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Efficiency of burnt oil as wood preservative submitted to field deterioration tests

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ABSTRACT: The objective of this study was to evaluate the efficiency of oil burned as a wood preservative of *Trattinnickia rhoifolia* Willd submitted to field deterioration tests. The preservatives treatments with burnt oil were performed by the simple immersion method considering two variation factors: oil viscosity (SAE 10 and SAE 15) and immersion time (3 min, 3 h and 24 h). The effectiveness of the preservative treatments was evaluated through oily product retention rate, quantification of leaching after exposure in the field and mass loss caused by biological deterioration. Additionally, the colorimetric technique was used to assess the darkening caused by preservative treatment and monitoring of the change of surface color of the wood due to leaching by exposure to the field. Based on the results, it can be concluded that the preservative treatment with burnt oil was efficient, to provide the woods a greater biological resistance, especially the use of the oil with lower viscosity (SAE 10). The higher retention rates and low mass loss due to biological deterioration were obtained when employing the burnt oil SAE 10, and on the other hand also showed the highest rates of leaching.

Keywords: wood preservation, simple immersion, oily preservative, tropical wood.

Eficiência do óleo queimado como preservativo de madeiras submetidas a ensaios de deterioração de campo

RESUMO: O objetivo desse estudo foi avaliar a eficiência do óleo queimado como preservativo de madeiras de *Trattinnickia rhoifolia* Willd. submetidas a ensaios de deterioração de campo. Os tratamentos preservativos com óleo queimado foram realizados pelo método de imersão simples considerando dois fatores de variação: viscosidade do óleo (SAE 10 e SAE 15) e tempo de imersão (3 min, 3 h e 24 h). A eficiência dos tratamentos preservativos foi avaliada por meio da taxa de retenção do produto oleoso, quantificação da lixiviação após exposição em campo e perda de massa causada pela deterioração biológica. Adicionalmente, foi empregada a técnica de colorimetria para avaliação do escurecimento causado pelo tratamento preservativo e no monitoramento da alteração da cor superficial da madeira devido a lixiviação pela exposição à campo. Com base nos resultados pode-se concluir que o tratamento preservativo com óleo queimado foi eficiente, de modo a proporcionar às madeiras uma maior resistência biológica, com destaque para o uso do óleo de menor viscosidade (SAE 10). As maiores taxas de retenção e menores perdas de massa devido à deterioração biológica foram obtidas ao empregar o óleo queimado SAE 10, por outro lado também apresentaram as maiores taxas de lixiviação.

Palavras-chave: preservação da madeira, imersão simples, preservativo oleoso, madeira tropical.

1. INTRODUCTION

Being of a natural origin, wood is classified as a heterogeneous material, characteristic resulting from the presence of different anatomical and chemical elements in its internal structure (ROWELL, 2005). Variations of anatomical arrangement and chemical composition influence different technological properties of the wood, highlighting the natural ability to resist biotic and abiotic deterioration (EATON, HALE, 1993).

In general, woods with low levels of extractives and lignin, low specific density and high porosity have a low potential for natural resistance (CARNEIRO et al., 2009; STANGERLIN et al., 2013), especially when used in contact with the ground or high humidity. The use of preservative treatments is very important for the extended life of wood in service and consequent reduction of the costs involved with damaged wood replacement, especially by biological agents such as fungi and termites.

The preservative treatments may be performed by modifying the chemical composition of wood or by impregnating the wood with chemicals products, this being more usual. According to Santini (1988), resistance to deterioration of the preserved wood is related to the quality preservative product (toxicity to xylophagous organisms) and preservative treatment efficiency (retention and penetration of the preservative product).

According to Lepage et al. (1986) the wood preservative treatments may be performed through industrial and homemade methods, a classification associated with the application or not of pressure to impregnate the chemical products. Among the homemade methods, a simple immersion appears as a satisfactory option, especially for treatment of wood on a small scale employing oil-soluble products. Preservatives products can be classified into soluble oil and water soluble, with creosote and CCA as the main representatives of the two classes, respectively (ARCHER; LEBOW, 2006).

Although is not a commercial preservative product, the use of burnt oil of combustion engines has been highlighted by some authors (OLANIRAN et al., 2010; SSEMAGANDA et al., 2011; MATTOS et al., 2013; GALLON et al., 2014) as being effective for increasing the biological resistance of wood. Also, Omole; Onilude (2000) and Mattos et al. (2012) recommended the use of burnt oil as being a residue of the automotive industry which can be obtained at low cost and which does not require the use of industrial methods for wood impregnation. Given the above, this study aimed to evaluate the efficiency of burnt oil as a preservative of *Trattinnickia rhoifolia* Willd woods, (*amescla*) submitted to field deterioration tests.

2. MATERIAL AND METHODS

2.1. Collection and preparation of material

Logs were selected in different timber establishments in the municipality of Sinop, Mato Grosso, *Trattinnickia rhoifolia* Willd (*amescla*), submitted to unfolding to obtain tangential boards with dimensions of 2 x 20 x 300 cm, thickness, width, and length, respectively.

The logs were flattened and sectioned in a circular saw to obtain 140 samples with dimensions 2 x 2 x 20 cm, with the largest dimension in the axial direction.

Subsequently, the wood samples were subjected to the drying process in a forced-air circulation oven at 103 ºC, until achieving a constant mass.

2.2. Preservative treatments

Preservative treatments with burnt oil were performed by simple immersion method considering two variation factors: oil viscosity (SAE 10 and SAE 15); and immersion time (3 min, 3 h and 24 h). Twenty *amescla* samples were used in each preservative treatment (interaction between product viscosity and immersion time). The same number of samples was not immersed in oil to be used as evidence material and evaluate the preservative treatment efficiency.

Finally, the samples were again submitted to drying for subsequent determination of burnt oil retention rate (Eq. 1).

$$Txr = \left(\frac{Mf - Mi}{V} \right) \quad (1)$$

where: Rr = retention rate, kg m^{-3}; Fm = final mass after preservative treatment, in kg; Im = initial mass before the preservative treatment, in kg; V = volume in m^3.

2.3. Installation and evaluation of field trail

The samples preserved in burnt oil and control were submitted to impairment testing in the open environment, free of undergrowth, located at the Federal University of Mato Grosso - University Campus of Sinop, during the period from December 2013 to August 2014 totaling eight months.

Therefore, the 140 *amescla* samples were also distributed in four randomized blocks (each block with five lines). The blocks and their lines were spaced 30 and 15 cm apart, respectively, while samples were spaced 5 cm from each other. To provide the exhibition of both biotic as abiotic weathering, the samples were buried up to half of its length, that is, 10 cm.

Every 60 days, five *amescla* samples were taken from the test field for preservative treatment (including control samples) for evaluation of leaching quantification burnt oil (Eq. 2) and the mass loss due to biological deterioration (Eq. 3). After removal, the samples were cleaned with a brush, to remove the adhering soil, and then dried in a forced-air circulation oven at 103 ºC, until achieving a constant mass.

$$Lx = \left[\left(\frac{Mi - Mf}{Mi} \right) \times 100 \right] \quad (2)$$

where: Lx = the used burnt oil leaching in %; Im = initial mass after preservation, in g; Fm = final mass after the field test, in g.

$$PM = \left[\left(\frac{Mi - Mf}{Mi} \right) \times 100 \right] \quad (3)$$

where: ML = mass loss in %; Im = initial mass before the preservation, in g; Fm = final mass after the field test, in g.

In addition, samples were submitted to colorimetric characterization in two situations: a) before and after the preservative treatment to evaluate the burnt oil viscosity effect and the immersion time in a darkening of the *amescla* sample; b) after each removal of the field test to help the evaluation of burnt oil leaching through the full range of color.

The colorimetric characterization was performed by employing a spectrophotometer with a resolution of 3 nm and equipped with an integrating sphere of diffuse reflectance. For this purpose, D65 illuminant was used, composed of a xenon lamp, which simulates the diurnal solar radiation, with a 10° observation angle at room temperature. The colorimetric parameters L* (lightness), a* (red-green coordinate) and b* (yellow-blue coordinate) were obtained by employing the *CIELab* system, being performed an average of three readings for each sample.

For the color changes measurement in the wood during the period of exposure to the field test determined the total color variation (ΔE) as described in procedure D2244 of the American Society for Testing and Materials - ASTM (2009).

2.4. Statistical analysis

For the analysis of the results, the analysis of variance was performed followed by DMS averages test (least significant difference) Fischer (5% error probability). Also, statistical modeling was developed through regression analysis, which evaluated the weight loss percentage, leaching, and ΔE as a function of exposure time of the samples to field deterioration tests.

3. RESULTS AND DISCUSSION

The burnt oil retention rates obtained in different immersion times were statistically different, with higher values after 24 h of immersion, regardless of the product viscosity (Table 1). This result corroborates the described by Lepage et al. (1986), where most of the preservative product absorption is observed in the first 24 h of immersion, with subsequent stabilization.

Regarding the viscosity of the product, it is noted that the SAE 10 oil was further retained inside the wood compared to SAE 15 oil, except immersion during 3 min, where there was not a statistically significant difference between the means. The result is justified by the fact that SAE 10 oil is less viscous compared to SAE 15. The retention of the preservative product is directly related to the penetration obtained with the treatment, the lower the viscosity of the product, the greater the penetration and retention in the wood.

In Table 2 it was verified that the leaching of burnt oil was not statistically different between viscosities, within each immersion times. It can be observed that there is a direct relationship between retention rate and subsequent leaching of burnt oil upon exposure to the wood in service since the higher results for the two analyses were obtained for the preservative treatment with SAE 10 oil during 24 h.

Among the characteristics that a good preservative product should present, the resistance to leaching is highlighted (SANTINI, 1988), which is related to the action of soil moisture, rainfall, temperature and relative humidity. In Figure 1, it is possible to verify that the highest percentage of leaching burnt oil occurred in the first 60 days of exposure of the woods in the field, being practically stable values in other assessments, demonstrating the stability of the oily product. Regarding the analysis of the colorimetric parameters, it was observed that longer immersion time (24 h) and the higher viscosity burnt oil provided a significant reduction in L* and the coordinates a* and b*, to darkened the materials. Pereira (2015) also obtained similar results when assessing the colorimetry of three Amazonian kinds of woods after the immersion treatment in burnt oil.

Table 1. The comparison of the means rates of burnt oil retention, considering the interaction between oil viscosities x immersion time.
Tabela 1. Comparação das médias de taxa de retenção em óleo queimado considerando a interação entre viscosidade do óleo x tempo de imersão.

Viscosities	Immersion time		
	3 min	3 h	24 h
SAE 10	78.31 aA	87.49 bB	110.85 bC
SAE 15	76.36 aA	78.68 aA	88.19 aB

Where: Means followed by the same lowercase letters vertically or horizontally capital letters are not statistically different from each other.

Table 2. The comparison of burnt oil leaching means, considering the interaction between oil viscosities x immersion time.
Tabela 2. Comparação das médias de lixiviação do óleo queimado considerando a interação entre viscosidade do óleo x tempo de imersão.

Viscosities	Immersion time		
	3 min	3 h	24 h
SAE 10	14.66 aA	15.76 aAB	17.53 aB
SAE 15	13.19 aA	13.91 aA	15.61 aA

Where: Means followed by the same lowercase letters vertically or horizontally capital letters are not statistically different from each other.

$$Lx\ (3h - SAE\ 15) = -\ 0.0006*(t)^2 + 0.1899*(t) + 0.9774 \quad R^2 = 0.9486$$

$$Lx\ (3h - SAE10) = -\ 0.0005*(t)^2 + 0.1885*(t) + 0.8691 \quad R^2 = 0.959$$

$$Lx\ (3min - SAE10) = -\ 0.0005*(t)^2 + 0.1817*(t) + 1.4163 \quad R^2 = 0.8933$$

$$Lx\ (24h - SAE10) = -\ 0.0005*(t)^2 + 0.1976*(t) + 0.8077 \quad R^2 = 0.9732$$

$$Lx\ (3min - SAE\ 15) = -\ 0.0006*(t)^2 + 0.1844*(t) + 0.9129 \quad R^2 = 0.9732$$

$$Lx\ (24h - SAE\ 15) = -0.0006*(t)^2 + 0.1992*(t) + 1.0851 \quad R^2 = 0.9452$$

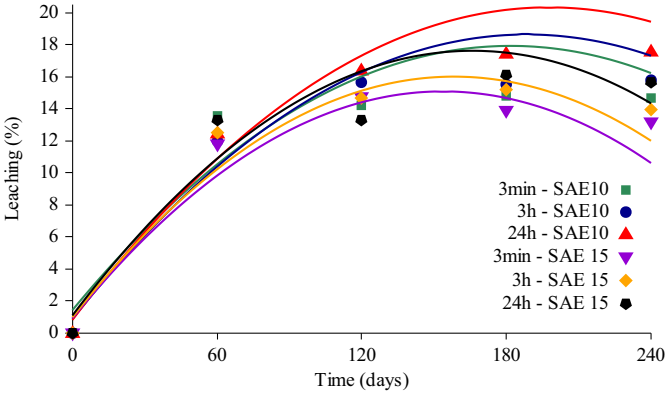

Figure 1. Equations adjusted to the estimated burnt oil leaching (Lx) of *amescla* treated in a function of time (t) of exposure field test.
Figura 1. Equações ajustadas para a estimativa da lixiviação do óleo queimado (Lx) das madeiras tratadas de amescla em função do tempo (t) de exposição ao ensaio de campo.

The results of total variation in color over the exposure time of *amescla* in the field test (Figure 2) confirm leaching values shown above (Figure 1), verifying the ΔE stabilization after 60 days of assay installation. Accordingly, the colorimetric technique proves to be effective in monitoring the leaching of oily products applied on wood. According to Stangerlin et al. (2013), the colorimetric technique has been used in several studies to quality wood classification.

Regarding the biological resistance of treated *amescla*; it could be observed in Table 3 and Figure 3 that the burnt oil employment provided a reduction in mass loss.

According to Gallon et al. (2014), the preservative treatment efficiency with burnt oil can be explained because of their repellency property to contact with water. Eaton; Hale (1993) stated that the moisture in the wood favors the development of decay fungi. Also, Matsuo; Nishimoto (1973) pointed out that wood at decay stage caused by fungi is more susceptible to termite attack compared to healthy wood.

Mattos et al. (2013) comparing the effect of the preservative treatment of eucalyptus wood with CCB and burnt oil, concluded that the oily product is efficient given the similarity between the mass loss values of the wood submitted to field tests. Likewise, Ssemaganda et al. (2011) also obtained satisfactory results by employing preservative treatment with burnt oil since

dE (24h - SAE 15) = 0.0019*(t)² - 0.5916*(t) + 46.699
R² = 0.8214

dE (24h - SAE 10) = 0.0009*(t)² - 0.3243*(t) + 34.108
R² = 0.9318

dE (3h - SAE 10) = 0.0009*(t)² - 0.2989*(t) + 26.359
R² = 0.8924

dE (3h - SAE 15) = 0.0018*(t)² - 0.5682*(t) + 47.123
R² = 0.8296

dE (3min - SAE 10) = 0.0005*(t)² - 0.2175*(t) + 25.074
R² = 0.835

dE (3min - SAE 15) = 0.0017*(t)² - 0.5425*(t) + 45.403
R² = 0.8026

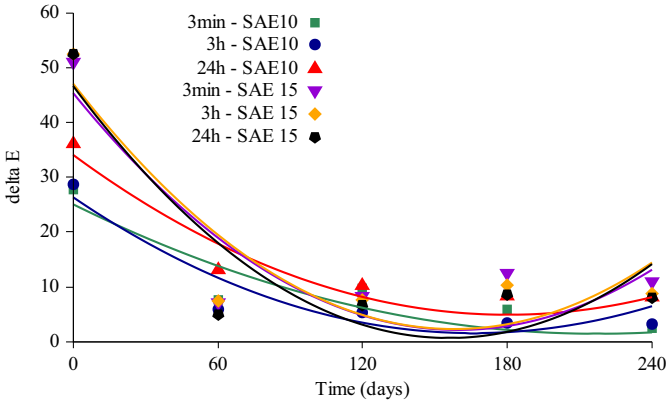

Figure 2. Equations are adjusted to estimate the total variation of color (dE) of treated *amescla* in a function of time (t) of exposure to the field test.

Figura 2. Equações ajustadas para a estimativa da variação total da cor (dE) das madeiras tratadas de amescla em função do tempo (t) de exposição ao ensaio de campo.

Table 3. The comparison of mean mass loss between the woods treated with burnt oil and untreated (control).

Tabela 3. Comparação das médias de perda de massa entre as madeiras tratadas com óleo queimado e não tratadas (testemunhas).

Treatment	Mass loss (%)
Control	15.70 b
3 min * SAE 10	4.99 a
3min * SAE 15	7.40 a
3 h * SAE 10	5.70 a
3 h * SAE 15	7.85 a
24 h * SAE 10	4.79 a
24 h * SAE 15	6.72 a

Where: Means followed by the same lowercase letters do not statistically differ from each other.

eucalyptus wood treated with this product showed no termite attack. Although there is no difference between the mass loss values between the preserved woods, there is a trend better result by employing the burnt oil of lower viscosity, which may be attributed to better penetration of the SAE 10 oil compared to SAE 15.

4. CONCLUSIONS

Based on the results, it could be concluded that the preservative treatment with burnt oil was efficient, to provide a greater resistance to biological decay in the *amescla* wood. The higher retention rates and lower mass losses due to biological

PM (3min - SAE 10) = 0.0246*(t) - 0.046
R² = 0.773

PM (3min - SAE 15) = 0.0334*(t) - 0.046
R² = 0.9432

PM (24h - SAE 15) = 0.0187*(t) - 0.73
R² = 0.815

PM (3h - SAE 10) = 0.0286*(t) - 1.058
R² = 0.7835

PM (3h - SAE 15) = 0.0368*(t) - 0.836
R² = 0.9439

PM (test) = 0.0682*(t) + 0.128
R² = 0.9825

PM (24h - SAE 10) = 0.0224*(t) - 1.19
R² = 0.5231

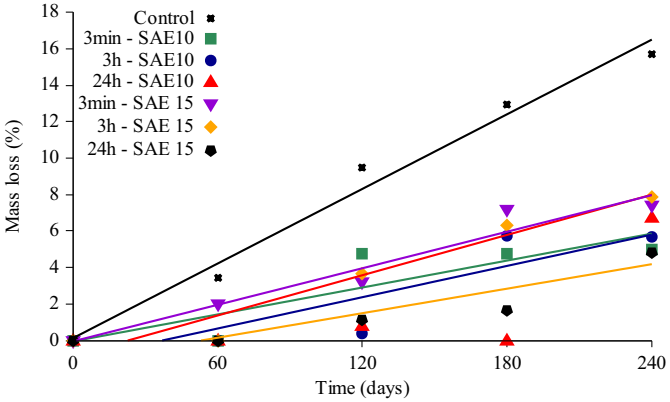

Figure 3. Equations were adjusted for estimating of mass loss (ML) of treated amescla wood in a function of time (t) of exposure field test.

Figura 3. Equações ajustadas para a estimativa da perda de massa (PM) das madeiras de amescla em função do tempo (t) de exposição ao ensaio de campo.

deterioration were obtained by employing the lower viscosity burnt oil (SAE 10). Moreover, SAE 10 oil was shown as unstable compared to SAE 15 oil due to higher leaching rates.

5. REFERENCES

ARCHER, K.; LEBOW, S. Wood preservation. In: WALKER, J. C. F. (Ed.). **Primary wood processing: principles and practice**. Dordrecht: Springer, 2006. p. 297-338. http://dx.doi.org/10.1007/1-4020-4393-7_9

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). **D 2244: Standard practice for calculation of color tolerances and color differences from instrumentally measured color coordinates**. West Conshohocken: ASTM, 2009. 11 p.

CARNEIRO, J. S.; EMMERT, L.; STERNADT, G. H.; MENDES, J. C.; ALMEIDA, G. F. Decay susceptibility of Amazon wood species from Brazil against white rot and brown rot decay fungi. **Holzforschung**, Berlin, v. 63, n. 6, p. 767-772, 2009.

EATON, R. A.; HALE, M. D. C. **Wood**: **Decay, pests and protection**. Londres: Chapman e Hall, 1993. 546 p.

GALLON, R.; STANGERLIN, D. M.; SOUZA, A. P.; PARIZ, E.; GATTO, D. A.; CALEGARI, L.; MELO, R. R. Resistência à deterioração de madeiras amazônicas tratadas por imersão simples em óleo queimado. **Nativa**, Sinop, v. 2, n. 1, p. 48-52, 2014. http://dx.doi.org/ 10.14583/2318-7670.v02n01a09

LEPAGE, E. S. **Métodos de tratamento**. In: LEPAGE, E. S. Manual de preservação de madeiras. São Paulo: IPT, 1986. v. 2, p. 343-420.

MATSUO, H.; NISHIMOTO, K. The consumption of fungus infected wood by termite, *Coptotermes formosanus* Shiraki. **Wood Research**, Kyoto, n. 55, p. 1-8, 1973.

MATTOS, B. D.; GATTO, D. A.; MISSIO, A. L.; LOURENÇON, T. V. Influência de tratamentos preservativos na propagação da onda ultrassônica na madeira de eucalipto. **Scientia Plena**, São Cristóvão, v. 8, n. 4, p. 1-6, 2012. http://dx.doi.org/10.5039/agraria.v8i4a3050

MATTOS, B. D.; GATTO, D. A.; CADEMARTORI, P. H. G. de; STANGERLIN, D. M.; BELTRAME, R. Durabilidade a campo da Madeira de três espécies de *Eucalyptus* tratadas por imersão simples. **Agrária**, Recife, v. 8, n. 4, p. 648-655, 2013.

OMOLE, A. O.; ONILUDE, M. A. Preliminary study on use of engine oil as wood preservative. **Journal of Tropical Forest Resources**, Ibadan, v. 16, n. 1, p. 66-71, 2000.

OLANIRAN, S. O.; OLUFEMI, B. Absorption and effect of used engine oil as wood preservative. **ProLigno**, Brasov, v. 6, n. 3, p. 1-2, 2010.

PEREIRA, P. A. C. **Eficiência da aplicação de óleo queimado em madeiras amazônicas submetidas ao ataque de cupins xilófagos**. 2015. 34f. Monografia (Graduação em Engenharia Florestal) – Universidade Federal de Mato Grosso, Sinop, 2015.

ROWELL, R. M. **Handbook of wood chemistry and wood composites**. Boca Raton: CRC Press, 2005. 473 p.

SANTINI, E. J. **Biodeterioracao e preservacao da madeira**. Santa Maria: CEPEF/FATEC, 1988. 125 p.

SSEMAGANDA, I. E.; MUGABI, P.; TUMWEBAZE, S. B. Effectiveness of selected preservatives in protecting ugandan grown *Eucalyptus grandis* wood against termite attack. **Maderas. Ciencia y tecnología**, Concepción, v. 13, n. 2, p. 135-142, 2011.

STANGERLIN, D. M.; COSTA, A. F. da; GARLET, A.; PASTORE, T. C. N. Resistência natural da madeira de três espécies amazônicas submetidas ao ataque de fungos apodrecedores. **Ciência da Madeira**, Pelotas, v. 4, n. 1, p. 15-32, 2013a. http://dx.doi.org/10.12953/2177-6830.v04n01a02

STANGERLIN, D. M.; COSTA, A. F. da; GONÇALEZ, J. C.; PASTORE, T. C. M.; GARLET, A. Monitoramento da biodeterioração da madeira de três espécies amazônicas pela técnica da colorimetria. **Acta Amazonica**, Manaus, v. 43, n. 4, p. 429-438, 2013b. http://dx.doi.org/10.1590/S0044-59672013000400004