Available online at www.sciencedirect.com

SCIENCE DIRECT®

Nuclear Instruments and Methods in Physics Research B 236 (2005) 137–140

NIM B
Beam Interactions with Materials & Atoms

www.elsevier.com/locate/nimb

# Wood Xylowall: New process to reduce water exchange by an intra-graft of polymer

Anne Uyttenhove *, Bernard Tilquin

*UCL CHAM Analytical and radiolysis laboratory, CHAM unit, Avenue Mounier 72, 1200 Brussels, Belgium*

Available online 24 May 2005

**Abstract**

Our research shows that poplar treated with selected monomer mixture and then irradiated at 50 kGy reduces the water exchange without adversely altering the desirable qualities of wood. Moreover, the environment is not polluted.

To retard changes in moisture content and dimensions, different commercial Radcures (UCB) were tested. A comparative study on the water retention showed significant reduction between non-treated and Xylowall wood for the species: poplar. The physical and mechanical measurements (density, volumetric shrinkage, elasticity, rupture, impact bending, hardness, compression strength) on poplar and pine show that the properties of the wood are not affected negatively by Xylowall treatment with irradiation. Moreover, the process does not discharge any toxic volatile residues into the atmosphere as proven by GC-MS trace analysis of heated wood samples.

The stereomicroscope by imagery reveals an impregnation of 0.5 mm on cross-section of darker-stained areas, and sometimes more due to the texture (the relative size and arrangement of the wood cells) of the wood.


*PACS:* 87.50.G; 83.80.L

*Keywords:* Wood; Preservation; Water retention; Irradiation; Poplar; Pine

## 1. Introduction

For many years now, researchers have tried to improve the dimensional stability of non-durable wood and enhance its durability provided the moisture exchanges between wood and air were reduced, thus enabling new applications for this new kind of timber.

* Corresponding author. Address: Place Louis Pasteur 1 bte 8, B-1348 Louvain-la-Neuve, Belgium. Tel.: +32 1047 9335; fax: +32 1047 2836.

*E-mail address:* uyttenhove@chim.ucl.ac.be (A. Uyttenhove).

0168-583X/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.nimb.2005.04.001

Wood polymer composite is a pressure-treating process in which a vacuum is created to remove air from the wood and admit a lot of monomers before gamma irradiation [1,2]. This process results in the heavy absorption and retention of polymers because the cells are almost filled and makes the wood polymer composite very hard to work [3].

The Xylowall process is innovative because produces negligible quantities of polymers in an air wood[1] which then conserves all the its properties.

The monomers absorbed under the surface are polymerized by electron beam. This transformation is close to a radiolytic catalysis process [4].

## 2. Materials and methods

One hardwood tree, poplar (*Populus* spp.), and one softwood, pine (*Pinus sylvestris*), are positioned in the low durability class (poplar, V,[2] and pine, III[3]). The Xylowall process uses tree impregnated monomers from Radcure ®: trimethylol propane triacrylate (TMPTA), polyether tetraacrylate (Ebecryl 40), urethane acrylic aliphatic (Ebecryl 8210). The Xylowall process consists of cold steeping in a monomer mix of planed wood for 1 h. After hanging up the impregnated wood to let it drip, polymerization is induced by electron beam. The monomers are absorbed and grafted onto the surface of the wood. The samples are irradiated by electron beam to a 50 kGy dose in a few seconds (LINAC).

The Xylowall wood retains its natural aspect after the treatment and is now tested for water exchange, weathering, physical and mechanical properties, and toxic gas.

### 2.1. Water retention

The samples of wood are steeped for16 h in cold water and water recovery is then measured.

### 2.2. Accelerated weathering

A simulation of the influence of a given atmosphere examines the quality of the wood samples, the purpose being to demonstrate the possible use of Xylowall wood outside. One cycle of the accelerated weathering consists of four steps: 8 h in an oven at 40 °C, 16 h in water at 20 °C, 8 h in a freezer at −18 °C and 16 h under UVA at 360 nm. Every sample is subjected to 15 cycles.

### 2.3. Mechanical and physical properties

The tests were performed in a specialized center, the Wood Technology Unit MRW Gembloux where all European standards are applied.

### 2.4. Depth of polymer graft

The depth of the monomers colored in blue (darker spot) was observed on a cross-section of wood obtained by the LEICA MZ6 Stereomicroscope at the Water and Forestry Unit in Louvain-la-Neuve (UCL).

### 2.5. Toxic gas

Gas emissions were measured by the GC-MS, ThermoQuest Finnigan Trace GC, with the Chrompak Pora Plot Q 25 mm × 0.32 mm column.

## 3. Results and discussion

The cold steeping procedure gives the best combined results where the reduction of water retention and the scant amount of polymers (5%) are concerned.

### 3.1. Water retention

The first step of our study was to record the water absorption capacity of a Xylowall poplar after 16 h of cold steeping in water at 20 °C.

Fig. 1 compares the water retention of treated and untreated poplar with the properties of two tropical, Sapelli (*Entandrophragma cylindricum*) and Padouk (*Pterocarpus soyauxii*). These tropical

[1] Process of drying or seasoning lumber naturally by exposure to air until ca. 12% moisture content.

[2] Low durability, less than 5 years.

[3] Medium durability, 10–15 years.

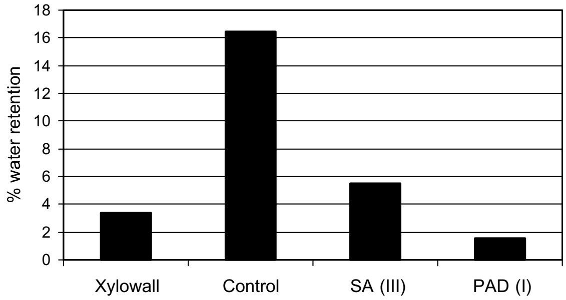


Fig. 1. Water retention for poplar treated, non-treated and two types of tropical woods (SA, Sapelli; PAD, Padouk).

species were graded respectively in Durability Class III (10–15 years) and Class I (more than 25 years). The moisture content of Xylowall poplar was reduced by 50–70% as opposed to untreated poplar. Moreover, the moisture content in Xylowall poplar was lesser than in Sapelli.

### 3.2. Accelerated weathering

Dimensional stability improves when poplar undergoes the Xylowall process. The Xylowall wood was compared to tropical species, Sapelli and Padouk regarding the water retention curve over 15 cycles. Fig. 2 shows that poplar is more stable in the long term but also that the moisture exchange is reduced from the beginning to the end of the cycles.

### 3.3. Mechanical and physical properties

Density, volumetric shrinkage, elasticity, bending stress, impact strength, hardness and compression were tested according to the standards NF B 51-016, NF B 51-008, NBN 225, DIN 52 189. All these measurements show that Xylowall wood preserves the mechanical and physical properties of an untreated wood in general. The only difference is the improved hardness under the surface (Table 1).

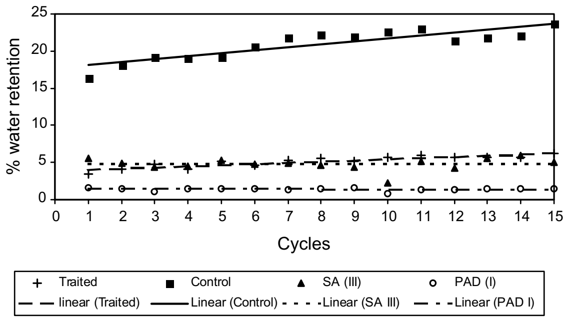


Fig. 2. Accelerated weathering for poplar treated, untreated and for two species of tropical woods (SA, Sapelli; PAD, Padouk).

Table 1
Hardness ($N = 1/t$ with $t$ = deepprint in mm)

| $N = 1/t$ | Poplar | |
|---|---|---|
| | Average | Standard deviation |
| Control | 0.59 | 0.16 |
| Xylowall | 0.72 | 0.23 |

### 3.4. Depth of polymer graft

The polymer mix in the darker areas, reaches a depth of 0.5 mm or more, depending on the texture of the wood (Fig. 3).

### 3.5. Toxic gas

GC-MS from pine shows that no toxic gas is released from treated and untreated wood. It is a qualitative test with a mass spectrum reconstructed (Table 2).

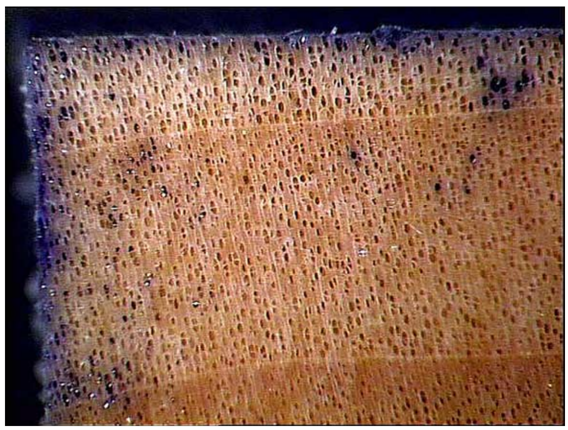

Fig. 3. Cross-section of poplar with polymer graft colored in blue (darker spot) under the surface. (For interpretation of the references in color in this figure legend, the reader is referred to the web version of this article.)

Table 2
Emission of gas from pine treated and untreated, and from pine irradiated only

| Gas | % Area | | |
|---|---|---|---|
| | Unirradiated | Irradiated | Xylowall |
| Furan | 4.71 | 3.73 | 7.81 |
| Acetic acid | 0.19 | 0.84 | 0.3 |
| Toluene | 0.04 | 0.22 | 0.925 |
| Benzene | 0.27 | 0.3 | 0.28 |
| Bicyclo(3.1.1)hept-2-ene | 61.69 | 60.52 | 51.42 |
| Camphene | 0.14 | 0.15 | 0.14 |
| β-Pinene | 20.5 | 20.36 | 22.4 |
| IR-α-Pinene | 12 | 13.28 | 15.24 |
| Limonene | 0.38 | 0.55 | 1.25 |
| 1S-α-Pinene | 0.01 | | 0.02 |
| Cyclohexene | 0.07 | 0.04 | 0.36 |
| Bicyclo(2.1.1)hept-2-ol | | | 0.05 |

## 4. Conclusion

Xylowall wood might be of more use as an industrial wood and should open up a new method of forestry management in temperate zones.

## Acknowledgement

Mölnlycke health care sponsored the experiments by supplying the irradiation.

The Unit for Wood Technology, MRW Gembloux sponsored the work on mechanical and physical properties.

We also thank Dr. P. Lardinois and Dr. P. Jacquemain for their technical assistance.

## References

[1] T. Czvikovszky, Wood-plastic combination by monomer impregnation and radiation polymerization. Atomic Energy Review, Vol. VI, no. 3. Plastics Research Institute, Budapest, Hungary, 1968.
[2] A. Villière, Etude générale des bois-plastiques, imprégnés et irradiés. Cahier d'information du bureau EURISOTROP no. 22, Paris, 1969.
[3] F. Rondenay, Un nouveau matériel Le bois plastique. Cahier d'information du bureau EURISOTROP no. 23, Courbevoie, 1968.
[4] B. Tilquin, Thèse d' agrégation: Composante radicalaire des transformations chimiques radio initiées dans les alcanes à 77K. Cabay, Louvain-la-Neuve, 1985, p. 325.