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Effect of an Antioxidant on the Efficiacy of Organic Wood Preservatives in an Accelerated Soil Contact Decay Test

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ABSTRACT

In comparison to inorganic wood preservatives, organic biocides in transient carriers are considerably less effective when the treated wood is exposed to soil contact. Various oils are used in some formulations with pentachlorophenol to improve the efficacy. However, use of these oils imparts unacceptable properties to products used in residential applications. Consequently, there is a need to develop additives other than heavy oils that improve the performance of organic biocides as wood preservatives. In this study the possibility of using the benign antioxidant BHT as a non-biocidal additive to improve the performance of wood treated with isothiazolone and azoles was investigated. The treated wood with and without BHT was exposed to unsterile soil and monitored for decay by dynamic MOE. It was found that the efficacy of both preservative systems was enhanced when BHT was added to the formulations. The use of Dynamic MOE to evaluate the progression of wood decay appears to be far superior to visual ratings.

Keywords: wood decay, wood preservatives, propiconazole, tebuconazole, isothiazolone, BHT, antioxidant, dynamic MOE

1. INTRODUCTION

Previous studies have shown that free radicals play a major role in the overall wood biodeterioration process (Goodell, 2003; Goodell et al. 2008). Consequently, it is logical to assume that the addition of antioxidants to organic wood preservative systems may enhance their performance. Indeed, previous soil block decay tests showed that antioxidants had a positive synergistic effect on the efficacy of some biocides (Schultz and Nicholas, 2000 and 2002). Nevertheless, additional research is needed to determine whether the addition of antioxidants to wood preservative systems is justifiable. Consequently, this study was initiated to determine if the addition of the antioxidant BHT would enhance the activity of organic biocide treated wood exposed to soil contact.

2. EXPERIMENTAL METHODS

2.1 Test Method

An accelerated laboratory unsterile soil contact decay test was used for this study. The test was carried out in accordance with the AWPA Standard E23 test method (AWPA 2010) with the exception that larger test specimens were used so that they could be evaluated by dynamic MOE. MOE measurements were made with a Grindo Sonic M.K 4.1 instrument (Limmens-Elektronika, NV Belgium). Prior to the MOE measurements, the stakes were saturated with deionized water. After measurement, the stakes were sealed in plastic bags to prevent drying before making two subsequent determinations after 24 hour intervals. Then all three MOE values were averaged to obtain the initial value.

2.2 Test Stakes

The stakes, 14 mm x 14 mm x 150 mm longitidual, were cut from two defect free, kiln dried southern pine (*Pinus* spp.) sapwood boards. Ten replicate stakes, five from each board, were used for each of the treatments.

2.3 Preservative Formulations

Two organic biocide classes, with and without the antioxidant butylated hydroxytoluene (BHT), were used in this study. The biocide used in the formulations were 4,5-Dichloro-2-octyl-isothiazolone (DCOI) and a combination of Propiconazole and Tebuconazole (Prop/Teb). The specific formulations used on the basis of active ingredients were:

- DCOI (0.23%)
- DCOI (0.23%) + BHT (2%)
- Prop/Teb (0.23%)
- Prop/Teb (0.23%) + BHT (2%)

Toluene was used as a solvent for all of the treatments. Following a full-cell treatment all of the stakes were allowed to air dry to remove excess toluene before further processing.

2.4 Decay Test Procedures

The soil was obtained from two forested sites, one near the MS Gulf Coast at Saucier MS and the other near upper central MS at Starkville MS, by first removing the upper duff layer and then taking soil from the upper two inch layer. The soils were then sifted to remove debris and a 1 to 1 blend of the Starkville:Saucier soils was used for this study.

The decay test was carried out in square plastic cups measuring 105 mm wide by 80 mm deep which had two fourteen mm square holes cut 30 mm below the top on two opposite sides. The test sticks were then inserted into these holes prior to filling the cups with soil. Deionized water was then added to each cup to achieve a soil moisture content of 103% of its free draining water holding capacity. The cups were weighed periodically and additional water was added to each cup to make up for loss due to evaporation. Following this the sticks were removed approximately every 3 months, cleaned of residual soil, soaked in deionized water over night, equilibrated in plastic bags for 24 hours and then subjected to dynamic MOE measurements. Following this the sticks were re-installed in the decay cups for additional exposure.

3. RESULTS AND DISCUSSION

From the data in Table 1 it is apparent that the unsterile soil used in this study was quite active, with decay being detected in the untreated control samples after only three months exposure. Following this, decay progressed at a rapid rate.

In comparing the two preservatives used in this study at comparable retention levels, DCOI appears to be more effective against wood decay fungi than Prop/Teb. This is illustrated by the fact that the onset of decay in the test samples was more rapid in the Prop/Teb treated samples, occurring after only approximately 15 months exposure. In comparison, at comparable retention levels decay was not detected in the DCOI treated samples until approximately 18 months exposure (Table 1). The addition of BHT to the formulations did not have any significant effect on the initiation of decay for the Prop/Teb and DCOI treated sticks, but did reduce the severity. However, the effect of BHT was greater with DCOI than Prop/Teb, where BHT co-addition reduced decay with DCOI and Prop/Teb by about 50% versus only 20%, respectively.

Table 1. Percent decrease in MOE_{dyn} of DCOI and Prop/Teb treated sticks with and without added BHT after exposure to unsterile soil.

Treatment	Retn. (pcf)[1]	Percent Decrease in MOE_{dyn} After Soil Exposure for (Months)											
		3	6	9	11	15	18	23	26	30	33	38	40
DCOI	0.063	-2	-3.4	1.8	-2.1	-0.5	5.4	13	24	35	41	47	51
DCOI + BHT	0.066 + 0.58	-3	-4.1	3.4	-3.7	-3.0	1.6	5.3	9.4	18	21	24	28
Prop/Teb	0.058	-1	-4.3	1.8	-0.7	8.6	13	26	41	51	56	61	63
Prop/Teb+ BHT	0.059 + 0.51	0	-1.9	0.4	-3.2	3.9	8.1	16	27	38	41	47	48
Untreated	0	5	15	32	49	68	80	87	90	92	95	----	----

[1]Retentions were calculated using treatment solution pick up and active ingredient.

In comparing the data in Figures 1 and 2, it is apparent that the rates of decay for samples treated with DCOI are somewhat lower than those for the Prop/Teb treated samples. Furthermore, the rates of decay were reduced for both preservatives when BHT was added. Hence, this difference along with the reduced decay levels at all exposure times clearly shows that the addition of BHT enhances the ground-contact performance of both of these organic biocide formulations.

Since visual decay ratings are the predominant method for evaluating wood decay in various test methods, it is of interest to compare this with the MOE_{dyn} method used in this study. Accordingly, visual decay ratings were made for the test samples in this study after 40 months exposure. The rating system used is in accordance with AWPA Standard E23 (AWPA 2010) for accelerated soil contact decay tests. The scheme used in this standard is as follows:

Rating	Description
10	Sound
9.5	Suspicion of decay
9	Trace/slight attack
8	Moderate attack
7	Moderate/severe attack
6	Severe attack
4	Very severe attack
0	Failure

On the basis of the comparative data in Table 2, the relationship between these two ratings system is not very good. For example, for the DCOI/BHT treatment the average visual rating is very high at 9.2, whereas the corresponding percent MOE_{dyn} loss is 28%. These samples undoubtedly have significant amounts of decay which is not reflected in the visual rating. Another example is the Prop/Teb data where the average visual rating is 8.1 for both sets of stakes, whereas the mean MOE losses are 63% and 48% for this treatment with and without BHT, respectively.

Table 2. Comparison Between Visual Decay Ratings and Decay Ratings Based on Dynamic MOE After 40 Months of Exposure.

Treatment	Retention (pcf)	Avg. Visual Rating	Avg. MOE Decrease (%)
DCOI	0.063	8.3	51
DCOI + BHT	0.063 + 0.58	9.2	28
Prop/Teb	0.59	8.1	63
Prop/Teb+ BHT	0.59 + 0.51	8.1	48
Untreated	NA	6.2	94

From the data in Table 1 it is apparent that all samples except the controls show slightly negative MOE_{dyn} values in the initial exposure periods of this study. This reflects the inherent variability in the MOE_{dyn} which was discussed in detail in a previous paper (Nicholas, et. al., 2009). Nevertheless, from Figures 1 and 2 it is apparent that the percent loss in MOE_{dyn} increases fairly consistently with additional exposure time once the decay process is initiated. This consistency provides further validation that dynamic MOE is a viable method for monitoring the progression of decay.

Figure 1. Percent decrease in dynamic MOE of DCOI treated wood sticks with and without BHT after exposure in unsterile soil.

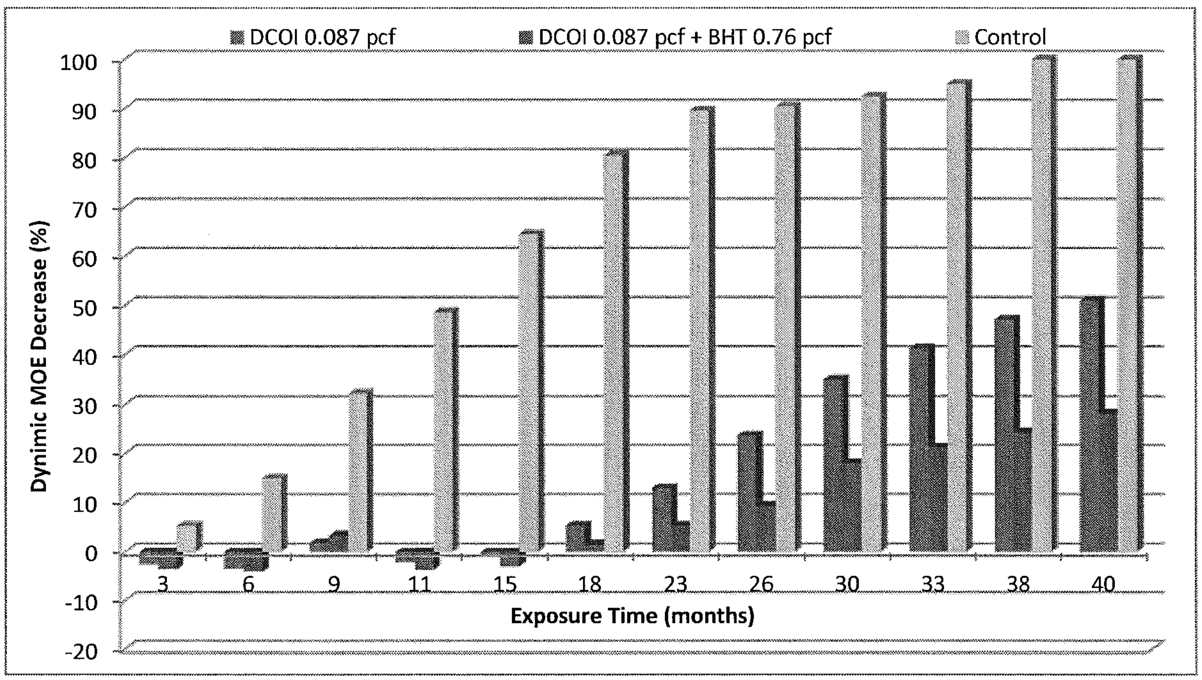
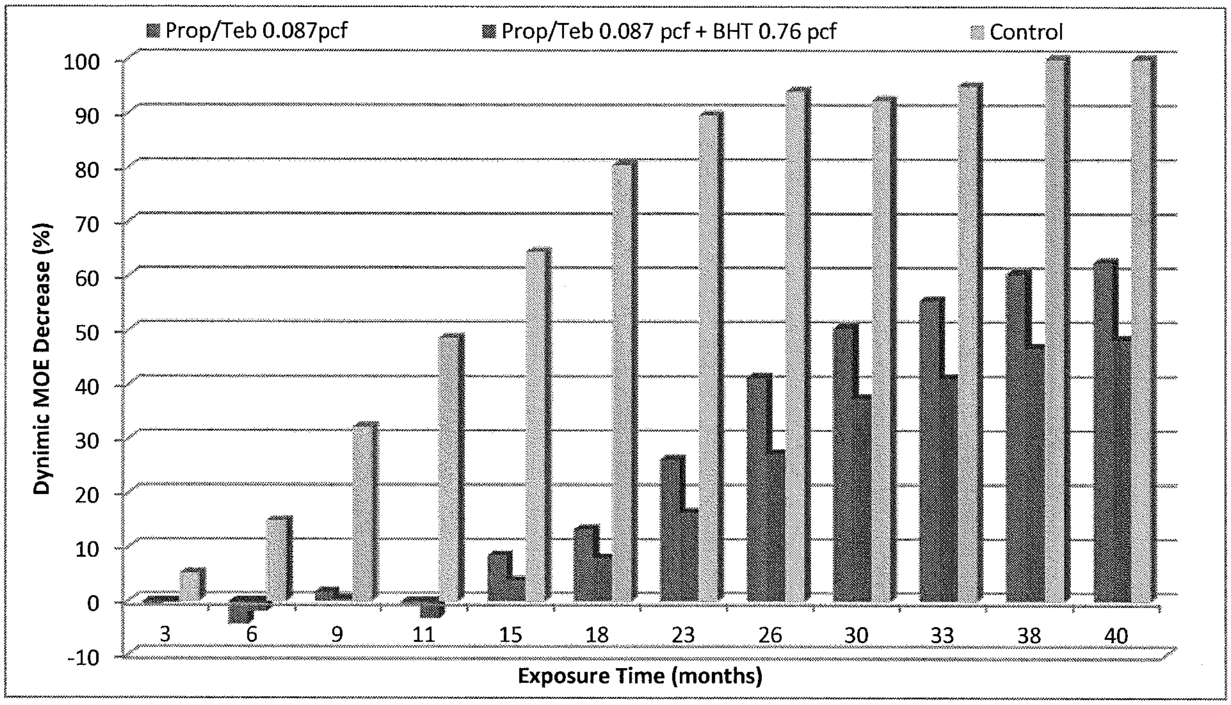


Figure 2. Percent decrease in dynamic MOE of Propiconazole/Tebuconazole treated sticks with and without co-added BHT after exposure in unsterile soil.



4. CONCLUSIONS

This study showed that the addition of BHT to DCOI and Prop/Teb preservative formulations enhanced the efficacy of treated wood exposed to unsterile soil. At comparable biocide retention levels, the performance of DCOI was superior to that of the Prop/Teb formulation. Use of dynamic MOE as a method to follow the progression of wood decay appears to be superior to the visual rating evaluation system.

5. ACKNOWLEDGEMENTS

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