PRESERVATIVE TREATMENT EVALUATION OF RED MAPLE AND YELLOW-POPLAR WITH ACQ-B

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ABSTRACT

This project sought to determine if there was a difference in treatment results of selected refractory hardwood species by comparing a heated solution of ammoniacal copper quaternary compound-Type B (ACQ-B) to an ambient solution of ACQ-B using three pressure period durations. Nominal 2-by-4 samples, 6 inches long, of red maple and yellow-poplar heartwood were end-sealed and vacuum/pressure treated with a 1 percent active ingredient solution of ACQ-B. Duration of pressure was varied as well as temperature of solution. Measurements were taken of minimum and maximum penetration, percentage of cross-sectional area penetrated, and retention of preservative as determined by x-ray fluorescence spectroscopy analysis (ASOMA). Statistical analysis indicated improved penetration into yellow-poplar heartwood when the preservative solution was heated. Red maple results were inconclusive in that there was difficulty in differentiating heartwood and confirming the refractory nature of the species.

Refractory softwoods have been studied using techniques to improve preservative treatment as characterized by penetration and retention. Improvement in these criteria has been demonstrated when an ammoniacal preservative solution was used in comparison to chromated copper arsenate (CCA). [1,2] These studies primarily focused on the effect of incising refractory softwoods before treating in commercial treating facilities or on a laboratory scale. Both studies compared CCA to ammoniacal preservative solutions (ACZA and ACA, respectively). When the effect of preservative was singled out, generally. better or statistically significant improved penetration was observed for the ammoniacal solutions. While Appalachian hardwoods are extensively used for railroad ties (treated with creosote), many species fall into the refractory category when treated with waterborne preservatives. Two of these refractory species, yellow-poplar and red maple, are found in abundance in the Appalachian forest and until recently were underutilized. In the past 10 to 15 years, both of these species have seen increased use in the furniture, composite, and export markets. If the wood of these species could be satisfactorily and consistently treated with preservative, the use, marketability, and value would be further enhanced for applications in adverse conditions.

From previous work done with the sapwood of these two species, vacuum/pressure-treated with CCA, it was determined that sapwood was 100 percent treatable and the decision was made to focus on the heartwood of both species for this work, treated with ammoniacal copper quaternary compound-Type B (ACQ-B) at three different pressure periods and two different solution temperatures. The treatability of red maple sapwood is further corroborated by Smith et al.[3]

[1] Lebow, S.T. and J.J. Morrell. 1993. Pressure treatment of sitka spruce lumber with ammoniacal copper zinc arsenate or chromium copper arsenate. Forest Prod. J. 43(10):41-44.

[2] Gjovik, L.R. and D.R. Schumann. 1992. Treatability of native softwood species of the northeastern United States. Res. Pap. FPL-RP-508. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.

[3] Smith, W. B., N. Abdullah, D. Herdman, and R.C. DeGroot. 1996. Preservative treatment of red maple. Forest Prod. J. 46(3)35-41.

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TABLE 1. — Treating matrix for yellow-poplar and red maple heartwood treated with ACQ-B.

Treatment temp.	Treatment time					
	60 minutes		90 minutes		120 minutes	
80°F	YP[a] *n*=10	RM[a] *n*=10	YP *n*=10	RM *n*=10	YP *n*=10	RM *n*=10
180°F	YP *n*=10	RM *n*=10	YP *n*=10	RM *n*=10	YP *n*=10	RM *n*=10

[a] YP = yellow-poplar; RM = red maple.

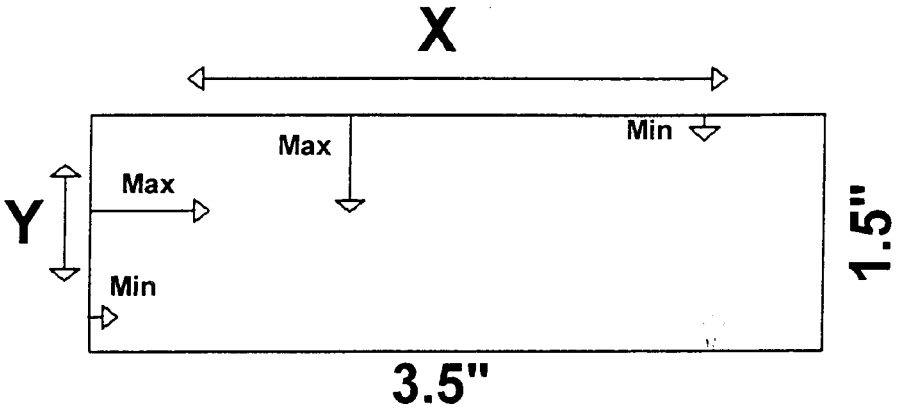

Figure 1. — Penetration measurements on cross sections of treated specimens.

MATERIALS AND METHODS

Green yellow-poplar *(Liriodendron tulipifera* L.) and red maple *(Acer rubrum* L.) logs were rough-cut into full 2-inch random width/length boards. Opening cuts were made to leave as much wane as possible (to help identify sapwood), while still producing 2-inch-thick boards. The remaining boxed-heart cant was cut into boards a full 2 inches in thickness. The green, rough-cut lumber was dried below the fiber saturation point (FSP) by either air-drying or dehumidification-kiln-drying. Once below FSP, oversized 2- by 4-inch blanks were ripped from the boards, making every effort to produce either sapwood or heartwood blanks. While wane on the opening cut boards helped to identify sapwood, proximity to the pith, and ring orientation combined with discoloration, were used as indicators of heartwood. The blanks were then processed through a molder/planer to produce random length nominal 2 by 4's. Straight-grained, defect-free, 6-inch-long samples were then cut and placed in a conditioning room (70°F at 65% RH) to equilibrate at 12 percent moisture content. Prior to vacuum/pressure treatment, samples were end-sealed with an elastomeric sealant.

A 4 percent active ingredient solution of ACQ-B was supplied by Chemical Specialties, Inc., from which a 1 percent active ingredient solution was prepared by dilution with water for use in vacuum/pressure treatment of the heartwood samples. Treatment constants were pressure (200 psi) and an initial vacuum (28 in. Hg) period of 30 minutes. Variables were pressure period duration (60, 90, and 120 min.) and solution temperature (80°F or 180°F) to give a simple matrix shown in **Table 1** for a total of 120 treated samples.

An entire cross section, taken from the center of each sample, was ground for copper retention analysis using x-ray fluorescence spectroscopy-ASOMA, while one of the freshly sawn faces was sprayed with chrome azurol-S for subsequent penetration measurements. The penetration measurements were made according to **Figure 1, so** that four depths of penetration measurements (in inches) per sample were recorded: minimum X, maximum X, minimum Y, maximum Y, as well as a rating of percentage of cross section penetrated. Maximum measurements were limited to one-half the total possible distance in each dimension, i.e., 0.75 inch in the X dimension, 1.75 inches in the Y dimension. Percentage of cross section penetrated was given a rating of 0, 1, 2, or 3; where: 0 = 0 to 25 percent, 1 = 25 to 50 percent, 2 = 50 to 75 percent, and 3 = 75 to 100 percent penetration. The penetration measurement data and ASOMA retention data were analyzed using an unweighed means analysis of variance where the following model was used:

$$y_{ijk} = \mu + Time_i + Temp_i + (Time \times Temp)_{ij} + \varepsilon_{ijk}$$

where:

y = actual penetration measurement

μ = overall mean penetration (in.) or retention (pcf)

$Time_i$ = effect of the i^{th} pressure period (min.) *(i* = 1,2,3 or 60,90, 120 min., respectively)

$Temp_j$ = effect of the j^{th} temperature (°F) (j = 80°F or 180°F)

$(Time \times Temp)_{ij}$ = interaction effect between the i^{th} pressure period and the j^{th} temperature

E_{ijk} = experimental error associated with y_{ijk};

$k = k^{th}$ observation of the ij^{th} treatment

All tests of significance are conducted at an alpha level of 0.05.

RESULTS AND DISCUSSION

Tables 2 and **3** give the penetration and retention results for yellow-poplar and red maple, respectively.

American Wood-Preservers' Association Standards 1995[4] do not specify use of ACQ-B with either of the species investigated in this study. However, as a point of reference. the specified retention of ACQ-B in southern pine (C2—Lumber, Timber and Ties-Preservative Treatment by Pressure Processes) is 0.25 (above ground) or 0.40 (soil and fresh water use) pcf. The following penetration of creosote, creosote solutions, and oil-borne preservatives is specified for maple: the average of 20 cores per charge must equal or exceed 1.50 inches or 75 percent of sapwood, whichever is less

[4] American Wood-Preservers' Association. 1995. AWPA Standards. AWPA, Woodstock, Md.

TABLE 2. — Penetration (in.), percentage rating of cross section penetrated, and retention (pcf CuO) means, standard deviations, and ranges for yellow-poplar heartwood.

Time/temp	MinX	MaxX	% rating	MinY	MaxY	Retention
	(in.)			(in.)		(pcf)
60/80	0.17 (.18)[a]	0.56 (.19)	1.1 (1.2)	0.22 (.21)	0.74 (.55)	0.123 (.056)
	.03 to .59[b]	.25 to .75	0 to 3	.04 to .71	.28 to 1.75	.063 to .201
90/80	0.08 (.04)	0.39 (.24)	0.8 (.8)	0.08 (.06)	0.38 (.25)	0.110 (.035)
	.05 to .17	.14 to .75	0 to 2	.04 to .23	.14 to .89	.068 to .181
120/80	0.19 (.21)	0.49 (.21)	1.4 (1.2)	0.28 (.52)	0.76 (.57)	0.102 (.04)
	.06 to .75	.28 to .75	0 to 3	.05 to 1.75	.27 to 1.75	.040 to .195
60/180	0.20 (.21)	0.66 (.13)	1.9 (1.3)	0.48 (.59)	0.90 (.61)	0.118 (.049)
	.01 to .75	.54 to .75	0 to 3	.10 to 1.75	.37 to 1.75	.062 to .204
90/180	0.27 (.18)	0.68 (.12)	2.4 (.8)	0.38 (.50)	1.04 (.58)	0.114 (.034)
	.14 to .75	.38 to .75	1 to 3	.12 to 1.75	.38 to 1.75	.071 to .173
120/180	0.22 (.10)	0.62 (.18)	2.3 (.9)	0.25 (.12)	1.06 (.60)	0.121 (.041)
	.11 to .40	.30 to .75	1 to 3	.09 to .47	.28 to 1.75	.080 to .183

[a] Values in parentheses are standard deviations.
[b] Range.

TABLE 3. — Penetration (in.), percentage rating of cross section penetrated, and retention (pcf CuO) means, standard deviations, and ranges for red maple heartwood.

Time/temp	MinX	MaxX	% rating	MinY	MaxY	Retention
	(in.)			(in.)		(pcf)
60/80	0.33 (.16)[a]	0.66 (.16)	2.5 (.7)	0.66 (.22)	1.21 (.50)	0.171 (.027)
	.05 to .58[b]	.29 to .75	1 to 3	.27 to .91	.58 to 1.75	.121 to .209
90/80	0.24 (.31)	0.72 (.07)	2.3 (.8)	0.45 (.70)	1.38(.48)	0.142 (.031)
	.03 to .75	.56 to .75	1 to 3	.03 to 1.75	.74 to 1.75	.089 to .181
120/80	0.09 (.13)	0.62 (.18)	1.5 (1.0)	0.21 (.36)	1.25 (.49)	0.094 (.030)
	.00 to .34	.32 to .75	0 to 3	.00 to 1.08	.19 to 1.75	.033 to .142
60/180	0.03 (.02)	0.56 (.20)	0.8 (.9)	0.03 (.04)	0.86 (.66)	0.088 (.032)
	.00 to .07	.34 to .75	0 to 2	.00 to .12	.16 to 1.75	.047 to .137
90/180	0.06 (.02)	0.63 (.16)	0.7 (1.2)	0.08 (.08)	0.64 (.68)	0.091 (.038)
	.03 to .08	.31 to .75	0 to 3	.00 to .27	.00 to 1.75	.053 to .169
120/180	0.04 (.02)	0.44 (.27)	0.6 (1.1)	0.10 (.02)	.63 (.62)	0.078 (.040)
	.02 to .07	.11 to .75	0 to 3	.08 to .14	.13 to 1.75	.037 to .155

[a] Values in parentheses are standard deviations.
[b] Range.

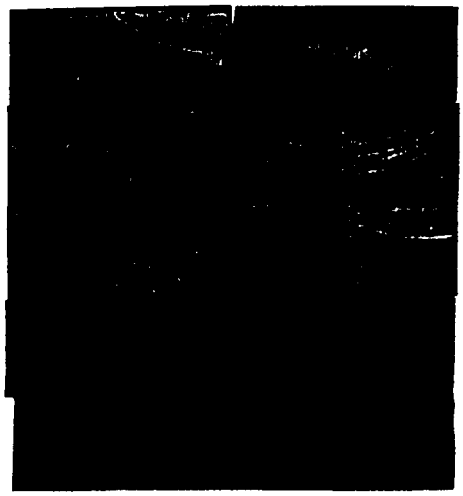

Figure 2. — Yellow-poplar heartwood pressure treated with an 80°F ACQ-B solution for 60 minutes.

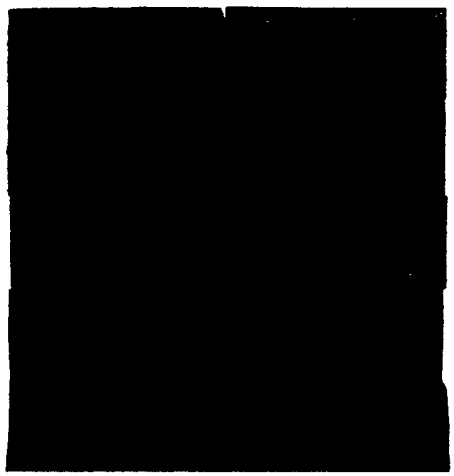

Figure 3. — Yellow-poplar heartwood pressure treated with an 80°F ACQ-B solution for 90 minutes.

Figure 4. — Yellow-poplar heartwood pressure treated with an 80°F ACQ-B solution for 120 minutes.

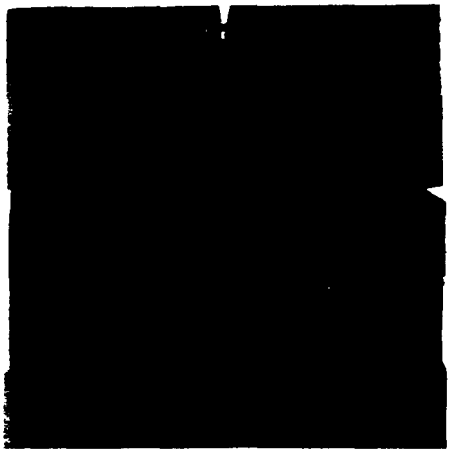

Figure 5. — Yellow-poplar heartwood pressure treated with a 180°F ACQ-B solution for 60 minutes.

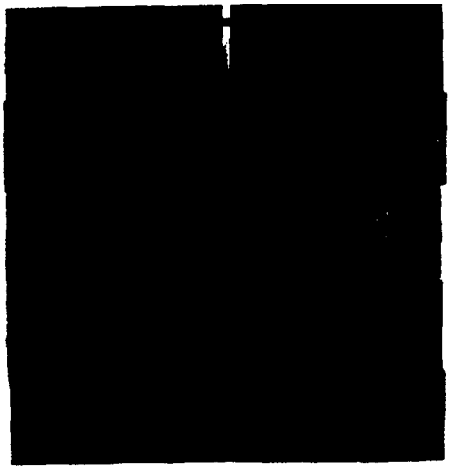

Figure 6. — Yellow-poplar heartwood pressure treated with a 180°F ACQ-B solution for 90 minutes.

Figure 7. — Yellow-poplar heartwood pressure treated with a 180°F ACQ-B solution for 120 minutes.

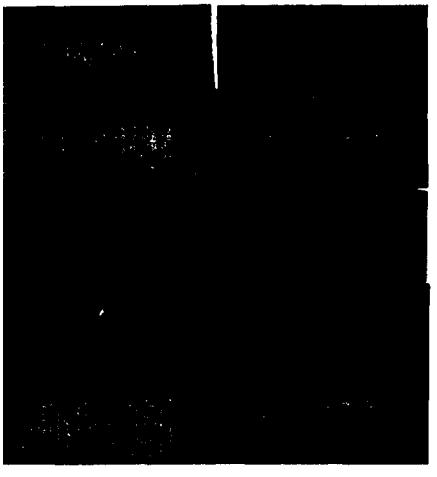

Figure 8. — Red maple heartwood pressure treated with an 80°F ACQ-B solution for 60 minutes.

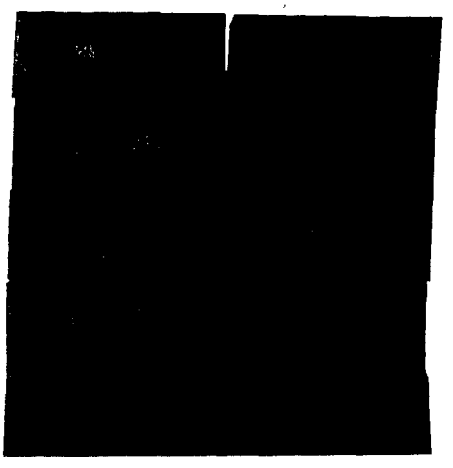

Figure 9. — Red maple heartwood pressure treated with an 80°F ACQ-B solution for 90 minutes.

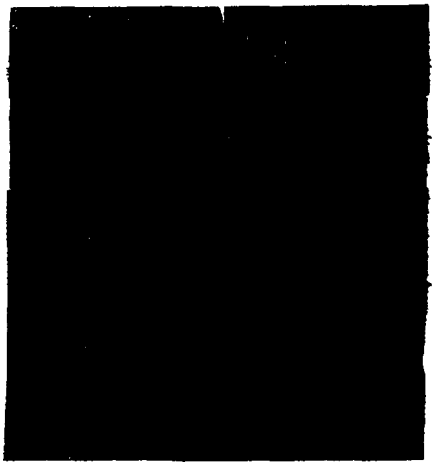

Figure 10. — Red maple heartwood pressure treated with an 80°F ACQ-B solution for 120 minutes.

and the maximum penetration required in any piece of sawn material will be no greater than half the width or depth of said pieces, depending on the orientation of the measurement (C1—All Timber Products-Preservative Treatment by Pressure Processes). Based upon these criteria and assuming that samples were 100 percent heartwood, it is conceivable that an aboveground retention level of 0.25 pcf and minimum penetration requirements can be consistently achieved.

For yellow-poplar heartwood, a solution temperature of 180°F showed statistical significance over 80°F in improving all measures of penetration (MinX, MinY MaxX, MaxY, % Rating). However, there was no significant difference in retention due to temperature. Also, there were no statistical differences among the three pressure periods, nor were any of the interactions significant.

Treatability results for red maple indicated a difficulty in differentiating between sapwood and heartwood. Temperature was statistically significant for all six dependent variables. Penetration was greater at 80°F than at 180°F. Whether there are chemical reactions between copper and maple extractives that limited penetration at the higher temperature is a matter of supposition. Pressure time, as with yellow-poplar, showed no statistical significance, although penetration for MinX and MaxX were both nearly significant, i.e., 0.056 and 0.054, respectively. In both cases, the 120-minute pressure periods exhibited poorer penetration. The Time × Temperature interaction was not significant, although MinX and MinY were both marginally significant (i.e., 0.051 and 0.058, respectively). In both cases, penetration was better at the lower temperature and shorter time period. Retention showed

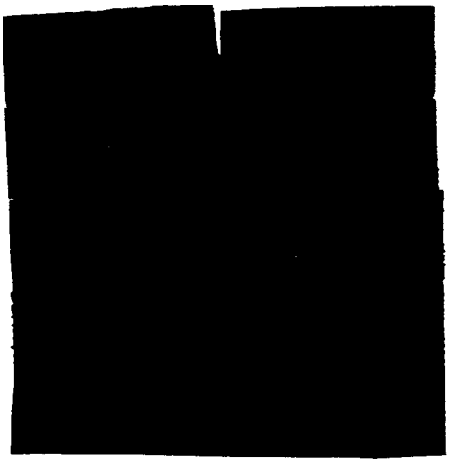

Figure 11. — Red maple heartwood pressure treated with a 180°F ACQ-B solution for 60 minutes.

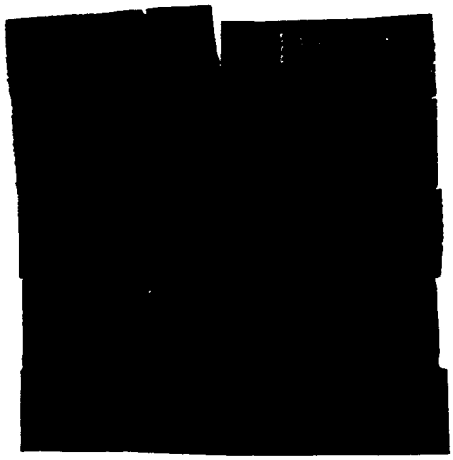

Figure 12. — Red maple heartwood pressure treated with a 180°F ACQ-B solution for 90 minutes.

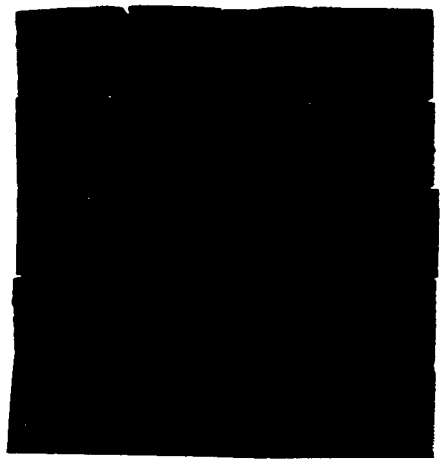

Figure 13. — Red maple heartwood pressure treated with a 180°F ACQ-B solution for 120 minutes.

statistical significance in all factors. The lower temperature and shorter pressure period showing improved retention in red maple. A close visual examination of the red maple specimens indicated a tendency for the lower temperature/shorter pressure period samples to have been located further from the pith than samples in other treatment combinations and may have contained greater amounts of the more treatable sapwood or some sort of transition wood. This result indicates the difficulty in accurately distinguishing between heartwood and sapwood in red maple. It may also be an indication that red maple has relatively little heartwood, as has been indicated in the previously mentioned study done by Smith et al.[3]

Figures 2 through **13** show the actual specimen cross sections. The most poorly treated red maple samples all have the pith within the cross section. Twenty-eight out of 120 red maple specimen minimum measurements (X and Y dimensions) exhibited less than 0.05 inch of penetration. In fact, seven specimens showed no penetration in at least one dimension. Of the 60 yellow-poplar samples, only 5 specimens showed penetration of 0.05 inch or less. Unlike the red maple, all of the specimens had at least 0.01 inch of penetration.

Conclusions

If ACQ-B proves to be an effective preservative for these species, particularly yellow-poplar, and a heated solution shows consistently improved, if modest, penetration results in heartwood, this may suggest a preservative treatment system for composite wood products is possible, adhesion studies notwithstanding. While some question as to whether the red maple samples were, in fact, all heartwood is bound to cloud any interpretation of the red maple results, it appears that red maple heartwood tends to be refractory in nature. Of the 10 samples where the pith was apparent in the sample, 6 treated very poorly, while 3 treated very well. This may indicate that the refractory nature of red maple heartwood may not be as pronounced as in the heartwood of other species. Further, some sort of incising, as suggested in the Smith et al. study.[3] may produce a consistently and adequately treated composite, or possibly a solid wood product, durability studies notwithstanding. Otherwise, this study further confirms the difficulty in treating refractory heartwood of hardwood species.