Evaluation of 15 Years Old Teak Heartwood Extractives against Termite Attack

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Abstract
The objective of this study was using teakwood extractive as natural wood preservative for protecting nondurable wood against termite. Heartwood of teak at the age of 15 from Thong Phapoom plantation in Kanchanaburi province was extracted with 2 solvents : Dichloromethane and Petroleum ether by using hot extraction method. Termiticidal efficiency of extractives was investigated and compared with standard Tectoquinone and Lapachol by using Rubberwood as wood specimens. Field experiment was conducted in ground contact condition for 3 months in Rachaburi province. The results revealed that 2.00% Dichloromethane extract and 2.54% Petroleum ether extract showed significantly good performance in protecting treated Rubberwood against termite attack, as well as, 2.00% Tectoquinone. However, 0.10% Lapachol was not able to resist the termite attack as it showed severe damage in the same level as control. Two species of subterranean termite; *Microtermes obesi* and *Microcerotermes paracelebensis* were found in the field experiment. Moreover, the quantity of Tectoquinone and Lapachol in these two extracts were further determined by using TLC (Thin Layer Chromatography) and densitometer methods. The results showed that there was Tectoquinone 0.12 % in Dichloromethane extract and trace in Petroleum ether extract. Both of them were not found any percentage of Lapachol substance.

Keywords *: teak heartwood extractives, termite attack, Tectoquinone, Lapachol, teak plantation*

Introduction
Teak *(Tectona grandis* Linn.) is a native wood in Southeast Asia such as Thailand, India, Indonesia, Myanmar , Malaysia, etc. Now it has been cultivated in many countries including Africa and Caribbean. Teakwood is considered as the most important high quality hardwood. Because it occupies many valuable characteristics such as beautiful texture, excellent mechanical properties and especially, high natural durability. (Sandermann and Dietrichs, 1957; Windeseisen *et al*, 2003). It was reported that teakwood coffin could be used for over hundred years in underground condition, in Indonesia. This durable property was vary with the age of teakwood. (Simatupang *et al*, 1999.) Many reports were also pointed out for its superior resistance to biodegradation agents, for instance to fungi, beetle and termites. Extractives isolated from naturally resistant heartwood of teak also reflecting effectiveness to these agents. (Wong *et al*, 1998; Thulasidas and Bahat , 2007; Tascioglu *et al*, 2012).

Biodegradation of wood by termites is recognized as one of the most serious problems for wood utilization in Thailand. (Sornuwat,1996a). There were many toxic wood preservatives were used in attempts to minimize termite damage, as a result, potential damage of the environment and

risks for human health. For recognition these problems, some environmental friendly wood preservatives were developed to enhance the durability of wood without the use of conventional toxic ones. Hence, wood extractives from teakwood was a dominant alternative for using as wood preservative in this aspect.

Anthraquinones and naphthoquinones are the major group of natural chemicals that found in teak heartwood extractives that made teakwood become high durable species. The most well-known of anthraquinones group is Tectoquinone, which plays a principal role in durability of teakwood. On the other hand, one of the important chemical in group of naphthoquinones is Lapachol. This substance was reported as toxic substance to termite. These effective chemicals were noted that corresponding directly to the maturity of wood (Wolcott, 1947; Sandermann and Dietrichs, 1957; Wong *et al*, 1998)

Therefore, the objective of this study were :

1) To determine the quantity of Tectoquinone and Lapachol in this wood extractives as air-dried weight.
2) To evaluate termite resistance property of 15 years old teak heartwood extractive as natural wood preservative for protecting nondurable wood as rubberwood.

Materials and methods

Part 1 Teak Heartwood Extraction

1 Sample Preparation

Teakwood samples, at the age of 15, from Thong Papoom plantation, Kanchanaburi province were cut into dishes and selected only heartwood partitions. After air-dried for 1 month, they were chopped, grinded and winnowed with glider passing through 40 and 60 mesh sieve. Using sample collected on 60 mesh sieve.

2 Wood Extractives Extraction

The 60 mesh wood sample was extracted with petroleum ether (boiling point 40-60 ° C) by using grass Soxhlet apparatus. Duplicated experiments were used for each sample. Petroleum ether extracted solution was then evaporated by vacuum rotary evaporator and recorded an amount of Petroleum ether crude extract.

Petroleum ether extractive free wood sample was then air-dried and extracted again with Dichloromethane by using the same apparatus and technique. Finally, an amount of Dichloromethane crude extract was also calculated after solvent evaporation.

3 Determination of Tectoquinone and Lapachol

Thin Layer Chromatography (TLC) technique was used to determine quality checking for Tectoquinone and Lapachol in both crude extracts; Petroleum ether and Dichloromethane , in comparison to, a series of standard Tectoquinone and Lapachol by using Camag Linomat IV

spotting instrument. Chloroform was responsible as a diluting blank in this study. This TLC technique was run in a condition of Petroleum ether and Dichloromethane mixture in a ratio of 1 : 4. Preliminary qualitative checking was done under Ultra Violet light at the wavelength of 254 nm. The concentration of Tectoquinone and Lapachol in each crude extract on TLC plate were determinate by using Densitometer instrument at the wavelength of 258 nm.

Part 2 Wood Treatment

1 Preparing testing solution

Preparing 5 type of testing solutions to specific concentration by using chloroform/as solvent;

1) Petroleum ether extracts from teak heartwood 2.54%
2) Dichloromethane extracts from teak heartwood 2.00%
3) Standard Tectoquinone 2.00%
4) Standard Lapachol 0.10%
5) Pure chloroform as blank or control

2 Treating wood specimens

Rubberwood *(Hevea brasiliensis)* specimens (2.0 X 2.0 X 2.0 cm) with 12 % of moisture content were soaked with 5 testing solutions by using vacuum method for 30 minutes and then air-dried for 1 month. Before subjection to termite resistance testing, these treated wood specimens were oven-dried at 60^{o} C and weighed for their original weights.

3 Testing for termite resistance

5 groups of treated wood specimens were investigated for their efficiency against termite in ground contact condition. This experiment was carried out in Rachaburi province by using Completely Randomized Design with 4 replications.

A circular cement tube (80 cm. in diameter and 60 cm. in height) was installed on the planned ground and thickened the ground inside with 5 cm. of sand. A set of treated wood specimens in each replication were randomly arranged on the sand and recorded their location layout in each cement tube before closing it with a lid.

4 Inspection and Evaluation

After 3 months exposure period, all treated wood specimens were carefully removed off, cleaned, oven-dried at 60^{o} C, reweighed and calculated for their weight losses. Visual inspection was also used to evaluate for percentage of damage on each wood specimen and classify its durability level according to the rate as shown in detail below (Sornnuwat,1996 b). The percentage of weight loss and visual rate were subjected to statistical analysis for determination the effects of treating substances.

Percentage of damage	Visible attack on wood	Classified durability
0	None	Very durable (VD)
1-15	Hardly visible damage	Durable (D)
16-40	Superficial and slightly damage	Moderately durable (MD)
41-75	Moderately damage	Non durable (ND)
> 75	Heavy damage	Perishable (P)

Results

Part 1 Teak Heartwood Extraction

The percentages of Petroleum ether and Dichloromethane crude extracts of teak heartwood from Kanchanaburi province at the age of 15 and theirs active ingredients ; Tectoquinone and Lapachol were demonstrated in Table 1. The preliminary checking of these substances on TLC plate under UV light at the wave length of 254 nm were exhibited in Figure 1 and Figure 2

Table 1 Percentage of crude extract, Tectoquinone and Lapachol contents in teak heartwood from Thong Phapoom plantation, Kanchanaburi province, at the age of 15 years old.

Substances	**Petroleum ether (%)**	**Dichloromethane (%)**
Crude extractive	8.24	2.87
Tectoquinone	Trace	0.12
Lapachol	Not found	Not found

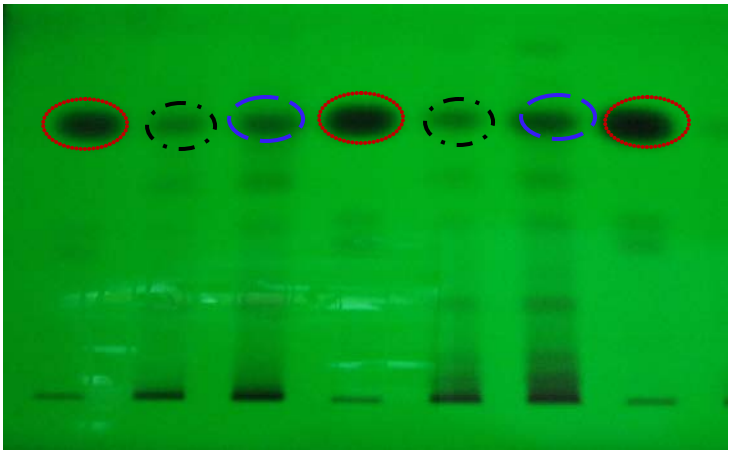


Figure 1 Preliminary checked of Tectoquinone in teak heartwood extract and standard Tectoquinone by TLC under UV light at the wave length of 254 nm

Standard

Tectoquinone in Petroleum ether crude extract

Tectoquinone in Dichloromethane

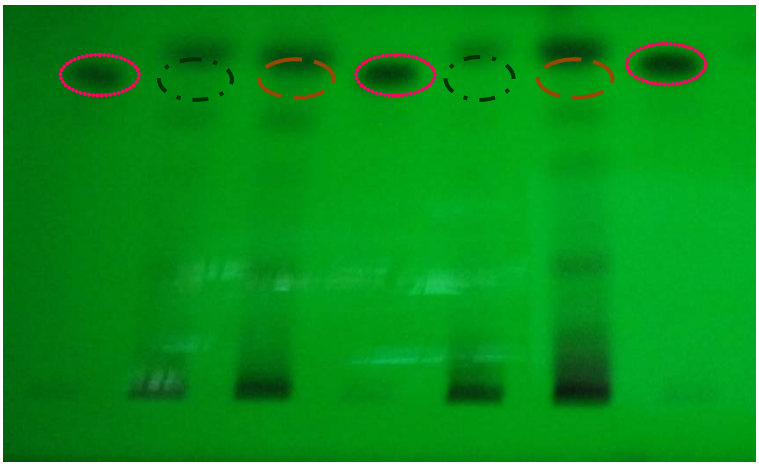


Figure 2 Preliminary checked of Lapachol in teak heartwood extract and standard Lapachol by TLC under UV light at the wave length of 254 nm

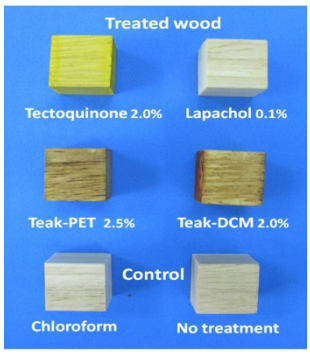
Standard Lapachol

No Lapachol in Petroleum ether crude extract

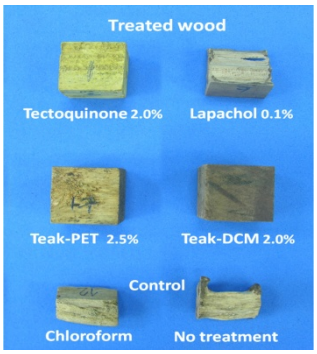
No Lapachol in Dichlomeyhane crude extract

Part 2 Wood Treatment

Rubberwood specimens after 3 months exposure period and results of their termite resistance evaluations were shown in Figure 3 and Table 2.



Before testing (A)



After testing (B)

Figure 3 Wood specimens (A) before testing termite resistance in ground contact condition (B) after 3 months testing.

Table 2 Percentages of damage of wood specimens evaluated by visual rate and weight loss after 3 months exposure in ground contact condition.

Treating substances	Concentration (%)	Percentage of Damage		Durability level
		Visual rate	Weight loss	
Tectoquinone (standard)	2.00	1.50 a	5.88 a	D
Lapachol (standard)	0.10	51.25 b	42.15 ab	ND
Petroleum ether extract	2.54	7.75 a	7.99 a	D
Dichloromethane extract	2.00	6.75 a	9.94 a	D
Control (Chloroform)	-	55.75 b	55.01 b	ND
Control (No treatment)	-	76.25 b	75.17 b	P

Note : Means having the same letter in the same column are not significantly different by Duncan's New Multiple Range Test at 95 % confidence level

Discussion

The two crude extracts of teak heartwood from Kanchanaburi province at the age of 15 illustrated different in percentages. Petroleum ether crude extracts showed higher percentage (8.24 %) than Dichloromethane one (2.87%). The preliminary qualitative checking on TLC plate under UV light at the wavelength of 254 nm revealed that there were Tectoquinone in crude extract of Petroleum ether and Dichloromethane (Figure 1), but unable to find Lapachol in these two extracts (Figure 2).

The quantitative determination of these two natural chemicals by using Densitometer instrument at the wavelength of 258 nm indicated that there was only trace amount of Tectoquinone in Petroleum ether crude extract, but greater percentage in Dichloromethane one (0.12 %). On the other hand, for Lapachol, could not be found in both of these crude extracts (Table 1).

After treating rubberwood specimens with these crude extracts and testing for their termite resistance in field test for 3 months in ground contact condition as shown in Figure 3 and Table 3, 2 species of subterranean termites were found attacking the test specimens; namely *Microtermes obesi* (subfamily : Macrotermitinae) and *Microcerotermes paracelebensis* (subfamily : Termitinae). For the treated wood specimens, 2.0 % Tectoquinone standard showed best performance to protect rubberwood against subterranean termite attack. The treated rubberwood specimens were very slightly destroyed and gave smallest in percentage of damage and weight loss (1.50 and 5.88%). However, these figures were found no statistically significant differences from those ones of 2.54 % Petroleum ether (7.75 and 7.99%) and 2.00 % Dichloromethane extracts (6.75 and 9.94%). In general, it could be stated that all of them were in the same level of efficiency and performance for making wood more durable to termite attack. They could upgrade treated rubberwood durability from perishable and nondurable level in the 2 groups of controls (no treatment and chloroform treatment) to durable level. On the other hand, rubberwood specimens treated with standard Lapachol in lowest concentration (0.10%) demonstrated that this level of concentration was too low to retard the termite attack. The treated specimens were heavy destroyed and classified to nondurable level, as well as control group treated with chloroform.

These different in results might be attributable to the quantitative of Tectoquinone and Lapachol that presenting inside the Petroleum ether and Dichloromethane extracts. Thanom and Dietrichs (1967) stated that these two substances directly affected to termite. This was corresponded to Kittirattakarn and Sornuwat (2002) reported that Tectoquinone had a repellent activity against termite. It inhibited termite feeding but showed no toxic to termite. Because of higher in concentration of Tectoquinone found in Dichloromethane extract (0.12%), compare to trace in Petroleum ether extract, thus, Dichloromethane extract should show better performance than Petroleum ether extract. But the results did not correlate with this trend, both extracts demonstrated in the same efficiency. Therefore, there might be other effective substances inside the Petroleum ether extract that could retard termite attack.

Conclusion

In 3 months of this testing, Petroleum ether and Dichloromethane extracts from 15 years old of teak heartwood from Kanchanaburi plantation showed excellent efficiency in protecting rubberwood against subterranean termite attack in ground contact condition. These two extracts could improve durability of termite attack from perishable level to durable level, therefore, they

could be highly potential to be used as natural wood preservative for protecting nondurable wood against termite attack.

Literature cited

Kitirattrakarn,T. and Soranuwat,Y. 2002. Tectoquinones in Plantation Teak. Forestry Annual Conference. Royal Forest Department. Thailand. 14 p.

Sandermann,W. and H.H.Dietrichs. 1957. Untersuchungen uber termitenresistente Holzer, Holz als Roh-u. Werkstoff . 15:281–297 *In* Thanom Premrasmi and H.H.Dietrichs. 1967. Nature and Distribution of Extractives in Teak (*Tectona grandis* Linn) from Thailand. The Natural Histry Bulletin of Siam Society. Bangkok. 22 (1&2):1-14.

Simatupang, M.H. and Koichi Yamamoto. 1999. Properties of Teakwood(Tectona grandis L.f.) as Influenced by Wood Extractives and its Importance for Tree Breeding. *In* Regional Seminar on Site Technology and Productivity of Teak Plantations. Chiang Mai. pp 1-17.

Sornnuwat, Y.,1996 a. Survey and observation on damage houses and causal termite species..In. Studies on damage of constructions caused by subterranean termites and its control in Thailand. Wood Res. No. 83 : pp 8-22

Sornnuwat, Y.,1996 b. Resistance of commercial termites and fast growing timbers of Thailand for building constructions to Coptotermes gestroi Wasmann. In. Studies on damage of constructions caused by subterranean termites and its control in Thailand. Wood Res. No. 83 : pp 96-106.

Tascioglu, C., Yalcin, M., Troya,T.,and Sivrikaya, H. 2012. Termiticidal Properties of some Wood and Bark Extracts Used as Wood Perservatives. BioResources 7 (3) : 2960-2969.

Thanom Premrasmi and H.H. Dietrichs. 1967. Nature and Distribution of Extractives in Teak (*Tectona grandis* Linn) from Thailand. The Natural History Bulletin of Siam Society. Bangkok. Vol. 22. No. 1&2. 14p.

Thulasidas, P.K. and Bahat , K.M. 2007. Chemical Extractive Compounds Determining the Brown-rot Resistance of Teak Wood. Holz Roh Werkstoff 65 : 121-124.

Windeseisen, E.,Klassen, A. and Wegener, G. 2003. On the Chemical Characterisation of Plantation Teakwood from Panama. Holz als Roh.und Werkstoff 61: 416-417.

Wolcott, G.N. 1947. *The Permanence of Termite Repellents.* Journal of Economic Entomology. 40:124.

Wong, A.H.H., Grace, K.G. and Kirton, L.G. 1998. Termite Resistance of Malaysian and Exotic Woods with Plantation Potential : Field Evaluation.10 p.