Wood Treatment by Paraffin Impregnation - Preliminary Research

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ABSTRACT

Pinus pinaster wood was impregnated with paraffin to different levels using a hot-cold process with the hot step at 170-180 ºC and 2-4h. Weight gain, density, equilibrium moisture and dimensional stability (ASE) at 35% and 65% relative humidity and termite durability against *Reticulitermes grassei* (Clément) were determined. The weight gain (WG) ranged between 16% and 87% according to treatment. It was determined that 30 minutes in the cold bath was enough to reach maximum penetration. Density increased from 0.57 to 0.99, almost reaching the water density. ASE ranged between 38-96% and 16-71% for respectively 35% and 65% relative humidity. The best anti shrinking efficiency (ASE) was obtained for a combined treatment at 180 ºC (4h) and 61% WG. Nevertheless the use of a higher temperature bath did not significantly improve the dimensional stability when compared at the same paraffin WG. Equilibrium moisture content decreased drastically due to the treatment from 9.9%, 12.0% to 0.5% and 2.1% for 35% and 65% relative humidity. Termite durability improved from level 4 to level 3 of attack. Treated wood presented higher termite mortality (52%) against (17%) of untreated wood. The preliminary tests with paraffin impregnation showed that wood has lower equilibrium moisture, higher dimensional stability and density and a higher resistance against termites.

INTRODUCTION

The environmental concerns about the use of dangerous chemicals on wood preservation have led to an increase in research on processes to improve properties of less noble woods without the use of chemicals or with less harmful chemicals. Several wood modification processes have reached commercialisation, mainly those based on heat treatment, chemical modification or impregnation. Paraffin is used as a surface treatment to prevent water uptake. Scholz *et al.* (2010) studied the efficacy of distinct waxes, including paraffin, impregnated in Scots pine sapwood (*Pinus sylvestris L.*) against termites and concluded that waxes reduced termite damage, without preventing it. Nevertheless wax-impregnated pine sapwood showed, according to EN 117, a 100% termite mortality rate. The treatment made with paraffin resulted in a good resistance against *R. banyulensis* while amide wax-treated beech sustained less 5% mass loss against *C. acinaciformis* and *M. darwiniensis*. The objective of this research was to test

the improvement of some properties of pine wood through paraffin impregnation alone and combined with heat treatment.

EXPERIMENTAL

Pinus pinaster wood was used for the tests. Equilibrium moisture was determined for untreated samples. The samples for dimensional stability had approximately 20x20x20 mm, without knots or other singularities and well-defined tangential, radial and longitudinal sections. The paraffin impregnation was made by hot and cold process. The treatment was done using a hot bath at 140, 170 and 180 °C and a cold bath at 70 ºC. Six sets of conditions were tested. The time spent in each bath and the temperature of the bath can be found in Table 1. Three samples were tested for each treatment. For the determination of the weight gain it was assumed that after the treatment the moisture was approximately zero.

Table 1: Temperature of cold and hot bath

	Sample	A	B	C	D	E	F
	Temp (ºC)	140	140	170	180	180	180
Hot bath	Time (min)	120	120	120	120	240	240
	Temp (ºC)	70	70	70	70	70	-
Cold bath	Time (min)	30	120	30	30	30	-

The samples for the determination of equilibrium moisture content and dimensional stability were kept in a conditioned room at 35% relative humidity (RH) and 20 ºC until reaching a constant weight. When this was achieved the samples were weighted and their dimensions measured in all directions with a Digital Caliper (±0.01mm). After that the same proceeding was done for wood conditioned at 65% RH and 20 ºC. The dimensional stability of the treated samples was calculated as an Anti Swelling Efficiency (ASE) method used by Stamm (1946) and presented in Esteves *et al.* (2006), between 35% or 65% relative humidities and dry samples. ASE gives the shrinking difference between treated and untreated samples calculated in percent. Density was determined on both environments as mass/volume.

To assess the termite resistance against *Reticulitermes grassei* Clément the general procedure of EN117 (2005) was followed. Colonies of 250 workers of *R. grassei*, collected from broken trees and stubs in a forest of *Pinus pinaster* Ait. situated approximately at 25 km east of Lisbon, Portugal, were established in 500 ml glass conical flasks with moisturised sand (Fontainebleau sand and water; 4:1 v/v) as substrate. Five paraffin impregnated replicates were then placed in contact with the termites and the test run for eight weeks at 25 ºC ± 2ºC and 80% ± 5% relative humidity. Maritime pine test specimens with the same dimensions were also included as virulence controls.

RESULTS AND DISCUSSION

Table 2 shows the weight gains achieved following treatments. The highest percentage of weight gain was obtained with the treatments A and B that correspond to a temperature of 140 °C for 2 h in a hot bath, and 30 min and 2 h in the cold bath. It was found that a longer duration in the cold bath did not significantly improve the percentage of impregnation, which was approximately the same in treatments A and B. At temperatures above 140 °C there should be a combined effect between some mass

loss due to thermal degradation and the weight gain due to impregnation with paraffin. The treatments D and C only differed on the temperature of the hot bath and it turned out that while in C there was an increase of about 78%, in D the increase was around 70%. This might be due to the higher temperature on D that led to a higher mass loss than in C or the use of a higher temperature decreases the impregnation. The same was true between the treatments D and E where the difference was the time spent in the bath at 180 ºC, which was 2h in D and 4 h in E. Since the weight gain was higher in the treatment D (70%) than in E (61%) that might be due to the mass loss by thermal degradation. Another reason for the differences might be the assumption that all of the samples were dried in the end of the treatment, which might not be true. Treatment F showed that most of the weight gain was done in the cold bath since even with 4 h in the hot bath the weight gain was around 16%.

Table 2: Weight gain and density by paraffin impregnation

		A	**B**	**C**	**D**	**E**	**F**
Weight gain (%)	Average	86.6	86.9	78.1	69.7	61.4	16.0
	Standev	3.7	4.3	3.1	2.1	3.6	1.8
	Density	0.98	0.99	0.95	0.92	0.88	0.65

As a result of paraffin impregnation there was a significant increase in wood density (Table 2) from 0.57 in untreated wood, to between 0.65 (treatment F) and 0.99 (treatment B). This meant that wood treated with a treatment similar to B has a density closer to water.

ASE values (Table 3) ranged between 38-96% and 16-71% for respectively 35% and 65% relative humidity. The best anti shrinking efficiency (ASE) was obtained for a combined treatment at 180 ºC (4h) and 61% WG (E). Nevertheless the use of a higher temperature bath did not significantly improve the dimensional stability when compared at the same paraffin WG.

Table 3: Dimensional stability as ASE at 35% and 65% RH measured in the radial and tangential directions. WG: weight gain in %.

		ASE35%		**ASE65%**	
	WG	**Rad35**	**Tang35**	**Rad65**	**Tang65**
A	87	84	79	45	42
B	87	87	90	41	61
C	78	82	78	54	55
D	70	80	86	52	71
E	61	89	96	66	59
F	16	38	57	18	16

Equilibrium moisture content decreased drastically due to the treatment from 9.9% and 12.0% to 0.5% and 2.1% for 35% and 65% relative humidity (Figure 1). Nevertheless it should be mentioned that since it was assumed that equilibrium moisture content was approximately zero after the treatment, and this is not necessarily true, these equilibrium moisture content might be somewhat higher than the values presented but surely much smaller than the content for untreated wood.

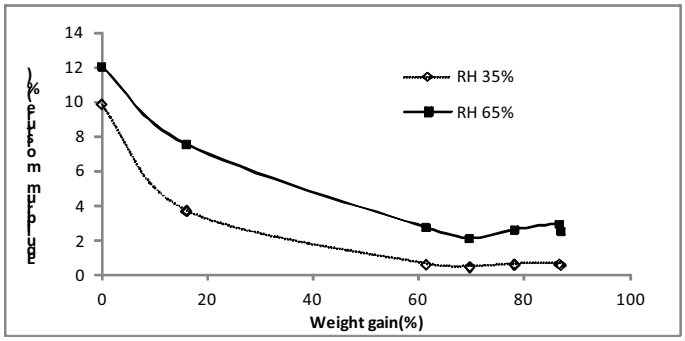

Figure 1: Equilibrium moisture content vs weight gain

As regards the resistance towards termite degradation (Table 4), it was found that although treated wood still was attacked by *R. grassei* termites, the durability improved from level 4 to level 3 of attack. The paraffin impregnated wood also presented a higher termite mortality (52%) against (17%) of untreated controls.

Table 4: Mortality and attack grade of termites

	Survival	**Grade**		**Survival**	**Grade**
	82.0	4		47.3	3
Untreated	83.3	4	Paraffin	48.0	3
	84.7	4	impregnated	65.3	3
				17.3	2
				62.0	4
Average	83.3	4.0	Average	48.0	3.0

CONCLUSIONS

The preliminary tests with paraffin impregnation showed that wood properties were improved with regard to lower equilibrium moisture, higher dimensional stability and density, and a higher resistance against *Reticulitermes grassei* termites.

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REFERENCES

Esteves, B., Marques, A. V., Domingos, I., and Pereira, H. (2006). "Influence of steam heating on the properties of pine (*Pinus pinaster*) and eucalypt (*Eucalyptus globulus*) wood." *Wood Science and Technology*, **41**: 193-207.

Scholz, G., Militz, H., Gascón-Garrido, P., Ibiza-Palacios, M. S., Oliver-Villanueva, J. V., Peters, B. C., and Fitzgerald, C. J. (2010). "Improved termite resistance of wood by wax impregnation." *International Biodeterioration and Biodegradation*, **64**(8): 688-693.