

# **PRESERVATIVE TREATMENT OF RUBBER WOOD (HEVEA BRASILIENSIS)**

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## ABSTRACT

Susceptibility of rubber wood to fungal and insect attack limits its wider utilisation otherwise possible. The objective of this study was to increase the service life of rubber wood by introducing a cheap preservative into wood by diffusion process, employing a simple technique which can be carried out even in a small size saw-mill.

Treatment with boron solutions of higher concentration resulted in higher loading of chemicals into wood. However, using solutions of higher concentration has some disadvantages. This study found that adequate loading of chemicals can be obtained by using solutions of lower concentration at ambient temperature.

Immersing 25 mm thick material in a 10% boric acid equivalent (BAE) solution containing 0.5 sodium pentachlorophenoxide at ambient temperature for 40 minutes gave adequate loading of chemicals. It was found that increasing the immersion time does not increase the loading of chemicals appreciably.

Rubber wood is very permeable and it does not pose any problem for the chemicals to diffuse into the wood. Treatment with boron chemicals to a loading of 0.4% BAE was found adequate to protect rubber wood against the insect borer *Sinoxylon anale*. Material treated by diffusion process will be suitable for making furniture, door and window frames, etc.

Keywords: rubber wood, boron chemicals, diffusion process, *Sinoxylon anale*, sapstain and mould fungi.

# INTRODUCTION

Rubber, one of nature's versatile products, is obtained from the latex of a variety of plants, principally, *Hevea brasiliensis*. Hevea, a native of South American forests, was introduced to the Far East in the 1870s by the Kew Botanical Gardens, England. In India, attempt to plant *Hevea* as a forest crop was made in the teak plantations of Nilambur in 1879 and, commercial plantation was started in the 1900s (RRII 1980). Today, India is one among the few rubber growing countries of the world.

Latex is the main source of income from the rubber tree for a period of 20 to 25 years. The economic life of a tree is around 30 to 35 years including the first 5 to 6 years when the tree is not tapped for latex. After the economic life, the tree is felled for replanting the area.

Hevea is a large tree attaining a height up to 30 m and girth up to 110 cm. Rubber wood is a light-coloured wood with a basic density of 450–550 kg/m<sup>3</sup>. It is straight-grained and medium in texture. Sapwood and heartwood are not distinct.

With timber shortage all over the world with the fast depletion of forests, timber supply from all possible sources are being seriously explored. In rubber growing countries, rubber wood has been found to be a valuable source of timber. In India, the area under rubber plantation at the end of 1978-79 was estimated as 236,000 ha and out of that Kerala State accounted for about 225,000 ha (RRII 1980). A study conducted by the Rubber Board of India has shown that on an average, there were 184 rubber trees per hectare at the time of clear-felling and a tree had 0.62 m<sup>3</sup> of round wood and 0.39 m<sup>3</sup> of branch wood (RRII 1980). The Rubber Board has a programme to replant 5000 ha every year. When the programme is fully implemented, 5000 ha could furnish about 570,000 m<sup>3</sup> of round wood and 360,000 m<sup>3</sup> of branch wood every year. Though only about 80,000 m<sup>3</sup> of round wood is reported to be now available annually, there is potential for increased availability in the coming years. Timber from rubber tree will add substantially to the timber production from Kerala forests (about 450,000 m<sup>3</sup> of round wood and 300,000 tonnes of fuel wood were extracted from Kerala forests in 1978-79).

In India, at present, rubber wood is mostly used for firewood, packing-cases and, match veneers and splints. Its susceptibility to fungal and insect attack limits its wider utilisation, although studies elsewhere have established the suitability of rubber wood for furniture, panel products, etc. Rubber wood will continue to be under-utilised if it is not treated with preservative chemicals for protection against fungal and insect attack,

Preservative chemicals can be applied to wood by pressure methods or non-pressure methods. Diffusion process, a non-pressure method, works on the principle that when timber containing free water (green timber) is placed in contact with a

solution of a highly water-soluble chemical, a dilution tendency is set up and the chemical moves in solution from the zone of high concentration on the surface of the wood to the zone of zero concentration at the centre till a state of equilibrium is reached.

Generally, preservative chemical is introduced on the surface of the green timber either by dipping the timber in the chemical solution momentarily or by immersing for a longer period depending on the concentration of the solution employed. Then the timber is stored under retarded air drying conditions so as to permit distribution of the chemical throughout the cross-section of the timber.

Two early methods of diffusion process used commercially in New Zealand are known as the 'hot immersion' method and 'momentary immersion' method. In the hot immersion method, the solution concentration used is generally 3 to 6% boric acid equivalent (BAE) and the immersion times vary from 2 to 4 hours for 25 mm thick timber. In the momentary immersion method, solution concentration of 20 to 40% BAE is used and the green timber is dipped for a few seconds or sprayed on all surfaces. In both the methods, the timber is held in 'diffusion storage' for completion of the treatment, normally four weeks for 25 mm thick material. Choice of the method is dictated by practical convenience.

In pressure processes, the preservative solution is forced through the capillary structure of the wood, and it is essential that the timber is dried before treatment to ensure that the capillaries are not blocked with water. The diffusion process, however, utilises the water that is already present in green timber for the preservative solution to move inside, and, the higher the initial moisture content of the timber the more readily the diffusion proceeds. Thus the diffusion process eliminates the need for the initial drying of timber required for pressure treatment and also it does not need special equipment for the treatment.

Among the preservative chemicals, water-soluble boron compounds (borax and boric acid) are highly toxic to decay fungi and insects, and non-poisonous to mammals. Boron compounds could be applied to wood by adopting the diffusion process. But it must be noted that boron preservative is not fixed in the wood and it will leach out slowly if used outdoors. But it is well-suited for the protection of furniture items and building timbers where leaching is not a normal hazard.

The objective of this study was to increase the service life of rubber wood by introducing a cheap preservative into wood by diffusion process, employing a simple technique which can be carried out even in a small size saw-mill.

## LITERATURE REVIEW

Application of boron preservative by diffusion process on commercial scale was developed in New Zealand and Australia in the 1950s. Several articles have appeared in the literature, mostly in the New Zealand and Australian journals, in the last three decades. Bunn (1974) compiled an annotated bibliography on boron

compounds in timber preservation. This comprises review articles and papers of a general nature, references to information on methods of qualitative and quantitative estimation of boron in treated timber, references on physical phenomena which influence the practical application of boron treatment, papers dealing with methods of treating timber with boron compounds and toxicity of boron compounds to wood-destroying organisms. No attempt has been made here to review the articles covered in the above bibliography except the ones which are pertinent to the discussion in this report.

Seriousness of the susceptibility of rubber wood to insect and fungal attack is quite evident from the literature. A common blue stain fungus *Sotryodiplodia theobromae*, occurring together with surface moulds *Aspergillus* spp. and *Penicillium* spp. has been reported to infect rubber wood (Ali *et al.* 1980). Among the eight Basidiomycetes isolated from rubber wood, *Lenzites palisotii* and *Ganoderma applanatom* caused heavy damage.

Tan *et al* (1980) studied the control of fungal attack in rubber logs in storage. They found that under-water storage was the most effective method. End-treatment with fungicides, 2% Captafol or 3% sodium pentachlorophenoxide (NaPCP), incorporated in a bituminous compound gave fairly good control of fungal attack for a storage period of four weeks. In a similar study, Hong *et al.* (1980) tried various concentrations of different fungicides with and without bituminous compound (Shellkote 3). The most effective were 2% Captafol and 1% Fennotox S2 in Shellkote 3.

It has been reported in the literature that certain sapstain and mould fungi grow prolifically on boron-treated pine and other timbers during diffusion storage period (McQuire 1959). This problem was observed in the case of rubber wood also (Tisseverasinghe 1969; 1970).

Tisseverasinghe (1970) found that *Heterobostrychus* spp. and *Sinoxylon conigerum* were the most destructive insect borers of rubber wood in Sri Lanka.

Norhara (1981) documents a total of 25 beetle species as pests associated with rubber wood in the form of standing tree, felled logs and seasoned timber, in Malaysia. The common species were *Minthea rugicollis*, *Heterobostrychus aequalis*, *Sinoxylon anale* and *Xylothrips flavipes*.

The Rubber Research Institute of Malaya compiled an annotated bibliography of articles on the utilisation of rubber wood, based on the investigatory work carried out in Malaya and Sri Lanka during the 1950s and 1960s (RRIM 1972). The articles deal with the suitability of rubber wood for hardboard, particleboard, pulp and paper, etc.

Several articles have appeared in the literature recently also. Wong (1979) assessed suitability of rubber wood for plywood manufacture and found that veneers dried easily but were prone to defects like warping, end-waviness and drying splits.

Wong and Ong (1979) found that experimental rubber wood particleboards conformed to the specifications stipulated in the British Standard. However, they mentioned that a difficulty in the utilisation of rubber wood for the manufacture of particleboard was the high susceptibility of rubber wood to attack by both fungi and insects.

Ser and Lim (1980) studied the steam-bending properties of rubber wood and observed that rubber wood has the potential for solid bent works. Sim and Mohd. Arshad (1980) concluded from their study that both air-dried and kiln-dried rubber wood boards can be satisfactorily moulded and the moulding properties could be improved if the moisture content of boards is maintained at around 15%.

Sharma and Kukreti (1981) examined the seasoning behaviour of planks (28 mm) and scantlings (63 x 105 mm) of rubber wood. They reported that spring, twist and bow developed quite commonly. Rubber wood is moderately refractory and moderately stable. Sharma *et al.* (1982) determined specific gravity, shrinkage, hygroscopicity and bending property of rubber wood to assess its potential for extensive utilisation. They concluded that rubber wood is suitable for furniture and joinery after preservative treatment.

Sonti *et al.* (1982) concluded from their studies that rubber wood should be preserved with about 50% more preservative using copper/chrome/arsenic salt than normally specified for different end uses. They reported that rubber wood has good nailing and screw-holding properties and can be polished and painted quite easily.

Not much work has been carried out in India on the preservative treatment of rubber wood. This study was undertaken to develop a simple technique to introduce a cheap preservative into rubber wood by diffusion process.



## MATERIALS AND METHODS

Only freshly-sawn rubber wood planks obtained from saw-mills in and around Ollur, near Trichur, were used in the study. Boric acid ( $\text{H}_3\text{BO}_3$ ) and borax (sodium tetraborate decahydrate,  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ), both of technical grade were used.

A 200 litre steel drum was cut vertically into two and the semi-cylindrical halves were used as treatment tanks. An immersion heater was used to heat the water to facilitate dissolution of boric acid and borax for making solutions of higher concentration. A concentration chart (Anon. 1972) was used to find solution concentration from hydrometer reading and temperature of solution.

The momentary immersion method was tried first. The minimum concentration of solution required for this method will vary with the density and thickness of the wood to be treated. The suggested concentration (Winters n.d.) for medium density wood is 25% BAE for 25 mm thick material, 30% for 37 mm and 35% for 50 mm; for high density wood, it is 30% for 25 mm, 35% for 37 mm and 45% for

50 mm. In our study, solution concentration of 15 to 20% BAE was tried to treat material of up to 56 mm thickness.

The weight of the sample before and after immersion was noted. From the solution pick-up, dry salt retention was calculated in terms of BAE ( $\text{kg/m}^3$ ) and BAE% on oven dry wood basis.

Although boron chemicals are effective against decay, they are much less toxic to some common mould fungi which grow on the surface of the wood and cause discolouration. In diffusion treatment, the diffusion storage period is particularly conducive to their development. Sodium pentachlorophenoxide and 2-thiocyanomethylthio benzothiazole (TCMTB) (Trade name-Busan), both fungicides, were investigated for possible control of fungal growth. Several trials were made to see the performance of these fungicides.

Because of the difficulties experienced with the momentary immersion method, alternative methods were explored. The hot immersion method was modified to 'cold immersion' Instead of using a hot solution and lower concentration as in the hot immersion method, it was decided to try solution at room temperature with highest obtainable Concentration without resorting to heat to dissolve the chemicals It was found that solution of 10% BAE could be made at ambient temperature (about  $30^\circ\text{C}$ ). Further trials were carried out with 10% BAE solution. Also, it was decided to see the effect of increased immersion time on the loading of chemicals to compensate the temperature effect. For 25 mm square material (size 25 mm X 25 mm X 30 cm), immersion times of 40, 50, 60, 80 and 100 minutes were tried on five samples each. Chemical analysis suggested by Wilson (1959) was carried out after the samples were kept for diffusion for four weeks under polythene cover and then for air drying. The method is a simple leaching procedure followed by titration with alkali in the presence of mannitol using pyrocatechol violet as an indicator.

Treated and untreated material were exposed to the insect borer, *Sinoxylon anale*, to test the effectiveness of the cold immersion treatment developed in this study.

Material needed for a small size table was treated with 10% BAE solution. The table was assembled to ascertain the suitability of treated material for furniture.

As part of the project, attempts were made to treat 9 mm thick packing-case planks of rubber wood with a simple dipping method. Low concentration solution was used without diffusion storage. The objective was to get surface protection against insect and fungal attack for a minimum period.

## **RESULTS AND DISCUSSION**

### **Treatment with solutions of higher concentration**

Treatment with 14.9% BAE solution by momentary immersion method resulted in a higher loading in the case of 12mm thick plankst han that for 19 mm

thick planks (Table 1). In New Zealand, the specified requirement for hardwoods susceptible to the insect borer, *Lyctus*, is 0.2% BAE in the core (McQuire 1962). The core is defined as one-ninth of the area of the cross-section taken at the geometrical centre of the timber (Anon. 1972). To ensure specified core loading of 0.2% BAE, McQuire (1962) found that the overall dry salt retention should be about 1% BAE. The average values obtained in the present experiment were less than 1.0%. This suggests that concentration of the solution used was not high enough to give the required loading of chemicals. Treatment with 19.6% BAE solution gave a loading of 1.15% BAE in 12 mm thick planks and 0.91% BAE in 19 mm thick planks (Table 2). Planks of 25 to 37 mm thickness with 18.4% BAE solution showed much lower loading, ranging from 0.45 to 0.53% (Table 3).

**Table 1. Loading of chemicals obtained in rubber wood when treated with 14.9%BAE and 0.5% NaPCP solution.**

Size cm	Thickness mm	No. of Samples	Average BAE (kg/m. <sup>3</sup> )	Average BAE (%)
60x10	12	9	4.66	0.86
60 x 10	19	10	3.61	0.66

**Table 2. Loading of chemicals obtained in rubber wood when treated with 19.6% BAE and 0.5% NaPCP solution.**

Size cm	Thickness mm	No of Samples	Average BAE (kg/m <sup>3</sup> )	Average BAE (%)
60x10	12	9	6.00	1.15
60x10	19	10	4.81	0.91

**Table 3. Loading of chemicals obtained in rubber wood when treated with 18.4%BAE and 0.5 % NaPCP solution.**

Size cm	Thickness mm	No, of Samples	Average BAE (kg/m <sup>3</sup> )	Average BAE (%)
75 X 21.2	25	3	3.17	0.53
75 x 10	31	4	2.68	0.45
7 5 x 5	37	3	3.27	0.52

Using solution of higher concentration (20% and higher) has its own disadvantages. The solution has to be heated to a higher temperature. Tisseverasinghe (1969) heated the solution to 46°C to make 25% BAE solution and to 54°C to make 35% solution. Tewari and Chandrasekhar (1966) heated the solution to 50°C to make both 16.7% and 23.3% BAE solutions. Another factor is the solubility of NaPCP, a fungicide used for controlling fungal growth during diffusion storage period, in solutions of higher concentration. Tests have shown that the maximum solubility of NaPCP in a 30% BAE solution was about 0.2% (McQuire 1959). Any amount in excess of this precipitate very quickly as insoluble pentachlorophenol (PCP), the precipitate partly sinking and partly forming a scum on the surface. Although free PCP on suspension would be quite satisfactory it tends to adhere to any available surface so readily that it would soon be removed from the solution and thus lose its effectiveness.

Even if adequate solubility of NaPCP is ensured, a small size saw-mill owner will not always have facilities to heat the solution for the treatment operation. Considering these factors it was decided to try solutions of lower concentration.

### **Treatment with solutions of lower concentration**

Using a solution of lower concentration is advantageous. The boron chemicals can be dissolved in water even in room temperature. Also, dissolving fungicide NaPCP will not be difficult.

McQuire and Goudie (1972) tried a 8.5% BAE solution. But the method they adopted involved keeping 25 mm thick samples in a hot bath at a temperature of 94°C for 90 minutes and then transferring to a cold bath at a temperature of 45°C for 120 minutes. The treated samples were held for diffusion at a temperature of 40°C. By this method the diffusion time was brought down to half a week from the normal four weeks. Though this method drastically cuts down the diffusion storage period, it requires sophisticated machinery. This method will not be suitable for the operator of a small size saw-mill in India.

Tisseverasinghe (1975) developed a method to introduce preservative into wood employing the principle of differential release of capillary tension in the vessels of wood. This method involves spraying a solution of lower concentration on green wood with a spray cycle of 15 minutes on and 15 minutes off. It was claimed that full penetration was obtained in 25 mm square in 12 to 15 hours. This method was the subject of patent application. But for this, this method could be adapted to small size saw-mills. A modification of this method will be to have repeated immersions in the preservative solution for shorter times instead of one immersion for a longer time. But it will be cumbersome.

Another method which uses solutions of lower concentration is the hot immersion method. This method also involves heating the solution and considerably long immersion period. The hot immersion method is governed by the following formula (Harrow 1952):

$$\frac{\text{solution concentration \%} \times \sqrt{\text{time (hr)}}}{\text{loading \%} \times \text{thickness of timber (in)}} = K \text{ (Constant).}$$

Harrow arrived at  $K = 7$  for radiata pine and Winters (n.d.) suggests a  $K$  value of 8 for different species. Though diffusion rate will be lower at room temperature than at a higher temperature, the above formula will hold good for the cold immersion method employed in this study also.

For the hot immersion method, to get a loading of 1% BAE, assuming  $K$  to be 8, immersion time required for 25 mm thick material using 10% BAE solutions is 38.5 minutes. In the cold immersion method with the immersion time of 40 minutes, the loading was only 0.57% BAE (Table 4). This confirms that lower the temperature lower will be the loading.

**Table 4. Loading of chemicals obtained in rubber wood when treated with 70% BAE and 0.5% NaPCP solution under cold immersion method.**

Duration of immersion (min)	No. of samples	Average BAE (kg/m <sup>3</sup> )	Average BAE (%)	Average BAE (%) by chemical analysis
40	5	3.06	0.57	0.43
50	5	3.84	0.71	0.50
60	5	4.25	0.79	0.49
80	5	*	*	0.56
100	5	*	*	0.63

\* not determined

The loading increased with the increase in immersion time but the rate of increase was very low (Fig. 1). A possible explanation is that the excess NaPCP would have precipitated and adhering to the timber surface it would have inhibited additional loading of boron chemicals with increased immersion time. So, increasing the immersion time does not increase the loading of chemicals appreciably. If the solution is stirred periodically, precipitate adhering to the timber surface can be checked.

One sample which was kept immersed for 40 minutes had an average loading of 0.42% BAE; the loading on the surface was 0.58% and the core 0.30%. The core loading is higher than the specified requirement of 0.2% BAE. The average loading of 0.42% BAE also exceeds the British Wood Preserving Association's (BWPA) requirement of average total net dry salt retention of 0.4% BAE (Anon. 1972). According to the BWPA specification, the average loading of 0.43% BAE obtained by 40 minutes immersion (Table 4) is quite satisfactory so long as the core retention is above 0.2% BAE.

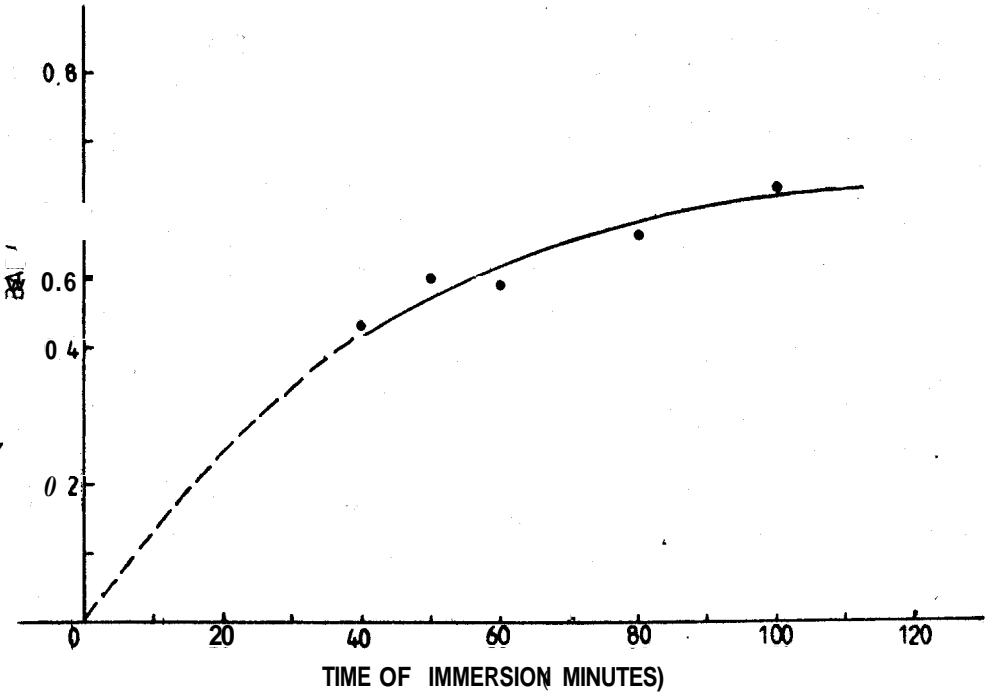


Fig 1. **Loading of chemical as a function of Immersion time**

Our study has clearly shown that for 25 mm thick material, 43 minutes immersion in a 10% BAE solution at ambient temperature will give adequate loading of chemicals. Assuming  $K$  to be 8, the formula governing the cold immersion method can be simplified to

$$T = \left( \frac{3.2 \times t}{C} \right)^2$$

where  $T$  = time, hr  
 $t$  = thickness, cm  
 $C$  = solution concentration, %BAE.

Immersion time for rubber wood of any thickness can be arrived at from the above formula.

McQuire's (1962) findings in the case of radiata pine that overall retention should be about 1% BAE to ensure a core loading of 0.2% was not applicable in the case of rubber wood. Penetration of chemicals throughout the cross-section suggests that rubber wood is very permeable and it does not pose any problem for the chemicals to diffuse into the wood in spite of lower solution temperature employed.

### Fungal problem during diffusion storage

Sodium pentachlorophenoxide is the most widely used preservative for the control of sapstain. A concentration of 0.4 to 0.5% is suggested (Anon. 1972) to

control sapstain which can develop during diffusion storage. In our study, a 0.5% concentration was used. Rubber wood treated with 15 to 20% BAE developed fungal growth during diffusion storage period in spite of the presence of 0.5% NaPCP. Tisseverasinghe (1969) also had noticed fungal growth on rubber wood planks kept for diffusion in spite of the addition of 1% NaPCP to the treating solution (25 to 35% BAE). According to Butcher (1980), the relatively low alkalinity of the concentrated boron salts solution (20%BAE) limits the solubility of NaPCP to about 0.2%. This explains why even when 0.5 to 1% NaPCP was added, sapstain could not be controlled. If solutions of higher concentration are used, control of sapstain and mould through NaPCP will not be effective..

In the place of NaPCP, a fungicide recently introduced in India, Busan, was tried. It was suggested by the manufacturer that 0.1 % Busan and 2% borax will control sapstain and mould. In field tests conducted at Brazil, only a higher dose of Busan (1.5%) showed effectiveness against sapstain and mould fungi (Milano 1981). Plackett (1982) found that treatments with 1% and 2% Busan were 89% and 97% effective respectively against sapstain and mould over a five month field test period. Though studies have been conducted to ascertain the effectiveness of Busan against mould and stain, effectiveness of Busan as fungicide in boron diffusion has not been tested (Butcher 1980).

A simple test was carried out. Four different treatment solutions were made—(1) 10% BAE; (2) 10% BAE with 0.5% NaPCP; (3) 10% BAE with 0.3% Busan and (4) water as control. Three slats, 62 x 12 x 27.5 mm, were kept immersed in each solution for 10 minutes and then kept under polythene cover for diffusion storage. Though for 12 mm thick material, two weeks of diffusion storage are sufficient, the material was kept for three weeks to get clear indications of the performance of Busan and NaPCP. Treatment with boron alone and boron plus Busan were not effective. Heavy fungal growth was seen on all the slats. Material treated with boron plus NaPCP was free from fungal attack. The control material had patches of discolouration and low fungal attack. Many trials were taken to confirm the findings.

Higher doses of Busan were not tried as they will not be cost-effective compared to NaPCP. Though the performance of NaPCP was poor with boron solutions of higher concentration, with solutions of lower concentration as tried here, it was satisfactory.

Though NaPCP has high mammalian toxicity, safer and cost-effective alternatives have not been arrived at in spite of screening many fungicides (Ali *et al.* 1980; Butcher 1980; Milano 1981; Plackett 1982). Till cost-effective alternative is found, NaPCP may continue to be used.

## **Insect attack**

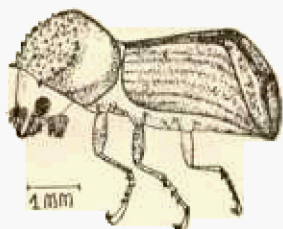
Our study showed that rubber wood in log form as well as after conversion was susceptible to heavy insect attack. These insects were collected and identified. They all belong to the order Coleoptera (beetles) (Table 5).



**Table 5. List of insects found to attack rubber wood.**

No	Species	Family	Material	
			log sawn timber	
1.	<i>Dinoderus</i> spp.	Bostrychidae		X
2.	<i>Heterobosf ry chus</i> <i>aequalis</i>	..		X
3.	<i>Sinoxylon anale</i>	..	X	X
4.	<i>S. conigerum</i>	..	X	X
5.	<i>Undetermined grub</i>	Cerambycidae	X	
6.	<i>Phaenomerus</i> <i>surde walli</i>	Curculionidae	X	
7.	<i>Minthea rugicollis</i>	Lyctidae		X
8.	<i>Platypus latifinis</i>	Platypodidae	X	
'9.	<i>P. solidus</i>	..	X	
10.	<i>Xyleborus similis</i>	Scolytidae	X	X

Out of these 10 species, *Sinoxylon anale* was noted to cause serious economic loss. This insect (Fig. 2) is small in size measuring about 5 mm. in length and dark brown in colour. It has a wide host range and attacks about 73 species of timber in India (Beeson 1941). The life cycle is short and takes only two months for completion. Under favourable conditions the generations are continuous and they overlap causing heavy damage (Fig. 3) to material under storage.



**Fig. 2.** *Sinoxylon anale* borer



**Fig. 3.** Damage caused by *S. anale*

As the cold immersion diffusion treatment with 10% BAE solution gave adequate loading of chemicals even with 40 minutes immersion, it was decided to test the efficacy of the treatment against *S. anale* attack. Material from 40 and 50 minutes immersion and untreated control ( $T_1$ ,  $T_2$ , and  $T_3$ , respectively) formed three treatment variables. There were three replicates for each treatment. The samples were put in glass bottles and 40 field collected insects, starved for 24 hours, were introduced in each bottle. The bottles were kept in a humidity chamber maintained at 52% RH at the ambient temperature of

There was considerable insect activity in the first few days in all the samples. Weekly observations were made for mortality (Table 6). After two weeks, it was observed that all the insects were dead under treated samples and an average of nine live insects were present in the control. As the contrast was very clear between the treated and untreated samples in terms of frass produced (Table 7), it was decided to discontinue the observation.

**Table 6. Mortality of *Sinoxylon anale* exposed to treated rubber wood samples.**

Observation	Treatment			—
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	
One week	31	30	7	
Two weeks	40	40	31	

**Table 7. Weight (g) of frass produced by *S. anale* when exposed to treated rubber wood samples.**

Treatment	Sample 1	Sample 2	Sample 3	Average
T <sub>1</sub>	0.31	0.22	0.28	(9.27
T <sub>2</sub>	0.25	0.19	0.20	0.21
T <sub>3</sub>	<b>3.09</b>	1.44	2.88	2.47

The frass weight data was analysed. There was a significant difference at 1% level among the treatments ( $F_{a_{2-6}} > 18.4$ ). There was no significant difference among the treatments T<sub>1</sub> and T<sub>2</sub> (Least Significant Difference was 1.04) and both were significantly different from treatment T<sub>3</sub> the control. This clearly points out that the loading of boron chemicals obtained for 25 mm thick material with 40 minutes immersion in 10% BAE solution will give effective protection against *S. anale* attack.

### Suitability of rubber wood for furniture items

A table was made with the treated material (Fig. 4). Rubber wood is easy to work with hand tools. It finishes to a fairly smooth surface. It can be polished easily. It does not split while nailing. Treated rubber wood will be highly suitable for making low-cost and medium quality furniture items, door and window frames, etc.

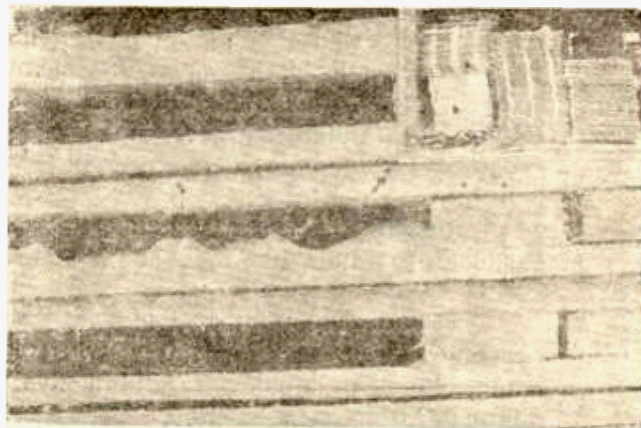
### Treatment of packing-case material

In Kotala, at present, rubber wood is mostly used for packing-cases. A number of small size saw-mill units are operating now in Kerala with rubber wood as the only raw material.

In general, for packing-cases, low-cost perishable timbers are sufficient because of the short-term utility. But they should be durable for at least six months to one year. For packing-case industry, sapstain is not a major problem but decay will degrade the wood in a short time. Also, insect borers can cause substantial damage to rubber wood as shown in Figure 5.



*Fig 4. Table made with the preservative-treated material*



*Fig 5. Borer holes (black arrow) in stacks of rubber wood planks and accumulation of dust (white arrow) between planks.*

After many trials, the following composition which proved effective in controlling insect and borer attack in packing-case planks of 9 to 12 mm thickness was arrived at. Material is dipped for a few seconds in a solution of 1.67% BAE (1% each of borax and boric acid) and 0.5% NaPCP. After draining the solution, the planks are stacked criss-cross leaving gap in between the planks to facilitate air movement and to inhibit fungal growth. The planks may be used when they are dry. Observations were made for five months on planks thus treated and there was no fungal and insect attack.

Since the packing-case planks are used sometimes to pack food articles, use of NaPCP should be avoided in such cases.

## CONCLUSIONS

Treatment with boron solutions of higher concentration resulted in higher loading of chemicals into wood. However, using solutions of higher concentration has some disadvantages. The solution has to be heated to a higher temperature, Also the solubility of sodium pentachlorophenoxide (NaPCP), a fungicide used in controlling fungal growth during diffusion storage period, is limited in solutions of higher concentration, making it ineffective. This study found that adequate loading of chemicals can be obtained by using solutions of lower concentration at ambient temperature.

Immersing 25 mm thick material in a 10% boric acid equivalent solution containing 0.5% NaPCP at ambient temperature for 40 minutes gave adequate loading of chemicals. However, it was found that increasing the immersion time does not increase the loading of chemicals appreciably. A diffusion storage of four weeks under polythene cover was necessary to get uniform distribution of chemicals throughout the cross-section.

Rubber wood is very permeable and it does not pose any problem for the chemicals to diffuse into the wood in spite of lower solution temperature employed.

Though the performance of NaPCP was poor with boron solutions of higher concentration it was satisfactory with solutions of lower concentration. Busan. another fungicide tried, was not effective in controlling sapstain and mould fungi during diffusion storage period.

Ten species of insect borers were found to attack rubber wood and among them, *Sinoxylon anale* caused substantial damage. Treatment with boron chemicals to a loading of 0.4% BAE was found adequate to protect against *S. anale* attack.

A simple dipping treatment which involves dipping 9 to 12 mm thick packing-case planks momentarily in a boron solution of 1.67% BAE (1% each of borax and boric acid) and 0.5% NaPCP was found to be effective against fungal and insect attack.

The suggested treatment for preserving rubber wood by diffusion process (cold immersion method) and for packing-case material by momentary dipping can be easily carried out even in a small size saw-mill. The material treated by diffusion process is well suited for making furniture, door and window frames, etc.

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