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The Influence of Preservative Viscosity on Fluid Absorption By *Gmelina Arborea* Wood

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Abstract

The effect of preservative viscosity on fluid absorption by *Gmelina arborea* wood was investigated using Copper Chrome Arsenate (CCA), Creosote Oil (CREO), and Cashew-Nut Shell Liquid (CNSL) preservatives. Viscosity test was carried out on these preservatives using viscometer. Hot and cold dipping methods of application were used for the preservative treatments on *Gmelina arborea* wood. The result revealed that hot treatment method lowered preservative viscosity and improved its uptake by the wood with percentage absorption of. 9.65 ± 4.32 compared with cold treatment; 7.70 ± 2. 79. This method statistically showed significant difference between hot and cold treatments. Also, there was significant difference between CCA and the other two preservatives in the absorption capacity of *Gmelina arborea* wood. The highest percentage absorption of 13.94 ± 3.7 was recorded for CCA, followed by CREO with 9.84 ± 4.32, while CNSL has the least absorption of 5.18 ± 1.3 for hot treatment. The result of viscosity test for the preservatives when compared with absorption showed that absorption is greatly influenced by the state of preservatives during application.

Keywords: *Gmelina arborea*, Copper Chrome Arsenate, Creosote Oil, Cashew Nut Shell Liquid, thermal process.

Introduction

The use of chemical preservatives has been a common practice among wood users in building construction, this has led to flooding of the market with different types of chemical preservatives under various trade names. Most of these chemicals have been used with little or no success due to treatment failures. According to a report on failure of termite protection for wood structures in Florida, 61% of pre-construction treatments for wood have failed while 9% of post-construction treatments failed due to chemical barrier failure (AWCAFPA 1995). The effectiveness of wood preservative treatment is not only a function of the toxicity and repellent nature of the preservatives alone, but also that of pre-treatment processing, state of preservatives and methods of application.Research work in the area of wood protection has intensified worldwide over the past two decades because of the need to protect wood in service (Barnes and Murphy, 1995)

Wood preservatives are chemical substances that when suitably applied to wood, make it resistant to attack by fungi, insects or marine borers (Hunt and Qrant 1967), but much has not been done in the area of viscosity test for preservatives. Wood is permeable to fluid, but the degree of its permeability depends on the state of the liquid at the time of application and method of application. According to Desch (1985), permeability is the quantity of the flow of fluids through a porous material. Fluid flow in wood can be by way of the cell cavities or diffusion through the cell walls; this flow is greatly influenced by its viscosity..

The molecules of liquids are not as tightly packed as those of solids or as widely separated as those of gases. Under appropriate temperature and pressure conditions, most substances are able to exist in the liquid state. Thus, viscosity of liquids characterizes its resistance to flow. The viscosity of a liquid decreases as temperature rises; and increases with pressure. Viscosity therefore is the property of a fluid that tends to prevent it from flowing when subjected to an applied force. High viscosity fluids resist flow; low-viscosity fluids flow easily. The tenacity with which a moving layer of fluid drags adjacent layers of fluid along with it determines its viscosity, which is measured with a viscometer; a container with a standard-sized orifice in the bottom. The rate at which the fluid flows through the orifice is a measure of its viscosity.

The vessels of *Gmelina arborea* constitute the main channel for the flow of preservative solution into the wood in the longitudinal direction; thereafter the solution penetrates laterally into the surrounding tissues through the bordered pits in the adjacent cells. The rays and the pits in the adjacent cells are the common pathways for lateral, radial and tangential penetration. (Ifebueme *et. al.*, 1990).

The dry heartwood is resistant to penetration by both water-borne and oily preservatives even when treated with vacuum pressure and hot treatment methods. Deposition of extraneous materials in the wood cell walls and in the lumens during the biochemical transformation of the sapwood into heartwood, encrustation of the pit membrane surface as well as the in-growth of obstructing tyloses into the vessels are majorly responsible for the impermeability of *Gmelina* heartwood.

CCA is a waterborne preservative that is highly effective and chemically fixed in wood by the formation of insoluble material that cannot be leached out by water. CCA is usually used in concentration from a dry mixture of paste or salt concentrates. Keneth (1998) reported that CCA treatment provided a very good protection against termites attack at retention as low as 1.6 kg/m^3. These CCA mixtures have been shown to give good protection to softwoods over long periods, being highly effective against fungal and insect attack, with copper part being particularly effective against soft rot fungi; Chromium fixes the chemical to the wood, and third compound arsenic is used against termites attack. The chemical penetrates wood well, is odourless, and wood surfaces can be painted once dried. (Zabel and Fengel, 1990).

Creosote oil **i**s the most widely used of all preservative oils. It is produced by the high-temperature distillation of bituminous coal. The distillate consists of solid aromatic hydrocarbons, and tar acids and bases. Creosote is toxic to fungi and insects, is relatively insoluble in water, and is generally low cost. For proper treatment of timber, creosote must be heated up to 100 to 120^{0}C or diluted with kerosene to reduce its viscosity. Application could be with pressure treatment, hot or cold bath treatment. It gives excellent protection against fungal deterioration termite and marine borer attack (Willeitner, 1977).

Cashew nut shell liquid is derived from the nutshell of cashew tree (*Anarcardium occidentale*) fruits. The cashew nut, kidney-shaped is from 2.5 to 3.2 cm long, 1.9.2 cm broad of the base and 1.3 to 1.6 thick at the stem end (Cornelius, 1966). The shell oil is around 18 – 28% of the total raw nut weight. The CNSL is oily and viscous and contains the following naturally produced phenolic compound: Anacardic acid (73.3%), cardol (19.1), methyl carchol (2.8%) and cardanol 4.8% (Tyman, 1975; Tyman, 1979).

Materials and Methods

Freshly sawn *Gmelina arborea* wood obtained from The Federal University of Technology Akure Forestry Plantation were cut (flat sawn) into fifteen pieces of 300mm x 38mm x 38mm. The Federal University of Technology, Akure, Nigeria (Lat. 7^{o}17'N, Long 5^{o}10'E), lies in the tropical rainforest zone of Nigeria (mean annual temperature, 20^{o}C; elevation, 350m; relative humidity 85-100% during the rainy season and 60% during the harmattan period). The weight of the samples were taken before oven drying and recorded as T_1. The samples were oven dried at 105^{0}C for 24hours to remove the moisture. The weight of the samples were taken and recorded as T_2. The first of samples which served as control were cold-dipped into solutions of CCA, CREO, and CNSL preservatives in an open tank for 24 hours after which they were drained on wire mesh and the samples weighed and recorded as T_3. The second set of samples were heated in an open container to a temperature of 105^0C and allowed to cool down overnight. The heating process was done by direct firing in an open tank. CCA, which is water-borne heated normally; Creosote, which is oil-borne derived from coal tar, got inflamed when firing was intense; the intensity was lowered to reduce the incidence of inflammability; While CNSL, an extraction from Cashew nut Shell also oily and highly viscous in nature foamed extensively during the heating process and was pouring out of the tank, firing intensity was also lowered and done gradually to reduce this phenomena.

The preservative absorption was calculated using the weight of samples before and after preservative treatments:

$$\text{Absorption } \% = 100 \times \left(\frac{T_2 - T_1}{T_1} \right)$$

Where T_3 = treated weight and

T_2 = Oven dry weight.

Viscosity of the preservatives was determined at hot and cold states in accordance with ASTM (1998) D5125 using a viscosity flow cup with an orifice of diameter 3.00mm. Flow rate was determined with stopwatch by observing time taken for the fluid to flow out. The cumulative percentage of each chemical preservative as determined by relative net uptake was subjected to statistical analysis, which include descriptive statistics (mean) and two-way analysis of variance (randomized Complete Block Design). Mean difference where significant difference existed was done with Fishers' least significant difference (LSD) and Duncan's multiple range test.

Results and Discussion

The result of mean percentage absorption of preservatives by hot and cold treatments of *Gmelina arborea* presented in Table 1 showed that CCA has the highest absorption with 13.94% and 10.12%, for both hot and cold treated samples respectively when compared with CREO and CNSL treatments. This was followed by CREO with 9.84% and 6.86%; while CNSL has the least with 5.18% and 6.12% respectively; (Fig. 1.) The result also revealed that there is increase in the quantity of preservative absorbed by *Gmelina* wood for hot treatment than for the cold (Table 3).

The analysis of variance showed that there were significant differences in the preservatives and also in the treatment methods (Table 2). Also, the follow up test, at least significance difference value of $p<0.05$ (Table 1), showed that there were significant differences between CCA and the other two preservatives; CREO and CNSL, thus indicating that the type of preservatives used affected the quantity absorbed by the wood. CCA treatment was significantly different from CREO and CNSL preservatives while there were no significant differences between CREO and CNSL preservatives due to the foamy nature of CNSL when heated which permitted the presence of air bubbles; this indicate that the nature of preservative determined the quantity that would be absorbed. This result showed that absorption was higher for CCA than CREO and CNSL because of their oily nature. The hygroscopic nature of wood makes it easily permeable to waterborne preservatives than oil borne. This agrees with the previous assertion of ASTM (1974) that absorptions are higher for water soluble preservatives than for oily types, because water does not only fill the cell cavities but it is also absorbed in the cell walls. Thus, CCA that is water base would readily be absorbed into the cell lumen as well as the cell walls, while Creosote Oil and CNSL would only fill the cell lumen because of their high viscosity.

Table 1: Mean percentage absorption of preservatives for hot and cold treatments of *Gmelina arborea* wood.

Preservatives	Mean % Preservative Absorption	
	Hot treatment	Cold treatment
CCA	13.94 ± 3.7 a	10.12 ± 2.18 a
Creosote	9.84 ± 1.3 b	6.86 ± 1.12 b
CNSL	5.18 ± 0.80 b	6.12 ±3.15 b

Means with the same letter vertically are not significantly different. (p>0.05)

Table 2: Percentage absorption for the preservative types and method of application.

sv	*df*	*Ss*	*ms*	*f-cal*	Significant level
Methods	1	28.62	28.62	4.21	0.052 *
Preservatives	2	205.12	105.56	15.08	0.00 *
Error	22	149.61	6.8		
Total	25	292.43			

*significant (p≤0.05)

Table 3: Mean percentage Absorption for hot and cold treatments.

Methods	Mean % absorption
Hot	9.65 ± 4.32a
Cold	7.83 ± 2. 79b

* Means with the same letter vertically are not significantly different. (p>0.05)

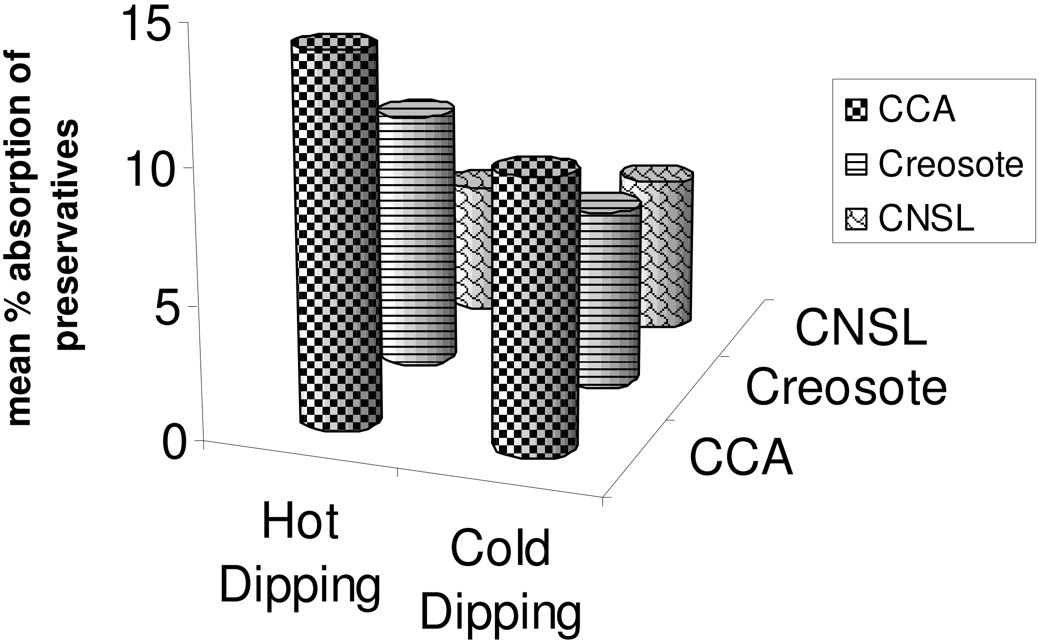

Fig.1: Comparison of Cold and Hot Dipping Preservative treatments of *Gmelina arborea* wood.

Thermal process improved the uptake of the treatment preservatives compared with the uptake in cold samples (Table 3). Hot treated *Gmelina* samples have the higher mean percentage absorption (9.44 ± 3.28) than for the cold treated samples (7.83 ± 2. 96). The Analysis of variance showed that the difference was statistically significant at $p<0.05$ levels. Hot treatment had relatively little effect on the quantity of CNSL preservatives absorbed because of its foamy reaction during heating. The presence of air bubbles during foaming accounted for the lower absorption of 5.18 ± 0.80 recorded as compared with 6.12 ± 3.15 for cold treatment (Table 1 and Figure 1)

Also, the result of the viscosity related test for CCA, CREO, and CNSL presented in Table 4 showed that CCA of 183.85cm^3 volume had a viscous flow rate of 1.92cm^3/s; CREO of the same volume recorded 1.19cm^3/s while CNSL of the same volume had a flow rate of 0.68cm^3/s. This result further illustrated in figure 2 revealed the same pattern of result for absorption test showing the effect of viscosity on the net preservative uptake by *Gmelina arborea* wood. This showed that the rate of flow is inversely related to the viscosity of the preservatives, that is, high viscous preservatives like CNSL and CREO would have low flow rate; while a low viscous preservative like CCA would have high flow. The higher preservative absorption evidenced in hot treatment also showed that fluid flow in *Gmelina* wood is enhanced when heated. This is in consonance with the assertion of Willeitner, (1977) that for proper treatment of timber, creosote oil must be heated up to 100 to 120^{0}C or diluted with kerosene to reduce its viscosity.

Table 4: Mean flow rate of CCA, CREO and CNSL preservatives.

Preservatives	**Volume (cm^3)**	**Flow time(s) (cold)**	**Flow rate (cm^3/s)**	**Flow time(s) (Hot)**	**Flow rate (cm^3/s)**
CCA	183.85	96	1.92	59.80	3.10
CREO	183.85	155	1.19	87.70	2.10
CNSL	183.85	269	0.68	282.40	0.65

Table 5: Mean flow rate for the preservative types and the viscous state

SV	***Df***	***SS***	***MS***	***F-cal***	***Sig. Level***
Preservatives	2	17.04	8.52	107.16	0.00*
Viscous state	1	3.54	3.54	44.47	0.00*
Error	26	2.07	0.08		
Total	29	22.65			

*Significant ($p<0.05$)

Table 6: Follow-up test for the mean flow rate for the preservative types

Preservative	**Mean flow rate**
CCA	2.51a
CREO	1.65b
CNSL	0.67c

*Means with the same letter(s) are not significantly different. ($p>0.05$)

Table 7: Mean flow time for the preservatives at different thermal states

Thermal state	**Mean flow time**
Hot	1.95±0.073a
Cold	1.26±0.073b

*Means with the same letter(s) are not significantly different. ($p>0.05$)

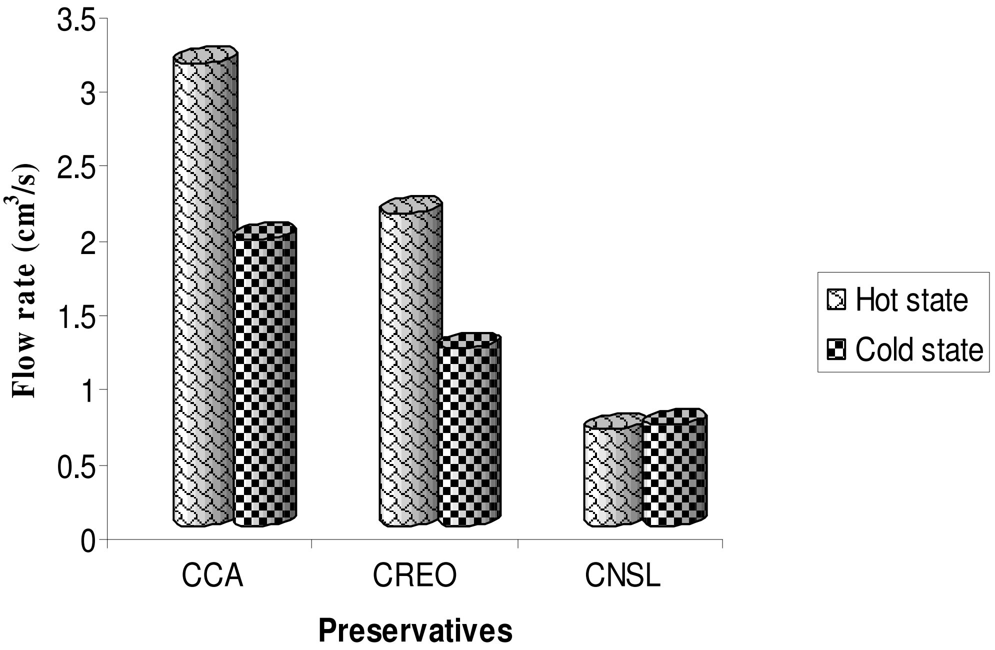

Figure 2: Mean viscosity test for CCA, CREO, and CNSL preservatives

Conclusion

The viscosity of preservatives is a major consideration when applying preservatives in wood protection because this will determine whether further dilution is necessary. Previous study carried out by Owoyemi (2008) showed that dilution of preservative tends to reduce concentration and lower its potency. It has been observed that most wood users ignorantly carry out further dilution of preservatives to increase quantity rather than enhancing flow consistency. This practice reduces the potency below the threshold value thereby causing treatment failure no sooner than the preservative is applied. Our research effort focused on the methods of enhancing absorption without any effect on the concentration level of the preservatives. However, this study did not include the effect of chemical breakdown due to heating. Further studies could be conducted to determine this.

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