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Environmental valuation of selected transparent wood coatings from the view of fungal resistance

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Abstract: *Environmental valuation of selected transparent wood paints from the view of fungal resistance*. Wood products with painted surfaces can reduce the risk of forming and spreading microbial infection on their surfaces. This study aims to characterize surface moulds resistance of selected transparent wood coatings based on polyurethane resins, polyurethane-acrylate resins, and natural wax withoilapplied in one, two or three layers. The growth activity of moulds (GAM) on the surface coated with wax - oil and waterbornepolyurethane-acrylate coating was higher than mould growth on the surface with polyurethane coating. The mould growth was decreasing with increasing number of coats of polyurethane or waterborne polyurethane-acrylate coating.

Keywords: mould, polyurethane resin, polyurethane-acrylate resin, oil, wax

INTRODUCTION

Under Regulation No 66/2010, the EU Ecolabel may be awarded to products which have a reduced environmental impact during their entire life-cycle. Document 2014/312/EU has established ecological criteria for the award of the EU Ecolabelto indoor and outdoor paints and varnishes.The criteria and the related assessment requirements for awarding the EU Ecolabel to paints and varnishes are following: (1) white pigment and wet scrub resistance; (2) titanium dioxide; (3) efficiency in use – spreadingrate, water resistance, adhesion, abrasion, weathering, water vapour permeability, liquid water permeability, fungal resistance, crack bridging, alkali resistance, corrosion resistance; (4) volatile and semi-volatile organic compounds; (5) restriction of hazardous substances and mixtures and other.

The product group of 'indoor and outdoor paints and varnishes' shall comprise: floor coatings and floor paints; paint products which are tinted by distributors at the request of consumer (non-professional) or professional decorators, tinting systems, decorative paints in liquid or paste formulas which may have been pre-conditioned, tinted or prepared by the manufacturer to meet consumer's needs, including wood paints, wood and decking stains.

This study was performed to determine the fungal (mould) resistance of the selected types of wood coating system. The influence of the number of layers and exposure time on the fungal (mould) resistance was studied.

MATERIAL AND METHODS

Beech (*Fagus sylvatica* L.) boards with dimensions 100 mm × 100 mm × 5 mm and the radial top surface were used. Average density of samples was 676 kg/m^3 and average moisture content of air-conditioned samples was 8 ± 2 %. All surfaces of testing samples were grinded by sandpaper (gradually with grain size number P60, P80 and P120) using the belt grinder machine. Surface treatments were applied as recommended by producers in the technical documents. Applied surface coatingsand the average thickness of the coating films are presented in table 1. The test samples were conditioned in horizontal position at 23 ± 2 °C and 50 ±5 % relative humidity for 5 days.

Table 1. The average thickness of the coating films.

Coating based on	Average thickness of the coating films (μm)		
	One Coat	Two Coats	Three Coats
Polyurethane(PUR-Strong 26303)	50	100	150
Polyurethane-acrylate (Aqua-Step Professional 30153)	40	70	100
Natural wax with oil (Naturnah Hartwachs 96050)	60	80	100

The resistance to mould fungi was tested using a method based on the standard EN 15457 (2006). The coated and uncoated (control) wood samples were exposed to a mixture of pure cultures of *Aspergillus niger* Tiegh. and *Penicillium brevicompactum* Dierckx fungus and incubated at the temperature of 27 ± 1 °C and the relative humidity of 90%. The fungi were from the Mycological Laboratory at the Faculty of Wood Sciences and Technology of the Technical University in Zvolen, Slovakia. The suspension of fungi was sprayed on the surface of the tested wood samples which were placed individually on the surface of Czapek-Dox agar medium in Petri dishes of 100 mm diameter and an outside height of 15 mm.The GAM was tested at the temperature of 24 ± 2 °C and therelative humidity of 50 -95 % during 21 days according to the standard EN 15457 (2007). The assessment was made visually by the naked eye and using a stereo microscope (10 magnifications). GAM was evaluated using the scale from 0 to 4, where: 0 is no growth, 1 is growth up to 10 %, 2 is growth up to 30 %, 3 is growth up to 50 %, and 4 is growth more than 50 % on the top surface of the specimen.

RESULTS

The untreated wood surfaces are easy and often colonised with different type of microorganisms such as microscopic fungi (moulds) under favourable conditions (Reinprecht and Vidholdová 2017, Vidholdová et al. 2015, Viitanen et al. 2010). Due this fact, one of the purposes of a coating is to increase the wood resistance against the environment and biodeterioration (Gradeci et al. 2017, Salca et al 2017, Slabejová et al.2016, Slabejová 2013, Gobakken et al. 2010). On the other hand, infestation by microorganisms can facilitate changes in the film structure, impairing its mechanical and protective properties (Wright et al. 2006).

Results of visual assessment of the resistance to mould fungi of uncoated and coated surfaces are shown in table 2 and in figure 1. The degree of mould growth on the surfaces varied primarily with the type of coating system, number of coats and exposure time.The untreated (control) wood surface and wood coated with naturalwax with oil had none resistance against moulds.A partial inhibition effect of wax with oil against moulds was observed mainly in the first days of the test when GAM was 3. Mean growth of mold fungi on wood coated with the natural wax with oilwas also almost the same as on the uncoated wood;however, the wetting of coated wood was distinctly lower if compared with control wood.The mould growth on the surface coated with waterborne polyurethane-acrylate based coating was similar in the case of one and two coats. On the other hand, a higher inhibition effect was in the case of three coatsapplied (GAM 1.5 after 7 days and 3 after 21 days).As can be seen, the increasing number of layers of polyurethane coating resulted in decreasing of the mould growth. Results reported by Garzón-Barrero et al. (2016) with surface treatment with polyurethane resin, which decreased mould colonization, were very similar. According toWright et al. (2006), increased levels of mould growth observed on commercial acrylic–polyurethane coated panel in comparison to commercial polyurethane coated panel suggests that the lack of particle coalescenceis responsible for the poor resistance to mould growth demonstrating the importance of optimized structural cohesiveness.

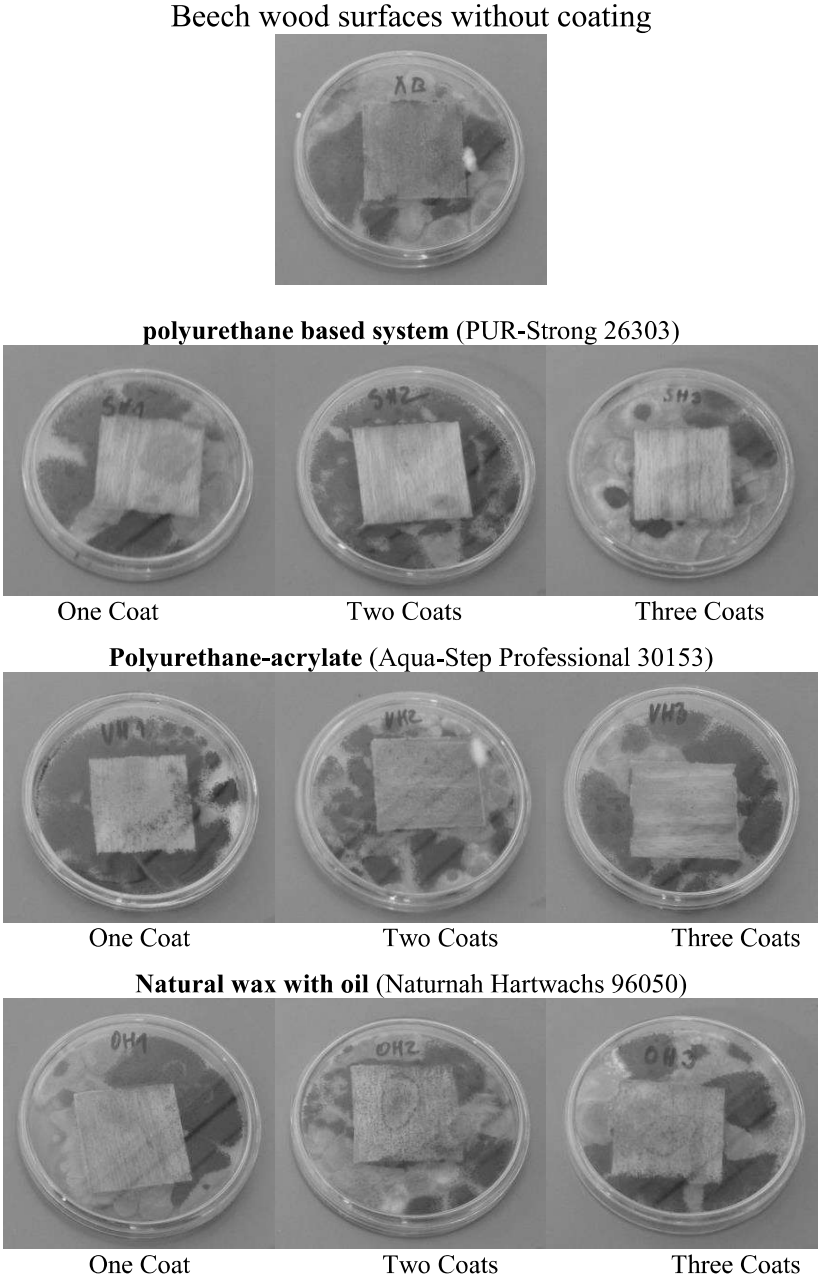

Figure 1. The GAM on the coated and uncoated surfaces after 14 days of exposure

The increase in coverage of moulds was clearly highest during the first period. This was expected since the period of laboratory test in Petri dishes includes the favourable moisture conditions for the mould infests. Coming out from a few scientific papers, which were mentioned in work byViitanen (2002), mould resistance of painted wood is affected by several factors: (1) wood material, permeability and nutrient content on the surface, (2) paint type, fungicides and their concentration in the paint, (3) wood quality connected with preservation and application of fungicides in the pretreatments, primers and paints, (4) use of products, climatic exposure conditions and exposure time, structures and service, and (5) colonies of microbes and fungi in materials and in ambient environment.

Table 2. The GAM on the top surfaces of uncoated and coated surfaces from 7th to 21th days.

Surface treatments	Coat number	The growth activity of the moulds (GAM)		
		after 7 days	after 14 days	after 21 days
Without treatment		3	4	4
Surface treatment based on:				
Polyurethane	1	2	2	3
(PUR-Strong 26303)	2	1	1	1
	3	0	0	0
Polyurethane-acrylate	1	3	4	4
(Aqua-Step Professional 30153)	2	3	4	4
	3	1.5	2	3
Natural wax with oil	1	2.5	3	4
(NaturnahHartwachs 96050)	2	3	4	4
	3	3	4	4

CONCLUSIONS

- Under favourable conditions, mould fungi grow on the untreated beech surface very easily, thus creating environmental hazard.
- The degree of mould growth on the surfaces varied primarily with the type of coating system, number of coats and exposure time.
- The growth activity of mould on the surfaces decreased in order: natural wax with oil>polyurethane-acrylate based system >polyurethane based system.
- The degree of mould growth on the surfaces decreased with increasing number of coats of polyurethane or waterborne polyurethane-acrylate resin coating.

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