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A COMPARISON ON THE ABSORPTION AMOUNTS OF HISTORICAL PINE AND OAK WOOD TREATED BY WATER-SOLUBLE TREATMENT MATERIAL AND TREATMENT MATERIAL WITH ORGANIC SOLVENT VIA INJECTION AND BRUSHING METHODS

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Abstract

To extend the physical life of wood elements in historical structures, a great number of chemical preservatives are applied via different treatment methods. In modern wood elements, treatment procedures which are generally applied via pressured methods, give more successful results. However in protecting historical wood structures, it is not possible to apply pressured methods. In ancient structures, the problems possible to arise after dismounting wood elements or the damage that may occur due to pressured method necessitate application of more superficial methods instead of pressured methods. Since there is not any compression enabling the penetration of chemicals into the material in methods without pressure, the amount of absorbed chemical remains lower. In such methods to ensure effective protection, absorption amount after application should be high and even after a while, the chemicals must be able to preserve durability. In this study, pine and oak samples extracted from historical structures have been applied on the material by using two types of wood preservative, water-soluble treatment material and treatment material with organic solvent, via brushing and injection methods. Following the treatment procedure, absorption amounts of chemicals have been measured. Then, samples have been worn out and absorption amounts after wearing procedure have been calculated. For each sample, absorption amounts measured soon after the treatment and wearing have been compared and the significance of in-place treatment procedure has been analyzed.

Key words: Absorption, historical wood material, treatment

1. Introduction

Modern treatment methods are widely applied today in order to protect wood material. At the end of treatment procedure which is mostly applied via pressured methods, physical life of wood material is greatly extended. However, in undetachable historical wood materials, it is not possible to apply pressured methods. In such materials, protective chemicals should be applied via more superficial methods without pressure such as brushing, spraying or injection. Nevertheless in these methods there is not any element (such as pressure, heat difference etc.) enabling the penetration of chemicals into material, therefore penetration depth and amount of chemical absorption may remain low. Oldness of material and in some cases cloggedness inside pores may decrease the absorption amount as well.

Due to above mentioned reasons, low amount of absorption in treatment methods applied in protecting historical wood materials poses a great problem. Low levels of absorption lessen the success in conservation procedure. On the other hand, lowness of absorption amount, combined with environmental factors and wearing, may cause easy removal of chemicals from surface. Common method to sustain the durability of conservation is to repeat the procedure frequently. Nevertheless frequent treatment procedures may also give damage to historical wood materials instead of advantage. For that reason in applications aiming to protect historical wood materials it is rather important to calculate the amount of absorption.

In this study pine and oak samples extracted from historical structures have been applied on the material by using two types of wood preservative, water-soluble treatment material and treatment material with organic

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solvent, via brushing and injection methods. To detect the amount of chemicals remaining on the material after treatment procedure, chemical absorption amounts after the procedure have been calculated. These amounts, in a sense, indicate the effectiveness of conservation procedure. Because the structures are always open to the damaging effects of weather, another indicator of the effectiveness of conservation procedure is the amount of chemical absorption remaining on material after wearing procedure. For that reason after calculating absorption amounts at the start, samples have been worn out in line with TS 6193 EN 94 [1]. After wearing procedure, absorption amounts have been recalculated and obtained results have been compared.

2. Materials and Methods

2.1. Setting test environment

In order to condition, treat and prepare the samples for the test, a test environment where temperature and humidity are under control is required. For this aim, an environment with below stated conditions has been set:

- Conditioning section: Finely air-conditioned, temperature 20 ± 2 Cº relative humidity 65 ± 5%.
- Laboratory Work Area: Finely air-conditioned area where test samples will be processed.

2.2. Preparing test materials

1- Tools:

- Testing bowls non-interacting with chemicals.
- A precision scale with 0.0001 g weighing accuracy.

2- Treatment Material:

As water-soluble treatment material, liquid-phase chemical of which active substances and ratios are below given is employed:

4.90% N, N-Bis (3-aminopropyl) dodecylamin ($C_{15}H_{34}N_2$)
2.00% Propiconazol ($C_{15}H_{17}Cl_2N_3O_2$)
0.20% Etofenprox ($C_{25}H_{28}O_3$)

As treatment material with organic solvent, liquid-phase chemical of which active substances and ratios are below given is employed:

3.00% Benzalkoniumchlorid ($C_{22}H_{40}ClN$)
0.90% Propiconazol ($C_{15}H_{17}Cl_2N_3O_2$)
0.30% 3-Jod-2- propinylbutylcarbamat ($C_8H_{12}INO_2$)
0.02% Flufenoxuron ($C_{21}H_{11}ClF_6N_2O_3$)

3- Wood Samples:

In this test, oak (0.82 g/cm^3) and pine (0.48 g/cm^3) samples extracted from an ancient structure in Tekirdağ Ertuğrul District, İskele Street 70 map section, 263 block, 14 parcel cadastral have been used. Samples have been sized as 25×50×20 mms. 5 sample set for each test group, total 40 sample sets have been used. These samples have been conditioned for a period of 2 weeks in an environment finely air-conditioned, under 20 ± 2 Cº and 65 ± 5% relative humidity. Each of the samples has been numbered; their weights and humidity levels have been recorded.

2.3. Processing the samples into protective operation

By using two types of wood preservative, water-soluble and with organic solvent, conditioned samples have been treated via brushing and injection methods. The amount of applied treatment material is standard in all methods and it is 150 ml/m².

In treatment via brushing, chemical material has been applied on the surface of wood samples with a fiber brush that is not affected from treatment material. For a better penetration of the chemical, brushing operation has been executed as two layers by thoroughly integrating with the material (Figure 2.1).

Figure 2.1. Applying treatment material via brushing method

In treatment via injection, two injection holes, tangent to each sample, have been opened. The holes are 1/10 (2 mm) size of the sample's thickness and 1/2 (10 mm) of its depth. Treatment material has been put into these opened holes (Figure 2.2.) and remaining surfaces have been brushed.

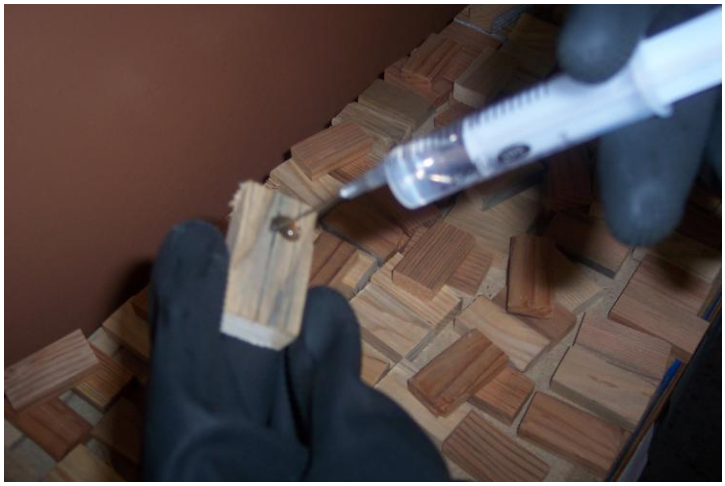

Figure 2.2. Injecting treatment material into opened injection holes

After treatment procedure, samples have been classified and coded. Sample types obtained after the application are as stated below:
P1: Water-soluble treatment material and pine samples treated via injection method.
P2: Water-soluble treatment material and pine samples treated via brushing method.
P3: Treatment material with organic solvent and pine samples treated via injection method.
P4: Treatment material with organic solvent and pine samples treated via brushing method.
O1: Water-soluble treatment material and oak samples treated via injection method.
O2: Water-soluble treatment material and oak samples treated via brushing method.
O3: Treatment material with organic solvent and oak samples treated via injection method.
O4: Treatment material with organic solvent and oak samples treated via brushing method.

2.4. Drying and conditioning the samples after treatment procedure

Following treatment procedure, samples have been placed over two glass sticks (staying motionless over their narrow surfaces and not touching one another) inside a dessicator. The dessicator, its lid closed, has been put into conditioning section. During drying period, samples have been reversed twice a week. Within the second week, the lid of dessicator has been opened gradually each new day. The weights of the samples that have been dried and conditioned until reaching start level have been recalculated and recorded.

2.5. Wearing the samples

In order to detect the durability of the chemical amount absorbed by samples, each sample has been worn out in line with TS 6193 EN 94. TS 6193 EN 94 is based on the method of washing prepared wood test samples to detect biological affect of wood protectors. In pre-conditioning of test samples that will be used in biological tests, by comparing test samples that have not undergone any washing procedure and test samples after washing and testing, they may be used to detect protective material' decreasing effect over time.

The main principle in wearing method is sinking treated test samples into water for a certain period of time, repressing the water under vacuum and normal pressure and viewing the conservation effect with appropriate standard methods.

Following wearing procedure, samples have been, as explained above, dried till they reached the humidity level at the beginning (9.9% for pine samples; 11.0% for oak samples). Weight of each dried sample has been recalculated and recorded.

2.6. Calculating chemical absorption amounts of the samples

As stated above, weight of each sample type has been calculated and recorded three times; before treatment procedure, after treatment procedure and after wearing procedure. Weighing has been conducted via a precision balance with 0.0001 g accuracy. After measuring, weighted averages for each sample set have been calculated and by using below stated relation explained by Usta [2], average absorption amounts have been calculated:

$Av = (W2 – W1) / V$

Av : After the procedure, the amount of chemical absorbed by the material
W2 : The weight of sample after treatment procedure
W1 : The weight of sample before treatment procedure
V : Volume of sample

3. Results

Calculated absorption amounts after treatment procedure:

Absorption amount for pine samples (P_1) treated via injection method by using water-soluble treatment material:
$AvP1 = (9.9168 – 6.9405) / 12.5 = 0.2381$ g/cm^3

Absorption amount for pine samples (P2) treated via brushing method by using water-soluble treatment material:
$AvP2 = (9.4261 – 6.9405) / 12.5 = 0.1989$ g/cm^3

Absorption amount for pine samples (P3) treated via injection method by using treatment material with organic solvent:
$AvP3 = (9.9826 – 6.9405) / 12.5 = 0.2434$ g/cm^3

Absorption amount for oak samples (P4) treated via brushing method by using treatment material with organic solvent:
$AvP4 = (9.4090 – 6.9405) / 12.5 = 0.1975$ g/cm^3

Absorption amount for oak samples (O1) treated via injection method by using water-soluble treatment material:
$AvO1 = (26.9628 – 22.3110) / 25 = 0.1861$ g/cm^3

Absorption amount for oak samples (O2) treated via brushing method by using water-soluble treatment material:
$AvO2 = (26.1275 – 22.3110) / 25 = 0.1527$ g/cm^3

Absorption amount for oak samples (O3) treated via injection method by using treatment material with organic solvent:
$AvO3 = (27.1874 – 22.3110) / 25 = 0.1951$ g/cm^3

Absorption amount for oak samples (O4) treated via brushing method by using treatment material with organic solvent:
AvO4 = (26.4795 – 22.3110) / 25 = 0.1667 g/cm^3

Absorption amounts of treatment material calculated after wearing process:

Absorption amount for pine samples (P1) treated via injection method by using water-soluble treatment material:
AvP1 = (7.6580 – 6.9405) / 12.5 = 0.0574 g/cm^3

Absorption amount for pine samples (P2) treated via brushing method by using water-soluble treatment material:
AvP2 = (7.1946 – 6.9405) / 12.5 = 0.0203 g/cm^3

Absorption amount for pine samples (P3) treated via injection method by using treatment material with organic solvent:
AvP3 = (7.8265 – 6.9405) / 12.5 = 0.0710 g/cm^3

Absorption amount for pine samples (P4) treated via brushing method by using treatment material with organic solvent:
AvP4 = (7.4791 – 6.9405) / 12.5 = 0.0431 g/cm^3

Absorption amount for oak samples (O1) treated via injection method by using water-soluble treatment material:
AvO1 = (23.8168 – 22.3110) / 25 = 0.0602 g/cm^3

Absorption amount for oak samples (O2) treated via brushing method by using water-soluble treatment material:
AvO2 = (23.7588 – 22.3110) / 25 = 0.0579 g/cm^3

Absorption amount for oak samples (O3) treated via injection method by using treatment material with organic solvent:
AvO3 = (24.2879 – 22.3110) / 25 = 0.0791 g/cm^3

Absorption amount for oak samples (O4) treated via brushing method by using treatment material with organic solvent:
AvO4 = (23.7759 – 22.3110) / 25 = 0.0586 g/cm^3

Absorption values calculated for pine and oak samples treated via different methods have been shown in Figure 3.1 and Figure 3.2. Since pine and oak samples are not identical, it will be more meaningful to compare the absorption amounts of each wood type within its own group.

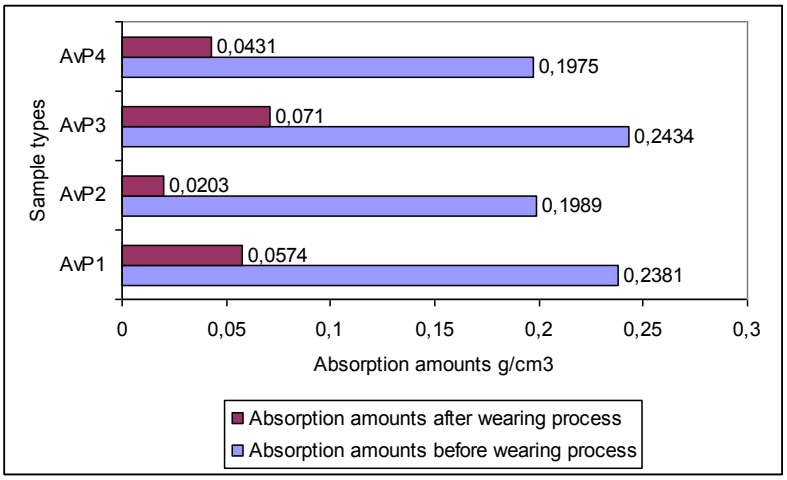

Figure 3.1. Absorption amounts for pine samples after treatment procedure and after wearing process.

AvP1: Absorption amount for pine samples treated via injection method by using water-soluble treatment material.

AvP2: Absorption amount for pine samples treated via brushing method by using water-soluble treatment material.

AvP3: Absorption amount for pine samples treated via injection method by using treatment material with organic solvent.

AvP4: Absorption amount for pine samples treated via brushing method by using treatment material with organic solvent.

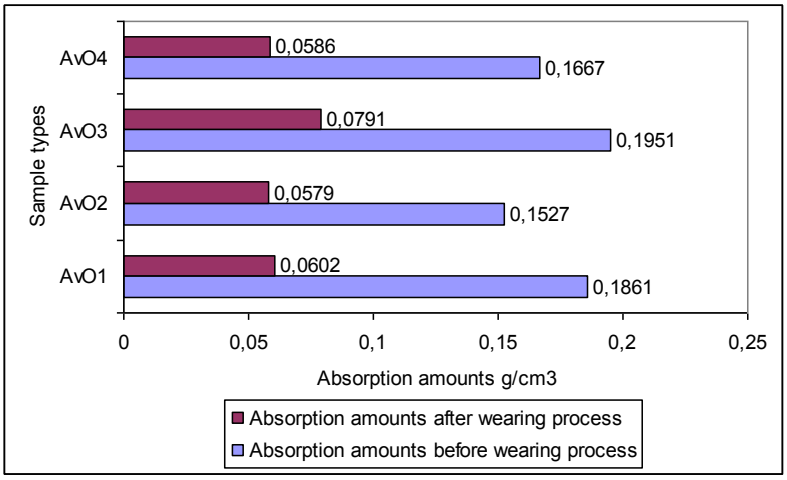

Figure 3.2. Absorption amounts for oak samples after treatment procedure and after wearing process.

AvO1: Absorption amount for oak samples treated via injection method by using water-soluble treatment material.

AvO2: Absorption amount for oak samples treated via brushing method by using water-soluble treatment material.

AvO3: Absorption amount for oak samples treated via injection method by using treatment material with organic solvent.

AvO4: Absorption amount for oak samples treated via brushing method by using treatment material with organic solvent.

4. Conclusion and Discussion

As injection method and brushing method are compared, it surfaces that in all samples treated via injection method, amount of absorption is higher. In both calculations before treatment and calculations after treatment, absorption amounts of samples treated via injection method is higher.

When samples treated by treatment material with organic solvent and water-soluble material are compared, there is no meaningful difference in terms of their absorption amounts (Figure 3.1 and Figure 3.2). In pine samples particularly, samples treated via water-soluble chemicals after wearing have lost greater amounts of chemicals. Since wearing procedure has been conducted according to the method of washing wood testing samples to detect biological effect of wood protectors, water-soluble treatment material has left the material more easily after wearing procedure. Considering the fact that wood materials in open air are exposed to frequent rain, this is a realistic conclusion.

Once the relationship between absorption amount and wood type is analyzed, it surfaces that at the beginning absorption is higher in pine samples. However after wearing procedure absorption of pine samples becomes lower than oak samples. Due to their cellular and porous structure, it is possible to claim that pine samples absorb treatment material better but again due to the very same characteristics, they remove the material more easily after wearing procedure. In other words, because of the same qualities, they are closer to wear and tear. Even though at the beginning they absorbed more chemicals after wearing procedure, the amount of

chemicals in them was lower than oak samples. This difference is even more apparent in brushing which is a more superficial method. In injection method which allows deeper penetration of the chemical than brushing method the difference between oak samples and pine samples is greatly lower.

The amount of chemical material remaining on the sample after wearing procedure is not higher than 0.0791 g/cm^3 even in samples with the largest absorption amount. In both pine and oak samples, the remaining amount of chemical on the material is quite low after wearing procedure. Despite the high amounts of absorption at the start, such great decrease after wearing procedure indicates the fact that treatment procedures without pressure can ensure protection for a brief period on ancient wood materials. To secure protection, treatment procedure needs to be repeated regularly. Since wearing will be faster in materials that are directly exposed to water and weather conditions, this procedure should be repeated even more frequently.

Low level of absorption amount within in-place treatment procedures proves that with these methods, an effective and lasting protection cannot be achieved. Similarly, great decreases in absorption amounts calculated after wearing indicate that although partial protection is possible with this method, still it does not ensure durability. However, according to measurement results, when pressured methods cannot be applied, injection method is more effective than brushing method to protect the material in-place.

References

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