Treating four-year-old Tasmanian blue gum posts with pigment emulsified creosote

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SUMMARY

Tasmanian blue gum (*Eucalyptus globulus* Labill. ssp. *globulus*) posts cut from four-year-old trees growing in an agroforestry trial at Middlesex, 15 km south of Manjimup, were treated with Pigment Emulsified Creosote (PEC) or High Temperature Creosote (HTC).

A hot and cold bath treatment process with temperatures between 95°C and 100°C and without mechanical shearing or agitation, caused the PEC to sediment in the base of the treatment drum. Subsequent reheating did not result in increased preservative retentions in retreatments. Posts treated with HTC required three hot and cold bath cycles to achieve the required retention and depth of penetration to between 30 and 45 mm. PEC costs about 50 per cent more than HTC. This trial demonstrated the need for a method of preservative agitation to maintain a stable emulsion, if PEC is to be used effectively in this process. HTC is a suitable preservative to treat Tasmanian blue gum fence posts using the hot and cold bath process for the butts and cold soaking the crowns.

INTRODUCTION

The Department of Conservation and Land Management (CALM) and private land owners have entered into partnerships with two overseas companies in which the Department will establish Tasmanian blue gum (*Eucalyptus globulus* Labill. ssp. *globulus*) plantations over 10 years. The first partnership is with the Japanese consortium Oji-Itochu to establish 20 000 ha, centring mainly on private land on the south coast around Albany. The second partnership is with Hansol Forest Products of Korea, with 10 000 ha of Tasmanian blue gums to be planted in the Wellington catchment near Collie (CALM 1993). Although planted primarily as a source of pulpwood, the plantation can reduce the effects of salination and eutrophication through soil rehabilitation and can provide habitats for fauna (Shea and Bartle 1988).

In addition, the species can provide sawlogs for structural or appearance grade timber, if the stands are well managed. Fence posts and strainers from thinnings are an alternative product, provided they are treated with preservatives to enhance their durability, when used in contact with the ground. Previous trials involved treating two-year-old and 2.5-year-old Tasmanian blue gum (Brennan 1992; Brennan and Pitcher 1993) using High Temperature Creosote (HTC) manufactured according to AS 1143 (Standards Association of Australia 1973) using the hot and cold bath process or cold soaking.

Pigment Emulsified Creosote (PEC) is a relatively new and unique formulation which contains a micronized finely dispersed pigment, the function of which is to lock the creosote into the wood structure and inhibit subsequent bleeding or sweating of the preservative (Chin *et al.* 1986), which is commonly experienced with HTC-treated timber. PEC is manufactured as an oil-in-water emulsion, by simultaneously bringing together and emulsifying the prepared aqueous and oil phases under conditions of ultra high shear (Chin *et al.* 1986). However, prior to use in the treatment process it is inverted to a water-in-oil emulsion in which the pigment particles distribute around the water droplets. Their deposition within the structure of the timber obviates bleeding and produces a dry clean surface upon weathering. PEC has been jointly patented by CSIRO Division of Forest Products and Koppers Australia Pty Ltd in Australia (Watkins 1977 Patent No. 514897; Watkins *et al.* 1989 Patent No. 570984). Chemically, PEC is composed of 65 per cent creosote, 30 per cent water and 5 per cent surfactants, stabilizers and finely dispersed, micronized pigment (Greaves *et al.* 1986). Unlike HTC, PEC does not crystallize and presents no problems with loss of active creosote components, or with the removal and disposal of crystallized products from work and storage tanks, or from the treatment cylinder, pump lines and valves. The odour in and around treatment plants is reduced significantly and there is reduced ground pollution. In addition, weathered PEC-treated commodities are odourless and do not bleed, even at elevated ambient temperatures.

PEC-treated timber and posts exhibit relatively dry oil-free surfaces, and therefore are much easier to handle than timber treated with HTC. PEC does not emit irritating vapours like HTC and can be used to treat wood at temperatures of 30° C lower than those used with HTC. After pressure impregnation, PEC-treated posts exhibit a rust colour when weathered, whereas HTC-treated timber is a dark to black colour. Additional pigment or colourant (white, brown, etc. pigment) can be added to PEC for aesthetic reasons, to further reduce the dark creosote colour.

PEC is designed for use in pressure impregnation treatment plants with poles being commercially treated with PEC at Kopper's Grafton plant in New South Wales. If PEC is left standing in storage tanks for long periods, sedimentation can occur. A mechanical agitator or a pump to occasionally circulate PEC and an in-line homogenizer called a Dispax Reactor® is required to maintain a homogenized emulsion. PEC is stable up to a practical working temperature of 95° C, and in commercial situations PEC can be heated to 90° C when a Dispax Reactor® is used (Hawkins[1] personal communication).

In the 1950s the CSIRO Division of Forest Products developed three on-farm methods for treating fence posts; cold soaking, low-pressure soaking and the hot and cold bath process (CSIRO 1955). The hot and cold bath process involves heating the dry posts in steam, hot water or hot liquid preservative to drive out any air in the posts, followed by cooling in preservative, when atmospheric pressure assists capillary forces in moving the liquid to replace the air driven out (Dale 1967). Heating to just below 100° C in water, or to higher temperatures in oil or steam, is most effective. In this trial the dry posts were treated by the hot and cold bath process with the butts immersed in hot PEC or HTC.

In the hot and cold bath process used in on-farm treatments, a relatively small volume of PEC would be heated to between 90°C and 95°C, with some agitation achieved by putting posts in and out of the treatment drum. The aim of this trial was to determine whether PEC could be heated to between 90°C and 95°C without sedimenting, in order to treat four-year-old Tasmanian blue gum posts using the hot and cold bath process. Posts treated with HTC were used as a control.

MATERIALS AND METHODS

Approximately 65 Tasmanian blue gum posts, 50 to 130 mm small end diameter under bark (s.e.d.u.b.) and 1.7 to 2.0 m long were cut from four-year-old trees growing in an agroforestry trial at the old agricultural research station, Middlesex, approximately 15 km south of Manjimup. The trees were planted in June 1989 at 330 stem ha^{-1} in rows 15 m apart and spaced at 2 m. A 1992 thinning reduced this to 165 stem ha^{-1} and remaining trees were pruned to 2 m.

Trees were felled on 15 March 1993, docked into posts and delivered to the Wood Utilisation Research Centre (now Timber Utilisation Centre - TUC) in Harvey the following day. Posts were debarked within three days of felling by manually striking the posts with the back of an axe and removing the bark by hand or the axe blade. After strip stacking, the posts were dried to below fibre saturation point (f.s.p.), about 25 per cent moisture content (based on oven-dry weight), by a combination of air and kiln drying. After five months all posts were below f.s.p. (mean moisture content 17.7 per cent) and were considered suitable for treatment using the hot and cold bath process.

Preparation

After drying, posts were sorted into diameter classes and randomly allocated to different treatment batches. Approximately 8 per cent of posts were severely split as a result of drying and were considered unsuitable for treatment.

Prior to treatment all posts had small and large end diameters under bark, and sapwood width, measured in four positions. Sapwood and total post volumes were then calculated. The mass of posts before and after treatment was measured to determine PEC uptake. Immediately before treatment, 20 mm was removed from the ends of each post as the end grain can become blocked with kino and dirt, restricting the longitudinal movement of liquids. Air-dry densities and initial moisture contents were assessed.

Equipment

The following equipment was used for treating 1.8 m posts with creosote:

- a 205 L drum (760 mm high) for butt treatment and an extended drum (1300 mm high) to treat the crowns;
- draining troughs made by cutting a drum (205 L) in half lengthwise;
- leaning rails to support the posts standing in the draining troughs;
- electric base hot plate with a thermostat to control temperature and a multimeter or thermometer to monitor temperature;
- insulation to wrap around the treatment vessel, e.g. R 2.0 batts;
- steel mesh or a metal grid cut to fit the base of the drum, to elevate the posts off the bottom of the drum, thus allowing creosote to readily penetrate the ends of the posts;
- temporary roofing erected over the treatment drums in wet weather, as any water entering the treatment drum would cause inaccuracies when estimating preservative uptake;
- dipstick with a lineal tape attached for measuring change in creosote levels, and a measuring jug;
- safety wear of full length clothing, gloves, shoes and hat and UV barrier cream for applying to exposed skin.

When cold soaking the electric base hot plate was removed.

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Although PEC or HTC can be heated in a 205 L drum over an open fire, creosote is flammable and use of an open fire is not recommended.

Butt Treatment

The butts (760 mm) were treated using the hot and cold bath process. This process involves heating dry posts in hot creosote to drive out some air (and additional water) in the posts, followed by cooling overnight in the treatment drum, when atmospheric pressure assists capillary forces in moving the liquid into the posts, to replace the air driven out (Dale 1967). Mean moisture contents at treatment were approximately 18 per cent for the three batches treated. Appendix 1 lists the schedules for treating the butt sections for each of the batches.

During the cold cycle, creosote was absorbed into the posts, causing the preservative level to drop. Measured amounts of creosote were added to keep the level at approximately 775 mm (above the critical level of 760 mm), but at least 75 mm below the top of the drum, to allow for expansion of the preservative when heated.

The CSIRO Division of Forest Products (1961) recommended a sapwood retention of 160 kg m^{-3} of creosote (146 L m^{-3}) for the butt ends, and between 48 to 64 kg m^{-3} (44 to 58 L m^{-3}) for the crowns. The butt end retention of 160 kg m^{-3} was specified 34 years ago and is higher than the current Australian standard of 99 kg m^{-3} for posts treated to hazard level 4 (H4) (Standards Australia 1993). The volume of PEC or HTC required to achieve these retentions was estimated from sapwood volume estimates. When the butts had absorbed the estimated volume of creosote the posts were removed, and excess creosote drained into troughs, measured and returned to the treatment drum. This amount was subtracted from the initial calculation to give the actual volume of creosote absorbed by the butts. The gain in mass for each post was used to accurately determine the PEC or HTC uptake for the butt sections.

Crown Treatment

After butt treatment, posts were inverted and placed in a 205 L drum extended to 1300 mm high to allow the full length of the posts to be treated. Crown treatment involved cold soaking instead of the hot and cold bath process, owing to the lower decay hazard in the above ground section. Based on the sapwood volume and the required preservative retention, the amount of PEC or HTC needed to treat the crowns was estimated. Batch 1 required 13 days and Batch 2 seven days soaking in PEC and Batch 3 required nine days soaking in HTC to adequately treat the crown sections. After crown treatment, posts were removed and any excess preservative was drained, measured and returned to the treatment drum.

Two or three sample posts per batch were cross-cut at 100 mm, 300 mm, 450 mm, 600 mm, 700 mm and 760 mm from the butt and the sections then split longitudinally with an axe. A visual assessment of the pattern and distribution of creosote treatment on both the transverse and radial longitudinal sections was used to determine whether further treatments were required. Insufficient radial penetration of creosote into the sapwood was indicated, therefore retreatment was required. Photographic records were made of transverse and radial longitudinal sections.

All posts were individually weighed and preservative retention was estimated by gain in mass for the butts, crowns and total lengths.

Chemical Analysis

Two 20 mm diameter cores were taken 600 mm from the butt of twelve posts (four from each batch) for chemical analysis by the Chemistry and Wood Preservation Laboratory of the Queensland Forest Service. Creosote retentions in percentage mass/mass and kg m^{-3}, depth of penetration, sample moisture contents and air-dry density were determined. Analysis was carried out according to AS 1605 - 1974 (Standards Association of Australia 1974). Creosote has been found to be more difficult to extract from PEC-treated samples than from HTC-treated samples, and often the PEC-treated samples required a longer extraction period (Kennedy[2] personal communication).

Post Identification

Following treatment with PEC or HTC, posts were tagged as follows:

Batch 1 (PEC)	1-1, 1-3, 1-5, 1-6, 1-7 and 1-11 to 1-19 (14 posts);
Batch 2 (PEC)	2-1 to 2-3, 2-5 to 2-14, 2-16, 2-18 to 2-20 (17 posts);
Batch 3 (HTC)	3-1 to 3-5 and 3-8 to 3-18 (16 posts).

The gaps in the sequence are because some posts were cut to examine creosote distribution during treatment, as discussed above.

Assessment

Posts have been placed in-service at a CALM share farming property in the Busselton District to assess long term performance.

RESULTS AND DISCUSSION

Air-dry Density and Moisture Content

The air-dry densities and moisture contents for four-year-old Tasmanian blue gum posts determined before and after treatment are given in Table 1.

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Air-dry densities measured in this trial for four-year-old Tasmanian blue gums is lower than the mean density of 727 kg m^{-3} determined by Kingston and Risdon (1961), but higher than the mean air-dry density of 475 kg m^{-3} for two-year-old Tasmanian blue gums measured by Brennan and Pitcher (1993). The standard deviation of 70 kg m^{-3} indicates greater variation between samples than the 47 kg m^{-3} quoted by Kingston and Risdon (1961). The differences in age between the trees assessed in this trial, and those assessed by Kingston and Risdon (1961) and Brennan and Pitcher (1993), would contribute to the difference in densities. Low mean air-dry densities indicate thin cell walls and large cavities within cells, which should allow a greater uptake of creosote, particularly PEC, where complex surface chemistry plays a role.

Moisture contents before treatment were well below fibre saturation point (f.s.p.), indicating that the cell cavities contained no free water, which could restrict preservative uptake. Moisture contents after treatment indicated slight moisture loss during the hot and cold bath treatment process. The moisture content before and after treatment was used to calculate PEC or HTC retentions based on mass loss using a formula described by Markstrom and Gjovik (1992), and is reported below.

Butt and Crown Retentions

Table 2 lists the butt retentions in percentage mass/mass and kg m^{-3}, and depth of penetration based on chemical analysis of sample cores taken 600 mm from the butt.

TABLE 1

Air-dry densities and moisture contents before and after treating four-year-old Tasmanian blue gum posts with PEC or HTC.

BATCH	AIR-DRY DENSITY (kg m^{-3})			MOISTURE CONTENT (%)					
				BEFORE TREATMENT			AFTER TREATMENT		
	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range
1	640	70	550-790	17.8	0.7	17.0-18.9	12.8	2.5	9-14
2	640	70	550-790	17.4	1.2	16.1-19.8	12.5	1.9	11-15
3	640	70	550-790	17.9	0.7	17.3-19.2	9.8	0.5	9-10

TABLE 2

Creosote retentions in percentage mass/mass and kg m^{-3} for four-year-old Tasmanian blue gum posts, based on chemical analysis.

SAMPLE No.	BATCH 1 (PEC) RETENTION[a]			BATCH 2 (PEC) RETENTION[a]			BATCH 3 (HTC) RETENTION[a]		
	% m/m	kg m^{-3}	Depth of penetration (mm)	% m/m	kg m^{-3}	Depth of penetration (mm)	% m/m	kg m^{-3}	Depth of penetration (mm)
1	12.4	80	35 - 40	9.1	90	30 - 35	11.0	70	40 - 45
2	14.2	90	40 - 45	9.5	60	35 - 40	15.3	100	35 - 40
3	11.0	70	40 - 45	13.8	90	35 - 40	6.1	40	30 - 35
4	14.3	90	> 40	28.9	185	45 - 50	1.3	10	30 - 40
Mean	13.0	82.5	35 - 45	15.3	106.2	30 - 50	8.4	55.0	30 - 45

[a] $$\text{Creosote retention (\% mass/mass)} = \frac{\text{Mass of preservative}}{\text{Mass of core analysed}} \times 100$$

$$\text{Creosote retention (kg m}^{-3}\text{)} = \text{Creosote retention (\% m/m)} \times \frac{\text{Air-dry density}}{100}$$

where air-dry density is the density of the sample analysed.

Australian standard AS1604 -1993 requires hardwoods to be treated to hazard level 4 (H4) to have a retention of 10 per cent mass/mass or 99 kg m^{-3} mass/volume. Hazard level 4 (H4) is for timber that is used in ground contact and subjected to severe wetting and leaching, for example, fencing, greenhouses, pergolas and landscaping timbers (Standards Australia 1993). The 99 kg m^{-3} estimate is based on the air-dry density of spotted gum (*E. maculata* Hook.). Batches 1 and 2 had mean preservative retentions greater than 10 per cent mass/mass and passed the H4 requirement, whereas the lower retention of 8.4 per cent mass/mass for Batch 3 was owing to the low creosote retentions in samples 3 and 4. AS 1604 requires the retention in 90 per cent of test pieces selected from the treatment batch to be not less than 10 per cent mass/mass and 90 per cent shall pass the requirement of full sapwood penetration. Only four samples in each batch were analysed, with two samples in Batch 2 just below the required minimum retention with retentions of 9.1 and 9.5 per cent mass/mass. Two samples in Batch 3 were below the required minimum retention, particularly sample 4 which had a retention of 1.3 per cent mass/mass. Further analyses would be an advantage because of the small sample size. Errors associated with this method of estimating preservative retentions are discussed below.

All the test samples must show evidence of preservative penetration across the full sapwood band. Although starch tests were not conducted, the young age of the trees would indicate the posts consisted of sapwood. Microscopic examination did not reveal any tyloses, which indicated that there was no heartwood or transition wood present. In comparison, Nicholls and Phillips (1970) reported that heartwood formation takes place in manna gum (*E. viminalis* Labill.) when the sapwood is about 4-years-old. Penetration depths are listed in Table 2 and indicate PEC and HTC penetrating greater than 30 mm with some samples up to 50 mm. Retentions in the first 25 mm, which represents more than half the radii of the posts, would be substantially higher than in the inner portion of the analytical zone, giving the posts a greater overall strength and a longer life in ground contact. Despite these penetration depths, low retentions were still recorded and retentions based on mass gain or reduction in creosote level while the posts were immersed, gave a better overall estimation of preservative uptakes. PEC is difficult to extract by the Dean and Stark method outlined in AS 1605 -1974 (Standards Association of Australia 1974) and chemical analysis may indicate lower retentions.

The mean percentage of treated sapwood (based on the full cross section) for the butt samples analysed were :

Batch 1	59 to 76 per cent
Batch 2	54 to 90 per cent
Batch 3	55 to 82 per cent

All samples had creosote penetrating the outer 50 per cent of the sapwood and in some samples as much as 90 per cent. In AS 1604 - 1993, the requirement for H4 is for all sapwood to be treated, and the preliminary redraft of AS 2209 - 1979 requires hardwood poles of durability class 4 to have a minimum depth of penetration of 20 mm and softwood poles 35 mm (Local Government Electricity Association of New South Wales 1992). Sapwood is non durable, i.e. lower durability than class 4 heartwood. In addition, where a species has a wide sapwood band but the inner portion is refractory, creosote is required to penetrate a minimum of 20 mm or 75 per cent of the sapwood thickness, whichever is the greater (Local Government Electricity Association of New South Wales 1992). All samples indicate penetrations greater than 30 mm and some as high as 50 mm, satisfying the requirements of the redrafted AS 2209 but not achieving the full sapwood penetration requirement in AS 1604. Achieving a mean preservative treatment band of 30 mm to 50 mm should give protection to any untreated sapwood in the centre of the post and give the post an adequate residual strength in the treated annulus to ensure structural integrity.

The pole standard (redraft of AS 2209 - 1979) specifies the size of the treated sapwood band for poles used for overhead lines, where strength and durability are critical, and therefore the depth of preservative penetration is important. Fence posts do not have the same load bearing requirements and safety factors as transmission poles, and it is not as critical to achieve a minimum sapwood penetration of 20 mm or 35 mm, but to have a treated envelope of sufficient penetration to protect any untreated heartwood. Without pressure impregnation it is difficult to achieve full sapwood penetration, and in some commercial situations it would be uneconomical to treat the full sapwood bands of posts similar to those treated in this trial, owing to chemical costs.

Retentions based on mass gain for the butts, crowns and full lengths are listed in Table 3. The retention level of each post was calculated using the following equation given in Markstrom and Gjovik (1992):

$$Y = \frac{W(100 + M_1) - X(100 + M_2)}{Z(100 + M_1)}$$

Y = retention of creosote (kg m^{-3})
W = weight of treated post (kg)
X = weight of untreated post at time of moisture content determination on sample posts
Z = volume of post (m^3)
M_1 = average moisture content, oven-dry weight, of five sample posts before treatment (%)
M_2 = average moisture content, oven-dry weight, of five sample posts after treatment (%).

Individual post retentions were used to calculate the mean retentions for each batch.

Table 4 lists the post dimensions, preservative uptake and costs based on the reduction in creosote level while treating the posts. Retentions determined using Markstrom and Gjovik's (1992) formula (Table 3) are similar to those given in Table 4, but as expected are greater than those determined by chemical analysis. The

TABLE 3
PEC and HTC retentions based on mass gain for butts, crowns and full lengths.

BATCH	RETENTION (kg m^{-3})								
	BUTT			CROWN			FULL LENGTH		
	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range
1 (PEC)	170	25	135-225	92	14	65-117	127	17.4	99-165
2 (PEC)	160	26	107-236	62	10	47-83	107	17	78-148
3 (HTC)	98	18	74-143	66	11	55-89	81	12	67-105

butt retentions estimated by the reduction in creosote level while posts were immersed and mass gain methods are between two and 2.5 times greater than those estimated by chemical analysis of a small specimen. The reduction in creosote level method was 1.3 times the mass gain retentions. When estimating crown retentions, the reduction in creosote level while the posts were immersed and mass gain methods gave similar results. All methods indicated that posts treated with HTC (Batch 3) had lower retentions than posts treated with the PEC emulsion (Batches 2 and 3). Despite the lower retentions of posts in Batch 3, the retentions estimated by mass gain, and reduction in creosote level while the posts were immersed indicated retentions above the minimum requirement for H4 in AS 1604 - 1993.

All three methods have potential for errors to occur. Measuring the reduction in the creosote level with posts immersed required reading a dipstick to the nearest millimetre, but owing to the large surface area of the treatment drum a difference of one or two millimetres leads to inaccuracies. Measurements needed to be taken at similar temperatures because of the amount of creosote expansion experienced at different temperatures. Inaccuracies can occur in determining sapwood volume, because generally the boundary between sapwood and heartwood is very difficult to see in posts cut from young trees. However, the young posts treated in this trial contained all sapwood, and as stated previously, microscopic examination did not find the tyloses associated with transition wood.

The mass gain method is the more accurate method because individual posts are weighed before and after treatment, and any additional weight gain is predominantly the result of preservative uptake. Any moisture loss during treatment was between 5 and 8 per cent for the different batches and is accounted for in Markstrom and Gjovik's formula. Retentions based on this method should be used for indicating post and batch retentions and a land owner could use scales to determine weight gain and preservative uptake. Chemical analysis was based on sampling four posts per batch and the retention for the butt section was determined by two small 20 mm diameter cores taken at one position. The results of analysis of retention at that position should be accurate, but only an indication of retentions in the whole butt section.

An alternative method to determining preservative uptake by the change in the creosote level in the treatment vessel with the posts immersed, is the 'top-up method' described by CSIRO (1955) which involves :

(1) Estimating the amount of preservative that a batch of posts should absorb during butt or crown treatment (based on sapwood volume).
(2) Measuring this quantity of preservative into a container.
(3) Marking on a dipstick the level of the preservative in the drum at the beginning of the butt treatment (use a metal dipstick because the creosote will be absorbed into a dry wooden stick, leading to errors).
(4) Ensuring the level is approximately 775 mm (which is above the critical level of 760 mm), but at least 75 mm below the top of the drum, to allow for expansion when heated.
(5) As the treatment proceeds, add measured quantities of creosote from the container to the drum, bringing the level back to the original.
(6) When all the preservative from the container has been used, treatment is complete.

The 'top-up method' allows the creosote level to be maintained at a set level and ensures that no untreated gaps occur. However, regular monitoring is required during treatment, particularly if using the hot and cold bath process, to ensure that the required retentions are achieved.

In the present trial, crowns were cold soaked for 13 days (Batch 1), 7 days (Batch 2) and 9 days (Batch 3). Seventy-five per cent of the PEC absorbed into the crowns treated in Batch 1 occurred in the first five days, therefore Batch 2 was soaked for only 7 days. Batch 3 had 80 per cent of the HTC absorbed into the crowns in the first six days and 20 per cent in the next three days. Retentions determined by the mass gain or reduction in creosote level while the posts were immersed gave similar results (Tables 2 and 3). All batches passed the minimum retention requirement of 48 to 64 kg m^{-3} given by the CSIRO Division of Forest Products (CSIRO 1961).

PEC is subject to sedimentation if left standing without agitation. When treating posts by cold soaking, homogeneity is easily restored by stirring. As stated previously, PEC is an emulsion composed of creosote,

TABLE 4

Post dimensions, preservative uptake based on reduction in creosote level in treatment vessel, and cost of treating four-year-old Tasmanian blue gum posts with PEC or HTC.

Batch	No. of posts treated	Mean s.e.d.u.b. (cm)	Total sapwood volume (m^3)	Total log volume (m^3)	Preservative uptake (L)									Preservative costs ($)		
					Butt			Crown			Post					
					Total	Per post	Per m^3	Total	Per post	Per m^3	Total	Per post	Per m^3	Per litre	Per post	Per m^3
1	16	9.1	0.27	0.27	21.5	1.3	189 (L m^{-3})	10.0	0.6	64 (L m^{-3})	31.5	1.9	117 (L m^{-3})	1.77	3.36	207.09
(PEC)							207 (kg m^{-3})			70 (kg m^{-3})			128 (kg m^{-3})			
2	18	8.2	0.25	0.25	20.8	1.2	198 (L m^{-3})	10.5	0.6	72 (L m^{-3})	31.3	1.7	125 (L m^{-3})	1.77	3.02	221.25
(PEC)							217 (kg m^{-3})			79 (kg m^{-3})			137 (kg m^{-3})			
3	17	8.6	0.25	0.25	12.5	0.7	119 (L m^{-3})	9.4	0.6	65 (L m^{-3})	21.9	1.3	88.6 (L m^{-3})	1.18	1.53	103.84
(HTC)							130 (kg m^{-3})			71 (kg m^{-3})			96 (kg m^{-3})			

Retentions are based on the reduction in creosote level while treating the posts.

water, surfactants, micronized pigment and stabilizers. When PEC is heated to 95°C in a commercial pressure impregnation treatment process a homogenizer is required, i.e. the emulsion is sheared through multiple teeth generators in a Dispax Reactor® and in storage tanks an agitator is used to stir the emulsion. When PEC is used without shearing either during or after treatment, the emulsion will tend to sediment in the base of the storage cylinder.

Batches 1 and 2 required three treatments to produce the required PEC penetration and retention, however, with each subsequent hot and cold cycle it appears to become more difficult to treat the posts. The build-up of deposits (concentrated emulsion/pigments) on the post surfaces can restrict radial movement. Stirring the solution between treatments and agitating by placing posts in and out of the treatment drum did not reconstitute the PEC, with sediment remaining at the base of the drum.

Some bleeding of PEC was observed when the posts were placed in direct sunlight, which could be caused by high creosote loadings, degraded emulsion as indicated above, or air in the posts expanding when heated and thus expelling some PEC. The pigment particles are deposited within the wood structure when a vacuum is applied and the emulsion breaks within the wood cells. The pigment has the critical role of both stabilizing the emulsion and producing the clean surface of the treated commodity, upon drying and weathering. The actual colour would be regarded as a bonus. The posts remain grey until they dry, then brown as the creosote is baked on the surface of the pigment particles by heat and, more importantly, ultra violet radiation. The brown colour is caused by the weathering of dried oxidized creosote on the surface of the pole. Eventually the posts weather to appear as if they are not treated at all, that is the colour becomes grey/white. The surface of a pole treated with PEC in a pressure impregnation process normally develops a rust colour instead of the dark colour of a HTC-treated pole. This rust colour was not observed on the posts treated in this trial.

Costs

A 205 L drum of PEC was donated by Koppers Australia, as PEC is not sold commercially in 205 L drums, and a wholesale price cannot be given. However, an estimated cost of PEC is probably an additional 50 per cent above the cost of HTC, i.e. about $1.77 per L (Hawkins personal communication). This price of $1.77 per L in 205 L drums includes the cost of transportation to Western Australia and can be significantly reduced when purchased in bulk commercial volumes of 20 000 to 25 000 L. Table 4 lists the cost per cubic metre and per post based on the uptakes determined by the reduction in creosote level while posts were immersed. The amount of PEC used to treat an 80 mm to 90 mm s.e.d.u.b. post in this trial cost between $3.02 and $3.36 per post ($221 and $207 per m^3) and HTC cost $1.53 per post ($104 per m^3). Preservative costs based on retentions determined by mass gain would be slightly less, i.e. $2.36 and $3.33 per post ($172 to $205 per m^3) for PEC and $1.29 per post ($88 per m^3) for HTC. For example, the difference in retentions caused the PEC cost in Batch 2 to be reduced by $0.66 per post. The retail price in the south-west of WA of a similar size CCA-treated pine post is approximately $6.90 (based on purchasing a bundle of posts), which is double the cost of a PEC-treated post and five times that of a HTC-treated post. Transport, plant, labour and posts (if not readily available to the land owner) would be additional costs.

When PEC is used to treat posts by the hot and cold bath process or cold soaking, simple agitation equipment is required to maintain a homogeneous emulsion. This equipment is not expensive and could be economical for land owners treating fence posts. The agitation equipment could be constructed by attaching a shaft and propellor to an electric motor, with a voltage regulator used to provide a variable stirring speed. Similar low cost equipment has been built by CSIRO Division of Forest Products to stir small volumes of PEC used in experimental trials. Because the cost of PEC is an estimated 50 per cent higher than the cost of HTC, and 35 per cent more PEC is necessary to get an equivalent HTC retention, this makes PEC-treated posts expensive.

Emulsified creosote (EC), is similar to PEC except it has no pigment, and is principally used for brush-on applications for poles in ground-line maintenance operations. EC could be used as a remedial treatment for treated posts at significantly less cost (Hawkins personal communication). Commercial potential could be realized if PEC or EC were manufactured in Western Australia. At present, the indications are that commercially treated copper-chrome-arsenic (CCA)-treated pine posts are competitive, and preservative penetration would be better.

Durability In-service

Regular assessments, every one to two years for the first five years, then every three to five years, will indicate the performance of the posts in-service at the Busselton property. This will give a comparison between posts treated with PEC and HTC. The overall post condition, whether it is still serviceable and the reason/s for any post failures will be recorded. Assessments will be carried out by manually pushing each post, with the assessor maintaining a uniform loading. A close inspection of the posts below ground-line, after scraping away the soil, will indicate the presence of any fungal or insect attack. Any damage to the exposed section of the post from weathering or mechanical means will also be recorded.

Conclusions

Fence posts cut from Tasmanian blue gum trees can be effectively treated with HTC by the hot and cold bath process for the butts, and cold soaking the crowns, to retentions suitable for use in ground contact. PEC can sediment when heated and when left standing for long periods without agitation, and under these conditions would be unsuitable for land owners treating posts by the hot and cold bath process or cold soaking. PEC requires shearing or simple agitation for this application either during or after the treatment. This trial indicated a need to purchase or make up simple agitation equipment to maintain a homogeneous emulsion. The requirement for agitation and the additional cost of PEC indicates that PEC-treated posts will not be as practical and competitive as posts treated with HTC by the hot and cold bath process. Regular assessments of posts treated with either PEC or HTC will indicate the performance in-service. Posts are in-service at a property in Busselton District, and regular inspections will be made, as explained.

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APPENDIX 1

Schedules for treating the butt sections for Batches 1 and 2 (treated with PEC) and Batch 3 (treated with HTC) are listed below.

BATCH 1 (PEC)

TREATMENT	TEMPERATURE (°C)	TIME (h)
Hot cycle	29 - 55	1.5
	81	1.5
	90	0.75
Hold at 90°C for 2 h	90	1.5
		5.15
Cold cycle (overnight cool)	85	1.0
	72	2.5
	40	14.0
	32	4.0
		21.5
First retreatment Hot cycle	32.61	2.0
	82	1.5
	89	0.5
	93	1.0
Hold at 93°C for 1 h	93	1.0
		6.0
Cold cycle (overnight cool)	93 - 48	14.5
Second retreatment Hot cycle	32 - 65	1.5
	73	0.5
	80	0.5
	90	1.0
	96	0.5
Hold at 96°C for 1 h	96	1.0
		5.0
Cold cycle (overnight cool)	99 -91	1.5
	45	15.5
		17.0

BATCH 2 (PEC)

TREATMENT	TEMPERATURE (°C)	TIME (h)
Hot cycle	50 - 60	1.0
	79	1.0
	89	0.5
	99	0.5
Hold at 99°C for 1 h	99	1.0
		4.0
Cold cycle (overnight cool)	99 - 92	0.5
	89	1.0
	41	16.0
		17.5
First retreatment Hot cycle	37 - 59	1.5
	96	2.0
Hold at 96°C for 2 h	96	2.0
		5.5
Cold cycle * (2 days)	96 - 88	2.0
	40	16.0
	14	48.0
		66.0
Second retreatment Hot cycle	13 - 64	3.5
	77	1.0
	86	0.5
	90	0.5
	98	1.0
Hold at 98°C for 1 h	98	1.0
		7.5
Cold cycle (overnight cool)	98 - 31	16.5

* Longer cold cycle was used as posts were cooled in the treatment drum over a weekend.

BATCH 3 (HTC)

TREATMENT	TEMPERATURE (°C)	TIME (h)
Hot cycle	73 - 96	2.0
	103	0.5
	107	0.5
Hold at 107°C for 1 h	107	1.0
		4.0
Cold cycle (overnight cool)	107 - 83	1.5
	62	2.0
	27	13.5
		17.0
First retreatment Hot cycle	27 - 89	2.5
	95	1.0
	106	1.0
Hold at 106°C for 1 h	106	1.0
		5.5
Cold cycle (overnight cool)	106 - 94	1.5
	58	3.5
	24	16.0
		21.0
Second retreatment Hot cycle	29 - 90	3.5
	113	2.0
Hold at 113°C for 2 h	113	2.0
		7.5
Cold cycle * (2 days)	113 - 16	51.5

* Longer cold cycle was used as posts were cooled in the treatment drum over a weekend.