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SAP-STAIN IN TIMBER
EVALUATION OF ANTI-SAPSTAIN PRESERVATIVES

by

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Introduction

Sap-stain is a serious discoloration (biodeterioration) problem of fresh-cut rubberwood (Figure 1) and other sapwoods of Malaysian timbers (1,4). The major causal fungus is a blue-stain organism, *Botryodiplodia theobromae* (Figure 2), while other Deuteromycete mould fungi contribute to staining only to a minor extent. The causes of sap-stain in timber and the availability of anti-sapstain preservatives for protection of fresh-felled logs or fresh-sawn boards of these susceptible timbers have been discussed previously (1,2,3).

In the development of any wood preservative, generally four criteria must be used to judge their suitability: (i) preservative must be safe to handle and apply, (ii) preservative must be effective against the target wood biodeteriorating organism, (iii) preservative permanence (formulation stability) in required prolonged use in treated wood, and (iv) the preservative must be cost-effective. On this basis, manufactures of anti-sapstain preservatives have striven to produce formulations which are both environmentally friendly and cost-effective. However, very often products which are found to be environmentally benign have met with high environmental and energy costs associated with their production.

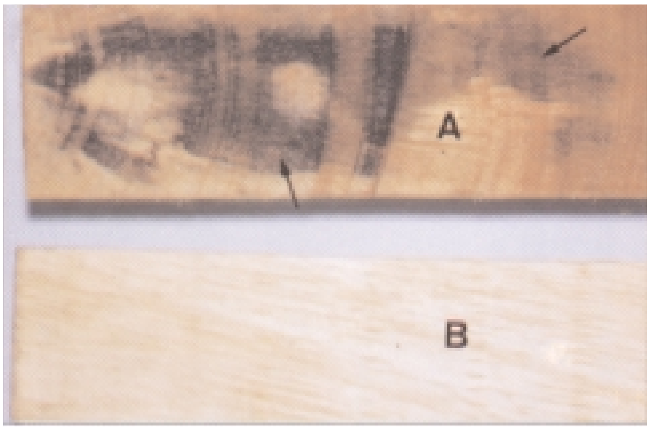

Figure 1. Rubberwood specimens with sapstain (A) and non-infected surface (B)

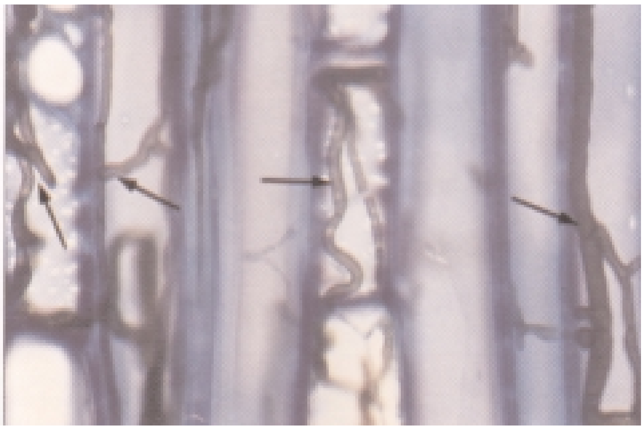

Figure 2. Microscopic view of sapstain (blue-stain) fungus,*Botryodiplodia theobromae*, in the rubberwood structure

1. Hong, L.T. 1980a. *Sap-stain in timber*. Timber Digest No. 14.
2. Hong, L.T. 1980b. *Sap~stain in timber - II. Availability of alternative anti-sapstain preservatives*. Timber Digest No. 24.
3. Hong, L.T. 1981. *Sap-stain in timber - III. Effective treatment to prevent blue-stain*. Timber Digest No. 37.
4. Hong, L.T. & Wong, A.H.H. 1994. *Biodeterioration and preservation of rubberwood (Hevea brasiliensis)*. International Research Group on Wood Preservation Document No. IRG/WP/94 -10084.

Why test anti-sapstain preservatives?

Anti-sapstain preservatives are being developed worldwide as alternatives to NaPCP which, though of proven effectiveness, is considered a health hazard to users and an environmental pollutant. Thus, the first criterion of suitability is not satisfied. These preservatives are meant to offer temporary surface protection (up to eight weeks in Malaysia, and up to six months in some temperate regions) to fresh-sawn less dense light hardwoods such as jelutong, mersawa, sesendok, ramin and rubberwood. The timbers can quickly become infected with sap-stain and mould fungi resulting in the discoloration of the sapwood. For effective surface protection, high mobility of most anti-sapstain preservatives into the wood is therefore considered less desirable. Such discoloration is normally unacceptable to buyers who regard the natural light colour of the timber, e.g. cream-coloured rubberwood, to resemble ramin wood or temperate beech. The only exception where anti-sapstain preservatives are not necessarily used is when the fresh-sawn wood is immediately kiln-dried.

Dipping (rather than spraying) of wood is the preferred application of anti-sapstain preservatives. Sodium pentachlorophenoxide (NaPCP) mixed with borax (both 2% concentration) is currently the most effective anti-sapstain preservative applied for dipping fresh-sawn rubberwood boards in Malaysia. However, the use of PCP-treated wood is banned in many countries, and in due course will also be phased out in Malaysia. Other potential replacement formulations are now being urgently sought.

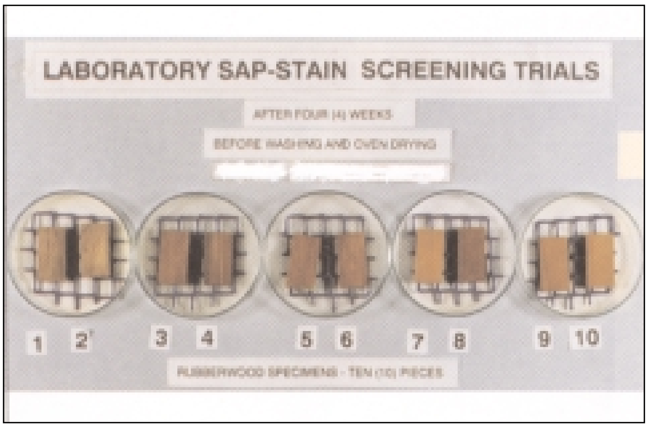

Figure 3. Typical laboratory anti-sapstain test of a preservative (undisclosed formulation) using small treated rubberwood blocks inoculated with blue-stain fungus in Petri dish

Evaluation of alternative anti-sapstain preservatives

The Forest Research Institute Malaysia (FRIM) is actively involved in evaluating the suitability of proprietary anti-sapstain chemicals for temporary protection of rubberwood and other decay susceptible hardwoods in Malaysia. This is done by assessing the efficacy of potential anti-sapstain products for use in the warm humid climatic conditions of this country. Among the various requirements to satisfy the four criteria mentioned earlier, new products must also be registered with the Pesticides Act 1974. The efficacy assessment requires stringent laboratory (Figure 3) and field tests (Figure 4-6). Such test results would form part of the recommendations to the Pesticide Board for the approval of the test preservatives. Performance of these new (or modified) preservatives are compared with the reference 2% NaCP/2% Borax mixture (e.g. Figure 4 & Figure 6 for field test), which has by far been shown to be more effective than the majority of the potential anti-sapstain preservatives tested in Malaysia.

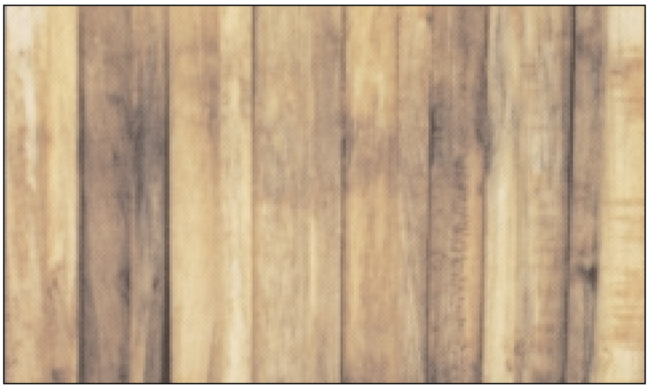

Figure 4. Typical field test of anti-sapstain preservative(undisclosed formulation) assessed on treated freshly sawn rubberwood boards

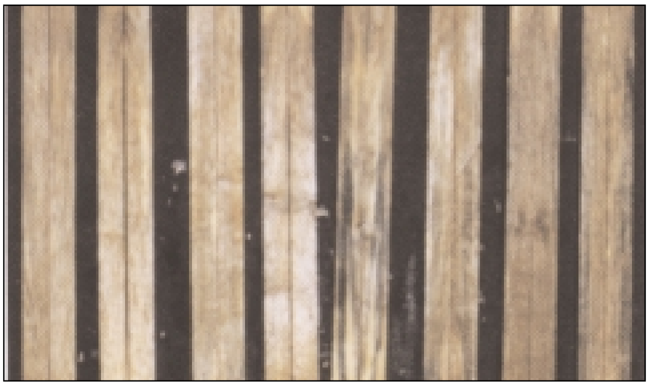

Figure 5. Typical anti-sapstain field test showing rubberwood "control" boards (without preservative) with severe sapstain

Figure 6. Typical anti-sapstain field test showing rubberwood boards treated with the reference preservative(2% NaPCP/2% borax) rnixture

New and common anti-sapstain preservatives (active ingredients) tested by FRIM

All formulations which have been laboratory or field tested are produced by international companies which have requested that product brand names, manufacturers and active ingredients be kept confidential. However, in order to indicate some progress in this area of study, typical active ingredients tested (proprietor's name withheld) have been compared with a mixture of 2% NaPCP and 2% borax. Table 1 shows some chemical compositions of potential formulations tested. Excluding NaPCP, all of the compounds listed have been incorporated into commercial formulations, singly or in combinations with active ingredients. Certain active ingredients have previously been used as fungicides in crop protection, for example some triazoles, carbendazim and chlorothalonil.

Influence of other components of preservative on performance

It has been suggested that the efficacy and stability of the active ingredients of a preservative is dependent on alterations of the emulsifier, solvent or co-solvent used as carriers of these chemicals (1). Additives such as water repellents can also influence the performance of active ingredients. However, this is beyond the scope of the anti-sapstain study in FRIM. Indeed, the performance of anti-sapstain formulations cannot be entirely due to the choice of the active ingredients used, as cited above. Unless information on emulsion system and additives is also available in addition to the active ingredients, thus yielding a sum total formulation of a particular test preservative, comparisons among the above list of active ingredients *per se* would not be adequate.

Other problems affecting the efficacy of active ingredients include the interaction of biocide and wood substrate, the nature of total formulation (active ingredients plus inert materials), timber species and quality or micro-environment conditions (1).

Table 1. Active ingredients of anti-sapstain preservatives*

ACTIVE INGREDIENTS	
Chlorinated phenol: NaPCP = sodium pentachlorophenoxide	
Boron-based compound:	Borax decahydrate = disodium octaborate decahydrate Borax tetrahydrate = disodium octaborate tetrahydrate
NaPCP + borax decahydrate (usually both mixtures at 2% w /v concentration)	
Thiocyanates, particularly Methylene-bis-thiocyanate = MBT	
Benzothiazoles, particularly 2 - (thiocyanomethylthio) benzothiazole = TCMTB	
MBT + TCMTB (usually at equal % w/w concentrations)	
Organo-metallic compound: oxine copper = Cu-8-quinolinolate = Cu-8	
Triazoles, eg. azaconazole	
Alkyl ammonium compound (AAC = quats = quatenary ammonium compound) particularly Didecyl-dimethylammonium chloride	
Iodine-based compound:	3-iodo propanyl butyl carbamate (IPBC) 4-chlorophenyi-3-iodo-propagyl formal (IF-1000)
Phenolic compound: p-cumyl phenol	
Carbamates, particularly carbendazim (methyl benzimidazol-2-yl-carbamate = MBC) IPBC	
Chlorothalonil (2,4,5,6-tetrachloroisopthalonitrile)	

*Preservatives with the above active ingredients if registered in Malaysia are sold under different trade names.

1.Williams, G.R. & Lewis, D.A. 1991. The performance of alternative anti-sapstain compounds. Pp. 275-281 in Thompson, R. (Ed.) *Proceedings of the Symposium of the Royal Society of Chemistry*. 28 February - 1 March 1991. Teddington, U.K.

Anti-sapstain formulations making in-roads

Worldwide survey has found that thiazoles, carbamates and triazoles have come to the fore in recent years as replacement for the water-soluble NaPCP (1). These groups of compounds are now being introduced in Malaysia by both the agri-pesticide and the wood preservation industries (FRIM tests). Judgements about the relative efficacies between some groups of anti-sapstain chemicals and NaPCP/borax are only subjective (non-definitive), since anti-sapstain efficacy of a formulation from field tests has been found to vary possibly due to unspecified/ uncontrolled natural conditions or to certain influences of undisclosed chemical characteristics in a formulation itself. Generally, it is found that tests under controlled laboratory conditions have given consistent reproducible efficacy results, but not necessarily so with field test results. However, given the necessity to determine the expected performance of an anti-sapstain formulation as applied commercially (mainly, dip treatment of fresh-sawn boards), field tests would therefore be more realistic. Repeated field tests (if feasible) should therefore expect to indicate some general consistency in efficacy of these alternative chemicals. Laboratory tests are nevertheless of considerable value for preliminary rapid screening of candidate formulations to provide indications (which are not necessarily definitive) of the likely efficacy of a formulation in a subsequent field test or consequent commercial application.

The common anti-sapstain compound 2(thiocyanomethylthio) benzothiazole (TCMTB) has been used (or tested) alone or in combination with methylene-bis-thiocyanate (MBT) where it is reported from overseas observations that TCMTB performs well (1). Laboratory evaluations demonstrated comparable efficacies of MBT or TCMTB/MBT mixtures with NaPCP (3). Field tests in Malaysia showed that the TCMTB/ MBT combination (both equal concentration) gave average-to-good efficacy and could come close to matching NaPCP/borax mixture (both 2% concentration) while MBT was judged less effective (5). Elsewhere, MBT was found, by field test, to perform very satisfactorily in comparison with NaPCP (2).

From FRIM laboratory tests, 3-iodo propanyl butyl carbamate (IPBC) was shown to be comparable in efficacy with NaPCP (4). In other countries, IPBC has been used extensively in retail sales formulations, paints, etc. for mould control (1).

The triazoles have also been reported to perform well against sap-stain fungi (1). While azaconazole, fenbuconazole and hexaconazole are being evaluated in Malaysia, the efficacy of these formulations and the other triazole compounds such as propiconazole and tebuconazole are being tested elsewhere. Alkyl ammonium compounds (AACs) tested in Malaysia appear to be only of moderate efficacy although these compounds are among the potential chemicals for anti-sapstain and above-ground applications in the developed countries (1).

Copper-8-quinolinolate (oxine copper) is also being used as an anti-sapstain chemical and for aboveground applications. This compound has been used in Australasia (mainly New Zealand) and has been fieldtested in Malaysia either singly or in combinations with other active ingredients. The anti-sapstain efficacy of oxine copper appears to match NaPCP/borax mixture. Oxine copper is classified as being "environmentally friendly" due to its extreme low toxicity coupled with its low effective dosage, and has been given by the United States Food and Drug Administration (USFDA) approval for use in food contact.

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1. Barnes, H.M. 1993. *Wood protecting chemicals for the 21st. century*. International Research Group on Wood Preservation Document No. IRG/WP/93-30018.
2. Dickinson, D.J. 1977. The effective control of blue-stain and mould of freshly-felled timber. *Hokforschung* 31: 121-125.
3. Hong, L.T. 1980. *Sap-stain in timber - II. Availability of alternative sap-stain preservatives.* Timber Digest No. 24.
4. Hong, L.T. 1989. *Performance of proprietary formulations of anti-sapstain preservatives on Hevea brasiliensis timbers in laboratory test.* International Research Group on Wood Preservation Document No. IRG/WP/3532.
5. Lewis, D.A. & Spence, M. 1985. The prophylactic treatment of green rubberwood. Pp. 124-139 in Daljeet Singh, K., Choo, K.T. & Hong, L.T. (Eds.) *Proceedings of the 2nd. Rubberwood Utilization Seminar*. Kuala Lumpur. 19-20 November 1985.

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