IRG/WP 08-10658

THE INTERNATIONAL RESEARCH GROUP ON WOOD PROTECTION

Section 1 Biology

Utilizing Cypress to improve the decay and termite resistance of OSB panels

Nadine Amusant[1] – Olivier Arnould[2] – Aurélien Depres[3] – Reza Hammid Mansouris[3] -Tony Pizzi[3] Christine Baudassé[1]

(1) Cirad-Forêt - 73 rue JF Breton, TA 10/16 34398 - Montpellier Cedex 5-France
(2) LMGC - UMR 5508 - Université Montpellier II - CC 048 Place Eugène Bataillon
34095 Montpellier cedex 5
(2) LERMAB - Faculté des Sciences et Techniques - BP 239 - 54506 VANDOEUVRE les Nancy cedex

Paper prepared for the 39th Annual Meeting
Istanbul, TURKEY
25-28 May 2008

IRG SECRETARIAT
Box 5609
SE-114 86 Stockholm
Sweden
www.irg-wp.com

Utilizing Cypress to improve the decay and termite resistance of OSB panels

Nadine Amusant[1] –- Olivier Arnould[2] –Aurélien Depres[3] – Reza Hammid Mansouris[3] -Tony Pizzi[3] Christine Baudassé[1] –

(1) Cirad-Forêt - 73 rue JF Breton, TA 10/16 34398 - Montpellier Cedex 5-France
(2) LMGC - UMR 5508 - Université Montpellier II - CC 048 Place Eugène Bataillon 34095 Montpellier cedex 5
(2) LERMAB - Faculté des Sciences et Techniques - BP 239 - 54506 VANDOEUVRE les Nancy cedex

ABSTRACT

OSB panels were manufactured with mixture of pine and cypress heartwood and lignin and tannin based resins in order to propose an eco-friendly wood composite. The resistance of OSB panels was tested against *Reticulitermes santonensis* according to the EN 118 and EN 117 standards and field tests methods. OSB made from cypress showed more resistance against the tested termite, the resistance decreased as the percentage of pine increased. The degree of attack differed according the choice of standard procedure. The field test results revealed that in exterior conditions and when the termites had a feeding choice, all mixtures showed the same behaviour.

Keyword: OSB panels, termites, cypress, pine, field tests, EN 118, EN 117.

1. Introduction

Wood composite production has increased dramatically over the past three decades due to a number of factors. The changing wood supply, the development of new composite technologies and the widespread acceptance by architects and builders have each contributed to increasing wood composite production (Gardner *and al*, 2003). OSB panels designed for end uses in which decay or termite attack are potential hazards often contain fungicides or insecticides because these panels are generally manufactured from nondurable wood species and therefore have little inherent biological resistance. Many different chemical compounds have been applied to wood composites. Leachability and toxicity are major problems that arise when preservative chemicals are used to treat composite products. Sometimes interactions between resins and preservatives are detrimental to bond performance and ultimately reduce the physical properties of the panel (Kirkpatrick, 2006). Moreover, it is widely known that wood-based composites are generally not resistant to termite attack (Muin and Tsunoda, 2003). To reduce the widespread use of chemical preservatives to protect bio-based materials against bioterioration, efforts should be focused on using naturally durable species to enhance the long-term service of these materials in hazardous environments (Behr, 1972, Evans, 2000, Yalinkilic, 1998, Kartal, 2003). There is increasing

concern about the safety and environmental effects of many artificial chemicals used to preserve wood and growing interest in alternative wood preservation methods. There is also renewed interest in using naturally durable species to overcome health risks and environmental problems associated with the application of chemical wood preservatives. It has been reported that mixing durable and nondurable species increases the fungal and termite resistance of composites (Wan *and al*, 2007, Kartal, 2003). A second environmental concern is the control of volatile and semivolatile compounds derived from resins. Modern product development should thus consider both the ecological and technical properties of products. Natural resins based on lignin (Lei, 2007, Mansouri *and al*, 2007or tannin (Garnier, 2002, Ballerini, 2005) are potential options that could be used to obtain environment-friendly products that meet consumers' needs.
This study was carried out to investigate the possibility of developing ecoproducts with durable and nondurable species and natural resin. We came up with an optimal combination that could give the best performance from a biological standpoint.

2. EXPERIMENTAL METHODS

2.1 Manufacturing OSB panels

The OSB specimens were made from cypress, pine or a mixture of these woods, as shown in Table 1. The original trees were around 60 years old and were grown in the Grenouillet Arboretum (France), felled and crosscut into 1 m long logs. The log bark and sapwood were removed. Sapwood was not removed from pine logs since it is nondurable against termites. Flakes (100 x 10 x 0.6 mm) were obtained from thin veneer. Care was taken at this and subsequent stages to keep the particles from the different species separate. The flakes were then dried to about 6–7% moisture before gluing. Commercial MUF (melanin-urea-formol) and pMDI (polymethylene-diphenyl-diisocyanate) resins were used as reference resins. We tested two natural resins, i.e. tannin-based resin (tannin from pine with hexamine hardener) and lignin-based resin (lignin with paraformaldehyde and pMDI) to blend the flakes. The panel manufacturing conditions are presented in Table 2. Three panels were manufactured for each species-resin combination. All panels were conditioned in a climatic room at 21°C –65% relative humidity (RH) for 2 months before the biological tests.

Table 1: Composition of OSB specimens

Composition	Type of Resins
100% pine	Tannin
100% pine	Lignin
100% pine	MUF / PMDI
100% cypress	Tannin
100% cypress	Lignin
100% cypress	MUF / PMDI
75% cypress – 25% pine	Tannin
75% cypress – 25% pine	Lignin
50% cypress – 50% pine	Tannin
50% cypress – 50% pine	Lignin

Table 2: Panel manufacturing parameters

Panel dimension	35 mm x 35 mm x 14 mm
Panel construction	Three layer – 2 exterior layers perpendicular to the middle one
Mass distribution	20%: 60%: 20% side /core / side
Wood species	pine, cypress, acacia
Target mat moisture content	7-6%
Resin content	13% side and 11% core
Blender	Dakota
Blender rotation speed	900 rpm
Pressing cycle	90s 35 bar, 120 s 16 bar, 150 s 8 bar
Press temperature	175°C (plate surface)
Total press time	6 min
Replicate	3

2.2 Test specimens and sampling

A total of 30 OSB panels (350 x 350 x 14 mm) were prepared, which corresponded to three panels for for each resin-species combination. For each panel, 18 OSB test specimens of 50 x 50 x 14 mm^3 were cut and maintained for 8 weeks in a climatic room (65% RH – 21°C) until constant mass. All OSB specimens were weighed prior to the bioassays. cypress heartwood was used for the solid wood controls.

2.3 Termite bioassay according to the EN 118 standard

The OSB specimens and solid wood were assessed for termite resistance according to the EN 118 procedure (AFNOR, 2005). With this method, termites are only in contact with the face of the OSB specimen. *Reticulitermes santonensis* termites were collected on Oleron Island (France) and transported to the laboratory where the termites were bred. Termites remained in breeding tubs from the collection date in May 2005 until their extraction in February 2006. The ground glass end of one tube (110 mm length – 25 mm width) was attached with colophane at the centre of the OSB test specimens. Some wet sand (1:4 v/v water-sand ratio) was added to each tube, occupying at least two-thirds of the volume of the tube, and 250 termite workers, 5 soldiers and 5 nymphs were distributed. Test assemblies were kept the in a testing chamber (27–70% RH) for 8 weeks. A total of nine replicates for each tested panel type (resin-species combination) and 6 cypress wood blocks were assessed. Three pine sapwood samples (50 x 50 x 10 mm) were used to check the termite virulence. At the end of the test period, the tubs were unsealed and the number of live termite workers, soldiers and nymphs were counted in order to determine the worker survival rate. In addition, each OSB specimen was examined and visually rated using a standard rating system (AFNOR 2005; Table 3). The cleaned OSB specimens and the solid wood were conditioned in a climatic room (21°C –65% RH) until constant mass and then reweighed to determine the weight loss. The bioassay was valid if the three virulence control specimens corresponded to level 4 when visually examined and if the colonies had a survival rate of at least 50%.

Table 3: Visual ratings in the termite test

Rating	Severity of termite attack
	No attack
1	Attempted attack
2	Slight attack
3	Average attacks
4	Strong attack

2.4 Termite bioassay according to the EN 117 standard

The OSB specimens and solid wood were also assessed for termite resistance using the EN 117 procedure (AFNOR, 2005). With this method, termites can be in contact with all sides of the OSB specimens. In a separate container containing an adequate quantity of remoistened sand, we placed a glass ring in the middle of one of the vertical walls of the test container, along with a group of termites (250 workers, 5 soldiers and 5 nymphs). The containers were placed in a climatic room (27°C –70% RH) for 48 h in order to ensure that the termites had settled in properly. Then the OSB specimens and solid wood were carefully placed on the glass ring. One of the narrow longitudinal sides was resting on the ring, with a wide longitudinal side in contact with a test container wall. Test assemblies were kept the in a testing chamber (27°C–70% RH) for 8 weeks. A total of nine replicates from each tested panel type (resin-species combination) and 6 cypress solid wood blocks were evaluated. Three pine sapwood samples (50 x 50 x 10 mm) were used to check the termite virulence. At the end of the test period, the tubs were unsealed and the number of live termite workers, soldiers and nymphs were counted to determine the worker survival rate. In addition, each OSB specimen was examined and visually rated using a standard rating system (AFNOR 2005, Table 3). The cleaned wood specimens were conditioned in climatic room (21°C–65% RH) until constant mass and then reweighed to determine the weight loss.

2.5 Field tests

The OSB specimens were directly exposed to tropical conditions (French Guiana). We also used a nondurable Amazonian species, i.e. yayamadou (*Virola surinamensis*), in order to attract termites and monitor their virulence. The specimens were placed under cover in order to protect them from bad weather and avoid fungal attack. The different OSB specimens were installed horizontally in a 1 x 1 *m* area directly in contact with the yayamadou control wood block. A total of nine replicates for each combination (*resin-species combination*) were used. The OSB specimens were randomly laid side by side. Each test specimen was sandwiched between two yayamadou wood blocks. A total of nine replicates from each tested panel type (r*esin-species combination*). At the end of the exposure period, the OSB specimens and yayamadou solid wood blocks were cleaned, stabilised in a climatic room (65% RH–21°C) in order to determine the mass loss. The OSB specimens were examined regularly to monitor the presence of termites. These assays were conducted at the Kourou research station in French Guiana (5°09 N, 52°3 O). This station is under an equatorial climate, with a mean annual rainfall of 3000 mm and a mean annual temperature of 26°C. *Nasitutermes existiosus*, *Heteroterme tenuis* and *Coptotermes testaceus* are the key target species. The trial began in January 2007 and lasted 6 months.

2.6 Statistical analysis

A suitable analysis of variance (ANOVA) was performed, with mass losses and the termite mortality rates as variables, to assess the effects of the panel composition and resin type (percentage of pine) on resistance to biodeterioration.

3 RESULTS

3.1 Results according to the EN 118 standard

The average weight losses, percentage termite survival and visual rate are shown in Table 4. Thettacks of pine sapwood clearly showed that termites were active under the test conditions, thus allowing comparison of the termicidal performances of the wood-based composites. According to the EN 118 standard, 250 termites were exposed to a 3.14 cm² panel surface. According to the visual rating, all panels were highly attacked but the mass loss study results showed that the panel composition had a significant effect on the susceptibility of OSB specimens to termite attack. The resistance depended on the percentage of durable species wood in the panel and the choice of resin. Panels composed of 100% pine were more resistant than solid wood: the percentage of termite survival and mass loss were lower than in pine sapwood blocks. Termites attacked earlywood in pine sapwood faster than they did in composite panels because this portion of growth ring is softer and the resin in the panel may interfere. There was a significant effect ($p > 0.0001$) of the panel composition on mass losses in OSB specimens. cypress solid wood is durable against termites. Panels composed of 100% cypress wood showed shallow testing nibbles, which were mostly on the surface and represented tentative termite attacks. A larger area was nibbled on 75% cypress panels than on 100% cypress panels. Termites built galleries within many panel specimens made with 50% cypress, while attacks were limited to the surface of specimens with higher cypress contents. Clearly, specimens containing high percentages of cypress heartwood were more resistant to termite attack than those containing a high percentage of pine. All differences between the different resin-species combinations were significant at the 1% level.

The percentage of termite survival relative to control is an important index of the panel specimen toxicity level. Survival data for controls demonstrated how termites were able to survive during the bioassays. There was evidence that specimens containing cypress were toxic to termites, i.e. the survival percentages decreased when the percentage of cypress increased, with no survival noted in the 100% cypress OSB specimens after 5 weeks exposure. With the cypress-pine mixture, termite mortality was higher than in the control. The mixture was nonrepellent and consumed by termites, and the toxicity acted slowly, thus enabling distribution throughout the colony. Volatiles from cypress suppressed termite activity. The resistance of cypress heartwood to termite attack has been attributed to the presence of tropolones, particularly thujaplicine in the heartwood (Haluk, 2000, Zavarin, 1959b, Zavarin, 1959a). Tropolones were found to have a strong a potent insecticidal activity against *C. formosanus* (Morita *and al*, 2003), but other compounds like terpene fractions may also confer durability. The high mortality level and the degree of attack indicated that the extractives are slow-acting toxicants. The better resistance observed in the solid block specimens than in the 100% cypress OSB specimens could be explained by a decrease in extractive activity. The high temperatures and steam encountered in OSB fibreboard manufacturing conditions may cause a loss of some extractives responsible for termite resistance in intact heartwood. Termites have to nibble the surface of the wood before to dead because the extractives remain intact in deep area. The visual rating results disqualified all OSB specimens because the laboratory test conditions were more severe than exposure in service conditions.

Differences in mass losses after termite attack and visible damage ratings were minimal between panels with 100% pine and those with 50% cypress and pine. The consumption rates were directly related to the termite feeding activity and clearly showed that the wood-based composites had different levels of resistance to termite attack. The highest termite resistance was obtained with the 100% cypress panels, followed by 75% cypress and 25% pine panels. Table 5 shows the results of an ANOVA to assess the effects of resin on mass loss in wood-based composites due to *Reticulitermes santonensis*. This analysis revealed that the effects of resin significantly affected the termicidal performance of OSB. Note that the OSB specimens made with tannin-based resin were consumed at a higher rate than the OSB specimens made with industrial or lignin-based resin.

Table 4: Percentage mean mass loss in OSB specimens, visual valuation according to the EN 118 standard

OSB type	**Resin**	**Average mass loss (%)**	**Rating scale**	**Survival (%)**
Control		14.9	4	66.1 (4.2)
Cypress solid wood		0.2	0	0
100% pine	Tannin	7.6 (2.1)	4	59.1 (21)
100% pine	Lignin	4.0 (1.3)	4	30.6 (19)
100% pine	MUF / PMDI	1.8 (1.8)	4	11.2 (22)
100% cypress	Tannin	1.0 (0.3)	4	0.1 (0.4)
100% cypress	Lignin	0.8 (0.8)	4	0.3 (0.8)
100% cypress	MUF / PMDI	0.5 (0.2)	4	0
75% cypress – 25% pine	Tannin	5.3 (2.2)	4	13.0 (16.0)
75% cypress – 25% pine	Lignin	1.0 (0.7)	4	16.5 (16.0)
50% cypress – 50% pine	Tannin	6.2 (0.6)	4	54.7 (28.5)
50% cypress – 50% pine	Lignin	1.7 (0)	4	36.5 (22.1)

Table 5: Variance analysis – resin effect – termite resistance

OSB panels	**Degrees freedom**	**Square root**	**Mean square**	**F**	**P**
Model	2	185.0	92.5	17.44	< 0.0001
Residue	67	355.2	5.3		
Total	69	540.2			

3.2 Results according to the EN 117 standard

The bioassay was carried out only with the best results obtained with the EN 118 standard. We tested lignin-based resin and pine-cypress mixtures (100%, 75%, and 0%). The assessment results for the different mixtures were same as those obtained with the EN 118 standard: 100% cypress panels were more resistant than 75% cypress and 100% pine panels. The panel composition had a significant effect (p> 0.0001) on mass losses in OSB specimens. In the presence of cypress, all termites died after 5 weeks of exposure. On the whole, the percentage mass losses were higher than those obtained with the EN 118 standard. This was due to the fact that termites could attack all sides of the OSB specimens. With the EN 118 standard, termites were in contact with a small area on the OSB specimens. Because of this difference in *the area* *exposed to termites* between these two methods, the degree of attack was less homogeneous than with the EN 118 standard, e.g. with 100% cypress, most of the OSB specimens (45%) underwent a level 1 of degree of attack while only 11% underwent a level 4 of degree of attack. Termites built galleries within many panel specimens with 100% pine, while the attack was limited to the surface of the panel specimens with a higher cypress content. Clearly, specimens containing high percentages of cypress heartwood were more resistant to termite attack

Table 6: Percentage mean mass loss in OSB specimens, visual rating according to the EN 117 standard

Panel type	Resin	Average mass loss	Rating scale	Survival (%)
Control			4	66.1 (4.2)
100% pine	Lignin	0.45 (0.3)	4	60.13 (20.7)
100% cypress	Lignin	1.12 (0.3)	2	0
75% cypress – 25% pine	Lignin	6.41 (1.5)	2.4	0

3.3 Field test results

Termites were present throughout the bioassay period. The mass loss obtained with the control was 25%, and the wood samples were completely degraded by both termite species (Table 7). The results obtained with the different mixtures of cypress confirmed those obtained under the controlled laboratory bioassay conditions. The presence of cypress prevented termite attacks. There was no significant difference when comparing panels with different proportions of cypress: all OSB specimens had the same performance. Indeed, in exterior conditions, termites had feeding preferences and avoided contact with all OSB specimens containing cypress. These results confirmed that some wood components affect the feeding-preference activities of some termite species. Because of the random installation of the OSB specimens, the high variability in the results could be explained by the interaction with OSB specimens containing cypress. OSB specimens made with lignin-based resin were more resistant than those made with phenol-based resin.

Table 7: Percentage mean mass loss in OSB panels – Field test

Panel type	Tannin resin	Lignin resin	Industrial resin
Cypress 0%	14.7 (13.9)	18.2 (15.5)	5.7 (3.4)
Cypress 50%	1.3 (0.4)	0.7 (0.2)	/
Cypress 75%	1.3 (0.5)	0.1 (0.2)	/
Cypress 100%	1.2 (0.31)	0.3 (0.2)	0 (0)
Control	25.0%		

4. DISCUSSION

The aim of this study was to assess the possibility of improving the resistance of OSB panels against termites by introducing durable species like cypress. Since there is currently no standard specifically designed to characterise the termite resistance of panels, we tested the termite resistance of OSB panels according to two European standards adapted for solid wood, i.e. EN 118 and EN 117. We also tested termite resistance under tropical conditions. In a last step, we tested the decay resistance of OSB panels against fungi according the European EN 12038 standard.

Both methods for testing the termicidal resistance of OSB panels did not allow us to confirm the termite resistance of the cypress-pine mixture because the validation was based on visual grading. The analysis of the results showed that termite resistance increased as the percentage of cypress increased. These two methods did not give the same degradation and mass loss levels according the type of mixture. The level of attack was higher with EN 118 than EN 117 because the number of termites per surface unit was higher in the first case. The mass loss obtained with EN 117 was greater because the termites were able to attack the entire surface of the OSB specimens and could select the most sensitive zone where the pine wood could be readily reached. The field test results obtained under tropical conditions complemented the study and highlighted no significant differences between panels with different cypress-pine mixtures: all OSB specimens underwent termite attack attempts and mass loss occurred in around 1% of the panels. The antifeedent properties of cypress play an important role under exterior conditions because termites have a feeding choice. Savory, 1969) pointed out that laboratory tests are generally more severe than exposure in service. The field test results were close to those obtained with the EN 117 standard.

5. CONCLUSION

OSB specimens manufactured with cypress and pine, mixed species and solid wood specimens were exposed to termite bioassays based on a no–choice test using the subterranean termite *Reticulitermes santonensis* and a choice test carried out under tropical conditions. OSB made from cypress showed more resistance against the tested termite, the resistance decreased as the percentage of pine increased, and the OSB specimens were non-durable. The degree of attack differed according the choice of standard procedure, i.e. lower when the termites were not directly in contact with the test sample. The field test results revealed that in exterior conditions and when the termites had a feeding choice, all mixtures showed the same behaviour.

Since pressure to restrict the use of wood preservatives in wood products has been increasing, alternative approaches to increase the resistance of composite wood products are important. It is possible to increase the resistance of OSB products to biodegradation, especially in regions with a low to moderate termite hazard using naturally durable wood species.

5. ACKNOWLEDGMENTS

The authors wish to thanks Dr Remy Marchal and Jean Claude Buteaud, Labomap, Ecole Nationale Supérieure d'Arts et Métiers, Cluny- France

6. REFERENCES

AFNOR, (2005): Produits de préservation des bois - Détermination de l'action préventive contre les espèces de *Reticulitermes* (termites européens) (méthodes de laboratoire).

Ballerini, A., Despres, A., Pizzi, A., (2005): Non-toxic, zero-emission tannin-glyoxal adhesives for wood panels. *Holz als Roh-und Werkstoff*. **63,** (6), 477-478.

Behr, E. A., (1972): Decay and termite resistance of medium density fiberboards made from wood residue. *Forest Products Journal*. **22,** (12), 48-51.

Evans, P. D., Dimitriade, S., Cunningham, R.B., Donnelly, C.F., (2000): medium density fiberboard manufactured from blends of white cypress pine and non-durable wood species shows increased resistance to attack by subterranean *Coptotermes lacteus*. *Holzforschung*. **54,** (6), 585-590.

Gardner, D. J., C. TasciogluM. E. Walindern, (2003): Wood composite protection. G. Babuder. B. Godell,.Nicholas, D.D., Schultz, T.P. 399-419

Garnier, S., Pizzi, A. Vorster, O., Halasz, L., (2002): Rheology of polyflavonoid tannin-formaldehyde reactions before and after gelling - Part 2: Hardener influence and comparison of different tannins. *Journal of applied Polymer Science*. **84,** (4), 864-871.

Haluk, J. P., Roussel, C., (2000): Caractérisation et origine des tropolones responsable de la durabilté naturelle des Cupressassées. Application potentielle en préservation du bois. *Annales des science forestière*. **57,** (8), 819-829.

Kartal, S. N., Green III, F., (2003): Decay and termite resistance of medium density fiberboard (MDF) made from different wood species. *International Biodeterioration and biodegradation*. **51,** 29-35.

Kirkpatrick, J. W., Barnes, H.M.: 2006: Biocide treatments for wood composites - A review. The internation research group on wood preservation. Normway, IRG/WP, IRG/WP 06-40323. 21.

Lei, H., Pizzi. A, Du, G., (2007): Environment-friendly, mixed tannin/lignin wood resins. *Journal of Appllied Polymere Science*. **107,** (1), 203-209.

Mansouri, N. E., A. PizziJ. Salvado, (2007): Lignin-based wood panel adhesives without formaldehyde,. *Holz als Roh-und Werkstoff*. **65,** (1), 65-70.

Morita, Y., E. Matsumara, T. Okabe, M. Shibata, T. Ohe, H. Tsujibo, N. IshidaY. Inamori, (2003): Biological activity of tropolone. *Biological and phamaceuctical bulletin*. **26,** (10), 1487-1490.

Muin, M.K. Tsunoda, (2003): Termicidal performance of wood based composites treated with silafluofen using supercritical carbon dioxide. *Holzforschung*. **57,** (6), 585-592.

Savory, J. G., (1969): Testing the fungus resistance of board materials Verhalen and Schutz von. *Verhalen and Schutz von gegen organismen, Dunker and Humblot, Berlin.* **2,** Wan, H., X. M. WangD. Q. Yang, (2007): Utilizing eartern white Cedar to improve the resistance of strand boards to mold and decay fungi. *Forest Products Journal*. **57,** (3), 54-59.

Yalinkilic, M. K., Immamura, Y., Takahashi, M., Kakaycioglu, H., Dermici, G.N., Ozdemir, T., (1998): Biological, physical and mechanical properties of particleboards manufactured from waste leaves. *International bioterioration and biodegradation*. **41,** 75-84.

Zavarin, E., Smith, R.M., Anderson , A.B., (1959a): Charaterisation of Cupressaceae tropolone as diclohexylamine salts. 1584-1585.

Zavarin, E., Smith, R.M., Anderson , A.B., (1959b): Paper chromatography of tropolones of cupressaceae II. **24,** 1318-1321.