TECHNICAL NOTE: THE SUSCEPTIBILITY OF CHEMICALLY TREATED SOUTHERN HARDWOODS TO SUBTERRANEAN TERMITE ATTACK

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Abstract. Ongoing research into chemically treating southern hardwoods for producing structural composite lumber suggests that some improvements may be imparted by modifying the wood. How chemical treatment(s) affect modified wood durability, particularly resistance to *Reticulitermes flavipes*, was the objective of this study. Water-saturated samples of yellow-poplar, sweetgum, and red oak were heated at 150°C for 30 min in two solutions: water and 1.0% NaOH; controls were also included. Samples were subjected to the AWPA E1-09 no-choice termite test in which mass loss from *R. flavipes* was determined. The species and treatments independently and significantly affected the mass loss. Yellow-poplar, which had the lowest specific gravity, averaged significantly greater mass loss than sweetgum and red oak for all three exposures. All species treated in water or NaOH showed a higher degree of termite degradation as compared with the controls.

Biological durability is a growing issue in wood composites as the industry continues to gain market share and species use diversifies. Durability is a particular issue in the southern US because termites alone inflict extensive economic losses. Hardwoods such as yellow-poplar (*Liriodendron tulipifera* L.), sweetgum (*Liquidambar styraciflua* L.), and red oak (*Quercus* spp.) are currently used on a limited basis in wood composites even though they are present in high volumes across the South. One reason is that soluble compounds in various hardwoods such as oak interfere with adhesion during resin blending and pressing (Beech 1975). However, some of these problems can be solved by chemical treatment. A hydrothermal treatment was shown to improve the wettability of red maple for oriented strandboard by removing extractives along with some hemicelluloses and lignin (Mills et al 2009; Paredes et al 2009). In addition, fungal durability of the composite can be maintained or improved (Howell et al 2009). The overall objective of this research is to improve the properties of three underutilized southern hardwoods for manufacturing structural composite lumber. The specific objective of this note was to understand how hydrolysis in pressurized high-temperature conditions would affect the wood susceptibility to termite degradation by the eastern subterranean termite, *Reticulitermes flavipes* Kollar.

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EXPERIMENTAL PROCEDURE

Yellow-poplar, sweetgum, and red oak specimens that had been machined from green lumber to 3 × 15 × 150 mm (T × R × L) were retrieved from storage at 2°C and then water-saturated. Each sample was treated in a 2-L reactor (Parr 4843) at 150°C for 30 min with either water or 1.0% NaOH. Untreated controls were also included. Treatments were done with 5 replications over 5 da for blocking of each species (3) and treatment (3) combination (n = 45). Treated samples were placed in a convection oven at 103 ± 2°C to obtain oven-dry weight. They were then placed in a dehumidification kiln at 21 ± 2°C and 41% RH until constant weight was achieved at this equilibrium moisture content (EMC) environment. Specific gravity (SG) of each specimen was determined by measuring the dimensions (oven-dry weight/EMC volume basis).

The guidelines for the no-choice test procedure described in AWPA Standard E1-09 were followed (AWPA 2009). One 60-mm section was cut from each miniature beam. The initial weights were recorded, and samples were subsequently situated with 2 corners along one side in test jars (80 × 100 mm) with 150 g of sand and 25 mL of deionized water. Four hundred termites of *R. flavipes* were placed along the other side as per AWPA E1. The test jars were placed in a conditioning chamber at 26 ± 2°C and 55% RH for 28 da for optimal termite feeding.

After exposure, the samples were removed from the jars and brushed clean. They were dried at 21 ± 2°C and 41% RH. The samples were reweighed and mass loss was determined. Results were analyzed using analysis of variance and linear regression with a 0.05 level of significance. Multiple comparisons were made using Fisher's protected least significant difference in SAS 9.1.3 (SAS 2003).

RESULTS AND DISCUSSION

Each factor independently and significantly affected the mean mass loss from termite feeding (Table 1) with species being the more significant of the two (species, $p < 0.0001$; treatment, $p = 0.0004$). Yellow-poplar averaged significantly more termite deterioration across the three treatments than the other two species (yellow-poplar: 84.5%, sweetgum: 60.8%, red oak: 51.7%). Termites tend to show a preference to wood with a lower SG, eg the earlywood of southern pine before the latewood as illustrated in the AWPA E1 standard (AWPA 2009). Although the hydrolysis-treated samples were not statistically different among individual species, they did have significantly higher mean mass losses from termite feeding than the controls (water: 73%, NaOH: 71%, control: 53%).

Hydrolyzing wood in water and NaOH solubilizes both nonstructural and structural components (Rowell 1984). Wood extractives, particularly phenolics containing antioxidants, possess termite toxicity and/or repellant properties (Little et al 2010). Therefore, removing extractives through hydrolysis may lower termite resistance. Another factor is that treating in water at 150°C would release some of the acetyl groups, increasing the water acidity to cause some autohydrolysis of cellulose to lower its degree of polymerization (DP) (Connor 1984). Furthermore, heating cellulose in basic water solutions is known to lower the DP through peeling reactions and random scission (Sjöström 1993). It has been shown that decreasing cellulose DP causes greater termite degradation (Katsumata et al 2007). Thus, the greater termite deterioration for the chemically treated wood samples might be because of reduction of cellulose DP.

Table 1. Average specific gravity at 21 ± 2°C and 41% RH, and mass loss (standard deviation), when exposed to *R. flavipes*.

Species	Treatment	Specific gravity	Mass loss (%)
Yellow-poplar	Water	0.37	95.1 (6.7)
	NaOH	0.43	91.0 (7.0)
	Control	0.38	67.5 (36.3)
Sweetgum	Water	0.62	64.6 (4.0)
	NaOH	0.65	62.7 (5.7)
	Control	0.61	55.2 (3.0)
Red oak	Water	0.73	59.2 (6.4)
	NaOH	0.75	59.0 (5.3)
	Control	0.64	36.9 (6.0)

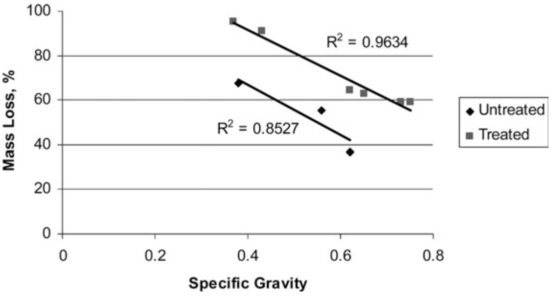

Figure 1. Plot of mass loss vs specific gravity at 21 ± 2°C and 41% RH for the treated and untreated means. R^2 for each regression line is also displayed. Treated samples include both water and NaOH as they were not significantly different at $\alpha = 0.05$.

It was generally observed using leftover portions of the samples that those subjected to the treatments became more friable when tested with a razor blade than the controls. Hydrolysis with NaOH especially degrades the structural components of wood (Wangaard 1966). It is therefore possible that degradation caused the wood to be more friable, increasing its susceptibility to subterranean termites. Behr et al (1972) conducted tests using several southern hardwoods, including yellow-poplar, and found that *R. flavipes* feeding was inversely proportional to wood hardness. The same effect was observed here, in which mass loss and specific gravity were significantly and negatively correlated for both the treated (water and NaOH) and untreated samples (Fig 1). As SG increased (ie the species effect), mass loss decreased for the samples.

CONCLUSIONS

Treating southern hardwoods at 150°C in water or 1.0% NaOH significantly increased their susceptibility to termite deterioration. This may, in part, be caused by the removal of soluble components along with the increased friability of the modified wood material. Termite feeding was also highly related to the wood-specific gravity. Using a choice test of beams made from treated and untreated southern hardwood flakes at different target densities to compare with southern pine structural composite lumber may provide a better understanding of the roles that specific gravity and chemical treatment play on termite deterrence.

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