Effect of Copper on Long-Term Performance of Dazomet as an Internal Remedial Treatment in Douglas-Fir Poles

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Abstract

A solid, crystalline fumigant (dazomet) with and without a supplemental copper compound was evaluated as an internal decay control treatment on Douglas-fir poles in two long-term field tests. Methylisothiocyanate (MITC), the decomposition product of dazomet, was used as a measure of effectiveness. MITC levels in the wood were above the threshold near the groundline application zone within 1 year after treatment. MITC levels above the groundline were much lower, suggesting that the treatment zone would need to be extended to produce protection in these higher zones. The addition of copper sulfate markedly increased MITC levels. Copper naphthenate was slightly less effective as a dazomet accelerant, but slightly better than dazomet alone. The results indicate that dazomet treatment remains at protective levels for 10 to 12 years. This range is well within the typical inspection cycle used by most North American utilities.

Preservative treatment of most large wood products produces a shell of protection that surrounds an untreated heartwood core. The depth of this shell is dependent on wood species. In some cases, deep checks can develop in these products while the wood seasons in service, and these checks can penetrate beyond the depth of the original treatment. This exposes the untreated heartwood to potential attack by decay fungi and insects. Internal fungal decay can have important effects on performance of larger wood products such as poles and timbers, and arresting this attack is critical for maximizing wood service life. The most common need for such treatments is in utility poles that support overhead electrical lines.

For decades, utilities have routinely applied fumigants to arrest internal fungal attack in their poles (Graham 1983). The treatments are applied through steep sloping holes drilled into the poles in and around the groundline. The chemicals are applied, the holes are plugged, and the treatment volatilizes into a gas that moves approximately 1 m up and down from the point of application (Morrell and Corden 1986). For many years, two liquid fumigants (trichloronitromethane and sodium *n*-methyl dithiocarbamate [NaMDC]) were the most commonly used chemicals for this application; however, concerns about spills and volatility led to a search for more easily handled fumigants. Methylisothiocyanate (MITC), a crystalline solid material that is the active breakdown product of NaMDC, was developed, first in gelatin capsules but later in a self-contained vial system (Morrell et al. 1990). While MITC has also proved to be easy to handle and highly effective, it has not seen widespread use (Morrell et al. 1992, 1998).

In an effort to identify other, more easily handled systems, dazomet (tetrahydro-3,5-dimethyl-2H-1,3,5-thiodiazine-2-thione) was examined for its potential as a fumigant. Dazomet is a solid, crystalline powder at room temperature. This compound decomposes in the presence of water to produce a variety of products, including MITC. Preliminary trials with dazomet suggested that the rate of decomposition was too slow to be of use as a remedial treatment. Subsequent studies suggested that the addition of small amounts of copper salts to the powder at the time of application markedly improved breakdown, and dazomet was eventually registered for use as an internal remedial

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Forest Prod. J. 60(2):194–199.

treatment for wood poles (Forsyth and Morrell 1993, 1995; Forsyth et al. 1998).

There are few long-term reports on dazomet performance in poles in service. These data are important for utilities since they identify the most appropriate treatment cycle for using dazomet to limit the risk of internal decay. In this report, we describe tests of dazomet with and without added copper in Douglas-fir (*Pseudotsuga menziesii*) transmission poles in western Oregon.

Materials and Methods

Dazomet was evaluated in two tests. The first occurred in an active utility transmission line, while the second was performed on pole sections installed at a field test site. In the first test, copper sulfate was used as an accelerant. At the time the test was established, dazomet was not registered for wood use. The second trial compared the effectiveness of copper sulfate and copper naphthenate, which is registered for wood use.

Effect of copper sulfate on dazomet performance

Douglas-fir transmission poles (420 to 510 mm in diameter) in a line located near Corvallis, Oregon, were selected for the test. The 21-m-long poles were American National Standard Institute Standard 05.1 Class 1 and 2 and had been in service for 10 to 15 years at the time of test (Alliance for Telecommunications Industry Solutions [ATIS] 2008).

Three steeply angled holes (20 mm in diameter by 375 m long) were drilled in each pole beginning at groundline and moving upward at 150-mm increments and around at 120° intervals. Drill shavings from each drill hole were retained. These shavings were briefly flamed and then placed on the surface of malt extract agar in plastic Petri dishes. These chips were observed for evidence of fungal growth, which was then examined under a microscope for characteristics typical of Basidiomycetes, a class of fungi containing many important wood decayers.

The poles were treated with either 200 or 400 g of dazomet with or without 1 percent copper sulfate (wt/wt). The dosages were premixed and evenly distributed among the three treatment holes. An additional set of poles was treated with 500 mL of 40 percent NaMDC, also distributed among three holes at the same locations as those drilled for the dazomet treatments. The treatment holes were plugged with tight-fitting wood dowels.

Chemical movement and efficacy were assessed annually for the first 5 years after treatment, then 7, 10, 12, and 15 years after chemical application by removing increment cores from three equidistant points around each pole 0.3, 1.3, 2.3, and 3.3 m above groundline. The 3.3-m zone was omitted from the 15-year sample because no chemical had been detected at this level at either 10 or 12 years. The outer, heavily treated zone was discarded, and then the outer and inner 25 mm of each core was removed and placed into 5 mL of ethyl acetate. The cores were stored at room temperature for 48 hours to extract any MITC in the wood, and then the increment core was removed, ovendried, and weighed. The core weight was later used to calculate chemical content on a wood weight basis.

The ethyl acetate extracts were injected into a Shimadzu gas chromatograph equipped with a flame photometric detector with filters specific for sulfur (a component of MITC). MITC levels in the extracts were quantified by comparison with prepared standards, and results were expressed in micrograms of MITC/ovendried grams of wood (Zahora and Morrell 1988a, 1988b, 1989). The remainder of each core was cultured on malt extract agar for the presence of Basidiomycetes, a class of fungi containing many important wood decayers. Other fungi present were classified as nondecay fungi. Although these fungi do not cause wood decay, their roles in chemical performance remain unknown.

Effect of copper naphthenate on dazomet performance

Douglas-fir pole sections (283 to 340 mm in diameter by 3 m long) were pressure treated with pentachlorophenol in P9 Type A oil before being set to a depth of 0.6 m at our field test site. Three steeply sloping holes (20 mm in diameter by 375 mm long) were drilled into the poles beginning at groundline and moving upward 150 mm and around the pole at 120° intervals. Two hundred grams of dazomet was equally distributed among the three holes. One set of three poles received no additional treatment, three poles received 20 g of copper sulfate, and three received 20 g of copper naphthenate (2% metallic copper) in mineral spirits. The holes were then plugged with tight fitting wood dowels.

Chemical distribution was assessed annually for the first 5 years after treatment and then at 8, 10, and 12 years by removing increment cores from three equidistant points around each pole at sites 0.3, 1.3, and 2.3 m above the groundline. The outer 25 mm of each core was discarded. The next 25 mm and the 25-mm section closest to the pith were analyzed for MITC, and the remainder of each core was cultured for decay fungi as described above.

Data assessment

MITC concentrations in fumigant-treated poles tend to vary widely, even in adjacent wood sections. This variation reflects the mobility of the chemical coupled with the natural variation in wood. Rather than assessing statistical differences between individual data points, we instead compare mean concentrations at a given location with a threshold value. Through extensive previous sampling, 20 μg of MITC/ovendried g of wood has been found to be the point where we begin to isolate Basidiomycetes. While there are always exceptions, this value has functioned as a good indicator for the time when reapplication of chemical is advisable, and this value was used in this study to assess the effect of the copper additives on MITC content in the poles.

Results and Discussion

Effect of copper sulfate on dazomet performance

Protective MITC levels were present 1 year after treatment in poles receiving NaMDC and with either dazomet dosage amended with copper sulfate (Table 1). MITC levels tended to be highest within 0.3 m of groundline, reflecting the concentration of the original application holes near that zone. MITC levels in NaMDC-treated poles remained above the threshold in this zone for the first 3 years after treatment and then declined sharply after the fourth year. These results are consistent with the

Table 1.—MITC levels at selected locations above the groundline in Douglas-fir poles 1 to 15 years after treatment with metam sodium or dazomet.

			MITC content (μg/g of wood)[a]							
			0.3 m		1.3 m		2.3 m		3.3 m	
Chemical treatment	Dosage	Year	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
Dazomet	200 g	1	8 (21)	2 (7)	5 (9)	13 (23)	0	0	1 (4)	1 (2)
		2	18 (20)	**29** (37)	8 (11)	7 (16)	4 (6)	1 (4)	4 (8)	4 (7)
		3	**51** (44)	**50** (63)	19 (21)	**38** (36)	8 (5)	9 (7)	2 (4)	2 (3)
		4	**25** (15)	**39** (31)	8 (4)	9 (11)	0 (1)	0	0	0
		5	**31** (31)	**37** (26)	10 (5)	7 (6)	0 (1)	0 (1)	0	0
		7	**38** (20)	**35** (30)	11 (7)	7 (8)	0	0	0	0
		10	**134** (178)	**68** (75)	**48** (17)	**44** (25)	20 (11)	10 (9)	7 (9)	6 (7)
		12	**43** (35)	**32** (19)	14 (8)	6 (5)	2 (4)	1 (2)	0	0
		15	14 (18)	5 (7)	11 (12)	6 (9)	**25** (26)	14 (18)		
Dazomet plus 1% copper sulfate	200 g	1	12 (27)	14 (31)	**26** (38)	**42** (65)	0	1 (5)	2 (5)	0
		2	**72** (100)	**50** (74)	13 (18)	8 (13)	7 (19)	4 (9)	6 (13)	10 (21)
		3	**182** (215)	**203** (272)	**63** (70)	**47** (52)	10 (13)	9 (17)	1 (4)	0
		4	**110** (86)	**103** (86)	**25** (20)	11 (16)	1 (2)	0 (2)	0	0
		5	**110** (92)	**59** (101)	**28** (21)	10 (10)	3 (4)	1 (2)	0	0
		7	**80** (73)	**77** (87)	**22** (14)	**21** (18)	5 (4)	4 (5)	0	0
		10	**114** (111)	**112** (90)	**55** (35)	**57** (56)	**30** (20)	19 (14)	15 (12)	11 (9)
		12	**70** (66)	**45** (62)	13 (5)	7 (7)	4 (4)	2 (4)	0	0
		15	6 (10)	6 (14)	9 (12)	6 (8)	5 (9)	2 (4)		
Dazomet	400 g	1	5 (9)	**22** (49)	16 (31)	**56** (86)	1 (4)	0	0	1 (3)
		2	**45** (47)	**110** (108)	5 (5)	1 (3)	1 (2)	1 (3)	1 (2)	4 (10)
		3	**102** (97)	**137** (207)	**107** (106)	**69** (105)	15 (15)	6 (8)	3 (6)	3 (6)
		4	**59** (35)	**84** (54)	11 (8)	7 (6)	0	0	0	0
		5	**42** (23)	**38** (31)	12 (8)	7 (6)	1 (2)	0	0	0
		7	**60** (31)	**59** (27)	15 (7)	12 (6)	1 (2)	0 (2)	0	0
		10	**139** (128)	**103** (80)	**58** (20)	**51** (36)	19 (7)	13 (8)	10 (7)	2 (4)
		12	**67** (56)	**76** (106)	11 (9)	6 (6)	3 (6)	1 (3)	1 (3)	0
		15	20 (28)	10 (16)	19 (21)	15 (17)	19 (22)	14 (23)		
Dazomet plus 1% copper sulfate	400 g	1	**25** (41)	**25** (76)	**31** (46)	**64** (139)	0	0	0	0
		2	**100** (93)	**69** (126)	7 (8)	3 (5)	2 (5)	3 (5)	3 (5)	4 (6)
		3	**435** (613)	**501** (787)	**149** (162)	**132** (185)	11 (11)	6 (8)	1 (2)	1 (2)
		4	**121** (82)	**130** (116)	9 (10)	7 (10)	1 (2)	0 (1)	0	0
		5	**108** (89)	**54** (70)	13 (14)	9 (10)	14 (48)	6 (21)	0	0
		7	**70** (89)	**51** (30)	10 (8)	10 (7)	1 (2)	1 (2)	1 (4)	0
		10	**79** (43)	**53** (29)	**40** (22)	**46** (46)	11 (10)	10 (7)	8 (8)	3 (7)
		12	13 (9)	16 (19)	5 (9)	6 (19)	4 (14)	0	0	0
		15	5 (7)	5 (9)	2 (3)	0	1 (3)	0 (1)		
Metam sodium	500 mL	1	**21** (43)	**30** (61)	**57** (82)	**38** (46)	1 (3)	0	1 (3)	0
		2	**53** (47)	**26** (28)	15 (17)	8 (16)	4 (7)	3 (5)	3 (6)	3 (5)
		3	**48** (34)	**64** (106)	**51** (122)	**25** (31)	12 (9)	5 (5)	7 (15)	2 (6)
		4	15 (16)	14 (11)	7 (8)	4 (7)	1 (3)	1 (2)	0	0
		5	8 (8)	7 (6)	6 (6)	2 (4)	0 (1)	0 (1)	0	0
		7	3 (5)	2 (4)	1 (2)	1 (2)	0	0	0	0
		10	8 (15)	3 (7)	1 (4)	1 (3)	0	0	0	0
		12	1 (4)	1 (2)	1 (3)	1 (2)	0 (2)	0	0 (2)	0 (1)
		15	0	0	0	0	0	0		

[a] Values represent means (1 SD) of 15 analyses per variable per year. Boldface values are at or above the threshold for fungal growth. Inner and outer zones correspond to the inner and outer 25 mm of each increment core.

finding that wood from NaMDC-treated poles remains inhibitory to decay fungi in bioassays for 3 to 5 years after treatment (Morrell and Corden 1986). It also shows the relatively minimal fungicidal effect of this fumigant in comparison with other fumigants.

Treatment of poles with 200 or 400 g of dazomet alone produced variable MITC levels 1 year after treatment (Table 1). Protective levels were present at the groundline by the second year for the 200-g dosage, but levels further above the groundline were more variable. Doubling the dosage improved MITC levels after the first year and also produced increased MITC levels 1 m above the groundline. MITC levels in all dazomet-treated poles were above the threshold level in both the inner and outer zones at the 0.3-m sampling site between 3 and 10 years after treatment. MITC levels were sometimes above the threshold 1.3 and 2.3 m above groundline, but the results were inconsistent and suggest that the protective effect against internal fungal attack is confined to a limited zone away from the original treatment zone. MITC levels in the low-dosage dazomet-treated poles with or without copper sulfate remained at or above threshold levels 12 years after treatment. MITC levels in poles treated with the higher dazomet dosage were above the threshold 12 years after treatment in noncopper amended

Table 2.—Percentage of increment cores at selected locations above the groundline containing decay and nondecay fungi 1 to 15 years after application of dazomet with or without a supplemental copper compound.

		Isolation frequency (%)[a]					
		0.3 m		1.3 m		2.3 m	
Copper additive	Year sampled	Decay fungi	Nondecay fungi	Decay fungi	Nondecay fungi	Decay fungi	Nondecay fungi
500 mL of metam sodium	0	0	47	—	—	—	—
	2	0	10	0	13	0	10
	3	0	5	0	3	0	7
	4	0	13	0	10	0	10
	5	0	27	0	30	0	40
	7	0	40	0	20	3	27
	10	3	28	0	28	0	21
	12	0	17	0	33	0	33
	15	0	54	8	58	3	42
400 g of dazomet	0	0	14	—	—	—	—
	2	0	7	0	23	0	7
	3	0	0	0	0	0	25
	4	0	0	0	0	0	20
	5	0	27	0	13	0	27
	7	0	0	0	0	0	7
	10	0	0	0	0	0	7
	12	0	27	0	47	0	36
	15	0	0	0	0	0	0
400 g of dazomet plus copper sulfate	0	0	27	—	—	—	
	2	0	7	0	13	0	13
	3	0	20	0	7	0	7
	4	0	0	0	0	0	7
	5	0	27	11	27	0	33
	7	0	0	0	0	0	7
	10	0	7	0	0	0	7
	12	0	20	0	20	0	47
	15	0	0	7	7	0	13
200 g of dazomet	0	7	20	—	—	—	—
	2	0	27	0	33	0	27
	3	0	0	0	0	0	14
	4	0	0	0	7	7	33
	5	0	33	0	40	0	33
	7	0	7	0	0	0	27
	10	0	0	0	0	0	13
	12	0	20	0	33	0	7
	15	0	0	0	7	7	33
200 g of dazomet plus copper sulfate	0	33	0	—	—	—	—
	2	33	0	13	0	0	27
	3	0	0	0	20	0	0
	4	0	7	0	0	0	7
	5	13	13	7	40	0	27
	7	0	20	0	20	0	7
	10	0	0	0	0	0	0
	12	0	60	7	50	27	27
	15	0	0	0	0	0	0

[a] Values represent means of 15 isolation attempts per treatment and time.

poles but below the threshold when copper was present. It is unclear why copper did not enhance activity at this dosage. In general, however, the long-term release rate is a secondary benefit of the use of dazomet. While initial chemical levels were lower than those found with metam sodium, the longer release period from this treatment should produce more uniform protection against renewed fungal attack.

Sampling of poles 15 years after treatment revealed that most of the wood contained no detectable MITC, and when MITC was present, the levels were less than half of our target threshold of 20 µg. The results indicate that the treatment has lost it efficacy. Regardless of initial dosage or the use of copper additives, the results suggest that treatment cycles between 10 and 12 years would be prudent for this system. These cycles are consistent with those used by most utilities across North America (Mankowski et al. 2002).

Culturing increment cores from the poles revealed that decay fungi were periodically isolated from various locations over the course of the test, but there was no consistent increase in fungal frequency over the 15-year test. For example, decay fungi were isolated near the groundline in poles 5 years after treatment with 200 g of dazomet plus copper sulfate; however no decay fungi were isolated from this location 7 or 10 years after treatment (Table 2). The

Table 3.—Residual MITC at various distances above the groundline in Douglas-fir pole sections 1 to 12 years after treatment with dazomet with or without copper sulfate or copper naphthenate.

		Residual MITC (μg/g of wood)[a]					
		0.3 m		1.3 m		2.3 m	
Copper treatment	Year sampled	Inner	Outer	Inner	Outer	Inner	Outer
None	1	**21** (14)	18 (37)	0 (0)	0 (0)	0 (0)	3 (8)
	2	**72** (47)	**36** (33)	0 (0)	0 (0)	0 (0)	0 (0)
	3	**57** (27)	**32** (42)	0 (0)	0 (0)	0 (0)	0 (0)
	4	**50** (41)	**32** (32)	6 (5)	6 (6)	0 (0)	0 (0)
	5	**67** (31)	9 (8)	12 (4)	10 (29)	0 (0)	0 (0)
	8	**21** (26)	16 (21)	**22** (24)	17 (28)	**21** (23)	**26** (39)
	10	10 (13)	6 (12)	19 (34)	12 (21)	13 (22)	4 (6)
	12	**35** (38)	**20** (22)	4 (5)	1 (4)	2 (6)	0 (0)
20 g of copper sulfate	1	**103** (78)	**55** (86)	4 (6)	0 (0)	0 (0)	0 (0)
($CuSO_4 \cdot 5H_2O$)	2	**101** (36)	**32** (17)	7 (7)	3 (7)	0 (0)	0 (0)
	3	**78** (25)	**29** (17)	7 (7)	5 (8)	0 (0)	0 (0)
	4	**95** (61)	**40** (20)	**20** (21)	**21** (27)	**25** (35)	**23** (33)
	5	**87** (12)	**21** (6)	18 (15)	3 (6)	7 (10)	0 (0)
	8	**35** (43)	14 (20)	**26** (29)	12 (21)	**29** (36)	**24** (40)
	10	16 (24)	7 (9)	**28** (41)	5 (8)	**30** (46)	4 (6)
	12	**40** (16)	**21** (16)	13 (6)	1 (2)	4 (6)	0 (0)
20 g of copper naphthenate	1	**34** (19)	**43** (54)	0 (0)	0 (0)	2 (5)	6 (19)
(2% Cu in mineral spirits)	2	**94** (45)	**94** (64)	6 (7)	5 (11)	0 (0)	0 (0)
	3	**110** (29)	**59** (46)	7 (7)	4 (8)	0 (0)	0 (0)
	4	**89** (33)	**73** (24)	18 (9)	9 (7)	1 (2)	0 (0)
	5	**102** (18)	**41** (39)	**23** (7)	1 (2)	2 (3)	0 (0)
	8	**27** (26)	**22** (23)	**26** (35)	**20** (24)	**26** (26)	**38** (55)
	10	19 (28)	11 (13)	**24** (37)	4 (9)	**28** (43)	9 (18)
	12	**57** (17)	**29** (14)	8 (30)	2 (4)	3 (6)	0 (0)

[a] Values represent means (1 SD) of nine replicates per treatment and time. Boldface values are at or above the threshold for fungal attack. Inner and outer zones correspond to the inner and outer 25 mm of each increment core.

Table 4.—Percentage of increment cores containing decay and nondecay fungi 1 to 12 years after application of dazomet with or without a supplemental copper compound.

		Isolation frequency (%)[a]					
		0.3 m		1.3 m		2.3 m	
Copper additive	Year sampled	Decay fungi	Nondecay fungi	Decay fungi	Nondecay fungi	Decay fungi	Nondecay fungi
None	1	0	11	0	11	0	11
	2	0	0	0	33	0	33
	3	0	0	0	33	0	0
	4	0	11	0	11	0	56
	5	0	0	0	0	0	100
	8	0	0	0	11	0	56
	10	0	0	0	33	0	0
	12	0	0	11	0	0	22
20 g of Cu sulfate	1	0	11	22	33	0	44
	2	0	0	44	56	0	33
	3	0	0	11	11	0	33
	4	0	11	22	33	11	33
	5	0	0	0	67	0	89
	8	0	0	0	22	0	44
	10	0	0	11	44	0	11
	12	0	0	0	0	0	33
20 g of Cu naphthenate	1	33	33	0	22	0	44
	2	0	0	0	0	0	67
	3	0	0	0	0	0	22
	4	0	0	0	0	0	67
	5	0	0	11	11	0	78
	8	0	11	0	0	0	33
	10	0	0	0	11	0	44
	12	0	0	0	11	0	22

[a] Values represent means of nine isolation attempts per treatment and time.

inconsistent isolations suggest that the treatment remains largely protective.

Effect of copper naphthenate on dazomet performance

MITC levels tended to be greater in the inner zones, reflecting the tendency of the treatment holes to encourage chemical movement to the pole center. MITC levels in poles receiving no supplemental treatment reached the threshold level 0.3 m aboveground 1 year after treatment (Table 3). MITC levels increased slightly over the next 4 years in these poles but appear to have stabilized at levels well above the threshold by 4 years after treatment. MITC levels in these poles declined to just at or below the threshold after 8 years and below that level after 10 years. Levels were again above the threshold 12 years after treatment, but only 0.3 m above groundline. Chemical levels at locations above this height were extremely low, suggesting that the treatment effect was confined to a relatively narrow zone around the application point (Table 3).

MITC levels 0.3 m above the groundline 1 year after treatment were two to five times higher when copper sulfate was added to the dazomet, and these levels continued to remain elevated over the next 4 years. MITC was also detectable 1.3 and 2.3 m above groundline 4 years after treatment at levels above the threshold. Chemical levels remained elevated 5 years after treatment but then declined to levels just above the threshold 8 years after chemical application. Threshold levels were only present at four sampling locations 10 years after treatment. These results clearly support the application of copper sulfate at the time of dazomet treatment to increase the initial release rate. Results at 12 years indicated that threshold levels were only present 0.3 m above groundline, while MITC was either barely detectable or not detectable at higher locations. These results indicate that any protective effect of dazomet had been lost except at the application point and that retreatment would be advisable.

MITC levels in pole sections 1 year after receiving dazomet with copper naphthenate appeared to experience less of an initial boost in release rate than poles receiving copper sulfate; however, chemical levels rose sharply 2 years after treatment and have remained elevated and similar to those for the copper sulfate treatment since that time. MITC was also detectable 1.3 and 2.3 m above groundline but was only just approaching the threshold 1.3 above groundline in the inner assay zone. These results indicate that copper naphthenate enhanced dazomet decomposition to MITC, but the levels were slightly lower than those found for copper sulfate. Despite the lower levels, copper naphthenate does appear to be useful for encouraging MITC production to more rapidly eliminate any decay fungi established in the wood. As with copper sulfate, MITC levels have declined 12 years after treatment but were similar to those found with the copper sulfate and noncopper amended controls.

Isolation of decay fungi from the inner zones of the poles 1 year after treatment were limited except from poles treated with dazomet amended with copper compounds. Fungi continue to be isolated from the aboveground zones of the poles, but the isolations were sporadic and suggest that isolated fungal colonies were present in the aboveground zones of the poles (Table 4). We suspect that the fungi present after 1 year were probably present at the time of treatment. The relatively low levels of chemical 1.3 and 2.3 m above groundline likely limited the potential for control in these zones. Decay fungi were isolated at various locations along the poles at 1.3 m and above the groundline, but there was no consistent pattern. In addition, no decay fungi were isolated from any cores 12 years after treatment (Table 4). These results suggest that treatment patterns and the zone of protection are more limited with these controlled release formulations than they are with liquid formulations that are applied at much higher dosages. As a result, some adaptation of treatment patterns may be necessary where decay control is desired above the groundline; however, one advantage of these treatments over liquids is the ability to more safely apply the chemical above the groundline.

Conclusions

Dazomet was capable of decomposing to MITC at levels capable of protecting Douglas-fir poles from internal decay for 10 to 12 years. The addition of copper sulfate or copper naphthenate at the time of dazomet application generally increased MITC levels in the wood, although there were some inconsistencies. The two field trials indicate that dazomet treatment results in protective levels of MITC that are consistent with the 10- to 12-year retreatment cycles currently used for internal remedial treatments.

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