DURABILITY OF PLANTED DARK RED MERANTI TREATED WITH FIRE RETARDANTS AGAINST BASIDIOMYCETES FUNGI

Noor Azrieda Abd Rashid
Bahagian Keluaran Hutan
Institut Penyelidikan Perhutanan Malaysia (FRIM)
Kepong, 52109 Selangor
Email: azrieda@frim.gov.my

Suffian M
Bahagian Keluaran Hutan
Institut Penyelidikan Perhutanan Malaysia (FRIM)
Kepong, 52109 Selangor
Email: suffian@frim.gov.my

Salmiah U
Bahagian Keluaran Hutan
Institut Penyelidikan Perhutanan Malaysia (FRIM)
Kepong, 52109 Selangor
Email: salmiah@frim.gov.my

ABSTRACT

Information on durability of wood against decay fungi is important for the wood to be utilised effectively since it may affect the wood performance and service life. Durability class is one of key indicators used to assess the durability and suitability application of wood. Natural durability of wood is the ability of wood to prevent attack by wood-decaying agents in the absence of physical or chemical modifications. This paper determined the natural durability of dark red meranti from plantation and durability of the wood after treated with fire retardants (Dricon & diammonium phosphate). The tests were conducted according to ASTM D2017. It was found that planted dark red meranti has natural durability of resistant class. Treatment of the wood with Dricon and diammonium phosphate has no effect to the durability class.

INTRODUCTION

Traditionally, wood is obtained from natural forest for industrial purposes. However, the wood supply becomes critical due to limited forest areas for logging. This is reflected by the production of logs in Malaysia which decreased from 40.1 million cubic metre in 1990 to 15.9 million cubic metre in 2012 (DOSM, 2013). As an alternative, wood from plantation resources can be used. However the material may have different characteristics than wood from natural forest which may affect the performance.

Natural durability of wood can be defined as the ability of wood to prevent attack by wood-decaying agents in the absence of any physical or chemical modifications (Sundararaj et al., 2015). Information on wood durability is beneficial for the wood to be used within its capability. The natural durability of wood varies with environmental condition, wood characteristics and decay organisms (Freitag et al., 1991).

Naturally, wood can be degraded by many types of fungi. Basidiomycetes such as white-rot and brown-rot fungi are aggressive colonisers and degraders of wood in appropriate environments (Adya & Tripti, 2014). White-rot fungi are common in nature and abundant in forest ecosystem especially hardwood forests, while brown-rot fungi are most common in coniferous forests and other habitats such as soils. These fungi are able to efficiently degrade wood components especially lignin (Rayner & Boddy, 1988) and lignocellulose, hence will affect the wood strength.

Wood is suitable for building construction because of low embodied energy, low carbon impact, and sustainability (Falk, 2010). Besides, it has a low weight in relation to strength and load bearing capacity (Anonymous, 2012). Treatment can be conducted to wood in order to increase its value. There are many ways to improve the wood properties (Rowell, 2006).

Fire retardant is a substance that is used to slow the spread of fire in product. Dricon and diammonium phosphate are among fire retardant chemicals can be used for wood treatment (Anonymous, 2002; Holmes, 1977). Dricon is commercial fire retardant produced by Arch Wood Protection, Inc.; consists of boric acid, guanylurea phosphate and phosphoric acid mixtures. Kartal et al. (2007) found that diammonium phosphate increased the resistance of plywood panels against fungal and termite attack. Whereas study by Terzi et al. (2011) showed that diammonium phosphate and some other fire retardant chemicals were not able to protect wood from decay fungi.

Dark red meranti is the standard Malaysian name for about ten species of trees of the genus *Shorea* (family Dipterocarpaceae) (Choo & Lim, 1982). The wood is moderately hard and moderately heavy with an average air dry density of about 700 kg/m^3. The heartwood is dark pink-brown, dark red and weathering to a dark red-brown. The sapwood is generally lighter in colour. The wood is suitable for a wide variety of uses and can be used for light construction. The wood from natural forest is resistant to decay fungi (Yamamoto & Hong, 1994).

In this study, the natural durability of dark red meranti from plantation and durability of the wood treated with fire retardant chemicals (Dricon and diammonium phospate) against two types decay fungi were determined.

MATERIALS AND METHOD

Sample preparation

Dark red meranti (DRM) was obtained from mature tree from plantation plot at Forest Research Institute Malaysia (FRIM), Kepong, Selangor. The wood was cut into blocks of 25 x 25 x 9 mm. Dricon and diammonium phosphate fire retardants were purchased from chemical suppliers. Twenty wood blocks were treated with Dricon and diammonium phosphate respectively in 14 litre capacity steel chamber. The wood blocks were vacuumed for 30 minutes followed by soaking in 5% (w/v) fire retardant solution and pressurized for 1 hour.

Fungal decay test

The untreated and treated samples (twenty blocks each) were tested against white-rot and brown-rot fungus, *Coriolus versicolor* and *Gloeophyllum trabeum*, according to ASTM D 2017 (2005).

Soda-glass test jars were half-filled with 150 ml malt-extract agar. These jars were then sterilized in the autoclave at 121 °C for 30 minutes. Plastic nettings were also sterilized separately where once the agar cooled and hardened these nettings were place on top of the agar surface. The main aim was to support the wood blocks when they were introduced later at the beginning of the test samples exposure.

The fungal strains were prepared by growing pure strains of *C. versicolor* and *G. trabeum* in 2% malt agar in the petri-dish and kept in the dark at 25 ºC for 2 weeks to ensure sufficient inoculum source for all decay test containers. The two fungal strains were inoculated onto agar medium in test jars aseptically. The test jar was ready to be used when the whole surface was covered by fungal mycelium and no contamination was detected.

The wood blocks were conditioned at 25 ºC and 75% relative humidity and weighed each to the nearest 0.01 g (T1). The blocks then placed into closed containers and steamed at 121 °C for 30 minutes for sterilization. After cooling, the wood blocks were aseptically placed in the test jars.

Two wood blocks were assigned to each jar which was already covered with the fungus; laid on the netting on the agar surface. The samples were incubated in the dark at 25 ºC and 75% relative humidity for 12 weeks. At the end of the incubation period the samples were removed from the jars and fungal mycelium was brushed off. The wood blocks were placed on trays and brought to moisture equilibrium in the conditioning room and weighed (T2).

Calculation of weight losses

The weight loss was calculated from the conditioned weight of wood blocks before and after testing, as follows:

Weight loss, % = [T1 – T2 / T1] x 100

These blocks based on the average weight loss percentage are assigned to the resistance class as in Table 1.

Table 1 Class of resistance to decay fungi according to ASTM D 2017 (2005)

Average Weight Loss (%)	Average Residual Weight (%)	Class of Resistance
0 – 10	90 – 100	Highly resistant
11 – 24	76 – 89	Resistant
25 – 44	56 – 75	Moderately resistant
45 or above	55 or less	Slightly resistant / non resistant

Statistical analysis of the results was conducted using Microsoft Excel.

RESULTS AND DISCUSSION

The fungi grew completely within 12 weeks of the incubation period. The *C. versicolor* became a fibrous whitish mass (Figure 1), whereas entire surface of wood blocks was covered with the *G. trabeum* mycelium (Figure 2). It was observed that the DRM samples showed encouraging protection against the fungi when exposed to eight weeks where severe fungal decay occurred.

Table 2 presents the decay resistance of DRM samples against *C. versicolor* and *G. trabeum.* The average weight loss of the DRM was between 14 and 17%. The weight loss due to decay fungi was not significantly different ($P<0.05$) between the untreated and treated samples. The results of *C. versicolor* were also not much different than *G. trabeum*.

The samples have considerably small residual weight variation with average between 83 and 86%. The values were within 76–89% range specified in Table 1. Therefore the treated and untreated DRM samples can be classified as resistant to decay fungi.

Yamamoto & Hong (1994) obtained 19.5% average weight loss in decay test of DRM against *C. versicolor* using modified ASTM D 2017 method; higher than 14.8% obtained in this study. The species used might be different and slight variation of the method may affect the results. The causes of decay resistance of wood are complex and take into account of factors such as wood density, lignin structure and extractive contents (Yamamoto & Hong, 1994; Syafii et al., 1988; Antwi-Bosiako & Pitman, 2009). Nevertheless the results were within 11–24% average weight loss in Table 1 thus confirmed the natural durability of DRM as resistant class. The planted DRM probably has similar characteristics with DRM from the natural forest.

Kartal et al. (2007) found that the decay resistance of plywood improved with diammonium phosphate treatment. Contradict to that, the decay resistance of untreated and treated DRM were not different. This is supported by Terzi et al. (2011) which found that diammonium phosphate and some other fire retardant chemicals were not able to protect wood from decay fungi. Since the DRM natural durability is resistant class i.e. second highest ranking, the level of durability may be difficult to improve further by using the diammonium phosphate and Dricon treatment. Combination of fire retardant and wood preservative might be beneficial in getting better performance against both fire and fungal decay as suggested by Terzi et al. (2011).

Figure 1: Sample of dark red meranti (Dricon treated) fully covered by Coriolus versicolor

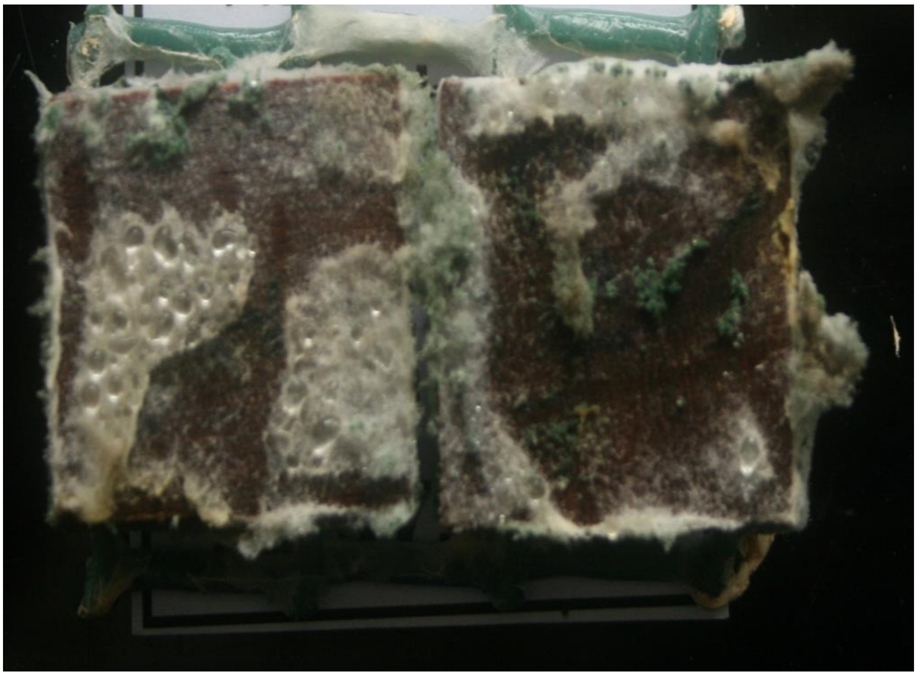

Figure 2: Sample of dark red meranti (untreated) fully covered by Gloeophyllum trabeum

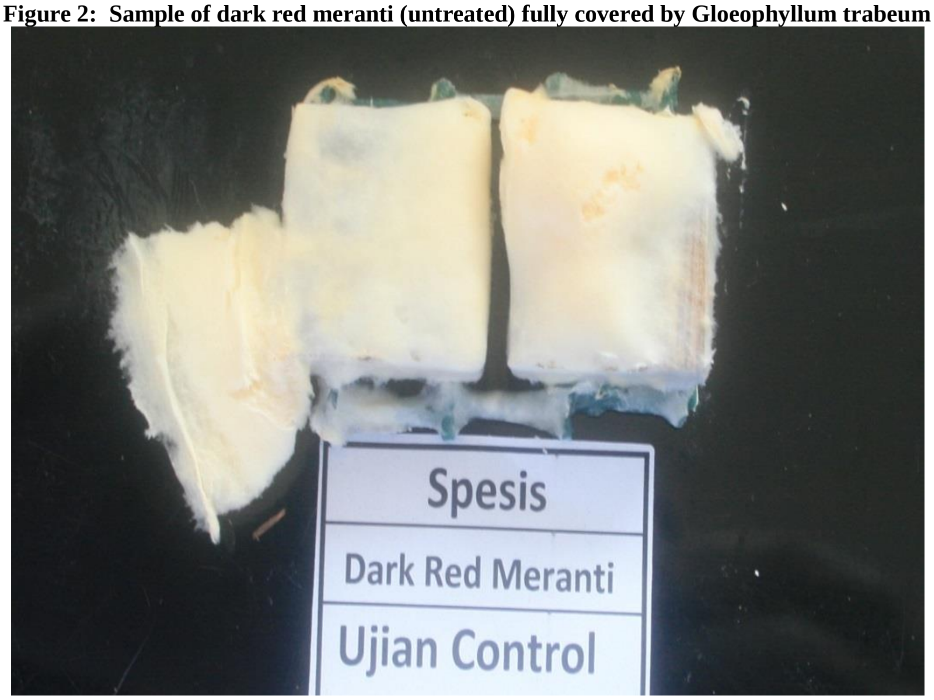

Table 2. Evaluation on resistance of dark red meranti samples against decay fungi

Treatment	Average weight loss (%)	
	Coriolus versicolor	*Gloeophyllum trabeum*
Untreated	14.8	14.2
Dricon	16.7	13.9
Diammonium phosphate	15.9	15.5

Note: Each value represents the mean of 20 replications. Means within the same column are not significantly different at $P < 0.05$.

CONCLUSIONS

The planted DRM has natural durability of resistant class when exposed to *C. versicolor* and *G. trabeum*. The durability class is similar to natural forest wood reported by Yamamoto & Hong (1994). The weight loss due to *C. versicolor* was not much different than the *G. trabeum*. The use of Dricon and diammonium phosphate has not improved the durability of DRM. The chemicals may be suitable as fire retardant but not to improve the fungal decay resistance of the wood. Combination of chemicals might be beneficial in getting both fire resistant and highly durable wood.

REFERENCES

Adya, P.S. & Tropti, S. (2014). Biotehnological applications of wood-rotting fungi: A review. *Biomass and Bioenergy*, 62, 198–206.

Antwi-Boasiako, C. & Pitman, A.J. (2009). Influence of density on the durabilities of three Ghanaian timbers . *Journal of Science and Technology*, 29, 34–45.

Anonymous. (2002). Material safety data sheet: Dricon® fire retardant.

Anonymous. (2012). *Building with Wood — Modern Solutions for Wood Construction*. Swedish Wood, Swedish Forest Industries Federation.

ASTM D 2017. (2005). *Standard Test Method of Accelerated Laboratory Test of Natural Decay Resistance of Woods*. American Society for Testing and Materials.

Choo, K.T. & Lim, S.C. (1982). *Malaysian Timbers — Dark Red Meranti*, Malaysian Forest Service Trade Leaflet No. 69. Malaysian Timber Industry Board.

DOSM. 2013. Forestry. Department of Statistics Malaysia. www.dosm.gov.my/v1/uploads/ files/3_Time Series/Malaysia Time Series 2012/12Perhutanan.pdf.

Falk, R.H. (2010). Wood as a sustainable building material. In R. J. Ross (Ed.), *Wood Handbook — Wood as an Engineering Material*, General technical Report FPL-GTR-190. US: Forest Products Laboratory, United States Department of Agriculture.

Freitag, M., Morrell, J.J. & Bruce, A. (1991). Biological protection of wood: status and prospects. *Biodeterioration Abstracts*, 5 (1), 1–13.

Holmes, C.A. (1977). Effect of fire-retardant treatments on performance properties of wood. In I.S. Goldstein (Ed.), *Wood Technology: Chemical Aspects*, ACS Symposium Series 43. Washington DC: American Chemical Society.

Kartal, S.N., Ayrilmis, N. & Imamura, Y. (2007). Decay and termite resistance of plywood treated with various fire retardants. *Building and Environment*, 43, 1207–1211.

Rayner, A.D.M. & Boddy, L. (1988). *Fungal Decomposition: Its Biology and Ecology*. John Wiley & Sons, New York.

Rowell, R.M. (2006). Chemical modification of wood: a short review. *Wood Material Science and Engineering*, 1, 29–33.

Sundararaj, R., Rashmi, R.S., Nagaveni, H,C. & Vijayalakshmi, G. (2015). Natural durability of timbers under Indian environmental conditions – an overview. *International Biodeterioration & Biodegradation*, 103, 196–214.

Syafii, W., Yoshimoto, T. & Samejima, M. (1988). The effect of lignin structure on decay resistance of some tropical woods, pp. 69–77. *Bulletin Tokyo University Forest*, 80, 69–77.

Terzi, E., Kartal, S.N, White, R.H., Shinoda, K. & Imamura, Y. (2011). Fire performance and decay resistance of solid wood and plywood treated with quaternary ammonia compounds and common fire retardants. *European Journal of Wood and Wood Products*, 69: 41–51.

Yamamoto, K., & Hong, L.T. 1994. A laboratory method for predicting the durability of tropical hardwoods. *JARQ*, 28, 268–275.