant treatments.

This study investigated the toxicity of MITC to the decay fungus *Poria carbonica* Overh. during long exposures at low vapor concentrations in Douglas-fir heartwood blocks, and the influence of wood MC on fungal survival and MITC sorption to wood. The results can help in determining the most effective treatment conditions and in defining treatment schedules for long-term control of decay in wood products.

MATERIALS AND METHODS

This study was done in two parts. In the first, MITC fungitoxicity was investigated over a range of fumigant concentrations and wood moisture contents. During that investigation, MITC sorption to sample blocks was found to depend on wood MC; as previously reported by Zahora and Corden (1985b), higher MITC concentrations adsorbed to wood below the fiber saturation point (FSP) than to wood above FSP. Therefore, in the second part of the study, this effect was investigated further over a wider range of wood moisture contents, and the influence of *P. carbonica* decay on MITC sorption to wood was also examined.

Fungitoxicity

Techniques for investigating fungitoxicity of MITC in wood were those previously described by Zahora and Corden (1985b) but modified to accommodate longer fumigation periods. In brief, blocks of coastal Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) heartwood, 0.5 cm grain direction by 2.5 cm square, were oven-dried, weighed, infiltrated with water, and autoclaved for 20 min at 15 psi. They were then adjusted to 75% MC by aeration under sterile conditions in a laminar-flow hood and inoculated with an aqueous suspension of fragmented *P. carbonica* mycelium. The inoculated blocks were placed on glass rods above wet filter paper (humidity source) in petri plates and incubated for 4 to 7 months at 22–25 C. At least 1 week before fumigation, blocks were adjusted by aeration to about 10%, 20%, 40%, or 70% MC. These adjustments were based on block weights and assumed a 5% weight loss from decay. Before and after fumigation, the MC of each block was estimated by removing a piece about 0.5 cm by 0.8 cm square and comparing its wet and oven-dry (OD) weights.

Blocks were fumigated in an apparatus that produced a continuous air stream containing a constant MITC vapor concentration (Zahora and Corden 1985b).

The air stream was split so that it flowed into three identical fumigation chambers (450-cc jars) at a rate of 15 cc/min/chamber. Concentrations ranged from 0.05 to 0.70 μg MITC/cc air. Control experiments also were conducted in which MITC was absent from the airflow.

During fumigation, wood MC was maintained by lining the sides of the jars with filter paper that was wetted with water (40%- and 70%-MC blocks) or with saturated NaCl solution (20%-MC blocks) or left dry (10%-MC blocks). The jars also contained magnetic stirring fans for air circulation and wire mesh supports to hold blocks above the bottoms of the jars.

Prior to fumigation, six radial sections (1.5 cm by 0.5 cm by 60 μm) were cut from each block with a microtome and homogenized in 16 ml of water for 1 minute (20,000 rpm). This homogenate was added to 60 ml of potato-dextrose-agar (50 C) and distributed into 5 petri plates. Plates were incubated at 20–24 C and the resulting *P. carbonica* colonies counted to estimate the initial fungal population density in the blocks. These figures represented the maximum fungal density for the blocks.

Five blocks were fumigated together at each wood MC and MITC vapor concentration. During fumigation, each block was periodically sampled as described above to estimate *P. carbonica* survival. To improve assay sensitivity, the number of sections removed was increased to 8 or 10 as the length of fumigation increased. Fumigant fungitoxicity was expressed as the percent reduction in the *P. carbonica* population density during fumigation, and was based on the maximum density estimated for each replicate block.

After 7 days of fumigation, small pieces of wood (0.5 cm by 0.8 cm square) were removed to estimate wood MC and MITC adsorption by the blocks. These samples were weighed, then extracted in 2 ml of ethyl acetate for 7 days. Extracts were analyzed for MITC content on a Varian 3700 gas chromatograph (GC) equipped with a flame-photometric detector and a sulfur filter. A glass column 3 m long by 4 mm ID, packed with 10% Carbowax® 20M on 80/100 Supelcoport® solid support, was used at injector and detector temperatures of 200 C, oven temperature of 170 C, and nitrogen flow rate of 75 cc/min. MITC concentrations were determined by comparing MITC peak areas with those obtained from standard solutions of MITC in ethyl acetate.

To further investigate the influence of wood MC on the toxicity of MITC to *P. carbonica,* additional blocks were fumigated under conditions of changing wood MC. Blocks which were initially below the FSP were exposed to 100% relative humidity (RH) during fumigation to increase wood MC. The specific fumigant concentrations and times when RH was changed during fumigation are detailed in the results.

Adsorption

Forty-two Douglas-fir heartwood blocks (0.5 cm grain direction by 2.5 cm by 0.8 cm) were inoculated with *P. carbonica* (Zahora and Corden 1985b) and incubated at 20–25 C for at least 6 months. All blocks were then oven-dried, and weight losses resulting from decay were determined. These blocks and 42 sound (undecayed) blocks were divided into 7 groups of 6 decayed and 6 sound blocks for fumigation in the apparatus described above, which could only accommodate 4 such groups at a time.

In the first fumigation, groups of blocks were adjusted (based on weight) to 10%, 20%, 40%, or 70% MC and fumigated at 0.25 μg MITC/cc air. To maintain wood MC, water (40%- and 70%-MC blocks) or saturated NaCl solution (20%-MC blocks) was placed in the bottom of the fumigation chambers. After 7 days, blocks were removed, weighed, and extracted in 5 ml of ethyl acetate for 7 days. Total MITC adsorption was then determined by GC analysis of the ethyl acetate extracts.

This process was repeated with the remaining 3 groups of blocks, which had been equilibrated at 0%, 55%, and 93% RH with anhydrous $CaSO_4$ or saturated solutions of $Mg(NO_3)_2$ or $NH_4H_2PO_4$, respectively. The same solutions were added to the fumigation chambers to maintain wood MC.

To determine the influence of moisture content on MITC adsorption by *P. carbonica* mycelium, fungus was scraped from the surface of decaying Douglas-fir blocks, and about 0.25 g was loosely wrapped in tissue and equilibrated at either 55%, 93%, or 100% RH. The mycelium was then fumigated, weighed, and extracted as described above to determine the effect of moisture content on MITC adsorption by *P. carbonica* mycelium.

RESULTS AND DISCUSSION

Poria carbonica population densities varied greatly among blocks before fumigation, ranging from about 100 to over 5,000 colonies per 6 microtomed sections sampled. For greatest accuracy in estimating fungal survival during fumigation, fungi should be uniformly distributed throughout each block so that a change in fungal population density reflects the influence of the fumigant treatment. However, fungal populations often fluctuated in successive subsamples, sometimes apparently increasing during fumigation. This effect was most apparent during short MITC exposures at low wood MC (limited fungal kill). As a result, Figs. 1 and 2 are more accurate at lower survival estimates.

In the absence of MITC, fungal population densities in wood at 63–87% MC (well above the FSP of Douglas-fir) fluctuated but remained high throughout an 18-day sampling period (Fig. 1). However, estimated fungal survival decreased substantially when wood MC either increased or decreased through the FSP during the sampling period. Drying blocks from 84% to 16% MC reduced fungal population densities to less than 5% of their original level but did not completely kill the fungus. Increasing block MCs from 17% to 30% by exposing them to 100% RH rapidly reduced fungal population densities to about 20% of original levels. Thereafter, they slowly increased over time, probably because the fungus started growing actively and the probability of a viable hyphal segment surviving the isolation process increased.

The physiological reasons for these population decreases were not investigated. Drying wood below the FSP may reduce fungal populations through hyphal death, possibly associated with formation of resting structures such as chlamydospores. The unexpected decrease in fungal population densities when dry wood was exposed to 100% RH may result because previously dry (dormant) fungus becomes metabolically active and susceptible to wood extractives or more sensitive to the fragmentation of sampling.

Although estimates of fungal population density varied with sample position in the block and were also greatly influenced by changes in wood MC during

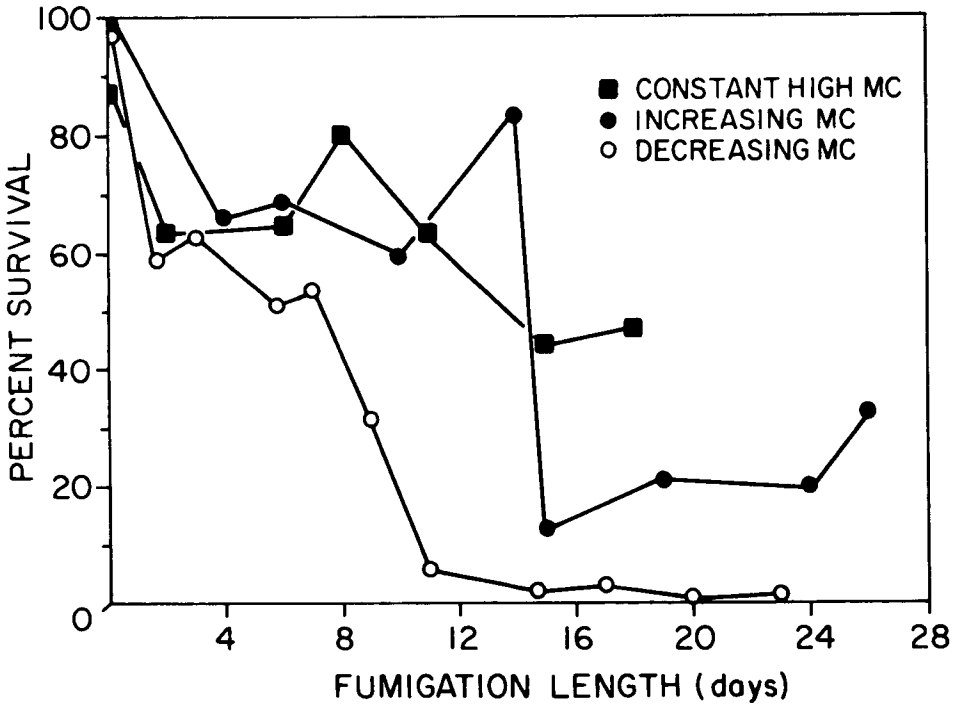

FIG. 1. Influence of wood moisture content on the observed *P. carbonica* populations estimated in Douglas-fir heartwood blocks in the absence of fumigant. Blocks were either maintained at a high moisture content (>63% MC) throughout the sampling period, increased from 17% to 27% MC at day 14 by exposing to 100% RH, or dried from 84% (initial MC) to 43% (day 9 MC) to 17% MC (day 10 MC) in the fumigation chambers. Each point represents the average fungal survival in 5 replicate blocks expressed as the percent of the maximum population density measured in each block.

fumigation, distinct relationships between wood MC and the susceptibility of *P. carbonica* to MITC were determined.

MITC fungitoxicity at constant wood MC

Poria carbonica was more sensitive to low MITC vapor concentrations in wood above the FSP than in wood below the FSP (Fig. 2). At 0.72 μg MITC/cc air, the exposure period required for a specific reduction in *P. carbonica* survival was more than 2.5 times longer in wood at 14–16% MC than in wood above the FSP (Fig. 2A); at 0.25 μg MITC/cc air, more than 4 times the exposure period was required for fungal control in the drier wood (Fig. 2B). Because of the long exposure times required to kill *P. carbonica* in dry wood, only blocks above the FSP were fumigated at 0.10 (Fig. 2D) and 0.05 μg MITC/cc air.

The exposure time (days) required to kill 98% of the *P. carbonica* propagules in replicate blocks was estimated for each wood moisture content at 0.70 and 0.25 μg MITC/cc air (Table 1). Significantly longer exposures were required for 98% kill in blocks below the FSP than in those above the FSP, and for blocks at 9% than for those at 15% MC, when the blocks were exposed to 0.25 μg MITC/cc air. Above the FSP, differences in wood MC did not consistently influence the length of exposure required for 98% kill; mean exposure times sometimes in-

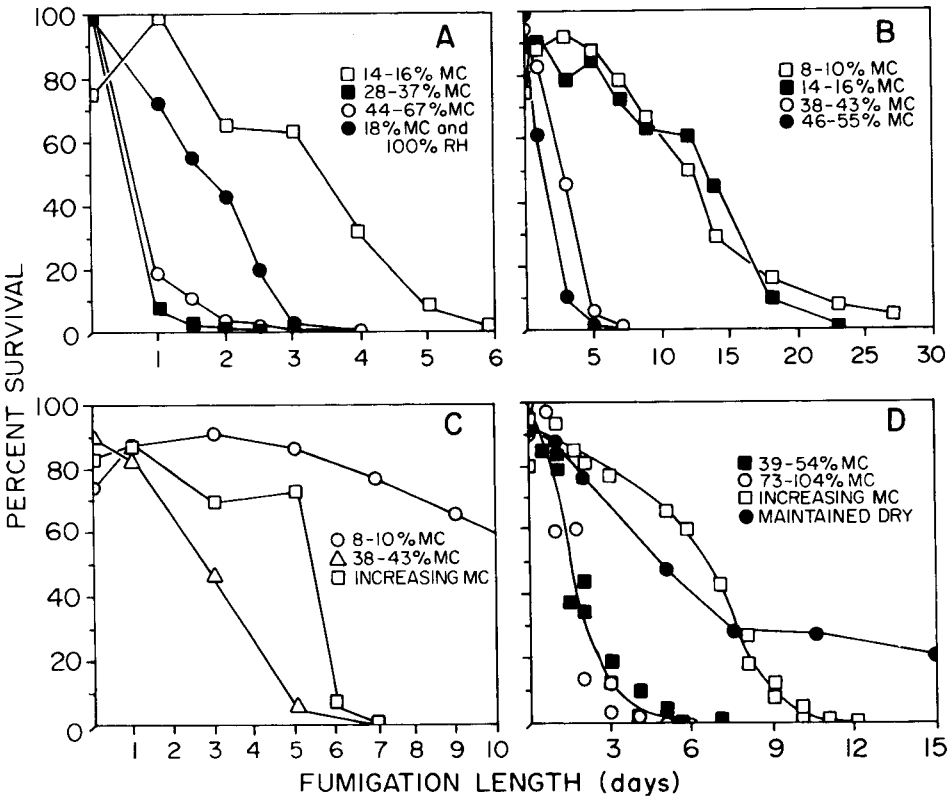

FIG. 2. Dosage-response relationships describing the influence of wood moisture content (MC) on the fungitoxicity of methylisothiocyanate (MITC) to *Poria carbonica* in Douglas-fir heartwood blocks. A) Infested wood blocks at 3 MC ranges were exposed at 0.70 μg MITC/cc air, with one set of blocks at 18% MC exposed at 100% relative humidity (RH). B) Infested wood blocks at 4 MC ranges were exposed at 0.25 μg MITC/cc air. C) Infested wood blocks were exposed at 0.25 μg MITC/cc air at 38–43% MC or 8–10% MC, or the MC was increased by exposing 8–10% MC blocks to 100% RH at 5 days. D) Infested wood blocks were exposed at 0.10 μg MITC/cc air. Two groups of wood blocks below the fiber-saturation point dried from 20% to 11% MC by day 7. One group was then exposed to 100% RH to increase its MC. Each point represents the average fungal survival in 5 blocks expressed as the percent of the maximum population density measured in each block.

creased and sometimes decreased with increasing wood MC at all MITC vapor concentrations. In wood fumigated at 0.10 μg MITC/cc air (Fig. 2D), fungal survival varied between replicate experiments at 42–52% MC and 91–104% MC but did not differ significantly ($\alpha = 0.05$) with wood MC. Zahora and Corden (1985a) also found no significant difference in MITC fungitoxicity at 40% and 75% for MITC vapor concentrations above 2.5 μg/cc air. This is as expected; a change in wood MC above the FSP should not substantially influence fungal growth unless it also limits oxygen. Therefore, in subsequent analyses, *P. carbonica* survival results were combined for blocks fumigated above the FSP.

Regression lines relating fungal survival (probit scale) to fumigant exposure (log scale) were used to estimate the length of fumigant exposure required to kill 98% of the *P. carbonica* propagules in blocks above the FSP. When MITC concentrations decreased from 0.70 to 0.25 μg/cc air, the estimated exposure requirement

TABLE 1. *Average methylisothiocyanate (MITC) vapor concentrations and times required to kill 98% of the* Poria carbonica *propagules in Douglas-fir heartwood blocks at different wood moisture contents.*

MITC concentration (μg/cc air)	Days of exposure to kill 98% of fungus[1]			
	8–10% MC	14–16% MC	28–43% MC	44–67% MC
0.70	—	5.5	1.5	2.3
0.25	27.3	20.4	6.2a	4.4a

[1] Means of 5 replicate blocks. Means followed by a letter are not significantly different ($\alpha = 0.05$) at that MITC vapor concentration according to the Student-Newman-Keuls test.

increased from 1.8 to 5.2 days. Further reduction of MITC concentrations to 0.10 and 0.05 μg/cc air did not significantly increase the required exposures (Table 2), which were estimated at 4.4 and 5.1 days, respectively.

These results were used to calculate CT98 values (the product of MITC concentration and the exposure time required to kill 98% of *P. carbonica* propagules) for comparison with results from an earlier study (Zahora and Corden 1985b) which tested MITC concentrations above 2 μg/cc air (Table 3). CT98 values in wood at 14–20% MC were comparable with earlier results and remained constant at about 5 μg MITC/cc air/day throughout the range of MITC vapor concentrations tested. These results indicate that decreased fumigant levels will require longer exposure periods to achieve equivalent control. However, in wood above the FSP, CT98 values declined as MITC vapor concentrations decreased. Between 0.05 and 0.25 μg MITC/cc air, MITC fungitoxicity was independent of vapor concentration and dependent only on exposure, as discussed above. The implication is that MITC concentrations over a given exposure time that are not toxic to inactive decay fungi in dry wood can become fungitoxic in wet wood, in which fungal growth and active decay are most likely to occur.

Lower fungitoxicity of MITC in dry wood may result from the lower susceptibility of desiccated (inactive) *P. carbonica* mycelium, or spores that are formed during drying, to MITC.

MITC fungitoxicity with changing wood MC

In blocks that were initially at 18% MC and fumigated at 0.70 μg MITC/cc air and 100% RH, MITC fungitoxicity was greater than in blocks that were maintained dry during fumigation, but lower than in blocks that were maintained above the FSP (Fig. 2A). The MC of these blocks after 5 days of fumigation was close to the FSP of Douglas-fir (28–30% MC). Although exposure of dry blocks to 100% RH in the absence of fumigant reduced fungal population densities (Fig. 1), it did

TABLE 2. *Statistical comparison of regression curves for fumigation length (log scale) and* Poria carbonica *survival (probit scale) at different methylisothiocyanate (MITC) vapor concentrations in Douglas-fir heartwood blocks above the fiber-saturation point.*

Regression comparison (μg MITC/cc air)	F* value	Critical F value[1]
0.70, 0.25, 0.10, and 0.05	11.4	F(0.99; 6, 34) = 3.47
0.25, 0.10, and 0.05	0.46	F(0.95; 4, 27) = 2.73
0.70 and 0.25	21.3	F(0.99; 2, 12) = 6.93

[1] Reduced models include all data points from the regression plots being compared. Alternative conclusions are: if $F^* < F(1 - a; r - 1, n - r - 1)$, then the lines are similar in both slope and intercept; or, if $F^* > F$, then at least one line in the comparison must differ with respect to either slope or intercept.

TABLE 3. *Estimated methylisothiocyanate (MITC) concentration × exposure times necessary to kill 98% (CT98 values) of the* Poria carbonica *propagules in Douglas-fir heartwood blocks fumigated under dry or wet conditions.*

Wood moisture content range (%)	CT98 values[1] in wood fumigated at MITC concentrations[2] of:				
	8.0	3.0	0.70	0.25	0.10
14–20%	6.1	5.1	3.7	5.4	—
Above FSP (>30%)	3.9	3.1	1.3	1.3	0.44

[1] CT98 values (μg MITC/cc air/day) were estimated from Zahora and Corden (1985b) for MITC concentrations of 3.0 and above, and from regression analyses of data in Fig. 2 for the rest.
[2] MITC concentration in μg/cc air.

not completely kill the fungus. In dry blocks fumigated at high RH, the shorter time required for complete fungal kill suggests that fungal propagules formed in dry wood lose their MITC resistance when wood MC increases and physiological activity of the fungus resumes.

The influence of increasing wood MC during fumigation on MITC fungitoxicity was even more pronounced when blocks at 10% MC were fumigated for 5 days under dry conditions before the RH was increased to 100% (Fig. 2C). When blocks were fumigated at 0.25 μg MITC/cc air, survival of *P. carbonica* decreased sharply after 1 day at 100% RH, as in nonfumigated controls (Fig. 1). This decline may reflect processing damage to fungal propagules at a particularly susceptible phase in their life cycle. Subsequently, however, instead of slowly increasing, the fungus was essentially completely killed (survival less than 0.5%) by the second day. This decrease in survival occurred faster than in blocks initially fumigated at 38–43% MC. Wood blocks adjusted quickly to the new RH conditions; after only one day at 100% RH, their MC increased to about 28%, and adsorbed MITC concentrations decreased from about 700 to 150 μg MITC/g OD wood. This decrease indicates a substantial release of adsorbed MITC from the dry wood, a release that would temporarily increase MITC vapor concentrations in the blocks by a factor of about four and may explain the observed rapid kill.

Similar results were observed in dry wood fumigated at 0.10 μg MITC/cc air (Fig. 2D). In these blocks, the initial decrease in fungal survival during the 7 days of dry fumigation may have resulted from drying of the blocks during this period. When the RH was increased to 100%, the rate of fungal kill increased to about that observed in wood initially fumigated above the FSP. Adsorbed MITC concentrations also rapidly decreased from about 170 to 40 μg MITC/g OD wood after 1 day at 100% RH. Although substantial MITC was apparently released in these blocks, it did not increase the rate of kill beyond that observed in wood initially above the FSP, probably because MITC vapor concentrations did not increase beyond the range where rate of kill is independent of vapor concentration (Table 2).

The rapid kill of *P. carbonica* when the RH was increased to 100% probably resulted from increased susceptibility of fungal propagules as well as the temporary increase in MITC vapor concentration within the blocks as adsorbed MITC was volatilized and released. The greatly increased susceptibility of *P. carbonica* to MITC in wet wood may help explain why Vapam®, which produces MITC during decomposition but is mostly water, has performed well as a wood fumigant.

Wood MC also influenced extractable MITC adsorbed by the wood; higher

TABLE 4. *Influence of wood moisture content (MC) and decay by* Poria carbonica *on methylisothiocyanate (MITC) sorption in Douglas-fir heartwood blocks in the first fumigation.*[1]

Wood MC[2] (%)	% weight loss from decay[3]	MITC sorption (μg/g OD wood)	Partition coefficient[4]
9.6 (0.2)	0	687 (26)	2,750
8.0 (0.3)	11	601 (63)	2,400
15.5 (0.3)	0	246 (9)	980
13.9 (0.8)	11	293 (9)	1,170
32.4 (0.5)	0	111 (11)	440
29.2 (1.0)	11	133 (10)	530
64.4 (5.9)	0	123 (5)	490
67.8 (9.3)	11	158 (8)	630

[1] Groups of 6 sound and 6 decayed blocks were fumigated together in a continuous-flow fumigation apparatus for 7 days at 0.25 μg MITC/cc air. Values represent the mean and standard deviation (in parenthesis) of the six decayed or nondecayed blocks in each group.
[2] Blocks were initially adjusted to either 10%, 20%, 40%, or 70% MC. Figures represent final block MCs.
[3] Weight losses of individual decayed blocks ranged from 7% to 14%.
[4] Partition coefficients represent the total MITC content in wood (per g) divided by the MITC vapor concentration (per cc).

MITC concentrations were found in wood below the FSP than in wood above the FSP. Specific concentrations detected during fungitoxicity experiments were similar to but less accurate than those found in the MITC adsorption study described below.

MITC adsorption in Douglas-fir heartwood

At a constant vapor concentration of 0.25 μg MITC/cc air, MITC adsorption by Douglas-fir heartwood blocks was strongly influenced by wood moisture content, but apparently was not greatly influenced by wood decay. The adsorbed MITC concentrations calculated from the two fumigations (Tables 4 and 5) did not correspond as expected; MITC concentrations in Table 5 were lower than suggested by Table 4. This might relate to the fact that these fumigations were conducted at ambient temperature, which may have varied between experiments. Similar variability in adsorption during replicate fumigations was also observed in the previously described fungitoxicity studies, whose temperatures also were not strictly controlled. Although such variability prevents combining Tables 4 and 5 to form a unified picture of MITC adsorption over the full range of moisture contents, the results permit some generalizations about MITC adsorption in Douglas-fir heartwood.

MITC adsorption differed substantially between decayed and nondecayed blocks that were fumigated together under the same conditions; adsorption was higher in decayed than in nondecayed blocks above 10% MC, but the opposite was true in blocks below 10% MC. Although these differences were often substantial, wood decay also reduced final block MC, which may explain the observed differences. The influence of wood MC on MITC adsorption was sufficient to mask any differences in adsorption that could be attributed to wood decay, and this suggests that the influence of decay was not great compared to that of wood MC.

Adsorbed MITC concentrations were highest in wood at about 10% MC, and decreased both below and above this moisture content. Adsorbed concentrations decreased substantially as wood MCs increased from about 10% up to the FSP. These results are comparable to partition coefficients (Table 4, ftn. 4) of 700 (18–22% MC wood) and 500 (36–43% MC wood) which were calculated using the

TABLE 5. *Influence of wood moisture content (MC) and decay by* Poria carbonica *on methylisothiocyanate (MITC) sorption in Douglas-fir heartwood blocks in the second fumigation.*[1]

Wood MC[2] (%)	% weight loss from decay[3]	MITC sorption (μg/g OD wood)	Partition coefficient[4]
1.7 (0.2)	0	238 (24)	950
0.9 (0.2)	23	226 (12)	900
8.0 (0.3)	0	312 (8)	1,250
6.4 (0.2)	19	215 (35)	860
22.0 (1.7)	0	97 (6)	390
19.0 (1.5)	21	136 (7)	540

[1] Same as in Table 4.
[2] Blocks were equilibrated and exposed at 0%, 55%, or 93% RH over salt solutions. Figures represent the final moisture contents of blocks.
[3] Weight losses of individual decayed blocks ranged from 9% to 27%.
[4] Same as in Table 4.

data of Zahora and Corden (1985b) from experiments conducted at 1–3 μg MITC/cc air for 32 hr.

The mycelium of *P. carbonica* showed a similar relationship; dry mycelium adsorbed much higher MITC concentrations than did mycelium fumigated at higher MC. Mycelium fumigated for 1 week (0.25 μg MITC/cc air) at 55% RH (11% MC) adsorbed 61 μg MITC/g OD fungus, whereas mycelium fumigated at 93% and 100% RH (36% and 54% MC, respectively) adsorbed less than 4 μg MITC/g OD fungus.

CONCLUSIONS

The brown-rot decay fungus *Poria carbonica* was much more susceptible to MITC in wood above the FSP than in wood below the FSP. Increased susceptibility was apparently dependent on the water content of the fungus; fungi in dry wood rapidly became more susceptible during fumigation if RH was increased. This may result because the fungus is more susceptible to MITC when actively growing, which suggests that temperature may also influence fumigant effectiveness. CT98 values remained constant at about 5 μg MITC/cc air/day in wood at 14–20% MC, but decreased with MITC concentration in wood above the FSP. This suggests that the relationship between fumigant dose and fungitoxicity differs between dry and wet wood, and that wood MC may be important in determining long-term wood protection by MITC fumigation.

Increasing the moisture content of wood in equilibrium at a low MITC vapor concentration will cause a rapid release of adsorbed MITC from wood as MITC sorption equilibrates to the new moisture content. This effect, which was not greatly influenced by *P. carbonica* decay, suggests that adsorbed MITC will be released whenever dry wood becomes moist and susceptible to decay. Although *P. carbonica* is less sensitive to MITC in dry than wet wood, adsorbing high levels of MITC in dry wood may provide a fumigant reservoir which is rapidly volatilized when wood becomes wet and susceptible to active fungal decay. This release may help explain the excellent long-term performance of MITC in wood.

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