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Response of *Coptotermes curvignathus* (Isoptera: Rhinotermitidae) to Formaldehyde Catcher-treated Particleboard

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Abstract: The objective of this study is to investigate the feasibility of formaldehyde catcher as termites repellent. Single-layered UF-bonded particleboard was post-treated with formaldehyde catcher and heat respectively. Besides that, some boards were also produced with the formaldehyde catcher was added into the resin during the blending process, called add-in method. Particleboard post-treated with formaldehyde catcher reported the most severe attack. Heat-treated particleboard showed slightly better durability than the control blocks while the add-in catcher showed the best durability among three methods. A valid test was obtained as the termites survived the first week of the test. However, all the termites were found dead at the end of the test.

Key words: Biological degradation, post treatment, formaldehyde catcher, *Coptotermes curvignathus*, heat treatment, biological durability

INTRODUCTION

Invasion of termites is one of the biological degradation that occurs on natural wood and wood composite products such as particleboard. Duryea *et al*. (1999) stated that termites exist throughout hot and warm climate areas and they account for majority of damage to wood in use. *Coptotermes curvignathus* is classified as the family of Rhinotermitidae, one of the three termite families exist in Peninsular Malaysia (Pong, 1975). Several researchers (Tho and Kirton, 1992, 1998; Kirton *et al*., 1999) reported that *Coptotermes curvignathus* is primarily a pest of nearly all the tree species as well as wooden structures in Peninsular Malaysia.

Applications of toxic and repellent chemical preservative are now widely used in wood industry. However, some chemical are now unacceptable due to their toxicity to the environment (Peralta *et al*., 2004). Regarding to this, many studies have been carried out to confer the resistance ability of wood towards termites attack. Post heat treatment, for example, has proved effectively improve the dimensional stability of particleboard (H`ng *et al*., 2012), also has significant influence on the attack of termites (Doi *et al*., 1997, 1999).

Formaldehyde catcher was widely applied by many manufacturers as an additive to bring down the formaldehyde emission from particleboard. It can be applied directly to the surface of the board or added into the resin during the blending process. However, due to the lack of literature reviews on the post-treatment liquid formaldehyde catcher, the ability of the formaldehyde catcher as termite's repellents is not yet fully known. The purpose of this research was to determine the termite-resistance of particleboards conferred by formaldehyde catcher.

MATERIALS AND METHODS

Preparation of particleboard: The rubberwood particles were oven dried with the temperature of 60°C to obtain the Moisture Content (MC) of 3%. The rubberwood particles, resin, hardener and wax, were weighed according to particleboard manufacturing recipe. The particles were then put in the blender and sprayed with the adhesive mixture. The particles were allowed to be blended in the blender for 5 min to make sure that the mixture really mixed well.

After 5 min, the resinated particles were taken out from the blender and weighed. Then, the particles were spread evenly on into a 340×340 mm wooden mould with a caul plate as the base to form a loose mat. The mat formed was then pre-pressed manually to consolidate the thickness. Next, the mat was hot pressed in a thermal-oil heated hydraulic hot press machine with the temperature of 180°C with a specific pressure of 18 kg cm^{-2} to achieve target board thickness of 12 mm. The mat was pressed for 4½ min based on the recommendation of the resin supplier and the particleboard manufacturing factory located in Negeri Sembilan.

The boards produced were conditioned for 24 h before the formaldehyde catcher was applied. Table 1 shows the test design for this study.

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Fig. 1: Bridging of termites

Table 1: Test design

Type control	Treatment	Description
S1	Post	Apply 40 g m^{-2} formaldehyde catcher on the surface
S2	Post	Apply 50 g m^{-2} formaldehyde catcher on the surface
S3	Post	Apply 60 g m^{-2} formaldehyde catcher on the surface
A1	Add-in	Add in 2% of formaldehyde catcher into resin
A2	Add-in	Add in 4% of formaldehyde catcher into resin
A3	Add-in	Add in 6% of formaldehyde catcher into resin
H1	Post	heat-treated at 180°C for 10 min

Three different dosage of the formaldehyde catcher which was 40, 50 and 60 g^{-2}, was applied directly onto the two surface layers of the boards using a sponge. Another three boards was produced by adding 2, 4 and 6% add-in formaldehyde catcher in the resin, respectively. One board was served as control while another one was treated with 180°C for 10 min. The boards were then conditioned for another 7 days in a conditioning room maintained at a relative humidity of 65±5% and 20±2°C prior to evaluation.

Termites test

Collection of termites: *Coptotermes curvignathus* were collected from infested trees, in Bukit Expo, UPM (Universiti Putra Malaysia). Termites were trapped by using pine wood blocks and cardboard as bait.

The termites shaken out on to a tray and were separated from collection debris using the bridge method (Fig. 1). The termites were later transferred to another container, which was filled with moistened filter paper to ensure the survival of the termites.

Preparation of test blocks: Wood samples subjected to the test were prepared and each was cut into replicate test wafers of 25 mm^2. Five replicates were prepared for each variable. The test blocks were oven dried at 45°C in the laboratory until they reached constant weights. All blocks were labeled and the mass were recorded.

Preparation of test medium: Sand sieved with mesh sieve No. 16 (aperture: 1.18 mm) was used as media in this test. Plastic screw-top jar of 80 mm diameter by 100 mm in height were filled with approximately 150 g of sand (Fig. 1). After that, 30 mL of distilled water was added into the sand. The containers were allowed to stand for two hours for better distribution of the water and facilitation of the termite activities.

The test block was placed on the surface of sand with two corners of the block against the side of the container. 1±0.05 g of termites (approximately 90% workers) were added to each of the previously prepared containers. Termites were placed on the opposite side of the container from the test block. The test bottles were kept at room temperature (25-27°C) for a period of four weeks. Five containers were assembled with sand and water but without test blocks. The containers were examined twice weekly and the presence of tunneling, termite mortality and position of the termites in the container were recorded.

The five test containers (without test blocks) were reweighed weekly and distilled water were added to all containers once the moisture content of the sand drops two percent points below the original moisture content.

Block evaluation: At the end of test, each block was oven-dried to a constant mass and the data of each sample was recorded as follow:

- Visual rating of block at end of test
- Percentage (%) change in dry mass of block at end of test
- Percentage (%) of termite mortality at end of test

Visual rating (Table 2)

Weight loss (%): The percentage weight loss due to termite attack was calculated as follow:

$$\text{Weight loss (WL) (\%)} = \frac{W_a - W_b}{W_a} \times 100$$

where, W_a is the weight of test block after conditioning and before exposure to the termite and W_b is the weight of test block after conditioning and after exposure to the termite.

Mortality rate (%): The percentage mortality of termites was calculated as follow and shown in Table 3:

$$\text{Mortality rate of termites (\%)} = \frac{\text{No. of termite dies } (N_0)}{\text{No. of termites before exposure } (N_i)} \times 100$$

Table 2: Visual rating scale of block

Classification	Scale
Sound or surface nibbles	10
Light attack	9
Moderate attack	7
Heavy attack	4
Failure	0

Table 3: Classification of the mortality rate of termites

Classification	Percentage
Slight	0-33
Moderate	34-66
Heavy	67-99
Complete	100

Statistical analysis: The data presented here were analysed using Analysis of Variance (ANOVA) to determine the significant difference of the variables used on the properties. The mean were further analysed using Tukey Honesty Significance Different Test (HSD) to determine the significant level of variables used in this study.

RESULTS AND DISCUSSION

Mean mass loss percentages of particleboards treated with different treatment are shown in Table 4. Based on Table 4, the mean mass loss of all the testing blocks is ranged from 12.17-26.37%. The control blocks recorded a mean loss of 21.45% in mass. The mean mass loss of S2 and S3 is reported higher than the control, which is 23.03 and 26.37%, respectively. The results of analysis of variance for mass losses are shown in Table 5.

According to Table 5, type of treatment are high significantly affected the mass loss percentage of particleboard. Particleboard treated with formaldehyde catcher on the surface reported more mass loss than the control. Post-treatment of formaldehyde catcher increase the final moisture content of the particleboard which encourage the attack of termites. While the particleboard treated with heat and add-in method show better durability against termites attack.

Particleboards made with add-in catcher show better durability against *Coptotermes curvignathus* than the other treatment. Add-in catcher may have potential to serve as termites repellent as well as formaldehyde scavenger. Heat-treated particleboard had slightly better durability than the control, longer treatment time is needed to improve the result.

For the first two weeks, the termites try to build mudding tunnel on the wall of the culture bottle and these were similar for all the culture bottle containing testing blocks but after the 14 days the activity was slowing down (except for the controls, S1, S2 and S3). According to the ASTM standard, if the termites live one week, they

Table 4: Mean mass loss of particleboard treated with different treatment

Type	Mean mass loss (%)
Control	21.45 ± 3.19^{def}
S1	18.97 ± 1.47^{cde}
S2	23.03 ± 3.92^{ef}
S3	26.37 ± 3.02^{e}
A1	15.35 ± 1.24^{abc}
A2	13.87 ± 1.09^{ab}
A3	12.17 ± 1.01^{a}
H1	2.54^{bcd}

*Standard deviation in parentheses, Means followed by the same letter do not differ significantly at the 0.05 level

Table 5: Analysis of variance for mass loss

Factor	F value	Sig.level
Treatment	19.773	0.000**

**Highly significantly different at p<1%

Table 6: Mortality and visual rating results of particleboard exposing to *Coptotermes curvignathus*

Type	Mortality (%)	Visual rating
Control	100	4
S1	100	5
S2	100	4
S3	100	4
A1	100	6
A2	100	6
A3	100	7
H1	100	6

are considered robust enough to have a valid test, even late in the season (Anonymous, 1998). Termite's activities became weak and termites started to die at the top of the sand and block.

As for the culture bottles containing control, the termites activities were remain active for the first three weeks. On the fourth week, termite's activities were slowing down. At the end of the testing period, it was found that all of the termites were dead in the culture bottles containing control (Table 6). Visual ratings of 4-7 were tabulated in Table 6.

After four weeks, completely mortality of the termites was recorded (100% mortality rate) in all the culture bottles (Table 6). Femi-Ola *et al.* (2007) stated that there was a high degree of correlation between the amount of wood consumed and survival of *Amitermes evuncifer*. Although, in this case, all the termites was found dead, but termites fed on the control and S3 last longer than the other.

CONCLUSION

Add-in catcher has showed the potential as termites repellent in this study. However, the actual mechanism that occurs between the resin and the add-in catcher should be further investigated. Heat-treated particleboard showed slightly better durability than the control blocks which proved that heat treatment is a promising method in enhancing the biological durability of particleboard. Longer treatment time or more severe heat treatment should be applied to enhance the result. Particleboard post-treated with formaldehyde catcher reported the most severe attack as the treatment increase the moisture content of boards.

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