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INVESTIGATION OF ATMOSPHERE SUSTAINABILITY OF PROTECTIVE-DECORATIVE COATINGS

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ABSTRACT

The strength of bonding between protective-decorative coatings and the surface of wood materials, plays a major role in the durability of the wooden products, exposed to atmospheric conditions in the open area. This article analyzes the effects, that has the protective-decorative coatings, like durability of the natural oils and synthetic lacquer products used for protective layer of wood and the surface condition, after stay under the environmental impacts. To achieve this aim, an experimental stand was built according to standard EN 350:2016 and mounted in the territory of Yundola, Velingrad municipality. By the determined 12 months under review time period it is followed the change of surface of different types of natural oils and synthetic lacquer products used for protection of wood exposed to open area. The change in color is reflected, the damage to the surface of the used protective-decorative coatings, the mold formation, and the moisture resistance of the protective coatings. The results are analyzed and graphically presented.

Key words: atmosphere sustainability, lacquer gloss, wood protection, coatings, oils, aging.

INTRODUCTION

The natural wood is the oldest building material, proved its irreplaceable qualities – beauty, strength, easy processing, good thermal and sound isolator, that brings coziness and warmth in the interior and exterior area. The only weakness of the natural wood is it needs some care and protection for to prolong its life and preserve its aesthetic appearance. Lacquer is a clear protective coating that enhances the natural beauty of wood grains, is quick-drying and creates a tough top coat. According to Sandberg (2007), the properties of the coatings, including curing time, adhesion, wettability of surfaces, antifriction, hardness and strength, are important parameters that can affect both the deformation of dimensional stability and the final hardness of the finished product. Additionally, lacquers provide good protection to wooden furniture against damage from water, acids and alkalis. Lacquers are comparatively thinner than other available wood finishes and easily penetrate deep inside the wood to provide added protection. In the “coating-substrate” contact zone, pores are not completely filled with a paint composition. With an increase in surface porosity, the number of such pores increases. When moisture condenses, the air in such pores is compressed and puts pressure on the paint layer, contributing to its destruction (Karyakina M.I., 1980). The application of the aging model, taking into account the hereditary factor in assessing the thermal aging of the coating, humidification of the complex effect of the environment. (Loganina, 2021).

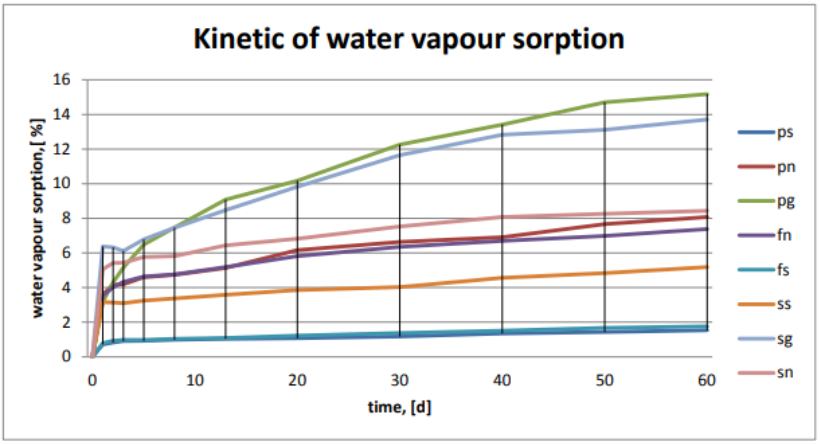

Figure 1: Graphic of kinetic of water vapour sorption of untreated and heat-treated wood samples in oil and glycerol (Panayotov *et al*., 2013)

It is shown that the value of air pressure in the pores of the material, provided that the moisture content of the wall material does not exceed the sorption limit, does not pose a threat to the integrity of most coatings (Panayotov et all., 2013; Panayotov et all., 2010). When the moisture content of the base material is higher than the sorption air pressure, it is comparable to the long-term cohesive strength of some protective and decorative coatings (Figure 2) (Loganina, 2020). Under the action of environmental factors, temperature variations, atmospheric oxygen, solar radiation (especially IR and UV), polymers suffer a series of consecutive process and/or parallel (polymerization, crosslinking, thermooxidation, degradation by the breakage of C-C bonds, etc.) (Yang, 2001; Hu, 2009; Caramitu, 2017).

The aim of the current study was to investigate the changes in the protective layer of wood and the surface condition in the territory of Yundola after a stay under environmental impact dependence with the following variables: the colour change, gloss change and the surface integrality of the protective coating.

Figure 2: Unevenly weather exposed wood facade

MATERIAL AND METHODS

Eight series were made for the experiment, with 8 different protective products and five experimental specimens for each series (40 pieces in total). The specimens with dimensions of 150 × 80 ×20 mm were made from pine wood (Pinus Sylvestris L.). The shape of the specimens was chosen from the most used cladding materials, such as rectangular, fasade cladding with tongue and groove and rhomboid shaped cladding façade materials. The surfaces of the experimental specimens were planed, sanded with sandpaper with grid P80 and P120 before applying the protective coatings. The amount of the coatings is rationally chosen to be 80 g/m^2, its applied only one layer on the surface of the experimental specimens and drying in normal environmental conditions with room temperature 25^{0}C and humidity 65%. For testing the protective coating products, under the environmental impacts an experimental stand according to the standard БДС EN 350:2016 was manufactured and mounted in the territory of Yundola (Figure 3).

For the protective coatings, synthetic varnishes and natural oils were used. The eight different protective coatings are: Akzo Nobel Pinotex Ultra–Lazur lacquer; Decorator Yacht lacquer, Lasure exteriour lazur lacquer; Levis hardwood oil; Albaco Proterra oil; Sokrates Acryl lazur lacquer, Leko impregnation primer and Bochemit Estetik Impregnant.

To determine the change of the gloss surface of the experimental specimens, a tri-angle gloss meter manufacturer Tricor Systems Inc. was used. The experimental gloss meter, make measurements at three angles of the ray of light applied – 20^0, 60^0 and 85^0. The measurements were carried out four times in a year– first in March, second in May, third in August and last in December. To determine the condition of the protective decorative coating, three classes of weather resistance were determined: D-durable, M-moderately durable and S-susceptible. To determine the class, a complex visual evaluation was used in relation to the colour change of the coating, and the wood surface, the gloss change of the surface of the protective coatings, violation of the integrity of the coating and cracks on the wood surface, compared to untreated and control experimental specimens.

a **b**

Figure 3: Experimental stand according to the standard BDS EN 350/1:2002 for investigating the weathering of protective coatings for wooden products: a) the positing of the experimental stand according to the sun movement, b) the experimental stand with mounted experimental samples specimens

RESULTS AND DISCUSSION

After the first time period, the carried-out measurements in March with average temperature of 170C and rain fall of 81 mm, show the measurements of the fresh applied protective coatings and placing them on the test stand. In the second time period, measurements made in May, with average temperature of 200C and rain fall of 104 mm, show the first changes of the gloss of the surfaces of the experimental specimens. Significant changes can monitored of the surface applied with Decorator Yacht lacquer, Lasure exteriour lazur lacquer, Levis hardwood oil, Sokrates Acryl lazur lacquer and Leko impregnation primer. The third period, measurements made in August, with average temperature of 290ºC and rain fall of 65 mm, show significant loss of gloss in mainly two protective coatings – Decorator Yacht lacquer and Leko impregnation primer. In the fourth and last test period, made in December with average temperature of 110ºC and rain fall of 82 mm, all of the 8 protective coatings show defervescences in the gloss, compared to the initial condition of the surface measured in the first time period in March. All of the applied protective coatings have lost the gloss condition of the surface, only in used impregnant Bochemit Estetik Impregnant the measurements show a little change of the initial condition measured in March (Table 1).

Table 1: Results of the gloss changes at the surface of protective-decorative coatings of atmosphere sustainability of free stay

Protective decorative coatings	Surface pretreatment - sanding									Period of collecting data from changes in lacquer coatings
	0			*P80*			*P120*			
	Data from the gloss meter, according to the inclination of the rays in degrees									
	20 °	*60 °*	*85 °*	*20 °*	*60 °*	*85 °*	*20 °*	*60 °*	*85 °*	
Akzo Nobel Pinotex Ultra–Lazur lacquer	4,8	7,9	6,1	4,8	7,8	8,7	4,9	5,3	9	March
	1,8	9,1	8,6	1,8	9,1	9,4	2	5	10,7	May
	1,3	2,2	3,3	1,2	1,8	1,6	1,1	4,7	9,3	August
	2,8	3,4	0,2	2,8	3,1	0,4	2,9	4,8	3,6	December
Decorator Yacht lacquer	4,7	6,7	6,6	5,1	6,9	5,1	4,2	10,9	11,1	March
	1,2	5,8	4,6	1,6	5,8	2,9	0,7	8,4	6,3	May
	1,1	2,6	3,1	1,2	2,9	2,9	1,4	4,9	7,8	August
	3,3	4,6	0,4	3,1	4,6	0,6	3,4	6,2	0,6	December
Lasure exteriour lazur lacquer	3,9	1,2	0,4	3,7	1,3	0,8	3,6	1,8	1,7	March
	0,6	1,1	0,2	0,3	1	0,5	0,2	1,5	1,1	May
	1,2	1,4	2,2	1,1	1,2	1,9	1,1	1,3	2,1	August
	2,9	0,3	0,5	2,8	0,5	0,2	2,8	0,5	0,1	December
Levis hardwood oil	3,9	1,2	0,4	3,7	1,3	0,8	3,4	2,6	1,5	March
	0,6	1,1	0,2	0,3	1	0,5	3,3	2,3	1,4	May
	1,2	1,4	2,2	1,1	1,2	1,9	1,2	1,4	1,5	August
	2,9	0,3	0,5	2,8	0,5	0,2	0	2	0,2	December
Albaco Proterra oil	3,7	5,8	2,9	3,3	4,1	1,1	3,4	2,6	6,3	March
	0	5,7	4,3	0	4	1,5	0	2,3	4,5	May
	2,5	5,4	3,5	1,9	3,7	0,9	1,2	1,4	2	August
	3,8	3,3	0,1	3,6	2,7	0,1	3,3	2	0	December
Sokrates Acryl lazur lacquer	4,3	5,1	9,4	4,5	4,4	5,6	4,8	4,8	6,3	March
	0,8	4,4	6,2	1,1	3,9	5,2	1,5	3,4	4,5	May
	1,3	2	3,1	1,4	1,5	2,9	1,5	1,4	2	August
	2,8	2,4	0,2	2,8	2,4	0,4	2,8	2,9	0	December
Leko impregnation primer	3,9	6,2	5,1	3,7	5,2	1,3	3,7	4,7	1,4	March
	0,1	7,5	5	0	4,7	1,4	0	4,8	1,3	May
	2,6	7,4	4,5	2,4	4,5	1,3	2,4	4,5	1,1	August
	4,2	5,6	0,5	4,1	2,4	0,3	4,1	2,7	0,6	December
Bochemit Estetik Impregnant	4	1,1	0,7	4	0,9	0,6	4	0,6	0,5	March
	0,6	0,8	0,3	0,5	0,8	0,3	0,7	0,7	0,3	May
	0,7	0,5	0,5	0,6	0,4	0,5	0,4	0,3	0,4	August
	2,1	0,3	0,2	2	0,3	0	2,2	0,1	0	December

By the carried-out experiment, clearly visible are the changes in gloss after 6 to 18 months of exposed to atmospheric conditions in the open area. These changes are evidence of the partial or complete destruction of the surface protective layer of the coatings. The same is also evident as an increased value for moisture absorption from the air, which reduces the initial gloss. Since the gloss meter, measures the realized gloss (matt) when the rays of light fall at different angles, it is understandable the difference in the values of the gloss, which is also influenced by the degree of absorption and the roughness of the surface of the protective coating after application. Coatings which already have a destroyed structure after a long stay show increased matting of the surface and respectively increased roughness, which is measured by the device at different testing angles.

After the first time period of the experiment, all of the protective-decorative coatings have no significant changes of the wholeness of the finish layer (Table 2). There are not any decolouration or fungi noticeable, and only by the UV radiation of the sun light spectrum has darken the colour of the protective coatings, compared to the control specimens in the laboratory conditions. In the second period (3 months in open area), the colour changes of some of the protective coatings are more visible, than the control test samples. In some of the lacquers, such as Decorator Yacht lacquer, Lasure exterieur lazur lacquer, Sokrates Acryl lazur lacquer, and Leko impregnation primer, can be observed places with minor cracks and gray stains of the wood surface. These cracks have gotten bigger in the next 3 months of stay in the open area. Also, the fungi and the gray stains, have get bigger and more noticeable. That means that the moisture resistance of those protective coatings, left for that time period in the open area, has greatly reduced.

Figure 4: Experimental samples and the changes in the surface of the protective coatings, compared to the control experimental specimens: a – Leko impregnation primer, b – Decorator Yacht lacquer, c – Sokrates Acryl lazur lacquer

Table 2: Results of the of atmosphere sustainability of protective-decorative coatings of free stay of 12 months (- no changes, + significant changes, +/- some changes)

	3 months				6 months				9 months				12 months			
Type of protective coating	*Change in colour*	*Damage of the surface*	*Mold formation*	*Moisture resistance*	*Change in colour*	*Damage of the surface*	*Mold formation*	*Moisture resistance*	*Change in colour*	*Damage of the surface*	*Mold formation*	*Moisture resistance*	*Change in colour*	*Damage of the surface*	*Mold formation*	*Moisture resistance*
Akzo Nobel Pinotex Ultra– Lazur lacquer	-	-	-	-	+	-	-	-	+	-	-	-	+	+/-	-	-
Decorator Yacht lacquer	+/-	-	-	-	+	+/-	-	-	+	+	-	+/-	+	+	+	+/-
Lasure exterieur lazur lacquer	+/-	-	-	-	+/-	+/-	-	-	+	+	-	-	+	+	-	-
Levis hardwood oil	-	-	-	-	+/-	-	-	-	+	+/-	-	-	+	+/-	-	-
Albaco Proterra oil	-	-	-	-	+/-	-	-	-	+	-	-	-	+	-	+/-	-
Sokrates Acryl lazur lacquer	+/-	-	-	-	+	+/-	-	-	+	+	-	-	+	+	+	+/-
Leko impregnation primer	+/-	-	-	-	+	+/-	-	-	+	+/-	-	-	+	+	+	+/-
Bochemit Estetik Impregnant	+/-	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-

The protective coatings, like: Akzo Nobel Pinotex Ultra– Lazur lacquer; Levis hardwood oil, Albaco Proterra oil and Bochemit Estetik Impregnant, have shown very good moisture resistance for the whole period of 12 months. In the Bochemit Estetik Impregnant, there are no noticeable damages of the lacquer layer or in the wood surface. It has very high moisture and mold resistance.

During the third time period, the untreated wood had a significant change in the color and surface condition of the specimens. At this stage it reached class S, exposed to the weather conditions for only 9 months (Figure 4). Products such as Bochemit Estetik Impregnant and Levis hardwood oil show significant resistance to atmospheric influences, with only color darkening observed without visible destruction of the coating surface. They belong to class D-durable.

CONCLUSION

From the obtained results, can be made the following conclusions:

- The experimental samples made from pines wood without and decorative-protective coating, have atmosphere sustainability about 3 months before any changes in the color can be observed. Cracks and fungi can be observed in 5 or 6 months of stay at atmospheric conditions.
- The products like Decorator Yacht lacquer, Lasure exterieur lazur lacquer and Sokrates Acryl lazur lacquer have moderately durable atmosphere sustainability to 6 months of stay. After that period changes in color and destruction in the wholeness of the protective layer can be observed.
- The best results can be obtained in the use of Bochemit Estetik Impregnant and Levis hardwood oil. The products have shown the best atmosphere sustainability. They can be graded to class D-durable, after the 9 months of controlled experiment.
- Measurements at different angles and their changes also proved the influence of the preliminary preparation of the surface (sanding with different grandness of the sandpaper or without treatment, only planed surface of the experimental speciments) on the changes in gloss, respectively, the matting of the surface of the protective coatings. In this way,

the degree of destruction of the coating can be determined even on already built structures, without the need to take parts off for testing.

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