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EFFICACY OF PYROLYTIC OIL OBTAINED FROM WOOD SAWDUST AGAINST WOOD DECAY SUBTERRANEAN TERMITE

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Abstract:

Pyrolytic oil and its toxicity were evaluated against wood decay termite using Boscia angustifolia wood. The wood samples prepared to size 2x2x6cm were soaked for 72h in light, heavy and mixed pyrolytic oil. The absorption rate after soaking and the weight loss after exposure to termite were determined. Data collected was analysed using simple statistics and analysis of variance at $\alpha_{0.05}$. Maximum wood absorption and lowest weight lost were obtained for mixed pyrolytic oil with 49.97% and 5.11% respectively. Light and heavy oils had poorer performance in protection after 8 weeks of testing, the rate obtained was 7 and 9 compared to 10 of the mixed oil. However, pyrolytic oil was found to totally protect the wood of Boscia angustifolia.

Key words: *pyrolysis; pyrolytic oil; wood sawdust; absorption; termite; weight loss.*

INTRODUCTION

Termites constitute an integral component of various ecosystems in Africa particularly in Nigeria. Thus, they are responsible for considerable damage of finished and unfinished building wooden structures (Sen-Sarma *et al.* 1975). In addition, termites are found to be very destructive in that they derive their nutrition from wood and other cellulosic materials. Malaka (1996) reported that the damage done by various termite species in Nigeria ranged from scavenging on wood products and timber-in-service, forest trees - tree barks and dead branches, synthetic products, wool and agricultural crops and eating out grooves in the roots and stems of plants.

Protection of wood products from degradation and deterioration through wood preservation is an active part of forestry, playing very important role in forestry conservation worldwide as well as allowing great strides forward in meeting global wood demand (Arun *et al.* 2006). However, some wood species are resistant to these degrading agents like subterranean termite while others are very susceptible to deterioration (Kityo and Plumptre 1997). Thus, these species need to be subjected to preservation procedure in order to increase their service life.

Apart from chemical preservation, recent studies on the use of biological preservative have opened a new avenue for the control of plant insects, disease, pathogens (Amienyo and Ataga 2007, Adegoke *et al.* 2015). Wood extracts are natural compounds and are rich in bioactive compounds such as tannins, polyphenols among which are also lignans. These are also part of a large group of polyphenols which are toxic to wood degrading organisms notably one is pyrolytic oil obtained from pyrolysis of wood residues.

However, pyrolytic oil is one of the wood extract obtainable by conversion processes called pyrolysis. Pyrolytic oil is a dark-brown organic liquid and also it includes a lot of the organic compounds like phenols, alcohols, ketones, esters, aldehydes, oxygenated hydrocarbons (Czernik and Bridgwater 2004, Goyal *et al*. 2008, Fuwape *et al*. 2011). This product can be readily stored, transported, and also used as chemical feedstock for the production of various industrialized chemicals. The synonyms for pyrolytic oil include bio-oil, pyrolysis oils, pyrolysis liquids, liquefied wood, bio-crude oil (BCO), wood liquids, wood oil, liquid smoke, wood distillates, pyroligneous acid, and liquid wood. It has been considered for biofuel and chemical feedstock because of complex structure and chemical composition (Adegoke and Ayodele 2015). Recently, the pyrolytic oil obtained from many different sources of wood is receiving intense interest as new wood preservative against biodeteriorating agents. Furthermore, a number of studies based this new usage are

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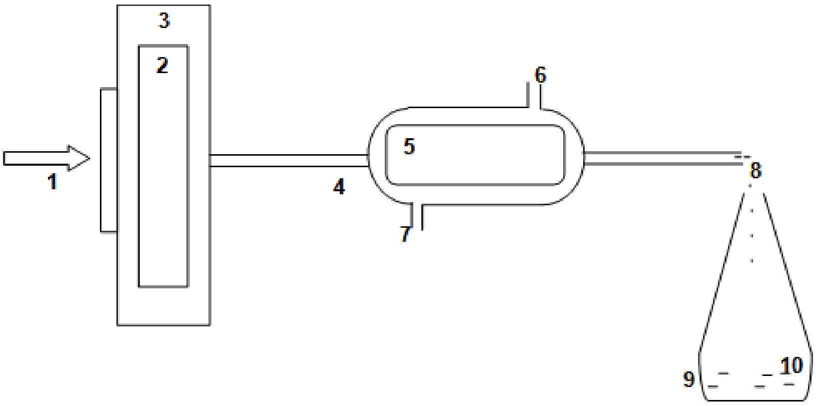
constantly increasing (Yatagai *et al.* 2002, Jung 2007, Lee *et al.* 2011, Sunarta *et al.* 2011, Oramahi and Diba 2013, Oramahi and Yoshimura 2013, Temiz *et al.* 2013). The aim of this study was to use the pyrolytic oil extracted from *Triplochiton scleroxylon* sawdust as preservative against termite attack.

MATERIALS AND METHODS

PYROLYSIS EXPERIMENT

Triplochiton scleroxylon (obeche) is used for timber manufacturing, thus a high quantity of saw dust resulted from process. Besides fuel the saw dust could be a source of pyrolytic oil producing. The sawdust was collected from sawmill section of Forest Products Development and Utilization, Forestry Research Institute of Nigeria, Nigeria. The sawdust was air dried until excess moisture was removed. It was then put inside the pyrolytic chamber and then subjected to a predetermined temperature of 500°C. The gases that evolved were distilled in the condenser to form pyrolytic oil which was retained in a conical flask. The oil retained was condensed at 4°C using a reflux system. The method used for pyrolysis of sawdust follows previous work from Adegoke *et al*. 2014.



(1) Feedstock, (2) Pyrolytic chamber, (3) Furnace, (4) Chamber rod, (5) Condenser (6) Cold water inlet (7) Cold water outlet (8) Emitted gas (9) Conical flask (10) Pyrolytic oil and tar

Fig. 1.
Schematic diagram of pyrolyser experimental set-up (Adegoke et al. 2014).

Pyrolytic Oil Fraction Separation

Pyrolytic oil obtained contains a viscous mostly oligomeric lignin-derived fraction settled at the bottom while water soluble, mostly carbohydrate derived compounds are found on the top layer. This is why a further separation by decantation procedure it had be done. The two fractions decanted represented a light and a heavy pyrolytic oil while mixed pyrolytic oil contained the two fractions.

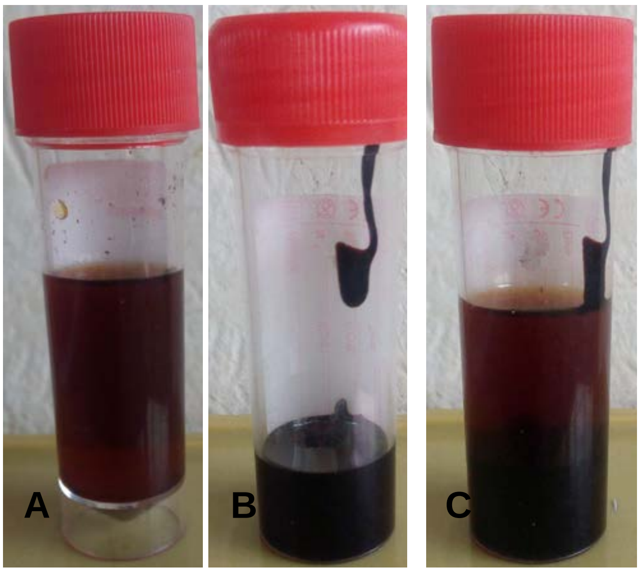


Fig. 2.
Pyrolytic oil: A: Light Oil; B: Heavy Oil and C: Mixed Oil

Wood Samples Preparation and Treatment

Boscia angustifolia is a shrub or small evergreen tree of 10-14m high. It is found in all savanna types and in deciduous wood bush land in West Africa. It usually grows in very arid sites such as hills, laterite outcrops and cliffs and sometimes dry riverbeds. It is also used in carpentry and water storage vessels (Orwa *et al.* 2009). The wood samples of *Boscia. angustifolia* were cut into 2x2x6cm. The samples were properly labeled, weighed (initial weight-T_1) and dried in an oven at a temperature of 103± 2ºC until excess moisture content were removed.

Soaking method was used for the treatment of wood with the pyrolytic oil for 72 hours. The three (3) types were used and the wood samples were completely immersed in the pyrolytic oil so as to absorb appreciable amount of light, heavy and mixed oil.

Wood Sample Test

Absorption Test

After the treatment, the wood was drained and reweighed to determine the oil absorption with the equation below. The treated wood test samples were placed on a wire mesh and conditioned under room temperature in the laboratory for 72h.

$$\text{Absorption (\%)} = \frac{T_2 - T_1}{T_1} \text{ X } 100 \qquad (1)$$

where: T_2= samples weight after soaking, in g.
T_1 = samples oven dried weight, in g.

Field Test

The treated and untreated wood samples were exposed to the *Coptotermes intermedius* at the Termite Grave Yard, Department of Wood and Paper Technology, Federal College of Forestry, Ibadan, Nigeria. These samples were brought out weekly for observation and evaluation of termites' activities. At the end of this evaluation, the wood samples were withdrawn and weighed (T_4). The visual observation and evaluation of wood samples was based on the American Society of Testing and Materials standard (ASTM D 3345-74). This standard classify the attack according to a scales as follow:

10 = sound surface nibbles permitted
9 = light attack
7 = moderate attack penetration
4 = heavy attack (30 % to 50 % of wood cross section is eaten)
0 = failure (over 50 % of the wood cross section is eaten)

Weight Loss to Termite Attack

The weight losses of each wood sample due to termites attack was calculated using ASTM D1413, 1999, with formula.

$$\text{Weight Loss (\%)} = \frac{T_3 - T_4}{T_3} \text{ X } 100 \qquad (2)$$

where: T_3 = samples weight after conditioning, in g.
T_4 = samples weight after exposure to termite attack, in g.

Data Analysis

Data obtained were analyzed statistically. Analysis of variance (ANOVA) was used for to test significant difference among types of oil. When the ANOVA indicated a significant difference among the oil types, a comparison of means was conducted, employing Duncan Multiple Range Test (DMRT) to identify which groups were significantly different at $\alpha_{0.05.}$

RESULTS AND DISCUSSION

Absorption Test

There is significant difference between the oil types with respect to percentage absorption *B. angustifolia* wood block exposed to termite (Table 1). The mixed oil recorded the highest percentage preservative absorption 49.97% while light and heavy oil recorded 47.23 and 16.25% respectively (Fig. 2). It was clearly noticed that there is significant variation in the oil types. The absorption increased with the increase in the viscosity of the oil thus absorption is proportional to the treatment time (Owoyemi *et al.* 2011). The viscosity and chemical composition of the oils can contributes to the differences in absorption.

Weight Loss to Termite

It was clearly observed that there is significant variation in the oil types concerning the weight loss of wood specimens exposed to termite attack. It was noticed that untreated wood block had the highest percentage weight loss to termite with 21.36% while mixed oil recorded the least weight loss (5.11%), (Fig. 3). It can be mentioned that that the pyrolytic oil has toxic compounds which explained the fact that the oil has insecticidal properties in form of phenolic compounds in prevention of termite attack (Nagnan and Clement 1990; Nakayama *et al.* 2000; Morisawa 2002)

Table 1

Analysis of variance of absorption and weight loss of Boscia angustifolia wood treated with pyrolytic oil

Test (%)	Source of Variation	df	Sum of Squares	Mean Square	F-Value	P-Value
Absorption	Oil Types	2	7013.09	3506.55	143.19	0.00*
	Error	27	661.19	24.49		
	Total	**29**	**7674.28**			
Weight Loss	Oil Types	3	12925.16	4308.39	113.12	0.00*
	Error	36	1371.14	38.09		
	Total	**39**	**14296.31**			

***-significant (P≤0.05)**

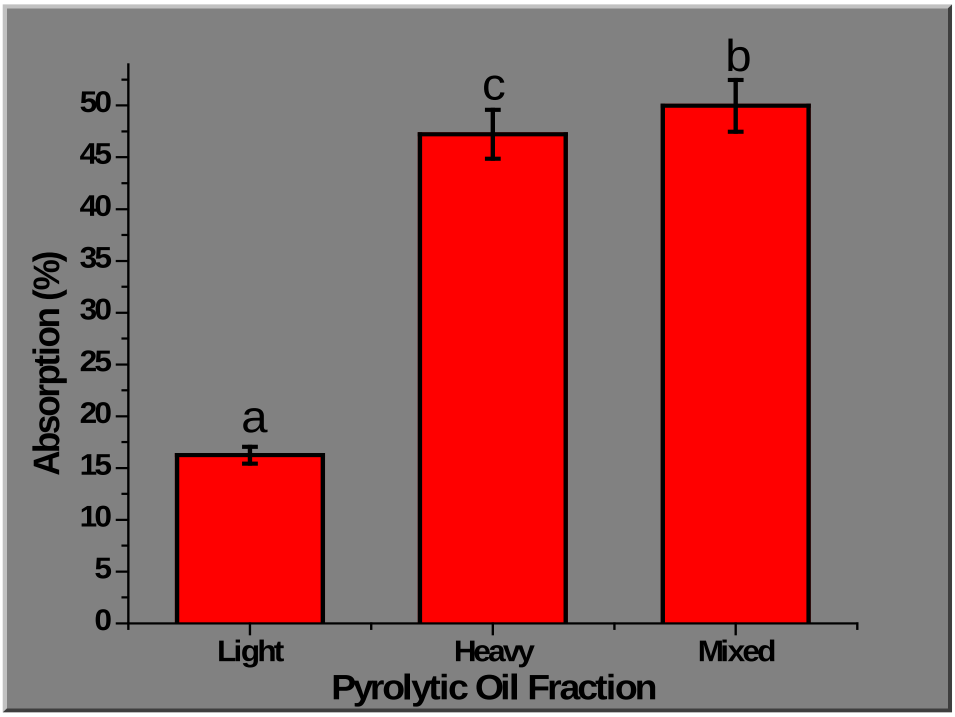


Fig. 3.
Influence of oil types on percentage absorption of B. angustifolia wood
****Bar with the different alphabet are significantly different (P≤0.05).***

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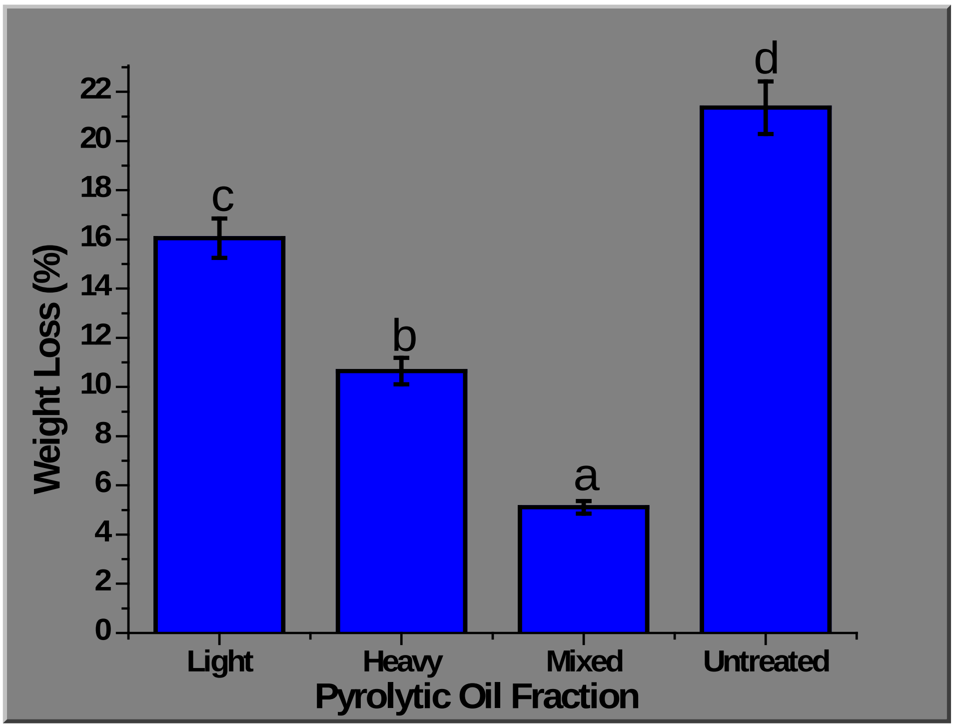

Fig. 4.
Influence of oil types on the weight loss of B. angustifolia wood to termite attack
****Bar with the different alphabet are significantly different (P≤0.05).***

Field Test Visual Rating

By visual observation, it was differentiated the attack of termites on samples and their physical appearance (Fig. 6). The visual observation for this study cover 8 weeks and 4 different visual ratings were considered at 2 weeks of testing. The differences in weight loss showed clearly the extend of effectiveness of preservative (pyrolytic oil) on the wood species used for this study after exposed to termite attack. This revealed clearly that untreated samples were greatly attacked by the termite (rated 4 after 6 weeks), while gradual attack occurred in samples treated with light and heavy oil (rated 7 and 9 at the end of test). Mixed oil had an appreciable effect on termite, with a lowest weight of samples mass (below 6%) and which maintained the rate 10 for all period of testing (Fig. 5). Untreated samples after 8 weeks failed more than 50% of the samples cross section was eaten by termites.

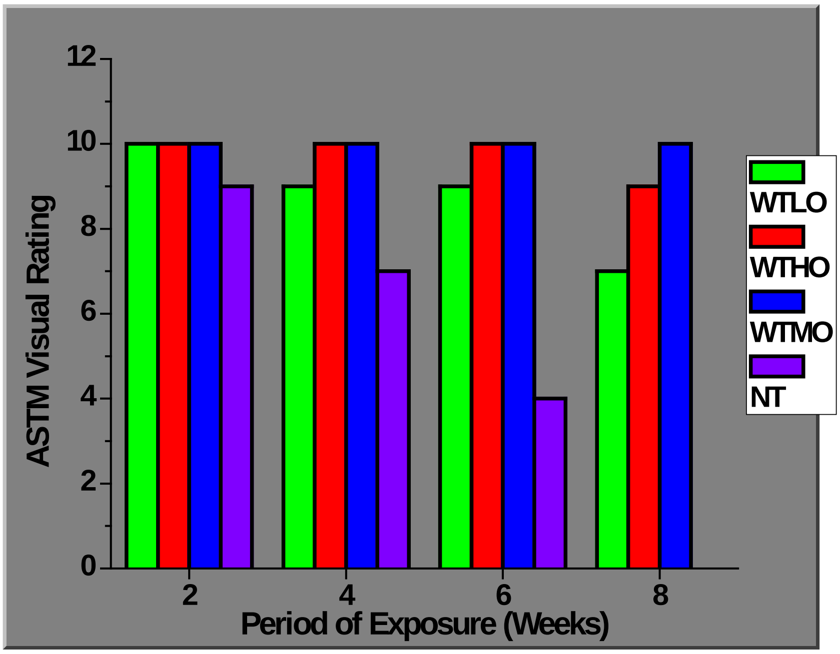

Fig. 5.
ASTM visual rating of wood exposed to termite B. angustifolia wood WTLO: Wood Treated with Light Oil; WTHO: Wood Treated with Heavy Oil; WTMO: Wood Treated with Mixed Oil; No Treatment.

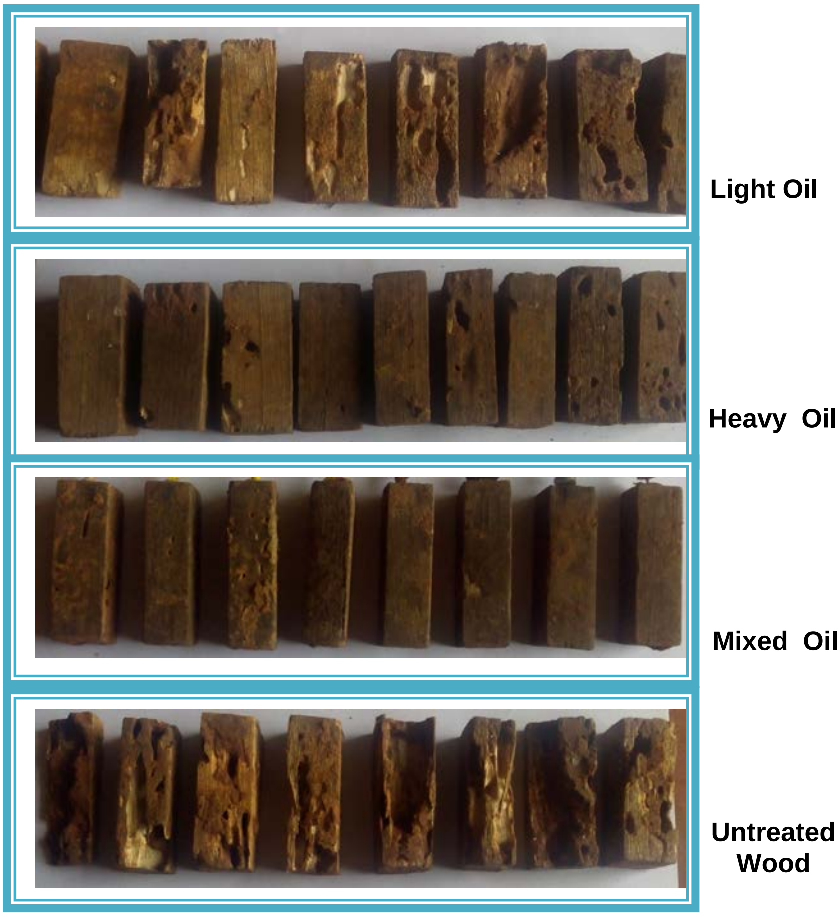

Fig. 6.
Physical appearance of termite attack.

CONCLUSIONS

The results presented here suggest that it is completely feasible to use pyrolytic oil as an alternative to chemical based preservatives. However, oil types (light, heavy and mixed) proved to be effective over the control, but mixed oil is the most efficient. Mixed oil gave a maximum rate for all period of testing. The soaking method (for about 72 hours) assured and adequate oil absorption in samples, the greater values was obtained for mixed oil. Furthermore, extended research should be done in other to examine the effectiveness of the pyrolytic oil against other bio-deteriorating agents.

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