Doctoral Theses

Leaching Characteristics of a Water-Borne Wood Preservative

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1. The aim of the research

If water-borne wood preservatives are applied to protect wood structures used in the open air, a constant concomitant phenomenon is the leaching of certain components of the preservative to some degree. The leaching of part of the agents from the treated wood is a problem, not only from the point of view of wood preservation but it has also effects on the environment. Since the leaching cannot be fully stopped, it is of high importance that we get to know as detailed as possible the leaching process and also the factors influencing it.

The aim of my research was to examine the leaching properties of a water-borne wood preservative made in Hungary. Besides examining the leaching behaviour of the certain components I also wanted to determine how the characteristics of the leaching behaviour change:

- In the case of different wood species:
    - By increasing the retention volume after the laboratory treating,
    - By significantly changing the treating technology,
    - By increasing the storage period between the treatment by industrial technology, and leaching.

According to the results suggestions can be made for

- The possibilities of employment,
- The changing of components and
- The employment of fixation technology of the researched wood preservative.

2. Introducing the examinations

The examinations were carried out on samples treated in laboratory and in factory.

2.1. The examined materials

The wood species used in the experiment were:

Laboratory	*Factory*
Beech (Fagus silvatica L.)	Beech (Fagus silvatica L.)
Scotch fir (Pinus silvestris L.)	Oak (Quercus robur L.)
	Scotch fir (Pinus silvestris L.)
	Spruce (Picea abies KARST.).

The two species used in the laboratory are the commonly used test species in the wood preservation. For the saturation in the factory spruce was treated as the most commonly used coniferous species employed in wooden structures and from the deciduous species oak was treated with its peculiar structure, as a species often used in the architecture.

By this means I had the opportunity to examine not only the effects of different chemical structures but also the effects of different structural composition on the leaching behaviour. The leaching properties are influenced by the chemical composition through the quantity, nature and existence of the function groups needed for the taking place of chemical reactions, which ensure the binding of the preservative's agents. The leaching properties are also influenced by the structural composition through the pore-diffusive inhibition, which is caused by the number, size, and distribution of pores.

The wood preservative used in the research

A wood preservative was examined by the name of TETOL RKB, which contains water-borne, copper-chrome-boron agent. It is distributed in a salt-mixture where the components are:

30% $CuSO_4 . 5 H_2O$

30% $Na_2Cr_2O_7 . 2 H_2O$

40% H_3BO_3

The suggested field of application: preventive preservation of wood-structures in open-air, exposed to the weather-adversities or wood-structures inside, endangered by fungi or insects (surface construction, civil engineering, cable masts, mining, agriculture, furnishing of parks and gardens, forestry establishments).

2.2. Examination method

Preparation

The samples were made according to the MSZ EN 113:1993 standard, in the size of 50 x 25 x 15 mm. In the case of the samples made from spruce, the biggest surface was the butt-end because the difficultness of saturation.

After drying to the absolute dry condition the beginning mass was measured, then groups of 20 samples per group were made. In the laboratory the different groups of species were separated according to the retention volume of wood preservative, and in the factory they were separated according to the duration of the storage period.

Treatment of the wood

Laboratory

The treatment was made according to the MSZ EN 84:1994 5.1.1. standard, with the method of “vacuum-pressure”. The applied preservative-concentration was determined by previous (made with distilled water) test-saturation, and the concentrations were 0.5%, 1.0% and 1.5%. Right after the treatment the mass of the treated samples was measured, and the average preservative quantity in the samples were determined from this.

Parameters of the pressure process

<table>
<tr><td rowspan="2">Treatment</td><td>Initial vacuum</td><td>-40 kPa</td><td>20’</td></tr>
<tr><td>Pressure</td><td>Normal</td><td>90’</td></tr>
<tr><td>Species</td><td colspan="2">Beech</td><td>Scotch pine</td></tr>
<tr><td rowspan="3">Retention (kg/m^3)</td><td colspan="3">2</td></tr>
<tr><td colspan="3">5</td></tr>
<tr><td colspan="3">8</td></tr>
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Factory

The saturation was made in the Dombóvár Factory-Unit of the MÁVFAVÉD Rt. (MÁVFAVÉD Rt. Dombóvári Üzemegysége).

The samples got the appropriate treatment in a real saturation process. They were wrapped into a thin plastic-net; the pallets were put on a transporter carriage, fixed on it and put into the saturating boiler. The stages of the saturation were initial vacuum, pressure period and final vacuum. The planned preservative absorption was 10 kg/m3, which was regulated with supplementation of the quantity brought into the wood.

Parameters of the pressure process in the factory

Treatment	Initial vacuum	-84 kPa	60’	
	Pressure	1.3 MPa	90’	
	Final vacuum	-84kPa	60’	
Species	Oak	Beech	Scotch pine	Spruce
Retention (kg/m^3)	21	18	25	28

Resting period

Laboratory

After the preservative treatment there was a resting period of 6 weeks (at room temperature), which is enough according to the manufacturer (the suggested resting period is 4 weeks) for the fixation to take place.

Factory

After the full-cell-pressure there was a 2, 4 and 6 week resting period (at room temperature). This enabled the examination of the resting period’s effect.

Leaching

The leaching process took place according to the MSZ EN 84:1994 standard, in the case of each sample group in the same way. Distilled water was used as the leaching material. One sample group (20 pieces of sample) was put into a container, filled up with water in the volume of 100 ml/sample. During the 14 day long leaching period the water was changed 8 times. Through this from each group 9 water-samples were taken. On the basis of

their time distribution I could determine the intensity-change of the leaching process of the certain agents. The leaching took place by soaking without stirring.

Analysis of the water samples

The analysis of the water samples took place in the laboratory of the Sopron Regional Instrument Center of OTKA (OTKA Soproni Regionális Műszerközpont). During the examination the concentration of the Cu, Cr and Br was determined by an ICP atomemission spectrometer by the type GBC INTEGRA XM.

2.3. Processing the research data

During the evaluation the measured data were the ion-concentrations of the individual water samples. From these data the changes of the volume –which was leached out of the ions during the leaching process – was determined along with the whole quantity leached out. On the basis of these values I determined the rate of the leaching expressed in percentage. Furthermore it was determined how many percentage of the whole ion-volume leached out in the individual point of times when the sample was taken. It also gives us the pace of the leaching.

3. Summary of the new scientific results

The boron leached out practically completely from the examined wood preservatives after saturating in the laboratory and also after full-cell-pressure in the factory. This necessitates the reappraisal the boron's role, the usage of it in a form of a different compound or the substitution of it in the preservative.

The effect of the retention volume was examined only in the laboratory and it has been found that after the treatment with different concentrations, in the case of the beech samples there was a significantly higher variance in the values of the leaching characteristics. In spite of the high variance the values attached to the chromium and copper changed in an exactly same manner. The changes in the values leached out did not follow the increase of the ingested volume.

In the case of the Scotch fir the changes in the retention volume in this dominion did not cause a significant change. The volume of the chromium leached out, increased parallel with the absorbed volume and the low (around 1%) value of the leaching proportion showed little fluctuation. In the case of the copper the volumes leached out are proportional to the absorbed volumes, the change in the proportion of around 10% is cca. 2 – 3%.

Comparing the values belonging to the two species it has been found that in the case of all the three agents there was a significant difference between the leaching characteristics.

The effect of the storage period – after the treatment in the factory – was examined in the case of four species. On the basis of the results it was established that the leaching characteristics were changed by the resting

period in the different species in significantly different dimension and character.

In the case of the oak the complete leaching of the boron was not influenced by the increase of the storage period. The leaching of the chromium increased after 6 weeks by 40% and in the case of the copper the result was a uniform increase, altogether 50%.

In the case of the beech the boron leached out completely in all three cases, the leaching of the chromium decreased slightly after 4 weeks and the leaching of the copper was not influenced by the increase of the storage period.

In the case of the Scotch fir the leaching of the boron already decreased after 4 weeks. The leaching proportion of the chromium is significantly high after 2 weeks then it strongly decreases and after 6 weeks it lessens only slightly. The change in the leaching of the copper is almost similar to the change of the chromium, only the values are lower by one order.

In the case of the spruce the leaching proportion of the boron declines more than 80% after 6 weeks. In the case of the chromium the leaching proportion of 26% after 2 weeks is extremely high then it falls back respectively to 14% and 11% after 4 and 6 weeks. In the case of the copper the characteristic of the changes is the same, only the values are lower by one order.

The leaching proportion of the chromium has to be accentuated because after the 6 weeks it decreased rapidly but it was still more than 10%. This is such a high value that it has to be changed.

Comparing the results of the different species it has been found that in the case of the two coniferous species the effect of the changes in the storage period is stronger than in the case of the deciduous species. It is the highest in the case of the spruce and lowest in the case of the beech.

Among of the chromium leached out changed to the highest degree.

The leaching after the treatment in the laboratory and in the factory was compared in the case of two species and four sample groups.

In the case of the beech samples the leaching values belonging to the highest laboratory concentration (8 kg/m^3 absorption) are already commensurable with the values, which we got after the saturation in the factory, for all three agents. In the case of the samples made from Scotch fir the leaching characteristics of all three agents are significantly different after the two kinds of treatment. After the full-cell-pressure in the factory in the case of the boron a slight decrease, in the case of the chromium a significant increase and in the case of the copper a similarly significant decrease was found compared to the data obtained in the laboratory. Thus after comparing the data belonging to the different species it can be said again, that the leaching of the examined agents is different in the various species and that the changes in the treatment are also influenced in a different manner and dimension the leaching properties of the agents.

The theses of the dissertation

1. The characteristics of the wood preservative's leaching changed in the function of the species in such a significant way, that those data has to be given at least according to the treated species groups (coniferous – deciduous).
2. The leaching of the boron is complete in almost every examined case; thus it is not suitable for usage in the preservative in its present form.
3. In the case of the leaching of the beech samples treated in the vacuum-pressure procedure, the leaching characteristics of the chromium and copper change in the same manner when the absorbed preservative volume is increased. The increase in the retention volume in the examined dominion (2 – 8 kg/m^3) significantly increases the fixation.
4. In the case of the leaching of the Scotch fir samples treated in the vacuum-pressure procedure, the leaching characteristics of the chromium and copper are different. The leaching of the chromium is slightly decreasing when the absorbed volume increases, in the case of the copper the result is fluctuating around a certain value. The leaching proportion decreases from 1.35% to 1.17% in the case of the chromium, in the case of the copper it fluctuates between 8.7% and 11.7%.

5. After high-pressure treatment the increase in the storage period between 2 and 6 weeks:

   - In the case of the oak samples the leaching proportion of the chromium and copper increases by cca. 50%,

   - In the case of the beech samples the leaching proportion of the chromium slightly decreases and has no effect on the copper

   - In the case of the Scotch fir and spruce samples the leaching proportion of the chromium and copper significantly decreases in the same manner, especially between 2 and 4 weeks.

6. After high-pressure treatment in the case of the Scotch fir and spruce samples the leaching proportion of the chromium is one order higher than those of the copper.

7. The leaching proportion of the Scotch pine after the high-pressure treatment, compared to the vacuum-pressure procedure is

   - In the case of the chromium increased 6 times,

   - In the case of the copper decreased 20 times.

8. The examined wood preservative – used in the given combination, in the open air and for treatment of coniferous structures – cannot be recommended without an application of an appropriate fixation technology.

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