TREATABILITY AND CCA PRESERVATIVE DISTRIBUTION WITHIN TEN INDONESIAN HARDWOODS[1]

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ABSTRACT

Samples were cut from stems of 10 Indonesian hardwoods. They were conditioned to 12% moisture content and then pressure-treated in a commercial plant using CCA type C. Liquid preservative uptake, penetration depth, fraction of voids filled, and distribution (percent of each cell type penetrated) were measured. Heartwood and sapwood of many of the species had high uptakes and good penetration, making them promising candidates for further work. Some of the species that showed good uptake exhibited poorly treated fibers, ray cells, or axial parenchyma. Tyloses, gummy materials, axial parenchyma presence and location, and ray canals affected preservative liquid uptake and distribution.

Keywords: Treatability, CCA, anatomy, tropical hardwoods, penetration index, uptake, preservation, preservative, void fraction, Indonesia, Irian Jaya.

INTRODUCTION

Over 80% of Indonesian wood species are classified as nondurable, which is a major reason they have little commercial use. Chromated-copper-arsenate (CCA) has been successfully used in many countries to protect wood (Pizzi 1980). However, there have been some reports of premature failures of CCA-treated hardwoods due to uneven preservative microdistribution (Greaves and Levy 1978; Greaves and Nilson 1982).

The objectives of this study were to obtain an indication of potential treatability with waterborne preservatives and observe microdistribution of preservative within the wood structure of 10 nondurable wood species from the island of Irian Jaya, Indonesia (Maturbongs 1995).

EXPERIMENTAL PROCEDURE

A tree each of *Buchanania arborescens* Bl., *Cananga odorata* Hook f.et Th., *Endospermum medullosum* L.S.Sm., *Flindersia ambionensis* Poir., *Hernandia ovigera* L., *Horsfieldia sylvestris* Warb., *Octomeles sumatrana* Miq., *Pterocymbium beccarii* K.Sch., *Spondias dulcis* Kurz, and *Tetrameles nudiflora* R.Br were identified and harvested for this study (Maturbongs 1994). Fourteen 30-mm × 50-

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TABLE 1. *Average specific gravity, treating liquid uptake, and fraction of voids filled for 7 samples of one tree of each pressure-treated Indonesian hardwood species listed.*

		Sp. Grav. 12% MC	Uptake (kg/m^3)	Fraction voids filled	End-coated uptake (kg/m^3)
B. arborescens	Sap	0.32	343	0.45	215
	Heart	0.30	304	0.39	230
C. odorata	Sap	0.36	366	0.50	442
	Heart	0.33	442	0.58	243
E. medullosum	Sap	0.44	234	0.35	175
	Heart	0.38	404	0.37	375
F. ambionensis	Sap	0.52	298	0.49	123
	Heart	0.52	301	0.50	101
H. ovigera	Sap	0.28	525	0.66	287
	Heart	0.27	395	0.49	236
H. sylvestris	Sap	0.52	344	0.57	217
	Heart	0.47	161	0.25	95
O. sumatrana	Sap	0.30	313	0.40	122
	Heart	0.23	100	0.12	28
P. becarii	Sap	0.34	349	0.46	330
	Heart	0.25	251	0.31	298
S. dulcis	Sap	0.31	512	0.66	186
	Heart	0.30	27	0.03	18
T. nudiflora	Sap	0.26	171	0.21	84
	Heart	0.26	208	0.25	121

mm × 270-mm samples, 7 sapwood and 7 heartwood, were sawn from each stem at its base, middle and near the top. The samples were conditioned at 21°C and 65% RH to 12% moisture content. One heartwood and one sapwood sample from the middle of each tree were end-coated with resin. All samples were then impregnated using a full-cell process in a commercial plant (AWPA 1992a, 1992b): preliminary vacuum at 70 kPa for 20 min, pressure at 1051.75 kPa for 30 min and final vacuum at 80 kPa for 30 min. A 3.64% solution of CCA type C in water was used. Density of each sample (at 12%) was used to calculate specific gravity and porosity before treatment (Siau 1971). These values were used to calculate net uptake and the fraction of voids filled following the procedure suggested by Siau (1971).

Before treating porosity

$$(V_a) = 1 - G_{12}(1/G_{CW} + 0.01M) \quad (1)$$

Fraction of voids filled

$$(F_{VL}) = \frac{W_L}{\rho_L V_a V} \quad (2)$$

Liquid uptake

$$(kg/m^3) = 1{,}000 \times F_{VL} \times \rho_L \times V_a \quad (3)$$

where: W_L = mass of the absorbed liquid (g); ρ_L = density of liquid (g/cm^3); V_a = wood sample porosity; V = volume of wood sample before treatment; G_{CW} = cell-wall specific gravity (1.5) and M = % moisture content, oven-dry basis.

Penetration (percent of cross-sectional area penetrated) was obtained by staining one, 5-mm-thick, transverse sample section cut from the middle of each sample with a solution of Chrome azurol S which is indicator for copper (AWPA 1991), and then measuring the colored area using a digitizer connected to a computer.

A 15-mm × 15-mm × 40-mm-long block was cut from the center of 3 sapwood and 3 heartwood samples from each tree. A 20-μm cross section was cut from the end of each block using a sliding microtome. These sections were stained with dithiooxamide as suggested by Belford et al. (1959) and mounted with glycerin. The cell walls containing preservative turned dark-green. Using a light microscope micrometer stage, a cross-hair reticule was positioned over successive 3.75-mm (parallel to the tangential surface) × 1.67-mm areas of the section, and the number of stained and unstained vessels, fibers, axial parenchyma, and rays observed were recorded. The average of these cross-sectional areas of each sample was used as the percent of the different cells treated and for calculation of penetration index. The distribution of preservative was calculated using a formula suggested by Kumar et al. (1990) but modified to have five penetration percent ranges rather than three:

$$\text{Penetration index} = \sum_{i=1}^{4} (W_i P_i)/45 \quad (4)$$

where: W = weight factor assigned to each cell type based on its importance in liquid con-

TABLE 2. *Average percent of cells containing preservative and penetration index calculated for 7 samples from one tree of each Indonesian hardwood species listed. Data were obtained from microscope sections stained with dithiooximide.*

		Percent of cells treated				
		Vessels	Fibers	Ray cells	Parenchyma	PI
B. arborescens	Sap	100	24	61	100	0.64
	Heart	100	12	33	100	0.60
C. odorata	Sap	95	54	99	80	0.84
	Heart	95	58	100	85	0.84
E. medullosum	Sap	98	30	68	68	0.60
	Heart	100	87	94	96	0.93
F. ambionensis	Sap	90	19	55	75	0.62
	Heart	84	18	53	99	0.58
H. ovigera	Sap	100	100	100	100	1.00
	Heart	99	56	80	100	0.82
H. sylvestris	Sap	100	17	19	29	0.47
	Heart	32	26	12	11	0.27
O. sumatrana	Sap	99	6	54	81	0.56
	Heart	58	4	6	53	0.27
P. becarii	Sap	98	24	100	100	0.73
	Heart	99	27	92	100	0.73
S. dulcis	Sap	100	100	100	100	1.00
	Heart	0	7	0	0	0.07
T. nudiflora	Sap	100	35	44	100	0.66
	Heart	100	41	57	100	0.71

duction and in its composition (vessels = 3, fibers = 3, rays = 2, and parenchyma = 1); P = an integer between 0 and 5 representing the percentage of each cell type penetrated (0 = $<10\%$, 1 = 10% to 30%, 2 = 30% to 50%, 3 = 50% to 70%, 4 = 70% to 90%, and 5 = $>90\%$); i = type of cell (vessel, fiber, ray parenchyma, and axial parenchyma). With all cell types penetrated completely, penetration index would be 1.0.

RESULTS AND DISCUSSION

Uptakes were good in sapwood and heartwood of all species except for the heartwood of *O. sumatrana* and *S. dulcis* (Table 1), which also had poor penetration of several cell types and low penetration index (Table 2). The sapwood of *O. sumatrana* also has poor penetration of two cell types and low penetration index.

C. odorata and *E. medullosum* had an abundance of fiber tracheids with their larger and presumably more permeable pits than libriform fibers. This may have contributed *C. odorata* heartwood and sapwood and heartwood of *E. medullosum* having well-treated fibers. *E. medullosum* sapwood fibers were treated near vessels but not farther away (Fig. 1). In *C. odorata* there was evidence that rays acted as fluid pathways, assisting the treatment of nearby fibers (Fig. 2). *H. ovigera* is a very low-density wood, largely because of very thin fiber walls. Fibers in this species were libriform, but perhaps the thin walls allowed preservative flow through pits, resulting in the good distribution of preservative (Fig. 3). The other low-density species with thin fiber walls in this study (*T. nudiflora*) had vessels occluded with tyloses in both sapwood and heartwood, severely limiting preservative movement. *S. dulcis* sapwood had open radial canals and vessels that contributed to the uniform treatment noticed. The heartwood of *S. dulcis* was heavily occluded with tyloses (Fig. 4), and the radial canals were filled with deposits (Fig. 5), sealing the heartwood from preservative entry and accounting for this species' differ-

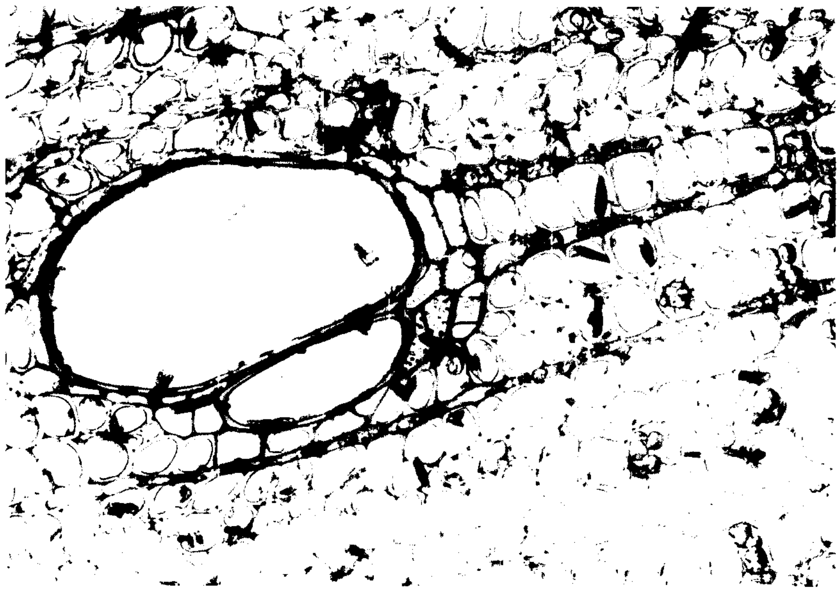

FIG. 1. *E. medulossum* sapwood vessel and nearby fibers showing evidence of preservative. 640×.

ence in sapwood and heartwood treatability. *O. sumatrana* heartwood had just over half its vessels treated, and few treated fibers. A treated vessel, surrounded by treated parenchyma, and several untreated vessels are shown in Fig. 6. *H. sylvestris* heartwood had about a third of its vessels treated. Fig. 7 shows adjacent treated and untreated vessels with parenchyma sur-

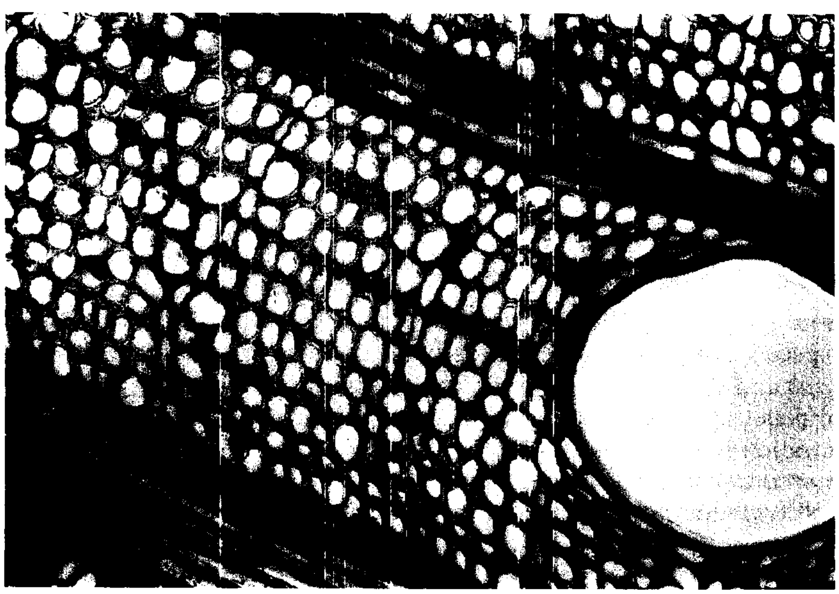

FIG. 2. *C. odorata* rays, cells immediately surrounding rays and band of apotracheal parenchyma joining rays containing preservative.

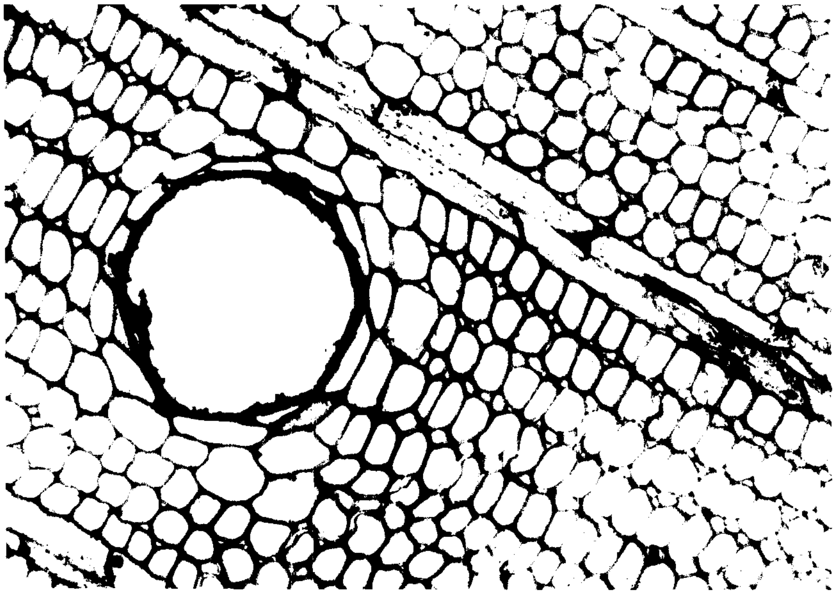

FIG. 3. *H. ovigera* sapwood treated vessel and all visible fibers. 640×.

rounding the treated one also containing preservative.

Sapwood and heartwood of *B. arborescens*, *F. ambionensis*, and sapwood only of *O. sumatrana* and *P. beccarii* have low percents of fibers treated, thus potentially leaving this cell type susceptible to the effects of wood-destroying organisms. All four species had paratracheal vasicentric parenchyma, so preservative flowing in vessels would have to cross the pa-

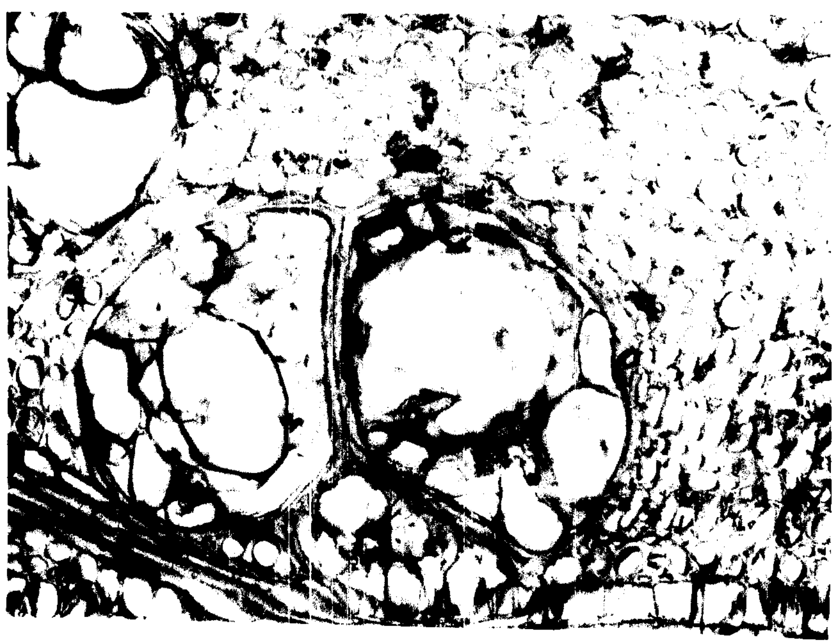

FIG. 4. *S. dulcis* tyloses in heartwood vessel. 640×.

FIG. 5. Rays containing gum in *S. dulcis* heartwood. 640×.

renchyma to reach fibers. Fig. 8 shows a treated *B. arborescens* vessel surrounded by untreated fibers. Low penetrability of these parenchyma may have shielded fibers from preservative flow. *B. arborescens* had low percent of rays treated. These rays contained an abundance of deposits. A treated vessel surrounded by a single, treated band of parenchyma and untreated

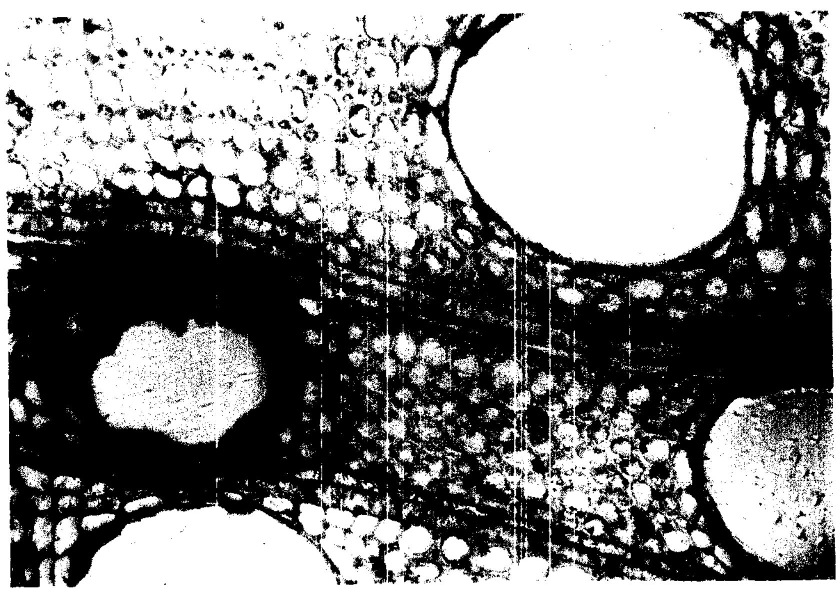

FIG. 6. Small, treated vessel surrounded by treated parenchyma and the remaining tissue including three vessels untreated in *O. sumatrana* heartwood. 640×.

FIG. 7. Heartwood of *H. sylvestris* showing one vessel and surrounding parenchyma treated, the remainder of the tissue including a vessel untreated. Rays contain gum. 640×.

fibers in sapwood of *P. beccarii* is shown in Fig. 9. *B. arborescens* and *T. nudiflora* had weak tyloses which were blown out by treatment.

The woods in this study fell into four of Kumar and Dobriyal's (1993) five penetration index (PI) treatability classes, with heartwood in many cases classifying differently than sap-

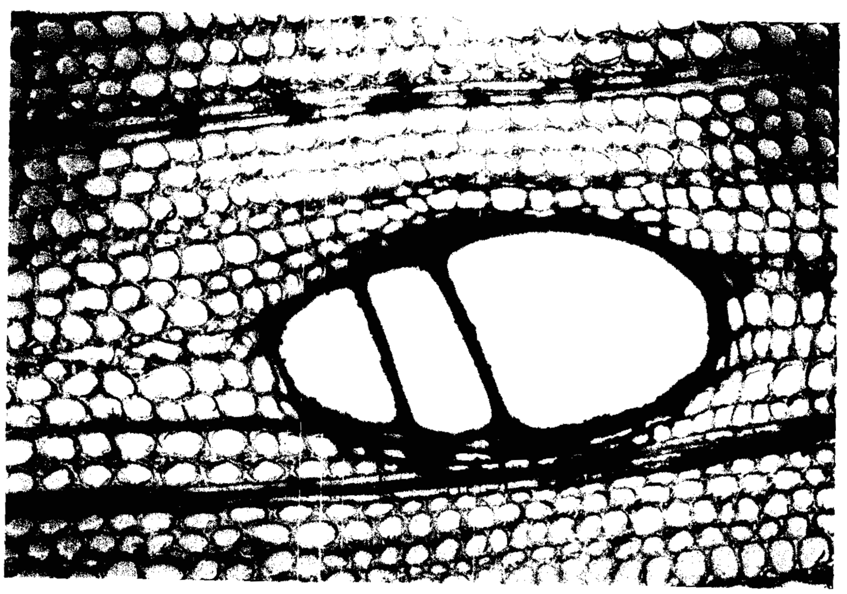

FIG. 8. Treated vessel walls in the heartwood of *B. arborescens*. 640×.

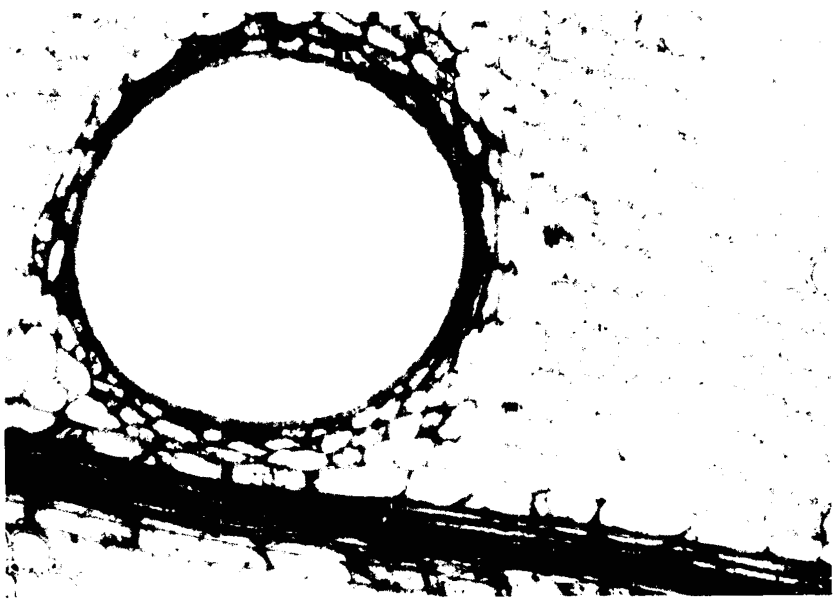

FIG. 9. Sapwood of *P. beccarii* showing vessel wall, surrounding parenchyma and ray containing preservative. 640 ×.

wood (Table 3). A potential shortcoming of using this classification alone is that it can indicate high treatability in woods that have a cell type such as fibers poorly penetrated. An example is *O. sumatrana* sapwood.

CONCLUSIONS

Most of the species studied appear promising for preservative treatment. Penetrability of cell types and pits and their arrangement within the wood and the presence of tyloses, gummy materials, and radial gum canals influenced treatability and uniformity of treatment. The preservative distribution in the two species with well-treated fibers suggested that flow from fiber to fiber had occurred. In species with axial parenchyma surrounding vessels, low parenchyma penetrability may have limited fiber treatment. When fibers directly contacted vessels (only apotracheal parenchyma present), fibers adjacent to vessels typically contained preservative.

TABLE 3. *Treatability classification based on PI values of Table 2 for sapwood and heartwood of the 10 Indonesian hardwoods studied.*

	Sapwood	Heartwood
C. odorata	Easily treated	Easily treated
H. ovigera	Easily treated	Easily treated
S. dulcis	Easily treated	Refractory
E. medullosum	Easily treated, incomplete penetration	Easily treated
T. nudiflora	Easily treated	Easily treated
P. becarii	Easily treated	Easily treated
B. arborescens	Easily treated, incomplete penetration	Easily treated, incomplete penetration
F. ambionensis	Easily treated, incomplete penetration	Easily treated, incomplete penetration
H. sylvestris	Easily treated, incomplete penetration	Refractory, some penetration
O. sumatrana	Easily treated, incomplete penetration	Refractory, some penetration

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