A TWO-STEP WOOD PROTECTION PROCESS USING ALTERNATIVE WOOD PROTECTION AGENTS IN COMBINATION WITH AN OIL TREATMENT

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ABSTRACT

In this study, natural polymers were tested as possible alternatives for conventional wood preservative in a two-step process. Scots pine sapwood blocks were impregnated with chitosan, tannin, propiconazole and Wolmanit and oil-treated afterwards with a modified linseed oil. Two different fixation parameters were performed. The treated samples were leached according to EN84. The outcome of trials shows that a two-step process reduces the leaching of the main active components. After leaching, the samples were exposed to fungal attack by *Coniophora puteana* and *Trametes versicolor* according to EN113. Mycological tests showed that most of oil treated samples were effective against wood decay.

Key words: chitosan, propiconazole, fixation, fungi test

INTRODUCTION

The combination of an impregnation process using a wood protection agent with a following treatment with modified natural oil was developed 31 years ago (Häger 1980), usually known as the Royal process. This process combines the fungicidal properties of a wood protection agent with the hydrophobical properties of oil in a two-step process. The wood preservative used in the Royal process is a water-based chromium-arsenic free preservative (commercial name Wolmanit CX-8). Modern copper-based preservatives have a lower fixation rate compared to CCA, and can easily be leached out during outdoor exposure conditions (Habicht et al. 2003). A combined impregnation process (CIP) has a great environmental advantage; it significantly reduces the leaching of copper in use (Treu et al. 2003).
The use of metal-based wood preservatives is facing increasing environmental and disposal concerns. Organic biocides and some natural polymers with ability to minimize fungal attack are considered as future wood preservatives (Evans 2003).
Chitosan, a natural polymer, is a derivate of chitin, which is manufactured primarily from waste products of the food industry - crustaceans such as shrimps, crabs and crayfish (Brine et al. 1991). In recent years chitosan has received attention as a potential eco-friendly wood preservative (Alfredsen et al. 2004).

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Propiconazole is a derivate of triazole, organic biocide, and is used in wood protection chemicals, because of good antifungal effectiveness and triazoles are biodegradable in soil (Buschaus et al. 1995).
Tannins are natural phenolic polymers, commercially produced from wood and barks. Several observations have shown fungicidal effect of tannins (Scalbert, 1991). It is known that tannins show poor fixation. They accumulate on the wood surface and leach easily (Sen et al. 2009).
The aim of this study was to investigate new potential alternative wood protection agents for a two-step process and to improve fixation by means of oil a subsequent oil treatment and evaluate the performance against fungal attack in lab trials.

MATERIAL AND METHODS

Wood samples

Scots pine sapwood (*Pinus sylvestris* L.) blocks (50 x 25 x 15 mm) were selected, end-sealed and oven-dried at 103 ± 2°C for 24 hours. Absolute dry weight was taken and samples were conditioned at 20°C and 65% relative humidity before impregnation.

Wood protection agents

Table 1: Overview of wood protection agents used in a two-step process

Solution	Concent. [%]	Description	Active agent	Chemical analyses
Wolmanit CX-8	4.0	Commercial wood preservative, pH = 9.5	Cu	ICP
Scanimp	5.1	Commercial microemulsion, pH= 3.0	Propiconazole	ICP
Kitoflokk	5.0	Chitosan, natural polymer produced from crabs, pH= 5.3	D-glucosamine	HPLC
Tannin	5.0	Water soluble polyphenol produced from mimosa bark, pH= 4.7		
Oil	-	Modified linseed oil produced from flax plant seed, drying oil		

The preparation of the chitosan solution, determination of the degree of deacetylation and the molecular weight were examined by methods described by Larnøy et al. (2006). Kitoflokk powder was dissolved in deionized water. Acetic acid was added until pH range 5 to 5.5 was reached. Mimosa tannin powder was dissolved with deionized water without any additional chemicals.

Two-step protection system

The two-step wood protection system included two process steps: 1. impregnation procedure where wood samples were impregnated with a wood protection solution for 30 min at 40 mbar vacuum and 1 hour at 9 bar pressure. 2. Oil process - in the second step the wood samples were treated with hot oil (modified-linseed oil) at temperature 80°C in a vacuum (100 mbar) for 3 hours. The samples were pulled out from the oil some seconds before the end of the process and air was released in afterwards in order to avoid high oil uptakes of the wood samples. Wood samples were either exposed to hot oil directly after impregnation or stored 24 hours for fixation. Samples without oil treatment were tested as controls. After the two-step protection process, samples were dried at a temperature of 55°C and using 20 mbar vacuum until stabilization (7 days) to determine the oil uptake.

Leaching

The conditioned samples were leached according to the European standard EN84 (1997), by impregnating (40 mbar for 20min) wood samples with deionized water to accelerate ageing of the samples. Collected water samples were analyzed for the amount of main active ingredients (Table 1). Tannin was not analyzed.

Decay test

Samples were vacuum dried after leaching. The specimens were exposed to fungi according to the EN113 (1996) using brown-rot fungi *Coniophora puteana* (CP) and white-rot fungi *Trametes Versicolor* (TV).

RESULTS AND DISCUSSION

Table 2 shows the retention of preservatives and oil. The average uptake for CX-8 was 25.2 ± 3.2 kg/m³, which is as twice high as the uptake achieved by a „ Lowry process”. Samples directly exposed to hot oil after impregnation process had higher oil retention compared to samples with 24 hour fixation. According to previous studies of CIP, the oil uptake increases with increasing fixation time. Higher oil uptake of wood samples without fixation could be explained by cracks that developed due to faster drying on end-sealed surfaces (Treu et al. 2008).

Table 2: Mean retention of solutions and mod. linseed oil.

Solution	Retention [kg/m³]	Treatment	Oil retention [kg/m³]
CX-8	25.2 (3.2)	directly	151 (43)
		24 h fixation	63 (25)
ScanImp	34.8 (1.2)	directly	207 (54)
		24 h fixation	75 (17)
Kitoflokk	33.2 (4.4)	directly	110 (40)
		24 h fixation	75 (29)
Tannin	32.1 (5.0)	directly	102 (37)
		24 h fixation	62 (13)

Leaching

When comparing leached main active ingredient, the lowest amounts were released from samples treated in oil directly without 24 hours fixation of the protective solution (Fig. 1-3), except samples treated with Kitoflokk. The amount of leached glucosamine was unexpectedly low, total amount for samples without oil treatment was 2.2 mg/L. Values for oil treated chitosan were < 0.001 mg/L. According to the leaching results, the degree of fixation is very high for all treatments.

Decay test

The mass loss during fungal exposure is displayed in Fig. 4-7. Samples treated with CX8, Scanimp and their oil combinations showed less than 3% mass loss for both fungi species. According to other studies, chitosan and tannin have fixation problems (Sen et al. 2009). This could not been proved by this study. However, chitosan treated samples without oil show poor protective properties when exposed to brown rot. Furthermore,

tannin- and chitosan- treated samples without oil show poor protective properties against white rot. Chitosan and tannin samples treated in oil directly after impregnation with a wood protection agent and after 24 hour fixation showed very high antifungal effect against CP.
However, chitosan and tannin treated samples without oil treatment showed low antifungal effect against TV.

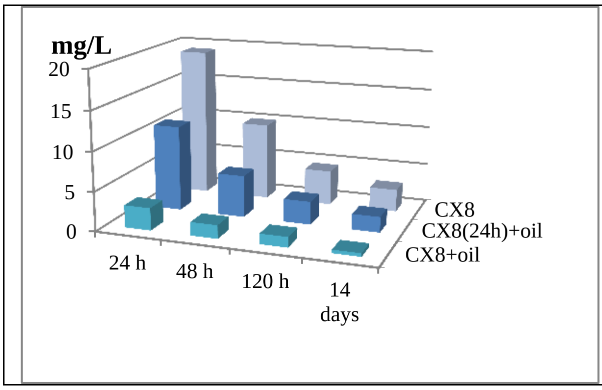


Fig. 1.

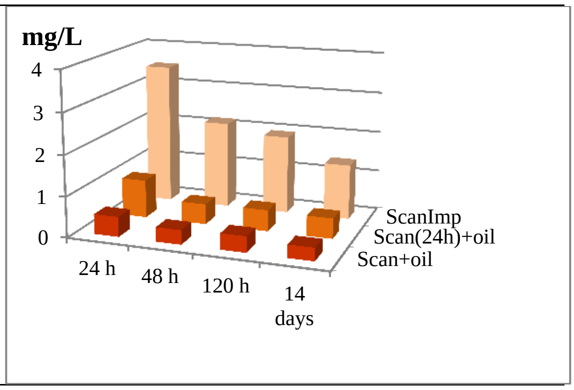


Fig. 2.

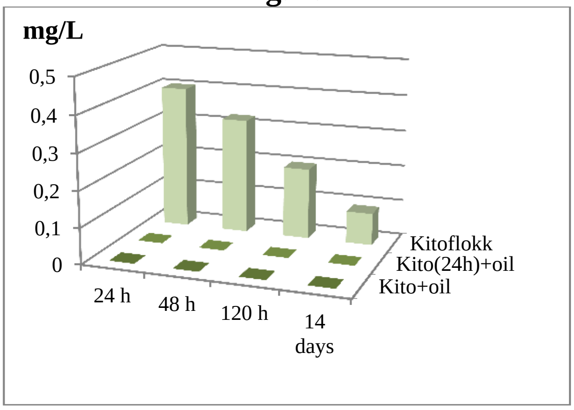


Fig. 3.

Fig. 1-3. Amount of main active component in leaching water during 14 leaching days. Values for oil treated chitosan < 0.0001 mg/L are not shown in the graph: Fig. 1 - copper (Total CX8= 89.4 mg/L, CX-8+oil= 11.9 mg/L, CX8(24h)+oil= 41.9 mg/L); Fig. 2 – propiconazole (Total Scan.= 21.9 mg/L, Scan+oil= 3.8 mg/L, Scan(24h)+oil= 5.2 mg/L); Fig. 3 – glucosamine (Total Kitoflokk= 2.2 mg/L).

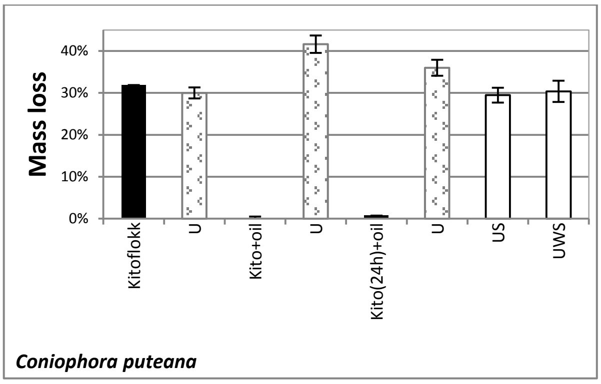


Fig. 4.

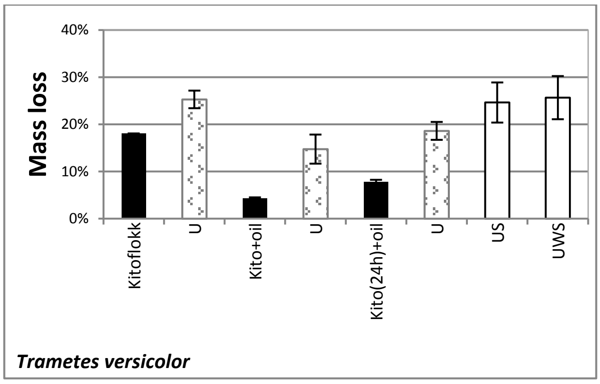
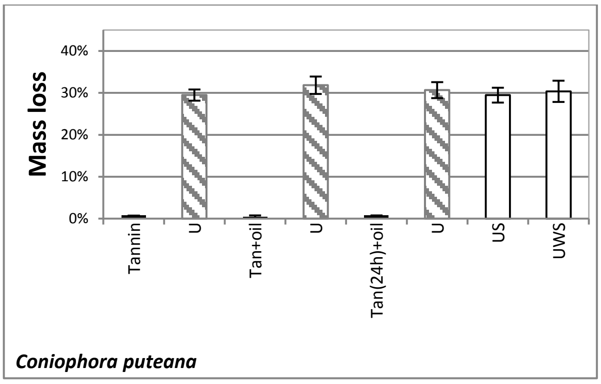


Fig. 5.



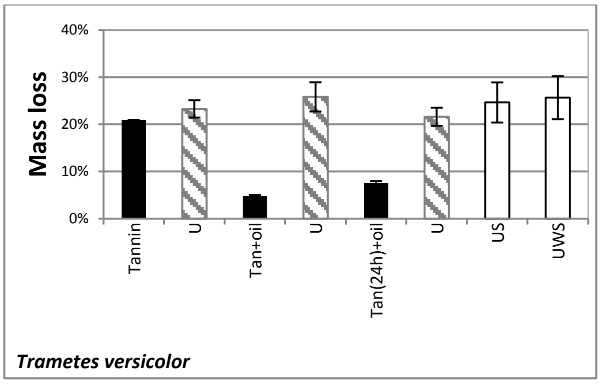


Figure 6. **Figure 7.**

Fig. 4-7. Mass loss of different treated and untreated wood samples after 16 weeks of exposure to brown rot (*Coniophora puteana*) and white rot (*Trametes versicolor*). U- untreated sample, US-virulence with end grain sealing, USW- virulence without sealing.

CONCLUSIONS

The two-step process significantly reduces leaching of the wood protection agents. The two tested commercial wood preservatives alone or in combination with an oil treatment showed high resistance against fungal attack.

The natural product chitosan showed low resistance against fungal attack. However, in combination with an oil treatment a high resistance against brown rot attack could be shown. In contrast, white rot attack could not be prevented with chitosan in combination with oil.

Wood samples treated with the natural product tannin and in combination with an oil treatment showed good antifungal properties when exposed to brown rot. However, white rot attack could not be prevented. Tannins and chitosan used as a wood protection agent in a two-step process, might be therefore not be suitable as an alternative to CX-8 in CIP.

Scanimp provides high antifungal effectiveness, low leaching, and as an organic biocide could be an alternative product for copper-based products used in CIP.

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