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Accidental mold/termite testing of high density fiberboard (HDF) treated with borates and N'N-naphthaloylhydroxylamine (NHA)

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Accidental mold/termite testing of high density fiberboard (HDF) treated with boric acid, borax and N'-N-naphthoylhydroxylamine (NHA)

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High density fibreboard (HDF) was made from beech and pine furnish (50:50) and treated with boric acid (0.1-3%), borax (0.1-3%) or N'-N-(1,8-naphthalyl)hydroxylamine (NHA) (0.1-1%) prior to gluing with urea formaldehyde (UF) resin in order to determine resistance to Eastern subterranean termites (*Reticulitermes flavipes* Kollar), the most economically important termite species in North America. HDF and southern yellow pine (SYP) sapwood specimens were tested in a modified no-choice soil-block test normally used for fungal decay tests for 5 weeks. Within the first week of incubation, all HDF specimens were heavily overgrown with a variety of mold fungi. This same contamination was not seen in regular SYP specimens tested under the same conditions. Mold contamination did not appear to inhibit termite attack in any measurable way. Weight loss in control HDF specimens was 28% after 5 weeks while weight loss in control SYP was 12% under similar test conditions. Selected treatments with boric acid, borax, didecyl dimethyl ammonium chloride (DDAC) and NHA reduced termite attack in HDF and SYP specimens below 5% weight loss. Synergy was not observed for boron containing compounds and NHA. We conclude that i) soil contact accelerates HDF mold contamination and termite damage in the absence of termidicides ii) HDF made with UF is more susceptible to moisture acquisition and mold contamination than SYP iii) NHA does not act as a mildewcide iv) 3% borates retard both mold and termite damage; and v) HDF is less durable, and requires more preservative to protect, than SYP.

Keywords: HDF, termite damage, preservative treatment, borate, DOT, termite-fungus interaction

Introduction

High density fiberboard (HDF) is a wood-based panel that is composed of wood fibers bonded together with UF or PU resins under heat and pressure. HDF panels are highly recommended for use in the manufacture of heavy duty flooring. Its application can be extended to institutional furniture, doors for kitchen and bedroom units, staircases, industrial shelving, moldings, exhibition stands and displays, classroom and play area furniture, laboratory and workshop fittings, hotel restaurant and bar furniture, office furniture, components for the transportation industry requiring rigid and harsh conditions in actual service life. High density means superior screw and fastener holding and better installation of every type of cabinet hardware. The machined core surface is ideal for finishes, paints, foils, lacquers, etc., saving materials, time and labor. The superior stability and strength lends itself to manufacturing special shapes where impact, load and durability are concerns. The range of size and thickness, ease of availability and versatility of the product itself are a specifier's dream.

It is generally conjectured that wood-based fiberboards show a greater resistance to decay and termite damage than solid wood, although these products are still susceptible to biological attack (Curling and Murphy, 1999; Kartal and Green 2003). Chung et al. (1999) showed that wood-based composite boards were as susceptible to microorganisms as solid wood. Tsunoda et al. (2002) showed that treatment of MDF with zinc borate dramatically reduced weight losses from decay fungi and termite damage. However, at least in the United States, the threat of mold contamination now exceeds that of decay and termite damage in terms of incidence of problems, insurance claims and health issues. Addition of zinc borate and DOT during the manufacture of wood composites has been shown to be promising in prevention of termite damage (Grace 1997, Manning et al 1907 and Tsunoda 2002). Zinc borate has been shown to give better performance against mold than DOT (Fogel and Lloyd 2002) In this no-choice laboratory study, designed to test the resistance of treated and untreated HDF to termite damage by *Reticulitermes flavipes,* we observed immediate and severe molding of the HDF specimens within 7 days of the beginning of the soil-block tests. Although the overgrowth of mold did not appear to interfere with the termites ultimate ability to consume the HDF, it did serve to dramatically illustrate how vulnerable the new composites are to mold contamination.

Materials and Methods

High density fiberboard (HDF) panels (500 X 500 X 10mm)were manufactured in a commercial plant in Gebze, Turkey using beech and pine furnish (50:50). Borax (DOT) or boric acid (Merck KgaA, Darmstadt, Germany), N'N-hydroxlyamine sodium salt (NHA) (Aldrich Chemical, Milwaukee Wi CAS #6207-89-02) or borax + NHA was added to the blender at target contents of 3, 1, 0.5, 0.1 percent boric acid equivalent (BAE) as shown in Table 1. Fibers were blended with UF resin (55% content) using a ratio of 10% based on oven dry furnish, and NH_4Cl hardener (30%) using 1% ratio to furnish weight, and pressed at 110C for 7 minutes w/o wax. Southern yellow pine (SYP) solid wood specimens were selected from sapwood as controls.

HDF specimens (50 x 28 x 4.5mm^3) were obtained by cutting thicker boards in half and subjected to termite bioassays according to a no-choice test procedure modified into soil-block standard test methods for decay fungi (ASTM 1996). Solid SYP specimens were included for comparison. Five specimens (n = 5) for each HDF and solid group were tested. One gram of termites was added to each soil bottle 2-3 days before test specimens were added. The bottles were maintained at 26C and 80% humidity for 5 weeks. At the end of the bioassay, HDF and SYP specimens were removed from the containers, cleaned, oven-dried and reweighed to determined weight loss. Termite survival rates were recorded during and after the test period. Molds were isolated and identified microscopically to genus.

Results and Discussion

The first observation considered in this HDF study was the rapid mold growth on the MDF test specimens within the first week of insertion in the soil-block tests. Two species of *Aspergillus* (one brown and one black) and one *Paecillomyces* sp (green) were keyed microspcopically. Only the high concentrations of borax (3%) and boric acid (3%) noticeably retarded mold growth. We conclude that the soil contact of the HDF samples and wicking of soil moisture resulted in the mold growth. Termites were temporarily deterred from attacking the HDF blocks, but only for the first week after which they ignored the mold. Research on termite/fungus/wood interactions are still of interest and has centered around the attraction of wood decayed by *G. trabeum* (Lenz et al 1991). UF-bonded wood composites are not water resistant, so water-absorbing capacity and thickness swelling increases can be expected in untreated HDF (Meyers et al 1984). Moisture content is probably the most important factor in determining the rate and extent of mold infestation.

Mean percentage mass loss (wood consumption) caused by *R. flavipe,s*, mean mortality and mean visual attack rating, are given in Table 1. Untreated HDF showed 27% mass loss, close to that observed for untreated MDF (25%)in a similar study with R. flavipes (Kartal and Green 2003). Wood consumption is an important parameter for assessment of preservative treatment. A protection/toxic threshold of <5% mean mass loss has been used to define the protection threshold by certain authors (Peters and Fizgerald; Brenton and Fitzgerald). Under this criterion, only borax (3%), boric acid (1.0 and 3%) were successful in protecting test specimens from termite attack. However, high visual ratings (9-10) and rapid termite mortality for borax and boric acid at the 1% and 0.5% level suggest that these were also successfully protective. The SYP test specimens were all protected at below 5% mass loss level at 0.1%. Maudin and Kard (1996) showed that 0.30% BAE will protect pine from significant damage by *Reticulitermes* sp. for 16-18 months in nonleaching conditions and >0.54% BAE will probably be needed to protect wood in buildings from *C. formasanus.*

No synergistic effect was observed when borax was combined with Na-NHA with either MDF or SYP. In a recent publication Green and Schultz (2003) showed that when H-NHA was combined with three commercial biocides (DDAC, IPBC, and propiconizole) and tested by soil-block and agar-block tests against white and brown-rot fungi, synergism was only observed with one of the three: IPBC. If Na-NHA was acting

Table 1. Termite resistance of high density fiberboards and SYP treated with **borates and N'N-napthaloylhydroxylamine. (n = 5)**

Compound	**% target retention[a]**		**Mean Mass Loss (%)**	**Mortality% (days)**	**Visual Attack[b]**
HDF:					
Control			**27.5(7.1)**	**42.5 (35)**	**4.6**
Borax	**3%**	**24kg/m^3**	**1.0(0.01)**	**100 (15.4)**	**10.0**
Borax	1%	8 kg/m	9.7 (7.95)	100 (18.6)	10.0
Borax	0.5%	4 kg/m^3	7.7 (0.87)	100 (23.2)	9.0
Borax	0.1%	2 kgm3	12.4(0.97)	75.6 (35)	4.0
Boric Acid	**3%**	**24kgm^3**	**0.95(0.04)**	**100% (15.6)**	**9.6**
Boric acid	1%	8 kgm^3	4.6 (1.59)	100% (18.4)	9.6
Boric acid	0.5%	4 kgm^3	6.4 (1.71)	100% (20.2)	10.0
Boric acid	0.1%	2 mgkg^3	18.6(0.97	65.8% (35)	5.6
Na-NHA	**1%**	**8 kg/m^3**	**7.6 (0.61)**	**84.7 (35)**	**9.0**
Na-NHA	0.5%	4 kgm^3	10.4(2.29	80.9 (35)	8.6
Na-NHA	0.1%	0.8 kgm^3	18.5(1.18)	44.1 (35)	4.0
NHA+B	0.1%+0.1%		19.8(3.34)	53.5% (35)	5.2
SYP:					
Control			**11.5 (3.24)**	**100% (28)**	**2.6**
NHA	0.1%		3.0 (0.89)	100% (28)	9.0
DOT	0.1%		2.9 (0.52)	40% (28)	9.0
NHA+DOT	0.1+0.1%		2.9 (0.31)	80% (28)	9.0
DDAC	0.1%		3.0 ((0.6)	60% (28)	7.0
DDAC+NHA	0.1%+0.1%		3.0 (0.13)	60% (28)	9.0

[a] based upon BAE for borax and boric acid
[b] 10=sound;7=moderate; 4=heavy.

as a non-biocidal component (ie antioxidant/chelator), such as chelating calcium, then we would expect synergism to be the same with all three biocides. Since this was not observed, this also supports the hypothsis that H-NHA is protecting wood by simply acting fungicidally as a polyaromatic hydrocarbon. This may hold true for termidicidal activity as well. Although NHA had previously been shown to be a non-repellant, slow-acting termidicide (Green et al 1996; 2001)-no anti-mold activity was detected.

N'N-naphthaloylhydroxylamine (NHA) is a water-soluble calcium-precipitating agent shown to protect SYP from wood decay and termite damage in laboratory and field testing (Green et al 1997; Crawford and Green 2002, Green et al 2001,2003). Because NHA contains no heavy metals, and has low mammalian toxicity arid low leachability, we wanted to determine if it was suitable for protecting HDF composites alone or in combination with borates. NHA, and related compounds have recently been patent-protected as environmentally friendly termite baits (Rojas et al. 2002). In similar study of MDF treated with Na-NHA and/or borax, weight loss was reduced from over 20% in untreated controls to below 5% for Na-NHA (1.0% and 0.5%); borax (3.0%, 1.0% and 0.5%) and borax plus NHA (0.1 + 0.1%) against *C. formosanus* (Akbulut et al; unpublished results). We have no precise explanation why the *R. flavipes* caused higher mass loss in the present setup, but it could be related to the test conditions of soil-block contact and moisture wicking leading to ideal conditions for mold contamination and termite damage. It is common knowledge that termites are moisture loving and moisture seeking, so luxurious mold growth likely encourages proximate termite feeding and damage.

Although we did not attempt to leach test any of NHA or NHA-boron treatments, we have previously shown that sequential treatment of boron plus NHA retards approximately **30%** of the boron from leaching in solid wood(Kartal and Green 2002). This retention of boron holds promise for leach retention strategies in composites.

We draw the following conclusions from this study; I) HDF boards prepared with UF resins are not inherently resistant to either termite damage or mold contamination.; ii) under high moisture conditions severe mold contamination preceeds mass loss in the absence of termidicides; iii) borax and boric acid treatments above 3% retard against both mold and termite damage and iv) borax, boric acid, and NHA treatments greater than 1% protect against termite damage in a no-choice laboratory test; iv) HDF is not more resistant to mold and termite damage than is SYP: and v) confirmation that NHA is not effective as a mold inhibitor.

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