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THE INTERNATIONAL RESEARCH GROUP ON WOOD PRESERVATION

Preliminary Investigation on the Natural Durability of Guayule (*Parthenium argentatum*)-Based Wood Products

by

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ABSTRACT:

Conventional preservatives used to protect wood from insect and microbial damages are presently of major concern to human health and the environment. Finding alternative and economical preservatives has not been successful. Previous studies have shown that the resinous material extracted from the guayule plant (*Parthenium argentatum*, Gray) has both insect- and microbial-resistant properties. Unfortunately, it has not been accepted commercially because of the lack of an adequate supply of the raw material. However, the potential domestication of the guayule plant to produce hypoallergenic rubber latex will result in the production of large amounts of waste wood material. This should provide opportunity to use this natural source of the biologically resistant resinous chemicals. The objective of this preliminary study was to determine the effects of the rubber latex-removed wood residues or bagasse and the resinous extracts on termite- and decay-resistant properties. Two types of test materials were used in the study. One was wood impregnated with organic-solvent extracted resinous material from the plant. The other was composite wood fabricated using the residue or whole plant and plastic binder, which was used to improve the physical properties of the composite. Accelerated laboratory tests were conducted to determine the resistance of the wood products against the Eastern subterranean termite and wood fungi (brown-rot). The wood and stem of the guayule plant, wood treated with the resinous extract, and particle and composite wood made from ground guayule exhibited termite and wood fungal resistance.

KEY WORDS: Brown-rot, decay, durability, extractives, fungus, guayule, bagasse, particleboard, specific gravity, termite, thickness change, weight loss, wood composite.

I. INTRODUCTION

Conventional preservatives used to protect wood from insect and microorganism damages are presently of major concern to human health and the environment. Finding alternative preservatives has not been simple. Previous study indicates that the resinous material extracted from the guayule plant (*Parthenium argentatum* Gray) had anti-termitic and anti-fungal properties (Bultman et al., 1991). This resin material is a by-product from the process for extracting rubber from the guayule shrub (Bultman et al., 1998). Unfortunately, the application of these findings has not been commercialized because the rubber extraction project was terminated, and consequently, an adequate source of the resin material was not available. Similarly, other plants have termite resistant compounds, but the plants are not readily cultivated for economical commercial production.

At present, the predicted commercialization of guayule for its hypoallergenic rubber latex will result in the production of a significant amounts of wood residue or bagasse, which would be considered waste material that must be disposed. It is estimated that about 60 t/ha of bagasse will remain after latex extraction. Several hundred thousand hectares of guayule will be required to fulfill the hypoallergenic latex requirement of the United States alone. Because the bagasse still contains the resinous material with its biocontrol properties, it should be a good natural source for making insect- and fungal-resistant wood. The bagasse can be directly incorporated with adhesives to make composite wood. The fabrication of this type of wood has not been seriously considered before. In addition, the resin extracted from the bagasse can be used to treat other types of wood. The production of insect- and rot-resistant wood should automatically reduce the need to harvest wood and avoid the cost of replacing termite-damaged wood structures.

In recent years, wood supply for making wood composites has become scarce and expensive in the United States because of competition from the paper industry for wood fiber. Thus, board producers will be forced to seek non-wood plant fibers to supply the increasing raw material requirement in the future.

Weight loss during the mycological testing of particle and fiberboards was reported as a good measure of decay resistance (Chow et al., 1980, 1993, 1994, and 1996). Walters and Chow (1975) reported that phenolic resin bonded boards are preferred in building construction for protection against water and high humidity. However, fungal attack in the phenolic bonded board was as severe as that in the urea bonded board. When composition board becomes wet, it swells mostly in thickness and in length, and considerable bonding degradation occurs.

The objective of this preliminary study was to determine the termite-and decay-resistance of various combinations of the guayule plant This includes composite wood made with guayule bagasse, wood impregnated with the resin extract, and the plant stem.

II. MATERIALS AND PROCEDURE

Three types of test materials were used in this study:

1. Southern yellow pine wood (*Pinus* spp.) impregnated with resinous material extracted from the guayule plant. The resin in this study is defined as the polar solvent extractable material removed from guayule. One guayule resin based on the azeotropic (acetone + pentane) extraction and fractionation, was supplied by Dr. Bultman and similar to the one used in his original study (Bultman et al., 1991). This resin material was diluted with acetone at different ratios and pressure-impregnated into the wood blocks to achieve various resin contents. Another guayule resin material consisted of using acetone alone as the extraction solution. For the resin treatment, wood blocks were placed into a pressure chamber and the system evacuated until maximum vacuum was attained. The acetone-guayule resin solution was then introduced to fill the chamber. Pressure using nitrogen gas was applied at 700 kPa for 30 min. After the impregnation treatment, the wood was oven-dried at 60° C to remove the volatile acetone solvent. The gain in weight of the wood block was attributed to the resin absorbed by the wood and on the surface of the block. Little if any excess resin was observed on the surface even at the highest resin concentration used.

2. The experimental composite particleboard was made from ground guayule plant residue without any binder. The bagasse contained approximately 10% rubber and 10% resinous material. Composite boards were made from the bagasse using commercial thermal-setting liquid phenol formaldehyde (PF) synthetic adhesive and a high-density polyethylene (HDPE) powder. The PF content of the composite was 6% and 30% for the HDPE. Guayule composition boards approximately 279-by-279 mm were made with a specific gravity of 0.8, 1.0, and 1.2 and thickness of 8.5 mm, 11.0 mm, and 14.0 mm. All composite boards were pressed on a steam-heated hydraulic press at about 160 EC at pressures of between 7.3 Mpa and 10.4 Mpa.

3. The guayule plant stem (composed of bark and core portion) was also tested to determine the decay and termite resistance properties of the unaltered, natural material.

All decay resistance specimens were tested according to ASTM method D2017 (ASTM, 1999) using cultures of two common brown rot fungi: *Gleophyllum trabeum* (ATCC 11539), and *Poria placenta* (Fr.) Cook (ATCC 11538). In this exploratory study, only duplicates that included two specimens of each fungus, guayule resin-extract content, and test materials type were used because of the limited amount or resin material available. Each cylindrical 225-cm^3 culture bottle contained one specimen of the test material. After between 65 and 80 days of exposure to fungus, specimens were removed from the test bottles, reconditioned, reweighed, and recalipered to determine the weight loss and dimensional changes.

Seven termite resistance test specimens were tested according to ASTMD-3345 (ASTM, 1999) using Eastern subterranean termites of *Reticulitermes* spp. for this preliminary experiment. Termite activity in each bottle was observed and rated after only one week.

III. RESULTS AND DISCUSSION

The guayule resin extract when impregnated into the southern pine made it resistant to fungal attack (Table 1). Resistance to *G. traveum* started at 10.3% resin content and 51.8% for *P. placenta.* At resin contents of 51.8% and higher, the treated wood was highly resistant (*G. traveum*). In a similar manner, the specific gravity change was less at the higher resin contents. Bultman et al. (1991) reported that the resin material inhibited *the activity* of *several types* of brown-rot (*Gleophyllum trabeum, Antrodia carbonica, Fomitopsis cajanderi,* and *Lentinus Ponderosa*) and white-rot (*Dichomitus squalens, Trametes versiclor,* and *Ganodermas* sp.) fungi. Maatooq et al., (1996) identified several eudesmane-type sesquiterpenoids extracted from the guayule plant that had antifungal activities.

The decay resistance of southern pine that was treated with two types of resin extracts is compared in Table 2. The acetone-only extract and the dual acetone + hexane extract or azeotropic extract (Bultman) showed similar results to decay resistance. The dual solvent extract also contained some rubber (Bultman et al., 1998), which could help reduce the leaching of resin from the wood.

The decay resistance and dimensional stability of composite board made from guayule bagasse are shown in Table 3. Both the composite board with phenolic resin and the particleboard without resin were resistant to *G traveum* and *P. placenta.* The composite board with 30% HDPE as the binder showed resistance to the two fungal organisms. The guayule board with no adhesive had the largest change (98 and 137%) in thickness. Thus, the guayule bagasse even though it has some resinous material and rubber will need a water-resistant type adhesive. The guayule stem alone had moderate resistance to fungi and also a negative thickness change unlike the other wood types.

Impregnation of guayule resin extract into wood at 50% and higher is needed to make the wood resistant to termite attack (Table 4). At the highest level of 97% resin content, complete termite mortality was achieved For the guayule composite board with 30% HDPE, 100% mortality occurred. The guayule particle board without any adhesive had a mild termite activity. Interestingly, the guayule branch material alone was termite tesistant causing high mortality. Bultman et al. (1991) had treated wood with a full-strength resin mixture and obtained 100% and higher resin retention in the wood. Their resin-impregnated *wood* samples were able to resist *Coptotermes, Heterotermes,* and *Reticulitermes* spp The eudesmane sesquiterpene argentone in the guayule resin was observed to be the most active ingredient for inhibiting termite activity (Gutierrez et al., 1999).

Iv. SUMMARY

The following conclusions can be made from this study:

1. The effects of the guayule resin extract contents on the decay resistance, specific gravity, and thickness change of the impregnated or treated southern pine wood specimens appeared to be significant. The treated specimens appeared to have greater resistance to *G. trabeum* than *P. placenta.* The latter wood-rotting fungus often causes decay in millworks and in wood situated above ground.

2. Southern pine wood specimens impregnated with both an acetone extract and the Bultman resin (acetone + hexane) were resistant to two types of wood-rotting fungi. Both the phenolic adhesive bonded, and the guayule only particleboard showed good decay resistance property (two fungi). The plastic composite board made from 70% guayule and 30% HDPE was highly resistant to both types of wood rotting fungi.

3. Both the phenolic adhesive bonded, and non-bonded guayule residue and stem fiber particleboards showed good decay resistance property to the two test fungi. The composite boards made from 70% guayule and 30% HDPE were highly resistant to both wood-rot fungi.

4. The natural guayule stems and branches were found to have some decay resistance property.

5. Most of the guayule fiber composite boards had a reduction in specific gravity of about 20% as a result of the thickness swelling of the specimens. Excessive thickness swelling and specific gravity reduction occurred to the specimens made from 100% guayule plant fiber without incorporating any phenolic adhesive.

6. The composite board made from 70% guayule fiber and 30% HDPE, the guayule branch, and specimens consisting of 97% guayule resin-extract all had anti-termitic property. Even the nonadhesive guayule particleboard and southern pine wood treated with 51.8% guayule resin extract showed some termite resistant property.

7. The results of this exploratory experiment indicate that further extensive studies are needed to determine the extent of both the insect and microbial resistant properties of the guayule plant. The plant appears to be a good renewable, and alternative natural source of wood preservative and possibly could be cultivated for this property alone.

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VI. ACKNOWLEDGEMENT

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Table 1. Average weight loss, specific gravity reduction, and thickness change of southern pine treated with guayule resin extract.

Guayule resin in wood (%)[a]	*Gleophyllum traveum*		*Poria placenta*	
	Weight Loss (%)	Rating (ASTM)[b]	Weight Loss (%)	Rating (ASTM)
0	58.60	Non-resistant	47.64	Non-resistant
2.6	52.46	Non-resistant	50.98	Non-resistant
10.3	22.42	Resistant	45.00	Non-resistant
51.8	8.69	Highly resistant	36.65	Moderately resistant
97.0	2.95	Highly resistant	11.11	Resistant
	Specific gravity reduction (%)	Thickness change (%)	Specific gravity reduction (%)	Thickness Change
0	40 (0.62)[c]	-7.1	39 (0.61)	-1.1
2.6	32 (0.62)	-5.5	34 (0.61)	-4.7
10.3	20 (0.66)	-1.5	35 (0.63)	-1.0
51.8	11 (0.84)	0	25 (0.85)	-4.9
97.0	7 (0.94)	+1.6	5(0.96)	-0.3

[a] Quantity (weight percent) of guayule resin extract that combined with the wood
[b] ASTM D-2017 standard
[c] original specific gravity

Table 2. Decay resistance and durability of southern pine treated with two different types of guayule resin extract.

	Gleophyllum trabeum		*Poria placenta*	
Resin-extract treated pine	Weight Loss (%)	Rating (ASTM)[a]	Weight Loss (%)	Rating (ASTM)
Acetone extract	10.48	Highly resistant	4.64	Highly resistant
Bultman resin	12.89	Resistant	8.29	Highly resistant
	Specific gravity reduction (%)	Thickness change (%)	Specific Gravity Reduction (%)	Thickness change (%)
Acetone extract	12 (0.69)[b]	-2.0	8.0 (0.68)	-1.4
Bultman resin	13 (0.58)	-3.5	10.0 (0.59)	-2.3

[a] ASTM D-2017 standard
[b] original specific gravity

Table 3. Decay resistance and dimensional stability of guayule composition boards and guayule stem.

Guayule Stem & Composites	*Gleophyllum trabeum*		*Poria placenta*	
	Weight loss (%)	Rating (ASTM)[a]	Weight Loss (%)	Rating (ASTM)
PF Adhesive, 14 mm	13.94	Resistant	19.61	Resistant
No Adhesive, 8 mm	19.66	Resistant	23.99	Resistant
30% HDPE, 11 mm	6.46	Highly Resistant	5.68	Highly Resistant
Guayule Stem (with bark & wood core)	30.28	Moderately	12.72	Resistant
	Specific Gravity Reduction (%)	Thickness Change (%)	Specific Gravity Reduction (%)	Thickness Change (%)
PF Adhesive, 14 mm	20 (0.83)[b]	+8.0	4 (0.77)	+8.1
No Adhesive, 8 mm	46 (1.28)	+98.0	67 (1.26)	+137.0
30% HDPE, 11 mm	21 (1.00)	+16.2	20 (1.02)	+16.1
Guayule stem (with bark & wood core)	12 (0.40)	-14.3	14 (0.42)	-13.0

[a] ASTM D-2017 standard

[b] original specific gravity

Table 4. Eastern subterranean termite resistance of southern pine treated with guayule resin extract, composite boards, and guayule branch.

Resin Treated Southern Pine	Observation (after one week)	Rating (ASTM)[a]
0%	100% of termites still alive	No mortality
10.3%	90% of termites still alive	No mortality
51.8%	30% of termites still alive	Low mortality
97%	0% of termites alive	High mortality
Guayule particleboard (no adhesive)	30% of termites still alive	Low mortality
Guayule composite board with 30% HDPE	0% of termites alive	High mortality
Guayule branches	0% of termites alive	High mortality

[a] ASTM D-3345 standard

THE INTERNATIONAL RESEARCH GROUP ON WOOD PRESERVATION

IRG/WP 00-60124

Agenda 2000 Plenary Meeting

Time: Monday 15 May 08.30-09.30
Friday 19 May 12.00-12.30

Place: Kona Surf Resort, Hawaii, USA

Agenda:

Monday 15 May 08.30-09.30

1. Opening of the meeting
2. Approval of the agenda
3. Ratification of the election of new members
4. Announcement of the year 2000 Ron Cockcroft Award recipients
5. Approval of the Annual Report 1999 and Auditors' report
6. Granting discharge for the Executive Council and Secretary-General for the administration and accountancy for 1999

Friday 19 May 12.00-12.30

7. Election of new officers
8. Appointment of auditors
9. Approval of membership fees for 2001
10. Approval of the budgets for 2000 (forecast) and 2001
11. Future venues
12. Any other business
    -notification of future international meetings
13. Closure of the meeting