

Treatments of Rubberwood, Radiata Pine and Poplar with Copper-Chrome-Arsenate Preservative

Dave Page and R. Gnanaharan*

Abstract

Three sets of kiln dried rubberwood samples were treated with CCA preservative using modified Bethell processes with 15 minute and 45 minute pressure cycles. Both treatments resulted in patchy or incomplete preservative penetration. The longer pressure cycle did not greatly improve preservative penetration.

Four sets of radiata pine samples were treated using modified Bethell processes with various vacuum and pressure periods, similar to those used for the rubberwood. The percentage of heartwood in some samples significantly influenced preservative uptake and penetration. Increasing the pressure period from 15 to 45 minutes improved penetration and uptake.

Five sets of poplar samples were treated at moisture contents from 10% to 70% using standard Bethell and APM treatment processes. Preservative penetration was patchy in all treatments with uptake increasing as moisture content was reduced for the standard Bethell treatments. APM treatment of samples at 70% moisture content resulted in poor penetration and uptake.

Introduction

Rubberwood (*Hevea brasiliensis*) use as sawn timber has increased rapidly throughout tropical Asia in the past decade and it is now a significant part of the available wood resource in areas such as southern India (2), (3). While widely accepted for packaging, furniture, plywood and small manufactured items, it is perishable and unsuitable for use in situations where it is exposed to the weather. Preservative treatment with copper-chrome-arsenate (CCA) could improve durability but information on the distribution of the preservative in the wood, preservative efficacy and optimum treatment schedules is limited.

Rubberwood from two clones grown in southern India and from a Malaysian shipment, was treated using two treatment schedules. Four groups of radiata pine samples were treated using modified Bethell (full cell) treatment processes and four groups of New Zealand grown poplar samples were treated at several moisture contents to see whether such modifications could be of benefit in treating rubberwood.

Materials and Methods

Rubberwood

Eleven pieces of 50mm thick, kiln dried, dressed rubberwood from a single clone and twelve from another were supplied by the Kerala Forest Research Institute in

*Wood Science Division, Kerala Forest Research Institute, Peechi, INDIA

India. Another eleven pieces of 50x50mm, kiln dried, dressed timber were selected from a Malaysian shipment used in tests determine processing characteristics. These were cut to provide two 250-300mm long treatment samples and a 20mm thick biscuit from between them. The biscuit was weighed, oven dried, reweighed, resaturated and measured for volume by immersion in water. These data were used for basic density and moisture content calculations.

The treatment samples were numbered and end sealed with two coats of an epoxy paint, Devshield 235 aluminium. One set of samples was treated using a modified Bethell (full cell) treatment process in an experimental pressure treatment cylinder at the NZFRI as follows;

Treatment 1 (T1)

Vacuum (-85 kPa) held for 15 minutes

Flood with preservative solution while maintaining vacuum

Pressure (1400 kPa) held for 15 minutes

Release pressure and drain solution from cylinder

Vacuum (-85kPa) held for 15 minutes

The second set of samples was treated using a similar treatment schedule but with the pressure period increased to 45 minutes (T2). The rubberwood samples for the second treatment had been stored in the laboratory for several months and were approximately 9% moisture content when they were treated.

The preservative solutions used were a 2.7% solution (commercial salt) of "Tanalith C" (copper-chrome-arsenate), for T1 and 2.6% "Tanalith C" for T2. The samples were weighed before and after treatment. The dimensions of the samples were recorded after treatment. These data were used to calculate preservative solution uptake and preservative retention.

Radiata Pine

Four pieces of ultra high temperature dried (UHTD) 100x40mm and nine pieces of high temperature kiln dried (HTKD) 100x50mm, sawn radiata pine (*Pinus radiata*) were cut to each provide four 590 mm long treatment samples and two 20mm biscuits. The pieces included a mixture of sapwood and heartwood, including two completely sapwood and two completely heartwood. The biscuits were used for density and moisture content measurements, as for the rubberwood. One sample from each piece of wood was included in each of four treatment groups. The samples were endsealed and treated with a 1.2% preservative solution using similar schedules to those used for the rubberwood, as follows;

Treatment A - as for the first rubberwood schedule

Treatment B - as for the second rubberwood treatment

Treatment C - as for A but with a 30 minute initial vacuum

Treatment D - as for B but with a 30 minute initial vacuum

Weights and dimensions were recorded, as for the rubberwood.

Poplar

Nine pieces of 50mm thick, green sawn, locally grown Italian hybrid poplar (*Populus x euramericana*) timber were cut to provide four 590mm treatment samples and five 20mm thick biscuits. The treatment samples were sorted into four end-matched treatment groups, end sealed, weighed and placed in air drying stacks in the laboratory with 20mm thick fillets between the sample layers.

The biscuits were weighed, measured for volume and oven dried to provide data for density and moisture content calculations. An oven dry weight was calculated for each treatment sample and this was used to estimate the moisture content as the sample dried. The samples were reweighed at intervals of one or two days. As soon as a sample reached the desired moisture content for the treatment group, it was placed in a plastic bag with other "dry" samples from the group. The target moisture contents for the treatment groups were PA 70%, PD 70%, PB50% and PC 30%. When all of the samples in a group had reached the desired weight they were treated with a 1.2% CCA solution using the following schedules (Treatments PA, PB and PC were in a single treatment charge);

Treatment PA, moisture content 70%, PB 50%, PC 30%

Vacuum (-85 kPa) held for 30 minutes

Flood with preservative solution while maintaining vacuum

Pressure (1400 kPa) held for 60 minutes

Release pressure and drain solution from cylinder

Vacuum (-85kPa) held for 15 minutes

Treatment PD, moisture content 70%,

Flood with preservative solution at atmospheric pressure

15 cycles of - Pressure (1400 kPa), held for 90 seconds,

Pressure released and held at atmospheric pressure for 60 seconds

Drain solution from cylinder

Vacuum (-80kPa) held for 15 minutes

A fifth set of ten poplar samples (group PE) was cut from six pieces of timber left over from the above treatments. They had been air dried in the laboratory to about 10% moisture content, were end sealed and treated with Treatment 2 of the rubberwood treatments.

After treatment the samples were wrapped in plastic and held the laboratory for one week to allow the CCA preservative to fix in the wood. A 10mm thick biscuit was cut from the centre of each sample, air dried, sanded on one side and spot tested with rubeanic acid reagent to determine preservative penetration.

Results and Discussion

Rubberwood

Wood density and T1 moisture content for the rubberwood are summarised in Table 1, treatment details are summarised in Table 2. Basic data are in APPENDIX I.

TABLE 1 - Summary of Rubberwood Sample Details

	Moisture Content %	Basic Density (kg/ m ³)	Maximum Potential Uptake (l/ m ³)
Malaysia			
Mean	8.9	549	585
Range	8.5-9.8	485-609	541-635
Std. Deviation		39.1	29.8
India Clone D			
Mean	13.8	496	601
Range	10.9-15.5	464-547	551-626
Std. Deviation		26.1	21.4
India Clone A			
Mean	13.8	476	616
Range	12.1-16.1	447-507	586-643
Std. Deviation		18.7	15.4

The Malaysian rubberwood samples had a higher average basic density than either of the Indian rubberwood clones. They also had a wider basic density range than the Indian samples and, for T1, were drier. The moisture content was close to 9% for all samples in T2. The average basic density for Indian "clone A" was lower than for "clone D" but the difference was only 20kg/m³ and there were samples with similar basic density from both clones. The individual Indian samples were matched between treatments whereas the Malaysian samples, although cut from the same eleven pieces of wood, were not individually matched between treatments.

The Malaysian Rubberwood was relatively defect free and completely free from sapstain whereas both clones from India were severely sapstained and contained numerous small bark pockets and other defects (see Figures 3-8).

A "maximum potential uptake" was calculated for all samples using the formula;

$$\left(\frac{1000}{1.5} - \frac{BD}{1.5} \right) - \left(\frac{BD}{100} \times \frac{MC}{100} \right)$$

Where BD is Basic density in kg/ m³ and MC is moisture content percentage.

This uses a standard figure of 1.5 as the specific gravity of wood substance without air and water and hence gives an approximate "maximum potential uptake". An

"uptake ratio" was calculated by dividing actual preservative uptake by maximum potential uptake and expressing the result as a percentage.

When the "T1" results in Table 2 (see also Figures 1 & 2) are compared, the samples from Indian "clone D" had a higher uptake than either the Malaysian or the Indian "clone A" samples. This is particularly noticeable in uptake ratios where "clone D" absorbed an average of 82% of the maximum possible compared to 73% for the Malaysian samples and 71% for "clone A". This would suggest that there was a feature of the "clone D" wood which made it easier to treat.

TABLE 2 - Summary of Rubberwood Treatment Details

	Treatment 1 (T1)			Treatment 2 (T2)		
	Actual Solution Uptake (l/m ³)	Preservative Retention (T.A.E.) (kg/m ³)	Uptake Ratio %	Actual Solution Uptake (l/m ³)	Preservative Retention (T.A.E.) (kg/m ³)	Uptake Ratio %
Malaysia						
Mean	425	4.18	73	442	4.07	77
Range	363-492	3.58-4.86	66-84	381-502	3.50-4.62	66-88
Std. Dev.	41.2	0.4		43.0	0.4	
India Clone D						
Mean	490	4.82	82	523	4.81	85
Range	410-539	4.04-5.31	67-94	482-574	4.43-5.28	74-92
Std. Dev.	39.5	0.4		27.6	0.3	
India Clone A						
Mean	440	4.34	71	520	4.78	82
Range	356-504	3.51-4.96	61-80	453-563	4.17-5.18	73-87
Std. Dev.	46.6	0.4		33.7	0.3	

A similar comparison of the ("T2") results, where the moisture content of all samples was similar, does not follow the same pattern. The Malaysian samples did not absorb as much preservative as either of the Indian clones and there is little difference between the Indian clones. This suggests that either the longer pressure period improved treatment in the "clone A" samples or the variability between individual end-matched samples was very high.

If the uptake in individual samples, matched between treatments is compared (APPENDIX I), sample 2A2-1 had the lowest uptake in "T1" but one of the highest uptakes in "T2". Sample A2 had the highest uptake in "T1" but was close to average in "T2". This inconsistency between matched samples is evident for both the "clone A" and the "clone D" samples. Also some of the samples from "clone D" did not treat as well in "T2" as they did in "T1". This indicates that the variability within pieces of wood was extremely high and that the longer pressure period was insufficient to significantly improve treatment.

Figures 3-5 show preservative penetration patterns in the rubberwood samples for "T1" and Figures 6-8 penetration for "T2". It was patchy for both treatments and for all sample groups. In the Malaysian samples, penetration was largely incomplete,

regardless of the pressure period and similar for both "T2" and "T1" (Figures 3 and 6). Note that the the numbers are different for the two sets of Malaysian samples and that they are not laid out in the same order in Figures 3 and 6.

Samples from the two Indian clones show that the numerous bark pockets caused small areas of poor penetration and that that patchy treatment occurred in wood that was sapstained as well as in sound wood. The three samples which had preservative uptakes lower in "T2" than in "T1", 2D1-3, 2D2-2 and 2D3-2, have no visible characteristics that would explain the poorer treatment results. This all suggests that it is difficult to achieve complete or even preservative penetration in rubberwood and that it may not be suitable for use in situations where a high decay hazard exists.

Radiata Pine

Radiata pine sample details are in APPENDIX II, treatment details are in APPENDIX III.

TABLE 4 - Summary of Radiata Pine Treatment Details

	Solution Uptake (l/m ³)	Preservative Retention (T.A.E.) (kg/m ³)	Uptake Ratio* %
Treatment A (15,15,15)			
Mean	421	1.78	59
Range	315-569	1.17-2.41	40-79
Std. Deviation	82	0.3	
Treatment B (15,45,15)			
Mean	549	2.32	77
Range	403-673	1.66-2.85	53-94
Std. Deviation	81	0.3	
Treatment C (30,15,15)			
Mean	485	2.05	68
Range	238-626	1.12-3.07	35-97
Std. Deviation	146	0.6	
Treatment D (30,45,15)			
Mean	558	2.36	78
Range	353-742	1.49-3.14	51-100
Std. Deviation	120	0.5	

The radiata pine treatments were intended to show whether preservative uptake and penetration were significantly reduced if shorter vacuum and pressure cycles were used. Preservative uptake figures in Table 4 indicate that the difference between a 15 minute and a 30 minute initial vacuum was negligible if a 45 minute pressure cycle was used but a 30 minute vacuum gave improved preservative uptake if a 15 minute pressure cycle was used. A 45 minute pressure cycle gave

better preservative uptake than a 15 minute pressure cycle, regardless of the vacuum period. However variability between individual samples in the treatment charges far exceeded the differences between charges (Figure 9).

Preservative penetration in Figures 11-14 is not markedly different between charges although treatments B and D, where a 45 minute pressure cycle was used, show marginally better penetration than the two charges where a 15 minute pressure cycle was used. The presence of heartwood had a major influence on permeability and preservative uptake and although the samples were end matched between charges, the amount of heartwood varied between samples from the same piece of timber.

Samples 10 and 12 were sapwood and treated well in all charges. By comparison, samples 5, 8, 11 and 13 all contained heartwood which was poorly penetrated most of the time. Preservative uptake in these four partly heartwood samples, did not follow the pattern indicated by the average preservative uptake for each charge, but varied according to the heartwood percentage and the sawing pattern of each sample. Sample 5 is a good example of this, where in treatment A it contained a high proportion of sapwood and preservative uptake was higher than for any of the other treatments. If spot tests of sample 5 in Figures 11-14 are compared, treatment D appears to have given the best penetration in the defined heartwood zone and treatment B appears to have been more successful than either treatment A or treatment C.

The UHT dried timber, samples 1-4, appeared to be largely heartwood but were from young trees and did not react to chemical reagent tests for heartwood. Reasonable preservative uptakes were achieved in these samples for all treatments but penetration was streaky in the charges where a short vacuum cycle was used and uptake was very variable in treatment A, where both vacuum and pressure cycles were short.

The use of shorter vacuum or pressure cycles appears to have no advantage where wood with variable permeability is being treated. Preservative penetration is likely to be reduced where relatively short pressure cycles are used.

Poplar

Poplar sample details are in APPENDIX IIA and treatment details are in APPENDIX IV.

Preservation of dry poplar using CCA preservatives and full cell treatment processes usually results in preservative uptakes close to 600 litres/m³ but patchy penetration, particularly if the wood contains dark pathological heartwood (4). The spot test results in Figures 15-19 show typical penetration patterns for poplar with poorly treated patches mainly in the heartwood, even in the samples which were dried to 10% moisture content. As expected, preservative uptake was reduced in the groups with higher moisture content, along with penetration.

The low uptake in treatment PE and the poor penetration may have been influenced by the treatment schedule, which used shorter vacuum and pressure cycles than the schedule used for the other poplar samples. While some of the PE samples were matched with samples in the PA - PC treatments, the groups in each treatment were not completely matched.

The lowest preservative uptake was in treatment PD, the APM treatment. The APM process does not use an initial vacuum, so the air in the wood remains trapped and is compressed during the pressure stages of the process. Expansion of the air in the wood when pressure is released removes some of the preservative from the wood resulting in lower preservative uptake. The repeated pressure/no pressure cycles are intended to gradually force the preservative solution deeper into the wood, mixing it with the water remaining in the wood and giving penetration similar to that achieved by the Bethell process. Figures 15 and 18 show that the penetration in the APM charge (Figure 18) was not as good as in the modified Bethell charge (Figure 15), even though the moisture content of the wood before treatment was similar. APM treatment is normally used for wood that has been steamed before treatment and although this has a very high moisture content, pretreatment steaming improves its permeability(1). In this case, partial air drying was not adequate to allow full penetration of the preservative, particularly in the heartwood.

TABLE 3 - Summary of Poplar Treatment Details

	Moisture Content Before Treatment %	Maximum Potential Uptake (l/m ³)	Actual Solution Uptake (l/m ³)	Preservative Retention (T.A.E.) (kg/m ³)	Uptake Ratio %
Treatment PA					
Mean	68.9	558	357	1.51	64.3
Range	64.6-72.9	487-630	262-503	1.11-2.13	43.2-93.1
Std. Deviation		46.0	73.4	0.3	
Treatment PB					
Mean	50.9	617	466	1.97	75.9
Range	47.1-61.7	575-669	326-562	1.79-2.38	66.9-93.4
Std. Deviation		33.6	62.6	0.3	
Treatment PC					
Mean	29.8	686	503	2.13	73.7
Range	26.0-32.3	640-735	412-611	1.74-2.59	61.0-92.8
Std. Deviation		31.8	60.1	0.3	
Treatment PD					
Mean	69.3	557	269	1.21	48.5
Range	65.0-74.1	501-623	241-300	1.09-1.36	42.6-56.2
Std. Deviation		44.6	15.9	0.1	
Treatment PE					
Mean	10.0	757	439	4.04	58
Range		718-795	336-522	3.09-4.81	42-69
			62.5	0.6	

The differences in penetration between the samples dried to 50% (Figure 16) and the samples dried to 30% (Figure 17) or even to 10% (Figure 19), were relatively small. Preservative penetration was incomplete in all sets of samples and obviously poorer in the samples treated at 70% moisture content. Because preservative uptake decreased as moisture content increased in treatments PA-PC and penetration followed a similar but less distinct pattern, treating poplar at moisture contents above 30% moisture content could not be recommended. The partial air-drying followed by APM treatment also did not give adequate treatment.

Conclusions

Preservative treatment of rubberwood with CCA preservatives resulted in patchy preservative penetration when pressure and vacuum periods of only 15 minutes were used in a Bethell (full cell) schedule. Only minor improvements were recorded when the pressure period was increased to 45 minutes.

Preservative penetration and uptake in radiata pine heartwood were reduced when modified Bethell (full cell) treatment schedules using short pressure and vacuum periods were tested. Preservative penetration was complete in sapwood for all of the schedules used.

Preservative uptake and penetration in poplar timber were patchy and were reduced when the moisture content of the timber before treatment increased above 30%. Partial air drying to 70% moisture content followed by APM treatment did not improve penetration or preservative uptake.

References

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Figure 3. - Preservative penetration in Malaysian rubberwood, Treatment 1.
Samples are numbered from right to left, top to bottom, i.e., the top right sample is No. 1, the bottom left sample is No. 11

Figure 4 - Preservative penetration in Indian rubberwood, "clone A", Treatment 1.
Samples are in the order right to left, top row, 2A1, 2A1-1; second row, 2A1-2, 2A1-3; third row, 2A2-1, 2A2-2; fourth row, 2A3-1, 2A3-2; bottom row, A1,A2,A3,A4.

Figure 5 - Preservative penetration in Indian rubberwood, "clone D", Treatment 1. Samples are in the order right to left, top row, 2D1-2, 2D1-1; second row, 2D1-3, 2D1-4; third row, 2D2-1, 2D2-2; fourth row, 2D2-3, 2D2-4; fifth row, 2D2-5, 2D3-1; bottom row 2D3-2.

Figure 6. - Preservative penetration in Malaysian rubberwood, Treatment 2.
Samples are numbered from right to left, top to bottom, i.e., the top right sample is No. 1, the bottom left sample is No. 11

Figure 7 - Preservative penetration in Indian rubberwood, "clone A", Treatment 2.
Samples are in the order right to left, top row, 2A1, 2A1-1; second row, 2A1-2, 2A1-3; third row, 2A2-1, 2A2-2; fourth row, 2A3-1, 2A3-2; bottom row, A1,A2,A3,A4.

Figure 8 - Preservative penetration in Indian rubberwood, "clone D", Treatment 2.
Samples are in the order right to left, top row, 2D1-2, 2D1-1; second row, 2D1-3, 2D1-4; third row, 2D2-1, 2D2-2; fourth row, 2D2-3, 2D2-4; fifth row, 2D2-5, 2D3-1; bottom row 2D3-2.

Figure 11 - Preservative penetration in Radiata Pine, Treatment A (15,15,15).
Samples are in the order, right hand side, top - bottom,1-7; left hand side,
8,9,11,10,12,13.

Figure 12 - Preservative penetration in Radiata Pine, Treatment B (15,45,15).
Samples are in the order, right hand side, top - bottom,1-7; left hand side,
8,9,11,10,12,13.

Figure 13 - Preservative penetration in Radiata Pine, Treatment C (30,15,15).
Samples are in the order, right hand side, top - bottom,1-7; left hand side,
8,9,11,10,12,13.

Figure 14 - Preservative penetration in Radiata Pine, Treatment D (30,45,15).
Samples are in the order, right hand side, top - bottom,1-7; left hand side,
8,9,11,10,12,13.

Figure 15 - Preservative penetration in Poplar, Treatment PA (70% Bethell). Samples are in the order, right to left, top to bottom, i.e., sample 1 is on the top right, sample 9 is at the bottom.

Figure 16 - Preservative penetration in Poplar, Treatment PB (50% Bethell). Samples are in the order, right to left, top to bottom, i.e., sample 1 is on the top right, sample 9 is at the bottom.

Figure 17 - Preservative penetration in Poplar, Treatment PC (30% Bethell). Samples are in the order, right to left, top to bottom, i.e., sample 1 is on the top right, sample 9 is at the bottom.

Figure 18 - Preservative penetration in Poplar, Treatment PD (70% APM). Samples are in the order, right to left, top to bottom, i.e., sample 1 is on the top right, sample 9 is at the bottom.

Figure 19 - Preservative penetration in Poplar, Treatment PE (10% Bethell). Samples are in the order, right to left, top row, 1A, 1; second row, 2A, 2; third row, 5, 5A, 3; bottom row, 9A, 9, 8A, 8.