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Section 4 **Processes and Properties**

Bending Properties of Southern Pine Treated with Micronized Preservative Systems

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ABSTRACT

This study indicates that treatment of southern pine with micronized copper systems have no deleterious effect on the residual strength property values. No statistical differences between wood treated with micronized systems and water-treated controls were noted when means were compared using either Tukey's test or S-N-K mean comparison tests. Using the more discriminating Least Squares analysis with specific gravity as a covariate, a few significant differences were found.

Keywords: southern pine, bending, micronized, copper, tebuconazole

INTRODUCTION

Over the past three decades, environmental regulations, public perception, changes in the market place, and other factors have contributed to the extensive search for new wood preservative systems with lower mammalian toxicity. It is a requirement that new systems do not harm metal or wood. As part of a comprehensive program, the Forest Products Department at Mississippi State University and others have been evaluating new preservative systems and treatments for wood, including their effect on wood properties (Barnes 1985a, b, 1992, 1993, Barnes & Murphy 1995, Evans 2003, Freeman *et al*. 2003, Freeman *et al.* 2006, Goodell *et al*. 2003, Schultz *et al.* 2007).

Post-treatment conditioning cycles have varying effects on the resultant strength of wood depending on species, treatment, and type of conditioning. Losses in modulus of rupture from 8-33% have been reported depending on the steaming time, temperature, and preservative retention (Barnes 1985a; Winandy & Barnes 1991).

Treatment with new generation preservative systems has shown only negligible effects on mechanical properties (Barnes *et al.* 1993, Barnes *et al*. 2005, Barnes and Winandy 1986). This paper summarizes our experience with the bending properties of wood treated with new micronized preservative systems.

EXPERIMENTAL METHODS

Materials

Preservative solutions are described in Table 1. Treating solutions were prepared by water dilution. All sapwood, defect-free southern pine (*Pinus* spp.) samples were cut from commercial kiln-dried dimension stock into test samples. Samples were assigned to treatment groups such that each group

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would have one sample from each board from which samples were taken. Sample cross sections are shown in Fig. 1.

Table 1. Preservative formulations and retentions.

Preservative Designation	Retention [kg/m^3 total ai]	Composition
CQ	6.40	Micronized copper carbonate + Carboquat (25.6% Copper oxide + 12.8% quaternary amine)
CA1	3.36	Micronized copper carbonate + tebuconazole solubilized in a solvent (20% Copper + 0.8117% tebuconazole)
CA2	3.36	Micronized copper carbonate + micronized tebuconazole (20.0% Copper + 0.8117% tebuconazole)
CONTROLS	0.0	Water-treated only

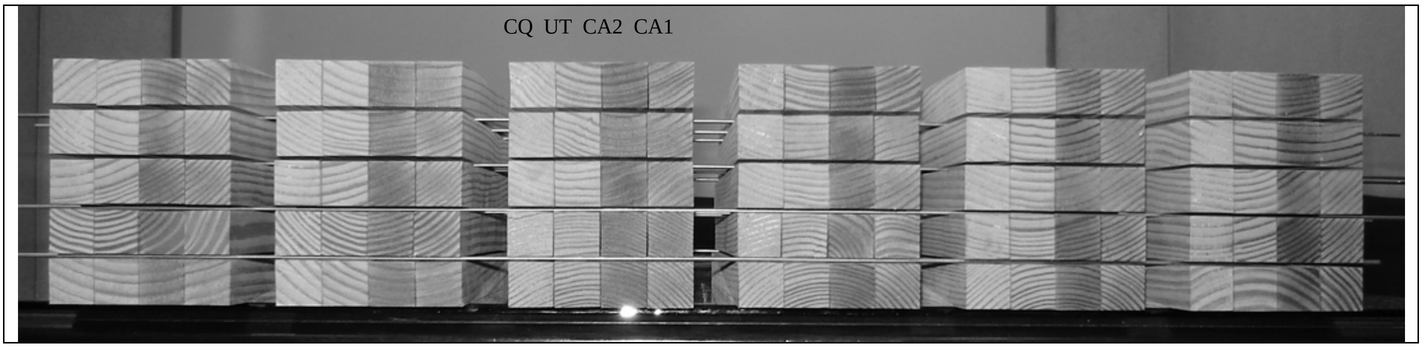

Figure 1. Treated samples (from left to right in each vertical group: CQ, untreated, CA2, CA1)

Treatment

The stakes were treated with a full cell process: 1**.** Initial vacuum at 3 kPa absolute-hold for 30 minutes; 2. slowly release vacuum, ~ 5 min; **3.** Pressurize to 1034 kPa gauge for 1 hour; 4. slowly release pressure, ~5 min. Samples were weighed before treatment and after the wiping of excess solution following treatment in order to determine preservative retention by weight gain. Samples were allowed to equilibrate at 24º C in a constant relative humidity room before testing.

Testing

Samples were tested in static bending with center-point loading according to D143 (ASTM International 2004). A typical test set-up is shown in Fig. 2. Thirty samples per treatment group were tested. Specimen size was nominal 25-mm x 25-mm x 406-mm long with a 356-mm span. A machine speed of 2.5 mm/min was employed. Modulus of elasticity (E_f), modulus of rupture (S_R), work-to-maximum load (W_m), work-to-proportional limit (elastic resilience, W_k), and fiber stress at proportional limit (S_f) were calculated. Specific gravity and moisture content at the time of testing were determined from small blocks taken adjacent to the failure area. Specific gravity values were corrected for the addition of preservative.

Data analysis—The data for each study were analyzed using covariate analysis. Mean comparisons using Tukey's and S-N-K mean comparison tests (p=0.05) showed very few differences. In order to be more discriminating, a least square (LS) mean separation technique (SAS Institute 2001) was employed. Specific gravity and moisture content were tested as covariates. In the LS technique, pre-planned comparisons are made. In this paper, the comparison of controls *vs*. other treatments was made.

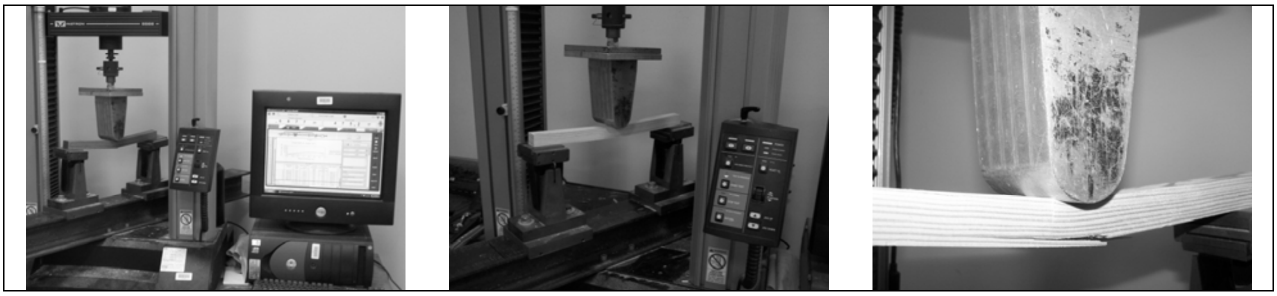

Figure 2. Typical bending test set-up

RESULTS AND DISCUSSION

The results of the bending tests are summarized in Table 2. Specific gravity values have been adjusted for treatment. With the exception of two samples which failed in shear, all bending samples failed in either simple tension or splintering tension.

Table 2. Unadjusted and least squares mean property values from the bending test.

UNADJUSTED MEANS							
System	Work-to-maximum load (kJ/m^3)	Elastic resilience (kJ/m^3)	Fiber stress at proportional limit (kPa)	Modulus of rupture (kPa)	Modulus of elasticity (GPa)	MC (%)	Sp Gr
CA1	111.8	12.8	46,657	90,425	9,805	14.5	0.484
CA2	102.3	11.4	44,899	91,714	10,209	15.5	0.481
CQ	117.5	12.1	45,174	90,701	9,843	16.2	0.467
H_2O	108.0	13.7	48,277	93,610	9,928	13.0	0.473
LEAST SQUARES MEANS WITH SPECIFIC GRAVITY AS COVARIATE							
CA1	109.8	12.7	46,160	89,315	9,675		
CA2	100.9	11.4	44,561	90,956	10,119		
CQ	120.0	12.2	45,802	92,107	10,008		
H_2O	108.9	13.7	48,484	94,072	9,982		

Least squares means for modulus of elasticity (E_f) are compared in Fig. 3. No statistical difference was found among the means for E_f. The means for the CA2 and CQ treatments were slightly higher, but not significantly, than the other means.

Figure 4 compares the modulus of rupture (S_R) means for the various treatments. In this comparison the water-treated control was significantly higher than the CA1 treatment but was equivalent to the other treatments. This small 5% reduction is not considered to be of any practical significance in terms of the utilization of material treated with this preservative.

For fiber stress at proportional limit (Fig. 5) no differences among treatments were found. Variable results were found with the work values. In the case of work-to-maximum load (Fig. 6), there was no significant loss when compared to control values. Samples treated with CQ had a significantly higher value than the other samples. Comparisons among treatments for elastic resilience, shown in Figure 7, showed no differences between the micronized systems and water treated controls except for the CQ system which was 16% lower that the controls. Since work values are not used in design, no practical significance is attached to the decrease.

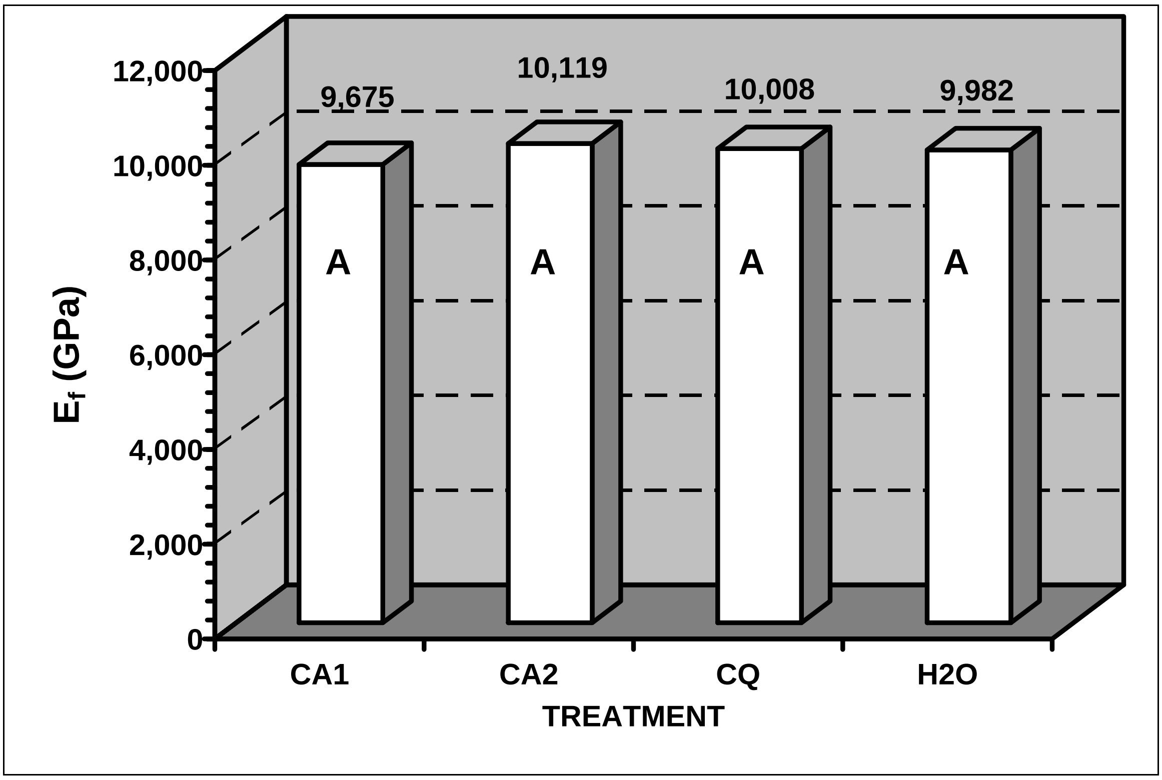

Figure 3. Comparison of least squares and unadjusted means for modulus of elasticity (treatments not marked by a common letter are significantly different at p=0.05).

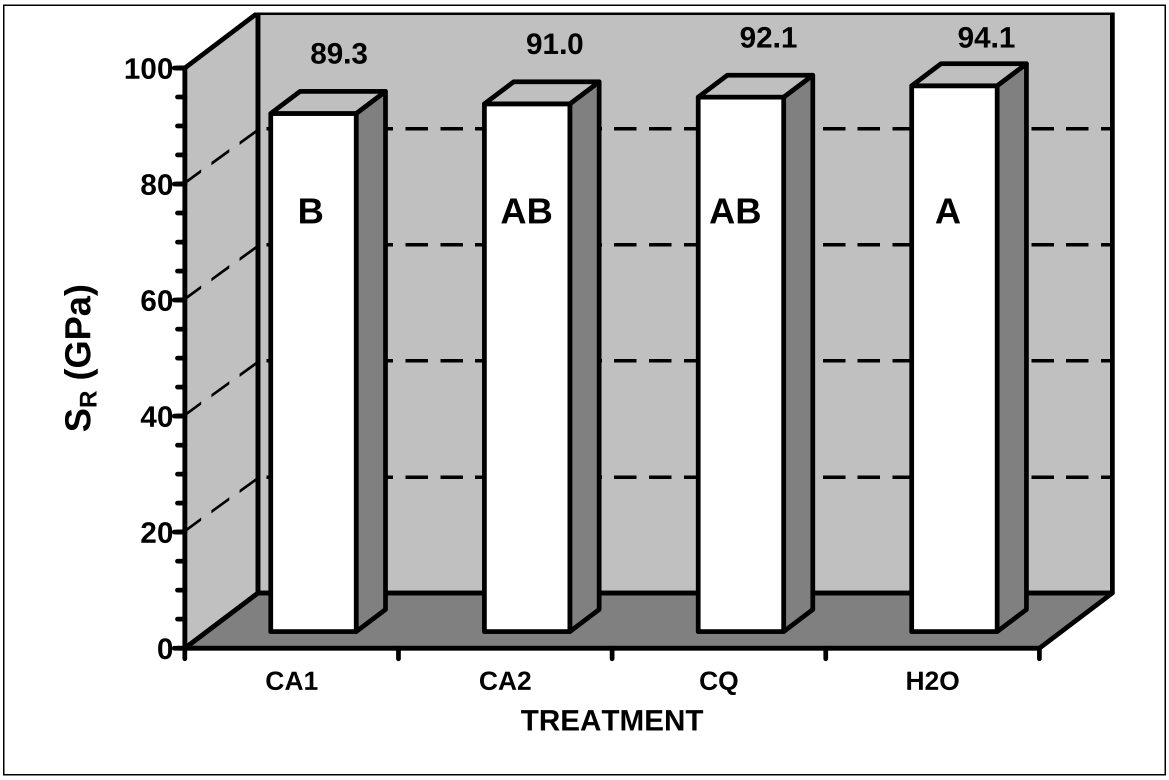

Figure 4. Comparison of least square means for the modulus of rupture of the various treatments (treatments not marked by a common letter are significantly different at p=0.05).

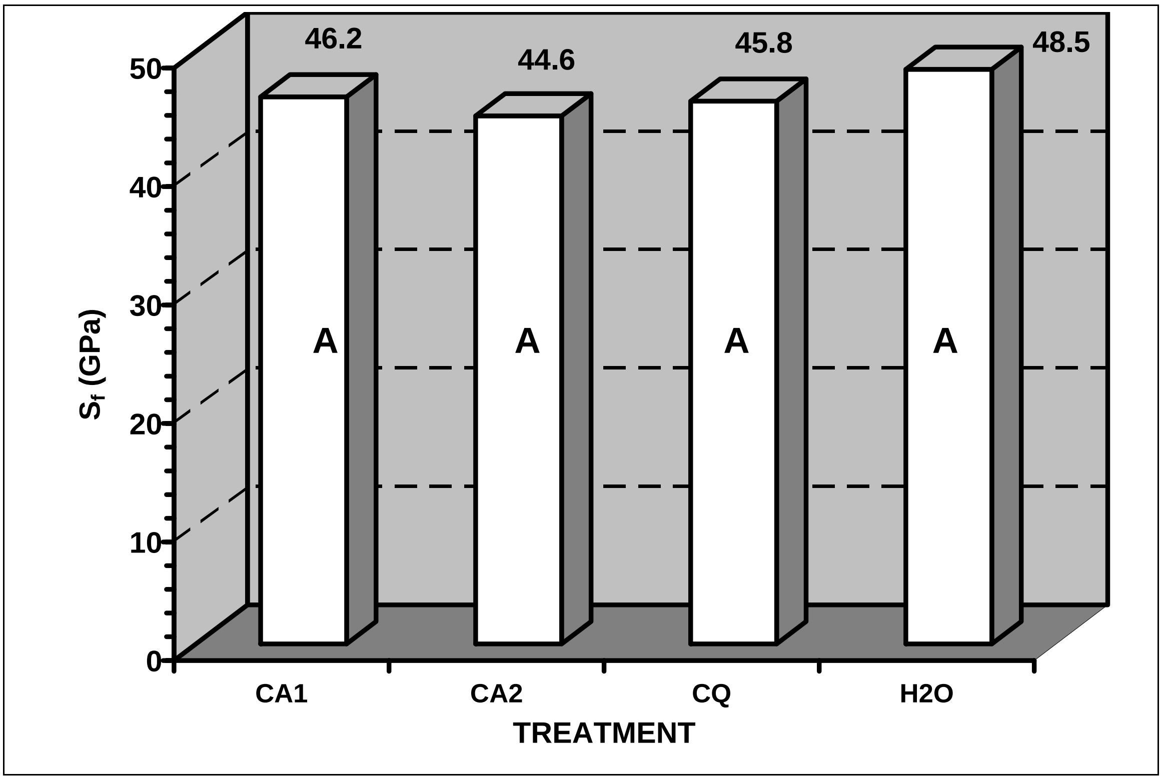

Figure 5. Comparison of mean values for fiber stress at proportional limit (treatments not marked by a common letter are significantly different at p=0.05).

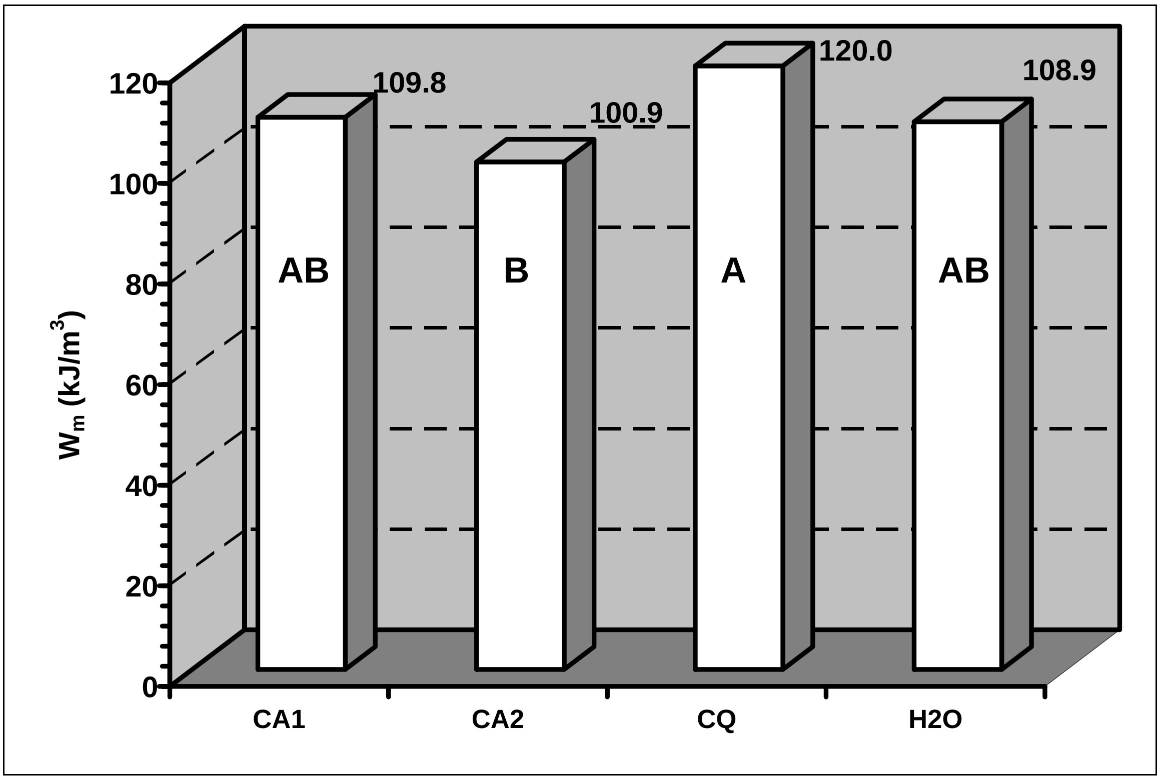

Figure 6. Work-to-maximum load least squares mean comparisons (treatments not marked by a common letter are significantly different at p=0.05).

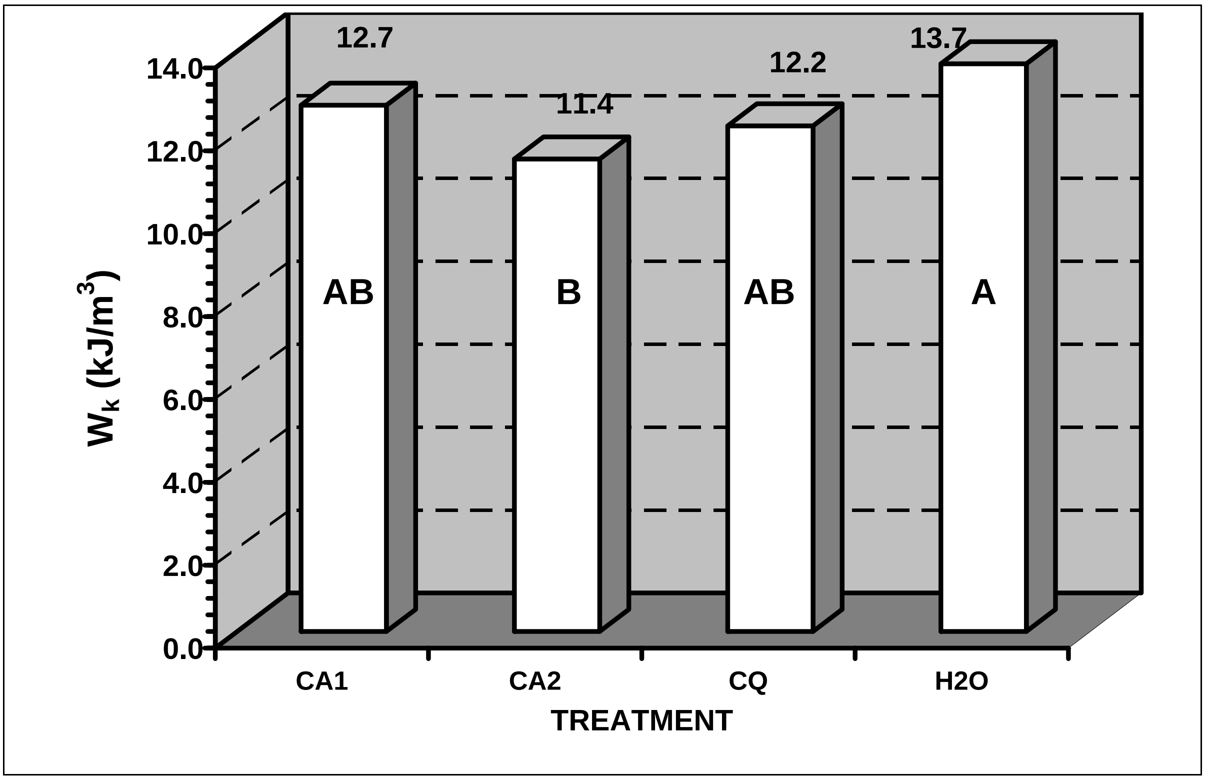

Figure 7. Comparison of least squares means for work-to-proportional limit (elastic resilience) (treatments not marked by a common letter are significantly different at p=0.05).

CONCLUSIONS

Comparisons of mechanical property values for the micronized preservative systems in this study indicate no practical deleterious effects of treatment. This indicates that these micronized systems can be used in construction without concern over strength property loss. Strength and stiffness appear similar to other copper-based systems and work values and failure modes do not indicate any induced brashness in the treated wood. As is common with all new generation systems, there is no indication of the impact of post-treatment drying schedule on residual strength and stiffness properties. The different equilibrium moisture content values for the various treatments suggest that a study into the sorptive nature of these treatments should be conducted.

REFERENCES

American Society for Testing and Materials International (2004) *Annual Book of ASTM Standards, Section 4: Construction, Volume 04.10 Wood*. ASTM. West Conshohocken, PA.

American Wood-Preservers' Association (2007) *AWPA Book of Standards*. American Wood-Preservers' Association, Birmingham, AL, 486 pp.

Barnes, H. M. (1985a) Effect of steaming temperature and CCA retention on mechanical properties of southern pine. *Forest Products Journal* 35(6):31-32.

Barnes, H. M. (1985b) Trends in the wood-treating industry: State-of-the-art report. *Forest Products Journal* 35 (1):13-22.

Barnes, H. M. (1992) Innovative approaches to wood protection. In: *Proceedings, The First International Symposium on the Development of Natural Resources and Environmental*

Preservation, New Horizons in Agricultural Science, Institute of Natural Resources and Environment, Korea University, October 13-18, 1992, Seoul, Korea, p. 161-198.

Barnes, H. M. (1993) Wood protecting chemicals for the 21st century. Int. Res. Grp. on Wood Pres., Doc. No. IRG/WP/93-30018, 29 pp.

Barnes, H. M.; Lindsey, G. B. 2008. Bending properties of wood treated with a new organic wood preservative system. *Bioresource Technology* (submitted).

Barnes, H. M.; Lindsey, G. B.; Hill, J. M. 2008. Mechanical properties of southern pine treated with copper betaine. *Proceedings, American Wood Protection Association* (submitted).

Barnes, H. M.; Maupin, M.; Lindsey, G. B. 2005. Bending properties of southern pine treated with waterborne copper naphthenate. *Proceedings, American Wood-Preservers' Association* 101:64-73.

Barnes, H. M.; Lyon, D. E.; Zahora, A.; Muisu, F. 1993. Strength properties of ACQ-treated southern pine lumber. *Proceedings, American Wood-Preservers' Association* 89:51-60.

Barnes, H. M.; Murphy, R. J. 1995. Wood preservation: the classics and the new age. *Forest Products Journal* 45(9):16-26.

Barnes, H. M. and J. E. Winandy. 1986. Effects of seasoning and preservatives on the properties of treated wood. *Proceedings: American Wood-Preservers' Association* 82:95-105.

Evans, Philip. 2003. Emerging technologies in wood protection. *Forest Products Journal*. 53(1):14-22.

Freeman, M. H.; Nicholas, D. D.; Schultz, T. P. 2006. Non-arsenical wood protection: alternatives for chromated copper arsenate, creosote, and pentachlorophenol. In: *Environmental Impacts of Treated Wood*, T. G. Townsend and H. Solo-Gabriele (eds.), CRC Taylor Francis Group, London, p. 19-36.

Freeman, M. H.; Shupe, T. F.; Vlosky, R. P.; Barnes, H. M. 2003. Past, present, and future of the wood preservation industry. *Forest Products Journal* 53(10):8-15.

Goodell, B.; Nicholas, D. D.; Schultz, T. P. (eds.). 2003. *Wood deterioration and preservation: advances in our changing world*. ACS Symposium Series 845, American Chemical Society, Washington, DC, 463 pp.

SAS Institute Inc. 2001. *SAS Proprietary Software, Release 8.2*. The SAS Institute, Cary, NC.

Schultz, T. P.; Nicholas, D. D.; Preston, A. F. 2007. A brief review of the past, present and future of wood preservation. *Pest Management Science* 63:784-788.

Winandy, J. E., Barnes, H. M. 1991. Influence of initial kiln-drying temperature on CCA-treatment effects on strength. *Proceedings, American Wood-Preservers' Association* 87:147-152.