



Treatment variation along the board of furfurylated sapwood and heartwood

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ABSTRACT

Wood modification by furfurylation depends on impregnation, so only some species can be treated and even so generally only sapwood samples can be used. Another question is that if the impregnation is not even the properties may vary along the board. The objective of this work was to determine the differences in the main wood properties along the treated board. Furfurylation was tested in maritime pine samples (*Pinus pinaster* Aiton,) with both sapwood and heartwood. Density, dimensional stability and water absorption by the water soaking method were determined. The differences between untreated and treated wood and also between treated heartwood and sapwood are high. Despite the higher density (and furfuryl content) near the sides of the board the differences along sapwood boards are very small.

INTRODUCTION

Furfurylation is one of the most competitive wood modification processes with sales increasing every year. Since furfuryl alcohol can be obtained from furfural which is a secondary product in the production of bioethanol, its price is expected to lower considerably with increasing bioethanol production (Esteves *et al.* 2011). Furfurylation was first suggested by Stamm (1977) and later improved by Schneider (1995) and Westin (1995) who developed similar processes with new catalysts based on cyclic carboxylic anhydrides substituting the zinc chloride used before. This wood modification method improves mechanical properties as reported by Epmeier *et al.* (2004) who obtained a slight increase in MOR and a stiffness stabilisation efficiency (SSE) of 40-70% for 48% WPG and an over 100% increase of the Brinell hardness for 92% WPG. Only impact bending strength is decreased by the treatment. Lande *et al.* (2004a) reported 57% decrease with furfurylated southern yellow pinewood with 70% WPG and Epmeier *et al.* (2004) reported a 75% decrease for furfurylated wood with 48% WPG. Epmeier *et al.* (2007) also concluded that furfurylation reduces creep deflection and relative creep. The main improvements are wood dimensional stability (Lande *et al.* (2004b) and durability. Furfurylated wood is resistant to brown and white rot (Gobakken and Westin 2008), termites and marine borers (Westin *et al.* 2006). Temiz *et al.* 2007 reported that furfurylated wood is slightly more resistant to weathering than untreated wood. One of the main problems is that, since this wood

modification depends on impregnation, only some species can be treated and even so generally only sapwood samples can be used. Another question is that if the impregnation is not even the properties might vary along the board.

MATERIAL AND METHODS

Furfurylation was tested in maritime pine samples (*Pinus pinaster* Aiton,) with both sapwood and heartwood. The wood was treated with a furfuryl alcohol mixture (FA 70 mix) at Kebony Products DA in Norway, in an autoclave using a vacuum and pressure stages and subsequently cured and dried in a vacuum drying kiln. The treated plank was cut longitudinally in 4 boards and each one in 19 samples. Boards 1 and 2 are sapwood only, board 3 is mostly sapwood but with a little heartwood and board 4 is only heartwood. For the determination of water soaking the samples were placed in water and the weight gain was measured after 2, 6, 24, 50, 96, 144, 192, 312, 504 and 1848 h., by removing and cleaning the samples before weighting them.

RESULTS AND DISCUSSION

The density profile along the initial treated plank is presented in Figure 1. The presence of knots was identified in the figure. The density is higher near the sides of the plank decreasing in the middle and that is the case for all the cut boards. Sapwood only, board 1, which was cut from the outer side of the main plank, has the highest density mainly due to a higher content of furfuryl alcohol. Heartwood only, board 4, was very difficult to impregnate and has lower density. The uneven treatment can also be seen in the samples with both sapwood and heartwood (Figure 2) where it is perceptible that the penetration of furfuryl-alcohol only reached the outer part of the heartwood.

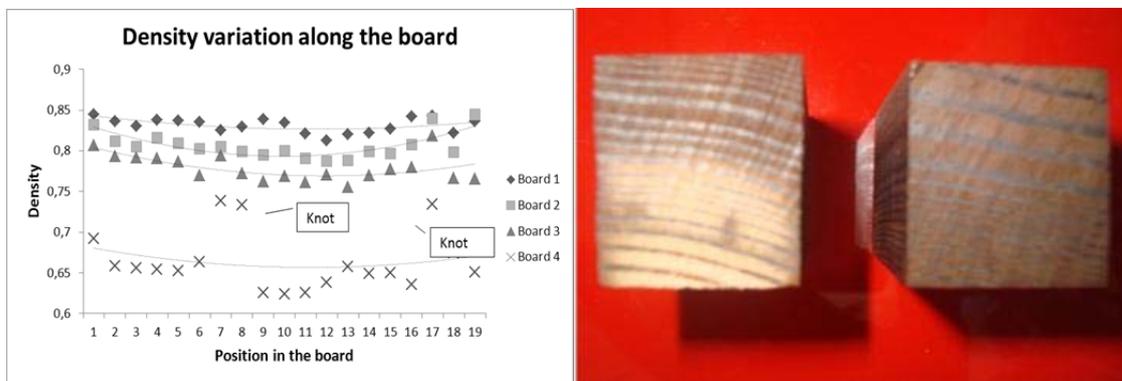


Figure 1: Density variation along the plank.

Figure 2: Mixed samples (Sap+heartwood)

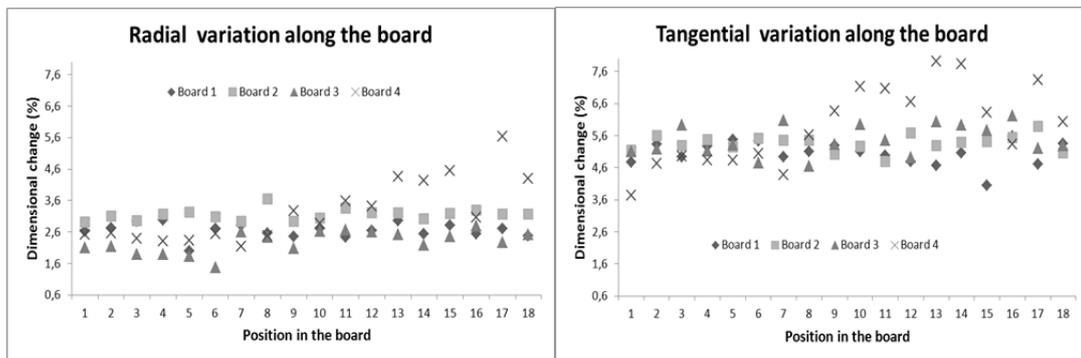


Figure 3: Dimensional variation along the board

The uneven distribution of furfuryl-alcohol through the board is expected to have some impact in wood properties. When determining the dimensional stability, one thing that is obvious to the naked eye is that the parts of the board with higher furfuryl content are more stable. It was noted that after drying, the light wood shrunk considerably more than the darker one, deforming the samples. Figure 3 presents the dimensional variations in radial (a) and tangential (b) directions. The difference between untreated and treated wood is high but along the boards the differences were very small except for board number 4 and somewhat for board number 3 where we can see that dimensional changes are lower for the first middle of the board which corresponds to the darker samples and with higher density and so with more furfuryl alcohol content. The difference in water absorption between untreated and furfurylated wood is high (Figure 4a), around 40% in the beginning and increasing with the water soaking time reaching almost 70% after 1848 hours (77 days). In only 2 hours untreated wood absorbs 50% of its weight in water while treated wood absorbed less than 10%. After 1848 hours the water absorption for untreated wood is more than 120%, compared with about 60% for treated wood. Comparing the several boards we can see that in the beginning of the test board number 4, which is an heartwood board, absorbs less water than the other ones but with the development of the test it starts to absorb more water attaining a higher water absorption in the end (Figure 4b). There is no big difference in the other boards although board number 1 which has a higher content of furfuryl absorbs less water in the end.

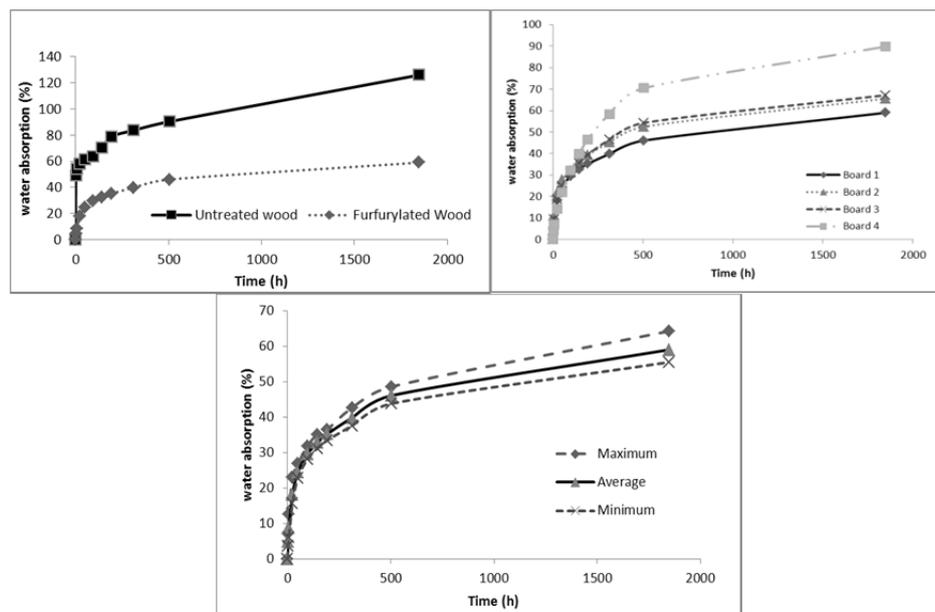


Figure 4: Comparison on water soaking between untreated and treated wood (a) between treated boards (b) along the board 1 (c)

Along the board the differences on water soaking are relatively small (Figure 4c). After 24 hours soaking, water absorption ranged between 15% and 23% but this difference is attenuated with the development of the test with water absorption ranging from 33% to 36% after 192 h. On average there is a 5% difference between the middle and the end of the board.

CONCLUSIONS

The furfuryl alcohol content affects the wood properties but the differences are mainly between boards and between sapwood and heartwood. Despite the higher density (and

furfuryl content) near the sides of the board, the differences along sapwood boards are relatively small.

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REFERENCES

- Esteves, B., Nunes, L., and Pereira, H. (2011). Properties of furfurylated *Pinus pinaster* wood, *European Journal of Wood and Wood Products* **69**(4), 521-525. DOI: 10.1007/s00107-010-0480-4.
- Epmeier, H., Johansson, M., Kliger, R., Westin, M. (2007). Bending creep performance of modified timber. *Holz Roh- Werkst.* **65**, 343-351.
- Epmeier, H., Westin, M., Rapp, A. (2004). Differently modified wood: Comparison of some selected properties. *Scand. J. Forest Res.* **19**(5), 31-37.
- Gobakken, L., Westin, M. (2008). Surface mould growth on five modified wood substrates coated with three different coating systems when exposed outdoors. *Int Biodeter Biodegr.* **62**, 397-402.
- Lande, S., Westin, M., Schneider, M. (2004a). Chemistry and ecotoxicology of furfurylated wood. *Scand. J. Forest Res.* **19**(5), 14-21.
- Lande, S., Westin, M., Schneider, M. (2004b). Properties of furfurylated wood. *Scand. J. Forest Res.* **19**(5), 22-30.
- Schneider, M. (1995). New cell wall and cell lumen wood polymer composites. *Wood Sci. Technol.* **29**, 121-127.
- Stamm, A. (1977). Dimensional stabilization of wood with furfuryl alcohol. In Goldstein, I. (ed.). *Wood Technology; Chemical Aspects. ACS Symposium Series* **43** 141-149.
- Temiz, A., Terziev, N., Eikenes, M., Hafren, J. (2007). Effect of accelerated weathering on surface chemistry of modified wood. *Appl Surf. Sci.* **253**, 5355-5362.
- Westin, M. (1995). Development and evaluation of new alternative wood preservation treatments. Mid-term status report to the Swedish Council for Forestry and Agricultural Research (SJFR). (In Swedish with English summary).
- Westin, M., Rapp, A., Nilsson, T. (2006). Field test of resistance of modified wood to marine borers. *Wood Mater. Sci. Eng.* **1**, 34-38