Potential of Water Wax Emulsions for Improvement of Wood Performance

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ABSTRACT

Waxes are used for treatment of wood surfaces for centuries. In order to improve penetration of waxes into the wood, five water emulsions were prepared namely; two emulsions of montan wax (LGE, MW1), emulsion of polyethylene (WE1), emulsion of ethylene copolymer (WE3) and emulsion of oxidized polyethylene (WE6) wax. Performance of impregnated beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) against white rot (*Trametes versicolor, Pleurotus ostreatus* and *Hypoxylon fragiforme*) and brown rot fungi (*Antrodia vaillantii, Serpula lacrymans* and *Gloeophyllum trabeum*) were tested according to the EN 113 procedure. In parallel, wood was impregnated with selected waxes and rate of water sorption in humid atmosphere (RH = 80%) and in water was determined. The results showed, that impregnation of wood with waxes reduce water sorption. Impregnation of the specimens with waxes improves their performance against wood decay fungi as well. Emulsions of oxidized polyethylene wax (WE6) were effective.

INTRODUCTION

In the past, most of the preservative solutions were designed to kill the pest as fast as possible. Future wood preservatives are designed completely different. They changes the structure of wood in that way, that wood pests did not recognize it as food source (Tjeerdsma *et al.* 1998) or wood moisture content is kept so low, that decay processes are not possible any more (Goethals and Stevens 1994). We believe wax emulsions can be used in such manner as well. Treatment of wood with resin/wax water-repellent formulations greatly reduces the rate of water flow in the capillaries and significantly increases the dimensional stability of specimens exposed to moist conditions (Kurt *et al.* 2008). And it should not be overlooked, that most of waxes are almost non-toxic and they are used for variety of applications. Some of the waxes are used for car and plastic polishing already (Wolfmeier 2003), as they protect surface against salt, dust and other pollutants. Until now wax (bee and paraffin waxes) was predominately used for surface coatings of wooden furniture. It was dissolved in organic solvent or melted prior use. Therefore it did not penetrate dipper into the wood and remained on the surface of the treated material. Therefore the premise of this study was that wax emulsions treatment could limit water penetration and therefore improve performance against wood decay fungi.

MATERIAL AND METHODS

For impregnation five types of wax emulsions of various concentrations were used namely; two emulsions of montan wax (LGE, MW1), emulsion of polyethylene (WE1), emulsion of ethylene copolymer (WE3) and emulsion of oxidized polyethylene (WE6) wax. Those solutions are commercially available and produced by Samson Slovenia and BASF Germany. Concentrations (dry content) of wax emulsions can be resolved from table 1. Fungicidal properties of wax emulsions were determined according to the EN 113 procedure. Specimens were prior fungal exposure (vacuum – 20 min; pressure – 60 min; vacuum – 10 min) treated with various wax emulsions resolved from table 1. Steam sterilized impregnated and control wood specimens were exposed to three brown rot (*Antrodia vaillantii, Serpula lacrymans* and *Gloeophyllum trabeum*) and three white rot fungi (*Trametes versicolor, Pleurotus ostreatus* and *Hypoxylon fragiforme*). Beech wood (*Fagus sylvatica*) specimens were exposed to white rot Norway spruce (*Picea abies*) ones to brown rot fungi. After 16 weeks of fungal exposure specimens were isolated and mass losses were gravimetrically determined and expressed in percentages.

For sorption properties only LGE emulsion was used, respectively. Norway spruce wood specimens (1.5 × 2.5 × 5.0 cm) with end sealed (epoxy coating) axial surfaces were impregnated with LGE emulsions of two different concentrations LGE 50 and LGE 100. After four weeks of air drying, specimens were oven dried (40° C) for three days. Half of the specimens were afterwards transferred to the chamber with relative air humidity of 80%. The mass of the specimens were monitored daily for six weeks. Second half of the specimens were immersed to distilled water. Masses of the specimens were monitored after predetermined periods resolved from figure 1b for three weeks.

RESULTS AND DISCUSION

Wax emulsions used in this experiment have different dry contents. They varied between 5.3% (LGE 50) and 23.1 (MW1 50) (Table 1).

All wood decay fungi used in this experiment were vital, as mass losses of control specimens were higher than 20%, with exception of *A. vaillantii*, where control specimens lost 16.9% only. However, this fungal strain is known as less aggressive, but on the other hand very effective degrader of impregnated and modified wood (Table 1).

Mass losses of specimens impregnated with different wax emulsions varied from 2% (WE6 50; *T. versicolor*) up to 32% (WE3 50; *H. fragiforme*). From the data presented in Table 1, it can be well resolved, that wax emulsions applied more or less protected wood against wood rotting fungi. Among treatments applied, wax emulsion WE3 (emulsion of ethylene copolymer wax) was found the least effective. On contrary, specimens impregnated with montan wax emulsions (LGE and MW) were decayed less than control ones. Montan wax emulsions were found the least effective against *G. trabeum*, among the fungi tested. During 16 weeks of exposure to above mentioned fungi, control specimens lost 35.7% while specimens impregnated with montan wax emulsions lost between 26.1% and 15.8%, regarding to the concentration of montan wax in emulsions. Specimens impregnated with emulsions of the higher concentrations were better protected against wood decay fungi than specimens impregnated with the lower concentrations of montan wax (Table 1). Among wax emulsions tested, emulsions WE1 (emulsion of polyethylene wax) and WE6 (emulsion of oxidized polyethylene wax) were found the most effective agents for protection of wood against wood rotting fungi. For example, mass losses of spruce wood specimens, impregnated with emulsion WE1 50, after 16 weeks of exposure to *G. trabeum* lost only 3.8% and 5.7% after exposure to *S. lacrymans*. This treatment was effective against white rot species as well. *P. ostreatus* cause mass loss of 8.4% while *T. versicolor* decayed only 3.9% of impregnated specimens (Table 1). Unfortunately, WE1 and WE6 emulsions were not that effective against *A. vaillantii* and *H. fragiforme.* Comparison of the dry content data and mass losses after fungal decay revealed that, there is no statistically significant correlation between those two parameters. This indicates, that fungicidal properties of impregnated wood depends more on properties of the wax, than of dry content.

Table 1: Mass loss of the wax treated spruce and beech wood specimens exposed to various wood decay fungi according to the EN 113 procedure.

Wax emulsion	**Conc. (%)**	**Dry content (%)**	**Wood decay fungi** *G. trabeum*	*A. vaillantii*	*S. lacrymans*	*P. ostreatus*	*T. versicolor*	*H. fragiforme*
			Mass loss (%)					
LGE	50	5.3	26.1	11.2	18.8	15.2	24.6	28.5
	100	11.4	24.7	14.8	17.8	11.4	20.4	23.7
MW1	25	10.9	22.2	10.4	17.2	13.2	21.4	24.4
	50	23.1	15.8	11.7	13.1	7.3	13.9	20.7
WE1	25	9.4	6.0	7.3	12.2	14.8	20.8	30.9
	50	18.2	3.8	10.9	5.7	8.4	3.9	18.3
WE3	25	7.3	21.2	16.1	27.4	13.7	30.6	27.6
	50	14.2	13.6	16.2	30.0	20.4	22.3	32.4
WE6	25	9.4	23.0	11.3	7.1	10.0	17.9	22.4
	50	19.1	7.7	7.8	3.2	8.9	1.6	21.7
Control	/	/	35.7	16.9	40.2	23.0	32.0	32.7

Impregnation of spruce wood with waxes has effect on sorption properties of impregnated wood as well. Moisturizing of LGE impregnated specimens was slower as at specimens conditioned in humid air as well as the ones immersed in water. Additionally, equilibrium moisture content (EMC) of wood impregnated with LGE emulsion was lower than of control specimens. It can be seen from figure 1a, that EMC of LGE 100 impregnated specimens at RH of 88% was 12.1%, while 15% higher moisture content was observed at control specimens. Even more, this EMC was reached after 18 days at control specimens and after 60 days of conditioning at specimens impregnated with LGE 100 emulsion. Similar effect was observed during wetting of wooden specimens (Figure 1b). Uptake of water at specimens impregnated with LGE emulsions was slower than at control specimens. Final MC of control specimens was 96%, while LGE impregnated specimens absorb approximately 17% less water. We presume that there are three reasons for this occurrence. Firstly waxes makes surface of the specimens more hydrophobic. Secondly cell lumina were at least partly filed with waxes, what physically prevents moisturizing. And thirdly, there were thin films-barriers formed on the surface of the wooden specimens, what slows down water movement.

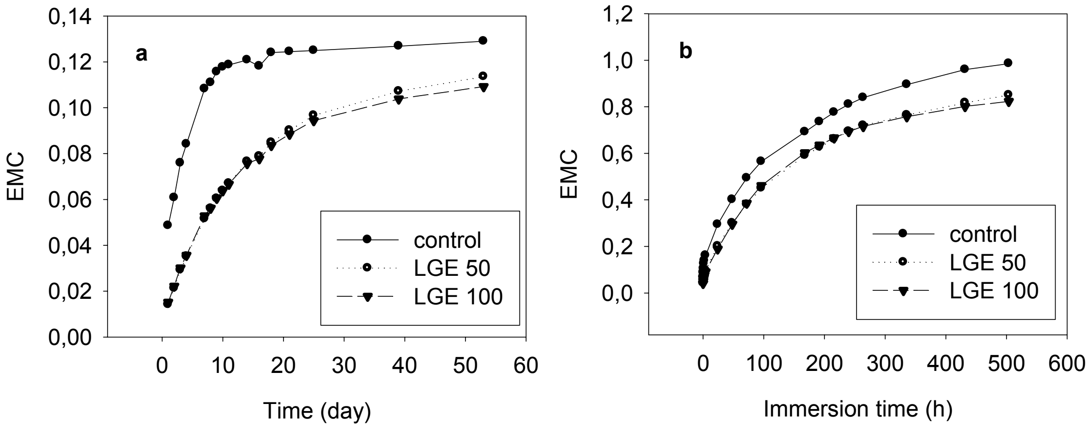

Figure 1: Changes in equilibrium moisture contents (EMC) of the control specimens and specimens treated with LGE wax emulsions in atmosphere with RH of 80% (a) or during immersion in water (b).

CONCLUSIONS

Impregnation of Norway spruce or Beech wood with waxes significantly improves their resistance against wood decay fungi. Furthermore, treatment of wood with emulsion of montan wax improves sorption properties of wood as well.

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