

Modification of wood by oil heat treatment

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Abstract – Poplar (*Populus × euramericana* Pannónia) and Robinia (*Robinia pseudoacacia* L.) wood were treated at 160°C and 200°C in different vegetable oils, in absence of Oxygen, using laboratory equipment. Three different vegetable oils were used, namely sunflower oil, linseed oil and rapeseed oil. Three different durations were chosen for the thermal treatment: 2h, 4h and 6h. The aim of the research work was to prove, in what extent the treatments influence some important characteristics of the wood. The investigated properties were: MOR, impact bending, compression strength, ASE and colour. Untreated samples from the same wood material served as control.

Keywords: wood modification / poplar / robinia / OHT

1. INTRODUCTION

The thermal treatment of wood was a research topic long ago, and the processes were permanently optimized in different countries. The first considerable trials aimed to enhance the biological durability of wood (STAMM et al. 1946). Since that time 4 different processes are mostly current in Europe. These are: ThermoWood – Finland, Plato wood – The Netherlands, Retification - France and OHT (Menz Holz) Germany. Basically all of them are based on a heat treatment in absence of Oxygen. The temperature of the treatment ranges between 160 – 260°C (LEITHOFF – PEEK 1998). The boiling point of the most vegetable oils is over this upper temperature limit, this fact enables to use these oils in the heat treatment technology of wood. Former investigations (SAILER et al. 2000) proved that better wood properties can be achieved by using hot vegetable oils compared to the gaseous atmosphere. Studying the literature the researchers reported about the improvement of the ASE and biological durability in different grades (Militz 2002). But some negative aspects of the treatment e.g. decreased mechanical stability and cracks cannot be left out of account. Further challenging phenomenon is the lower UV-stability of the surface (dark colour gets grey).

The main aim of our research work was to improve the dimension stability (ASE) of two Hungarian plantation timber species, namely Pannonia Poplar (*Populus × euramericana* Pannónia) and Robinia (*Robinia pseudoacacia* L.) using hot vegetable oil treatment. Further tasks were the investigations of different mechanical properties (MOR, MOE, impact bending, compression strength), and the colour change. By using three different types of vegetable oils, the effect of the treating media could be investigated as well.

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2. MATERIAL AND METHODS

2.1. Sampling and schedules

Two plantation grown timber species were chosen to the investigations: Pannonia Poplar (*Populus × euramericana* Pannónia) and Robinia (*Robinia pseudoacacia* L.). For both wood species 10 middle boards were cut from 10 freshly cut logs. The boards were air dried on normal climate to ca. 13% moisture content (oven dry based). The boards were then cut into smaller laths with the dimension of (18mm×40mm×220mm, RxTxL), which was determined by the size of the equipment used for the hot oil treatment. For each schedule 20 laths were treated, from each board 2 laths were taken randomly. After the treatment the laths were cut into smaller specimen, according to the further investigations. The samples were treated in 3 different vegetable oils, namely sunflower, linseed and rape seed oil. The wood samples were treated at 2 different temperatures (160°C and 200°C), and for 3 different durations (2h, 4h and 6h). Combining these parameters 18 different schedules were used for both wood species. The laths were put directly into the hot oil bath, and after the treatment time (2h, 4h and 6h), the specimen were taken out from the bath and placed to normal climate ($t = 20^{\circ}\text{C}$, $\text{rh} = 65\%$). The treated samples and the controls (untreated material) were kept under this climate condition until they reached the equilibrium moisture content (EMC constant mass). Directly after climatization the colour coordinates were measured on the specimen's surface. The laths were then cut into smaller pieces according to the different investigations. To each tested mechanical and physical property 20 samples were investigated.

2.2. Testing of properties

2.2.1. Dimensions of the samples

Compression strength and anti swelling efficiency (ASE): 18mm × 18 mm × 30mm (RxTxL)
MOR and impact bending: 18mm × 18 mm × 220mm (RxTxL)
Colour measurement: 18mm × 40mm × 220mm (RxTxL)

2.2.2. Testing parameters

To the static mechanical properties (compression strength and MOR) Universal Instron testing machine were used. To the dynamic property (impact bending) the Charpy's pendulum was used.

To determine ASE the samples were dried at 103°C to constant mass, and then placed under water for 7 days. The radial and tangential dimensions were recorded prior and after the water bath.

Colour coordinates were measured in CIELab system on the surface of the laths prior and after the treatment by a Konica Minolta CM-2600d device. The colour was measured on 5 places on each lath. The colour properties ΔL^* , Δa^* , Δb^* were calculated as the difference between the property before and after the treatment. The total colour change (ΔE^*) caused by the different treatments (schedules) was calculated as well.

3. RESULTS

3.1. Compression strength (Figure 1/a)

By Robinia the treatment at 160°C increased the compression strength by 5-15%, while the treatment at 200°C caused a loss of 5-10%, depending on the oil used. The treatment time had no clear effect on this property. By Poplar the increasing time and temperature resulted in higher compression strength values (15-25%).

3.2. MOE (Figure 1/b)

By Robinia the increasing treatment and time resulted in proportional decreasing MOE values. By Poplar MOE loss could be observed only by the most intensive two schedules, in other cases the MOE showed a slight increase.

3.3. Impact bending (Figure 1/c)

By Robinia the average impact bending values decreased by 45-70% (depending on the treatment). By Poplar the average impact bending values decreased by 10-55% (depending on the treatment). As a consequence of the treatment the wood material got more brittle.

3.4. ASE (Figure 1/d)

By Robinia the radial and tangential shrinkage decreased by 15-40% and 30-55% respectively. By Poplar the radial and tangential shrinkage decreased by 15-35%, regardless of the anatomical direction. The dimensional stability could be enhanced by the treatment considerably.

3.5. Colour properties

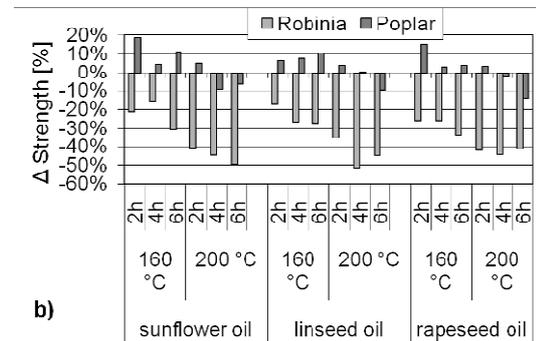
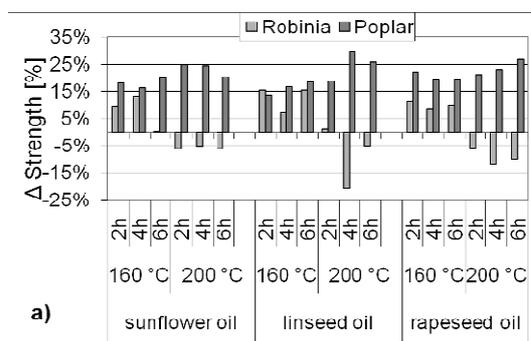
L* / Darkening: both species got darker with increasing treatment temperature and time (Figure 1/f).

a* / red hue: in case of poplar the longer durations and higher temperature resulted in a shifting of colour towards red, while in case of Robinia the 160°C temperature caused increased a* values, but elevating the temperature up to 200°C, the red hue decreased almost to the control values (Figure 1/g).

b* / yellow hue: Robinia and Poplar responded differently (Figure 1/h). By Robinia Higher temperatures and longer durations resulted in lower b* values. By Poplar Higher temperatures and longer durations shifted the colour towards yellow.

ΔE^* / total colour difference (Figure 1/i): The total colour change for Robinia reached values between 40 - 65. By Poplar the treatment caused a total colour change in the range of 25-40. For both wood species the treatments resulted in a high total colour change, easily detectable by naked eye.

No significant differences could be found for the effect of the vegetable oil's type to the investigated properties.



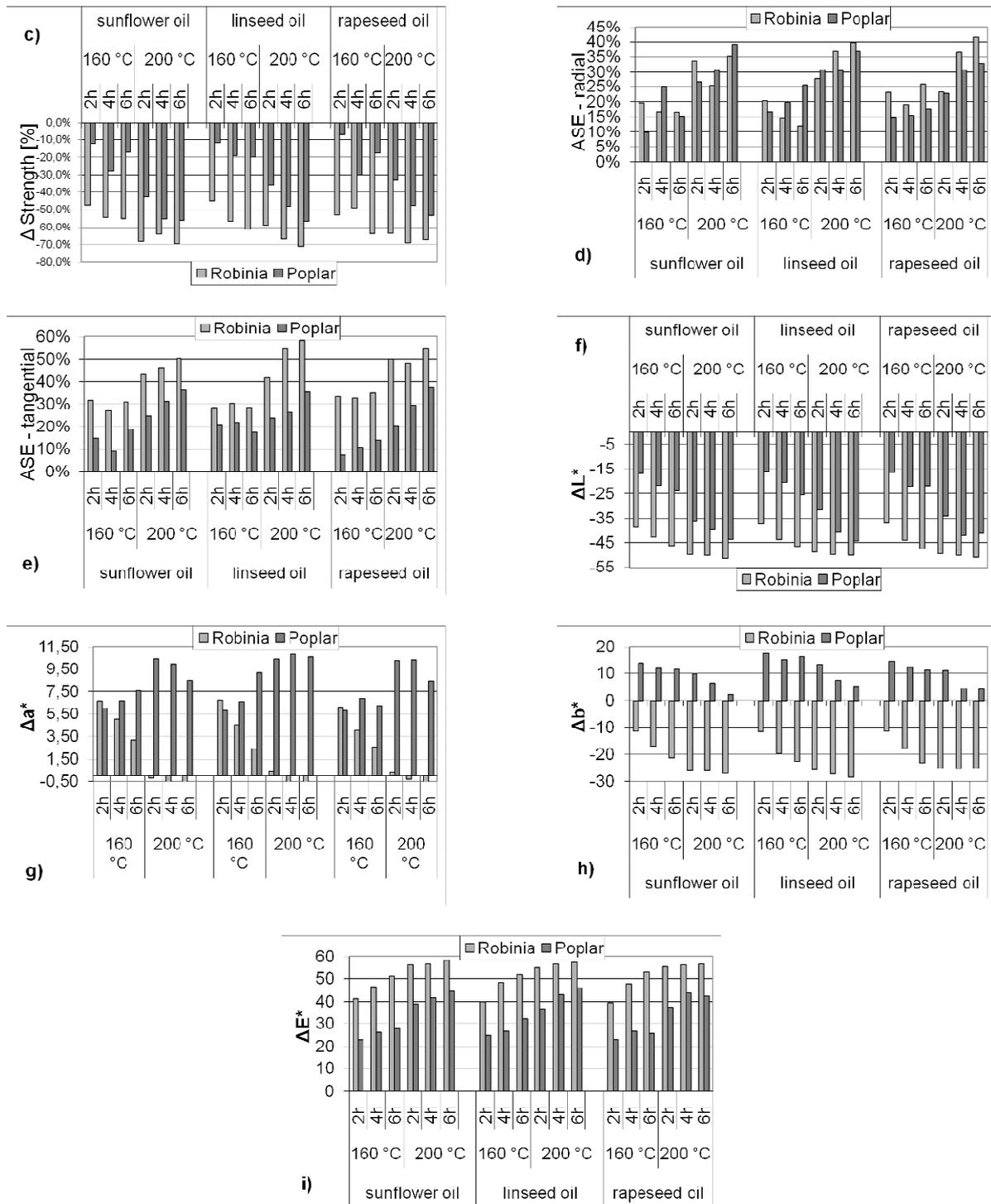


Figure 1. The change in different properties of Robinia and Poplar wood caused by the OHT (a) – compression strength, (b) – MOE, (c) impact bending (d) and (e) – radial and tangential swelling (f) - lightness L^* , (g) – red hue a^* , (h) – yellow hue b^* , (i) – total colour difference ΔE^*

4. CONCLUSIONS

As a general conclusion regarding the mechanical properties it can be drawn that the OHT resulted in lower strength values. The compression strength is an exception, as it increased by Poplar after all schedules and by Robinia at 160°C as well. As a consequence of OHT the material became more brittle as the impact bending values decreased. A very positive effect of OHT treatments are the considerable high ASE values, so the dimension stability could be enhanced by both investigated wood species.

Up to our expectations the colour of both species darkened significantly. The colour of the Robinia is more sensitive to the heat treatment, as it showed higher changes in the colour properties. In case of Robinia cracks could be observed after the treatment. The considerable strength losses by Robinia and the increased strength values by Poplar can be explained with the occurrence of cracks. Further investigations are planned to minimize the cracks (size and numbers), as this phenomenon lowers the quality of the wood material. A possible solution can be the use of pre dried wood material (lower than 13%, as it was used here). Regarding the oil types, no significant differences could be observed in terms of the investigated wood properties.

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