The Colour Change of Oil-Heat-Treated Timber During Weathering

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Abstract: *– The aim of this research work was to compare the weathering resistance of OHT and natural timber. The colour of the wood surface is a major factor during the service life of a product, thus it has to be tested. According to our former investigations several important properties of the wood can be enhanced with OHT, but these results would mean labour lost, if the colour would get lost by greying in outdoor. Pannonia Poplar (Populus × euramericana cv. Pannónia) and Robinia (Robinia pseudoacacia L.) wood was treated at 160°C and 200°C in vegetable oils, for 2h, 4h and 6h. The treatments were performed by using of three different oils: sunflower, linseed and rapeseed oil. The oil bath ensured the deficiency of Oxygen. Untreated air dried wood samples served as control. The colour of the samples was measured in CIELab system directly after the treatment and every 30th day for 12 month during weathering. The samples were fixed on wooden (Poplar) frames, facing to the south, with an inclination of 45°. According to our research work the wood material treated in different oils behaved similar, thus no significant differences could be found between the used oils. The colour change of the treated samples amounted lower values compared to the untreated ones. It can be concluded that the heat treatment in oil did not influenced the colour stability of the treated samples negatively. Although in order to protect the colour of treated material on long term, surface finishing is recommended.*

Keywords: *OHT, wood modification, outdoor exposure, weathering, colour change,* *color, pattern, harmony*

1 Introduction

The thermal treatment, or modification of wood has a long history, and different methods are continuously fine tuned and developed in European countries and worldwide as well. The first promising investigations aimed the enhancement of durability against wood destroying fungi in hot metal bath [1]. Wood samples were treated in different gaseous atmospheres and also melted metals [2][3]. During the next decades different other heat treatment options were investigated. In the recent past heat treatment was studies mostly in Finland, France, Germany and some other European countries [4][5][6][7][8]. The results of developments are documented in patents [9][10][11]. In most documents enhanced dimension stability and durability is reported, but the authors point out some negative effects of the treatments as well. Wood material treated in higher temperature ranges showed higher rigidity, and internal cracks occurred in some cases.

The heat treatments are usually performed in different gaseous atmospheres at temperatures between 180-260 ºC [12]. The boiling point of numerous vegetable oils is over this range, thus they can be considered as heat transferring medium. Earlier investigations [7] have shown that modification processes performed in vegetable oils result in better wood quality compared to the gaseous atmospheres.

The wood material is often preferred in outdoor using, nevertheless because of its aesthetic value. The appearance of wood is composed from the texture and the colour. But the latter one can be changed during the service life of the product due to exposure to sunlight, rain and temperature changes. The consequence of outdoor exposure is the well known greying effect. In order to prove the applicability of a material for using outdoor, weathering tests are recommended. The oil heat treatment (OHT) modifies the colour of the wood favourable, but the stability of the colour is a major factor of a product's value, thus it calls for special emphasises.

In the presented research work Pannonia Poplar (*Populus × euramericana cv.* Pannónia) wood was investigated. This wood specie is wide spread in Hungary, with considerable shares in the forests. Poplar is one of the most important plantation grown specie in our country, and considering the increasing area of new plantations their importance will even increase in the future. The main target of this research work was to compare the colour stability of OHT and natural timber under outdoor conditions without coatings.

2 Experimental Methods

Pannonia Poplar (*Populus × euramericana cv.* Pannónia) wood was oil-heat-treated. The dimension of the samples was limited by the size of the experimental device to (18×40×220) mm. Three different vegetable oils were used: sunflower, linseed and rapeseed oil. The treatments were performed at two different temperatures: 160°C and 200°C, the applied durations were 2h, 4h and 6h. 18 different treatments (oil, temperature, and duration combinations) were studied. 4 samples (laths) were used to each schedule, with an initial moisture content of 13%. The samples were placed directly into the hot oil bath without preheating. At the end of the OHT process the samples were taken out from the oil bath and were stored at room temperature. Untreated and air dried laths having the same dimensions served as control.

The treated laths and the controls were fastened onto stands made of Poplar wood, rather than metal or other wood material, in order to avoid contamination of the surface with metallic oxides, or extractives leached out of the wood. The tests were carried out according to DIN EN 927-3 (2007). The laths were inclined by 45° and faced to the south. The test area was free from any shadow, thus the sun could irradiate the test material directly (Fig. 1.).

The colour of the samples was measured on the face by a Konica Minolta CM-2600d device, using the CIELab system. The colour was measured right after the treatment. These colour values were considered as initial reference data (Start). The colour was measured every 30th day during the test period at 5 spots on each laths (4x5=20 data for each treatment combination at each time, on the same spots). The change of the colour coordinates (ΔL^*, Δa^*, Δb^*) can be obtained as the difference of the initial value (after treatment) and value measured after the given exposure time. The total colour change caused by weathering (ΔE^*) was calculated in order to show the significance of the changes.

In our investigations the curve of the colour coordinates versus time were presented, rather than the changes.

Fig. 1. The samples for outdoor exposure fixed on the stands, faced to the south, inclined by 45°

3 Results and Discusson

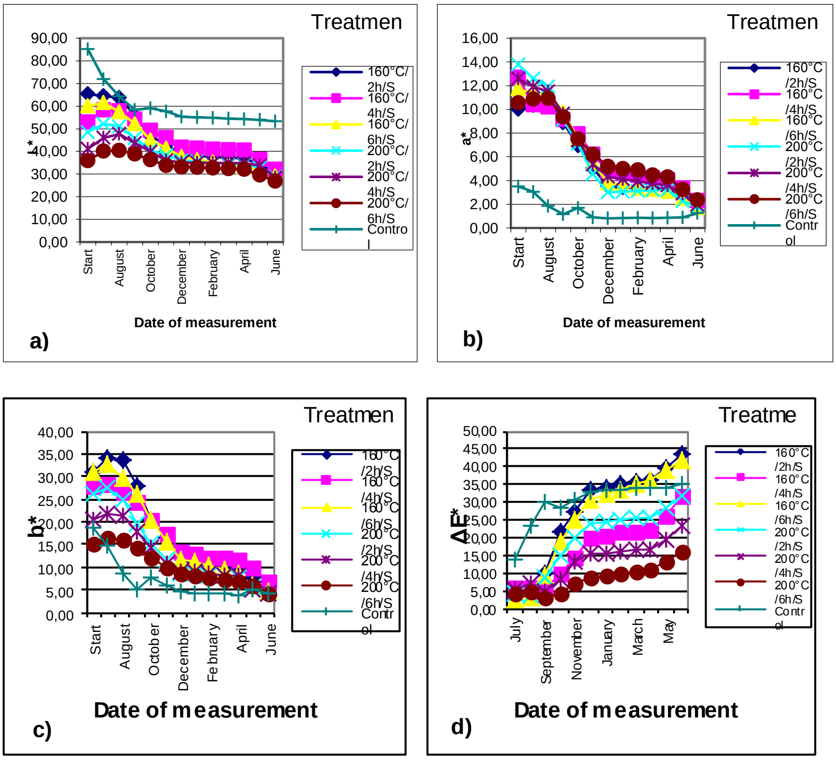

Fig 2. Colour change of Poplar during outdoor weathering
a) L* lightness, b) a* red hue, c) b* yellow hue) d) ΔE* total colour change
(S= sunflower oil)

The lightness (L*) of the treated samples showed minor increase after the first month, and decreased continuously in the subsequent period. The initially different L* values (as the consequence of different treatments) were equalized until the 12th month. Poplar samples darkened at the end of the experiments. The lightness of the untreated poplar decreased permanently, thus it has approached lightness of the treated ones, but remained squarely higher (Fig. 3. a).

The red hue (a*) of the poplar samples decreased continuously during the whole period. The untreated material underwent a slight decrease in this property (Fig. 3. b). At the end of the experiment the treated and the untreated samples showed similar a* values (Fig. 3.b), but the treated ones still had stronger reddish character.

After a slight increase during the first month the yellow hue (b*) of the treated samples declined remarkably and continuously. The measured differences in the initial b* values (different treatments) were equalized at the end of the exposure time. At the end of the 12th month no remarkable differences could be proved between treated and untreated samples in terms of yellow hue (Fig. 3. c).

The ΔE* values of samples remain unchanged for the first 2 months, but increased thereinafter. By the end of the 3rd and 4th month of exposure time, in case of untreated and low temperature treated wood the differences exceeded the significant, with naked eye well visible value of 12. Whereas the high temperature treated material only exceeded the value of 12 in terms of ΔE* after 7-10 months (Fig. 3. d). Wood material treated at lower (160°C) temperature underwent more sever total colour changes compared to the higher temperature (200°C).

CONCLUSIONS

Different treatments (temperatures and durations) resulted in different colour values. These initial colour values changed during outdoor weathering remarkably. Regardless the applied treatment, the initially different colours became similar by the end of the exposure time. The colour of the untreated samples drew near to the treated ones, thus due to longer exposure time the differences likely will be diminished. This result calls for colour protection in case of applications where the colour is important.

An interesting result for Poplar was found, as the higher (200°C) treatment temperature resulted in lower total colour change values, compared to the lower temperature (160°C). This behaviour of Poplar can be explained by the low extractive content.

The colour changes of the treated samples did not exceed the changes of the untreated materials during the investigated period. It means that the colour stability of treated material is no worse than that of the untreated one however on long term colour protection is needed for aesthetical applications (Fig. 3).

Further investigations are running in order to evaluate the checks and cracks due to long term outdoor exposure. The results are promising, as no cracks could be observed on the surface of the treated samples so far.

No differences could be proven between the investigated oils (sunflower, rapeseed and linseed).

Fig. 3. The colour change of Poplar during outdoor weathering
(lower: initial condition, upper. after 12 months exposure)
a) Poplar control; b) Poplar 160°C/2h; c) Poplar 200°C/6h

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