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Comparative Efficacy of Cypermethrin – Creosote and CCA-Creosote Treatments against Biodeterioration of Rubber Wood under Field Conditions

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Synthetic pyrethroids are increasingly being used as wood preservatives because of their high degree of contact toxicity, low solubility and low mammalian toxicity. A mixture of cypermethrin, a synthetic pyrethroid, with creosote is tried for its efficacy against biodeterioration of rubber wood under marine, atmospheric and soil conditions. This has been compared with the performance of CCA-creosote treatment, which has been effectively used for increasing the durability of many non-durable timbers. The compressive stress parallel to grain of the untreated, treated and exposed panels is assessed. The creosote component imparts higher strength to the treated wood in both types of treatments. It is seen that the cypermethrin- creosote mixture imparts resistance to biodeterioration under atmospheric and soil conditions while dual treatment with Copper-Chrome –Arsenic (CCA) and creosote is more effective under marine conditions.

Key words: CCA, compressive strength, cypermethrin -creosote mixture, field-test

Synthetic pyrethroids are synthesised derivatives of naturally occurring pyrethrins, which are taken from pyrethrum, the oleoresin extract of dried crysanthemum flowers. They are increasingly being used as wood preservatives because of the high degree of contact toxicity, low solubility and low mammalian toxicity (Carter, 1984). Cypermethrin is a light stable synthetic pyrethroid, used as a pesticide and creosote is a widely acclaimed wood preservative. The ketalcoholic dried crysanthemic and pyrethroic acid rapidly penetrate many insects and paralyse their nervous system. According to the World Health Organisation about 90% of the cypermethrin manufactured worldwide is used to combat pests feeding on cotton crops. The Environment Protection Agency has classified pesticides containing crysanthemum as toxicity class II or III (I most toxic IV least toxic). In fisheries cypermethrin is used in cage fish farming for sea lice treatment.

Copper-Chrome-Arsenic (CCA) and creosote are two major preservatives recommended for long-term protection of wood in the sea. The effectiveness of creosote as a preservative can be increased by fortifying it with more toxic agents, taking into consideration the biocidal side effects on non- target organisms. Even high retentions of creosote are not effective against *Limnoria* sp. Creosote in combination with CCA is very effective and the dual preservative treatment technology has been recommended by many researchers for effective protection of wood in the marine environment (Johnson, 1977, Edwin *et al*, 1993, Thomas 1998, Edwin & Thomas, 2000, Edwin *et al* 2001). Treatment with any kind of preservative alters the physical, chemical and mechanical properties of the wood. The mechanical properties of treated and exposed wood are also the indicators of the resistance to biodeterioration. Creosote fortified with synthetic pyrethroids has been experimented by Cragg & Eaton (1997) for their efficacy on target and non-target organisms in the sea. Synthetic pyrethroids have been studied for their effect against woodborers at sea due to their low solubility and permanence in wood (Rutherford *et al.*, 1981).

The aim of the present study is to compare the efficacy of cypermethrin – creosote treatment and CCA-creosote treatment in combating biodeterioration by assessing the compressive strength of preservative treated rubber wood panels exposed to field conditions.

Materials and Methods

Rubber wood panels were taken from a plantation grown tree felled after its useful latex yielding life. The wood had straight grains and good texture. Small clear samples of size 50 x 50 x 200mm were prepared as per IS 1708: 1986. The biocides used were cypermethrin–creosote mixture and combination treatment of CCA and creosote. Cypermethrin – creosote mixture was prepared by adding 0.004% of 0.1% cypermethrin to light creosote oil (v/v).The cypermethrin was obtained from Rallis India Ltd. Bangalore. 7.5% CCA solution was used for treatment. Light creosote oil used had a specific gravity of 1.1. Twelve sets of six samples each were prepared. Four sets were set apart as control without treatment, for exposure under marine, atmospheric and soil conditions and the fourth set for strength testing without exposure. Four sets were treated with cypermethrin – creosote mixture. The remaining four sets were treated with CCA (7.5%) followed by creosote. An intermittent drying period of 15 days was allowed between the two treatments. The preservative treatment was by steeping (immersion). The panels were kept weighted under the preservative for 22 days to achieve retention of above 320 kg/m^3 for creosote and 32 kg/m^3 for CCA, prescribed as the maximum retentions for tropical areas (Barnacle, 1976). One set, from each treatment (of 6 panels) was kept as treated controls. After treatment the panels were allowed to season for about a month. One set from each treatment along with untreated controls were arranged on an iron rack by tying with 2mm PE ropes. The panels were immersed at the institute test site. The hydrographical parameters like salinity, surface water temperature, pH, dissolved oxygen and turbidity was monitored at the test site throughout the period of the study (Table 1). The samples were subjected to visual observations every month. The rating scheme was patterned as per ASTM D- 2481-81(ASTM, 1982). The weathering test panels were fixed on iron racks by tying them to the racks and exposed in the institute terrace. The racks were then placed at an angle of 45 ^{0} to get maximum exposure to enable decay. The panels were rated at the end of the prescribed periods as per Highley (1995). The third set of panels was subjected to graveyard test in the institute premises where such tests have been carried out earlier. The specimens are buried in such a way that two-thirds of the length was inside the ground and one-third above ground. The spacing between the samples was uniform and about 30cm. Vegetation was removed manually as and when required. At the time of inspection specimens were removed from the ground, scraped clean, visually examined by using a sharp instrument and rated numerically for both decay and termite attack as per ASTM D1758 – 74 (ASTM, 1980). The period of exposure of all panels were 24 months (January 2002-December 2004).

The untreated control panels, treated control panels and the three sets of panels of each treatment exposed to estuarine, atmospheric and soil conditions were tested for compression parallel to grain test. Compression parallel to grain was selected for evaluation of loss of strength because wood has the maximum strength in the direction parallel to grain and also least shrinkage has been recorded in this direction of the grain. This test assesses the suitability of wood for frames for boat building. Before testing, the moisture content of the exposed panels was allowed to reach 12%. Tests were conducted in a 100 kN Universal Testing

Machine. The load was applied continuously throughout the test period at a speed of 0.6mm/min. The preservative treated panels and control panels were exposed to different field conditions and the results were statistically analysed using ANOVA.

Results and Discussion

The untreated control panels exposed along with the preservative treated panels under all the three field conditions were found to be completely destroyed in one year. Such panels exposed to marine conditions were destroyed within six months. The major types of borers were *Martesia* sp. and *Sphaeroma* sp. The untreated panels exposed to weathering conditions became stained and soft due to loss of wood substance. About 75% of wood substance were lost at the end of one year. The control panels subjected to graveyard test was completely destroyed by 10-11 months due to the attack of termites and fungi. The poor natural durability of rubber wood under different environmental conditions have already been established (Rao, *et al*, 1993; George, 1985)

Visual observations during the period of exposure and at the end of the study show that the preservative treated panels were in good condition. There was little or no attack by marine borers, as could be seen from outside. Panels exposed to weathering sometimes showed 'bleeding' of creosote but were free from attack of fungi and insect borers. There was no splitting and cracking. Panels exposed to soil conditions also were found to be in good condition with no signs of fungal or termite attack.

The results of compression parallel to grain test of untreated control panels and treated with cypermethrin – creosote mixture and CCA-creosote treated panels are given in the table 2. The analysis of the results of the compression parallel to grain test show that there is significant difference between the compressive stress of untreated control panels and preservative treated panels at 1% level. It is seen that the creosote – cypermethrin treated panels show an increase of 48.12% in the compressive stress. The combination treatment with CCA and creosote also showed an increase in compressive stress by 32.07%. Maximum displacement (compression) was found to be more in creosote –cypermethrin treated panels while it was less in CCA- creosote treated panels when compared to untreated control panels.

It is found that rubber wood on treatment with creosote shows an increase in

Table 1. Hydrographic parameters (2002-2004)

Month	Time	At. Temp. ^{0}C	Surface water temp.^{0}C	DO mg/l	Salinity ‰	pH	Tur. NTU
January	0920-1200	29.0-33.0	27.0-28.0	4.2-6.0	24.40-29.09	7.43-8.12	2.0-15.0
February	1025-1135	27.5-31.0	26.0-30.0	4.2-6.0	22.23-29.45	7.48-7.99	5.0-28.0
March	1020-1215	29.0-34.0	28.0-30.0	4.0-5.8	20.97-30.35	7.44-8.24	4.0-19.0
April	1010-1250	29.0-32.0	29.0-31.5	4.2-7.0	13.39-29.45	7.44-7.89	4.0-15.0
May	1055-1125	30.0-35.0	28.0-30.5	4.2-5.2	04.18-30.35	7.01-7.81	1.0-9.0
June	1025-1220	28.0-31.0	27.0-31.0	4.2-6.0	01.11-25.67	6.48-7.88	5.0-29.0
July	1045-1205	23.0-31.0	25.0-29.5	4.2-6.2	00.75-17.72	6.44-7.74	10.0-19.0
August	1025-1240	28.0-29.0	26.0-27.0	5.4-6.2	01.29-03.46	6.93-7.55	11.0-36.0
September	1015-1130	28.0-29.0	26.0-27.0	3.8-7.0	07.97-18.80	7.35-8.30	2.0-9.0
October	1005-1205	26.0-32.0	26.0-30.0	4.4-6.0	03.28-29.81	6.41-8.07	3.0-12.0
November	1035-1210	28.5-33.5	27.0-29.5	3.8-6.2	09.42-20.43	7.41-7.79	3.0-5.0
December	1055-1545	28.5-33.0	26.5-29.0	3.6-6.0	24.68-32.16	7.56-8.05	2.0-5.0

strength. Rao & Kamala (1993) observed that at higher levels of absorption CCA or oil type preservative improves the compressive stress at the limit of proportionality. A slight increase in compressive stress of 2-6% was noted in 80-85% of *Adina cordifolia* (Haldu) panels treated with creosote (Edwin & Thomas, 2000). Other creosote mixtures like arsenical creosote, copper creosote and dual treatment with CCA and creosote have also been found to cause an increase of 18.8% compressive stress (Edwin & Pillai, 2004). According to Hunt & Garratt (1953) the increase in strength may be due to the fact that creosote and creosote mixtures are inert and do not enter into chemical reaction that would affect the strength of wood. Creosote does not enter the cell wall but are restricted only to the cell cavities. Lahiry (1996) opines that the water repellent nature of creosote resists the increase in moisture of treated wood significantly, which would have caused the increase in strength. He has reported a minimum of 30% higher strength in oil borne preservatives treated timber than untreated or waterborne preservative treated timber.

Table 2. Compressive stress of untreated and treated (unexposed) rubber wood panels

Treatment	Max. Stress (N/mm^2)	Max. disp.(mm)
Untreated	24.82	3.38
	21.91	3.57
	25.75	3.24
	29.78	5.12
	31.53	5.18
	24.50	4.33
Creosote-Cypermethrin	40.38	6.41
	41.04	13.14
	39.81	5.03
	40.01	6.71
	32.19	13.75
	41.04	8.30
CCA-Creosote	30.47	4.02
	40.80	3.18
	35.65	3.06
	32.44	3.98
	34.84	3.56

The compressive stress of the two types of treated panels under each type of field exposure was also analysed using ANOVA. It is seen that there was no significant difference between marine exposed panels when the two treatments were compared. Similarly the compressive stress of panels treated with cypermethrin – creosote and CCA-creosote exposed to weathering conditions also showed no significant difference between them. However, significant difference was observed at 5% level in the compressive stress of two types of preservative treated panels under soil conditions. It is observed that treated panels exposed to field conditions show good retention of strength.

The cypermethrin – creosote treated panels exposed to marine conditions showed 32.34% loss of compressive strength when compared to unexposed (treated) control panels. In the case of CCA-creosote treated panels, marine exposure brought about a reduction in strength of 9.33% only when compared to unexposed (treated) control. Both types of treatment showed good resistance to biodeterioration under atmospheric conditions. CCA-creosote treated panels exposed to soil conditions suffered 22.07% reduction in strength. But cypermethrin – creosote panels showed 10.64% reduction in strength. In short, cypermethrin – creosote mixture performed well under atmospheric and soil conditions but not so under marine conditions. On the other hand, the combination treatment with CCA and creosote performed well under marine and atmospheric conditions than under soil conditions.

In the study conducted using different pyrethroids like cypermethrin, deltamethrin and permethrin it was found that deltamethrin was most effective against Limnoria. sp. at a loading of 16 mg/kg (Rutherford *et al*, 1981). However, in another study on the evaluation of synthetic pyrethroids for use in the sea, it was noted that there is no difference was detected between permethrin, cypermethrin and deltamethrin treatments (Cragg & Eaton, 1997). Low water solubility and permanence are properties, which make these chemicals potential preservatives for marine use (Eaton, 1985). The data on the toxicity of cypermethrin to saltwater organisms indicate that acute toxicity for crustaceans and fish begins at 0.05 microgram.l^{-1} (UK Marine, 2005). The biological activity of cypermethrin is estimated to be up to three times and deltamathrin up to ten times (Carter, 1984).

The efficacy of dual preservative treatment over single preservative treatment has already been proposed. Johnson (1977) noticed that embrittlement in CCA treated timber of high salt retention is offset by creosote in the dual treatment, which also prevents leaching of salt components. Qualitative and quantitative assessment of mango wood treated wood dual preservative showed better retention of residual strength after exposure to marine conditions when compared to timber treated with CCA and creosote separately (Edwin *et al*, 1993). A study on the effect of creosote and CCA treatments on the compressive strength of *Adina cordifolia* shows that an average reduction of 14% compressive stress was noticed in CCA treated panels and an increase of 2-6% strength in creosote treated panels (Edwin & Thomas, 2000). In a study on effect of single and dual preservative treatments on the strength of boat building timbers viz. *Artocarpus hirsuta, Antiaris toxicaria, Mangifera indica, Lagestromia lanceolata* and *Terminalia tomentosa* it was found that there is significant reduction in compressive stress parallel to grain due to CCA treatment but creosote and dual treatment do not bring about significant change in strength (Thomas *et al* 1998).

The property of creosote to impart higher strength to the treated wood is used in both types of treatment. It is seen that the creosote cypermethrin mixture imparts resistance to biodeterioration under atmospheric and soil conditions. However the effect of cypermethrin on non-target organisms have to be studied in detail.

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