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Comparison of VOC emissions from natural (untreated) Poplar wood and heat treated wood

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Abstract: *Comparison of VOC emission from natural (untreated) Poplar wood and heat treated wood.* This paper describes the VOC emissions emitted by massive poplar wood treated at 180 °C and 200 °C. The focus was on the influence of temperature, on the quality and quantity of volatile organic compounds, especially on the amount of emitted phenol and furfural. The emission was analyzed as function of time after heat-treatment. The influence of the finishing with water borne lacquer on VOC emission was also investigated.

Keywords: Poplar massive wood, TVOC, emissions VOC, finished surface of "thermally modified wood", finishing by water borne lacquers

INTRODUCTION

The emission of volatile organic compounds (VOCs) by furniture used indoor is essential for the acceptance by the consumer. Nowadays, the question is in focus, how the thermal modification influences the VOC emission.

Heat-treatment of timber is used to modify the properties of wood to resist dimensional changes in different humidity according to ***Viitaniemi et al.*** (***2000***), to achieve better heat insulation, improved decay and weather resistance, reduced moisture deformation and new shades of colour as an alternative to tropical hardwood. All these changes are achieved with heat treatment process without any added chemicals. Thus, heat-treated wood has been considered as an ecological alternative to impregnated wood material according to ***Kamdem et al.*** (***2000***), and it can also be used for several purposes, e.g. for garden, kitchen and sauna furniture, floors, ceilings, inner and outer bricks, doors and windows and for musical instruments according to ***Kähäri*** (***2001***).

Heat treatment affects all the wood components, i.e., cellulose, hemicelluloses, lignin, and extractives. Emissions and degradation products of wood differ according to wood species. Especially, differences can be detected between the hard- and softwood, which have different cell types according to ***Sjöström*** (***1993***).

Hemicelluloses usually crack down thermally easier than cellulose or lignin because of its heterogeneous structure and lack of crystallinity. Degradation of hemicelluloses occurs intensively at 200-260 °C. Aliphatic carboxylic acids (mainly formic and acetic acids) are the major volatile degradation products formed during the heat treatment according to ***Kotilainen*** (***2000***) and ***Sundqvist et al.*** (***2006***). On the other hand, large amounts of acetic acid were detected already from native wood samples according to ***Peters et al.*** (*2008*). Smaller emissions of acetic acid were observed from spruce than from hardwood due to greater number of acetyl groups in hardwood hemicelluloses. In addition, increased emissions of furfural from ash, beech, maple, and spruce were detected due to thermal treatment, which was interpreted to be caused by degradation of hemicelluloses. On the other hand, the emissions of the prevailing aldehydes in natural wood, pentanal and hexanal were observed to decrease during thermal treatment according to ***Peters et al.*** (***2008***).

RESEARCH OBJECTIVE

This research describes the VOC emissions emitted by solid poplar wood treated at 180 °C and 200 °C. The focus was on the influence of temperature, on the quality and quantity of volatile organic compounds, especially on the amount of emitted phenol and furfural. The emissions was analyzed as function of time after heat-treatment. Also the influence of the finishing with water borne lacquer on VOC emission was investigated.

MATERIAL AND METHODS

The tested wood (poplar [*Populus Alba L.*]) obtained from KATRES company Ltd., Czech producer of heat-treatment chambers, was investigated. The pre-dried wood samples were modified at 200 °C and 180 °C in a heat treatment process.

Samples were taken from the normal manufacturing process, wrapped in aluminium foil and delivered to the test laboratory. The wood was cut into pieces (sizes: 740 x 40 x 1mm) and put into the test chamber. As emission rate of VOCs also depends on age, the samples were put into the chamber as soon as possible after the delivery from the plant. The chosen heat treated wood in 180°C and 200°C was finished by water borne lacquers. In the present study, air samples were collected continuously onto the Tenax TA until their required testing days was obtained.

Tested materials

a) 10 pieces of lamellas made from native poplar wood, each of tested lamellas has these dimensions: 0,74 m x 0,04 m x 0,001 m, size tested sample: S=0,6 m^2,
b) 10 pieces of lamellas made from heat-treated polar wood at the temperature of 200°C, dimensions of one lamella: 0,74 m x 0,04 m x 0,001 m, size tested sample: S=0,6 m^2,
c) 10 pieces of lamellas made from heat-treated poplar wood at the temperature of 180 °C, dimensions of one lamella: 0,74 m x 0,04 m x 0,001 m, size tested sample: S=0,6 m^2,
d) 10 pieces of lamellas made from heat-treated poplar wood at the temperature of 200 °C and 180 °C, finished surfaces by waterborne lacquers, dimensions of one lamella: 0,74 m x 0,04 m x 0,001 m, size tested sample: S=0,6 m^2,

Equipment for measuring emitted emissions

- Short path thermal desorption tube, Silco trated Thermal Desorption Tube 786090-100, inner diameter 4 mm, fill in with 100 mg of Tenax TA (Scientific Instrument Services company) for collection of VOCs emissions emitted from tested samples in to the air in chambre
- Air sampler Gilian–LFS 113 SENSIDINE with air flow 6 l h^{-1} and 12 l h^{-1}
- Gas chromatograph Agilent GC 6890 N with MS (mass spectrometer) detector 5973 with cryofocusation, thermal desorption and library of spectra NIS 05, column type HP – 5 (AGILENT USA)
- VOC was tested in a small-space chamber with a volume of 1 m^3. Air temperature: 23°C; relative humidity in the chamber: 50%; air changing rate: 1 m^3 per 1 h; air speed over the tested samples: 0.1 to 0.3 $m.s^{-1}$

Standards applied:

ISO 16000: 2004	Indoor air
ISO 16000-1: 2004	General aspects of sampling strategy
ISO 16000-5: 2005	Measurement strategy for (VOCs) volatile organic compounds
ISO 16000-11: 2004	Determination of the emission of volatile organic compounds: sampling, storage of samples and preparation of test specimens

ISO 16000-6: 2005	Determination of volatile organic compounds indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and chromatography using MS/FID
ISO 16000-9: 2004	Determination of the emission of volatile organic compounds: Emission test chamber method

RESEARCH RESULTS

Based on the obtained results (figure 1, 2, 3) it is concluded that the heat-treatment of wood increases the quantity of VOC emissions emitted by tested samples. The main difference was found in the amount of emitted furfural and phenol in the blend of gaseous evaporated by heat-treated poplar in normal conditions. The temperature of heat-treatment has a great influence on the amount of emitted furfural by tested heat-treated wood. The higher the temperature during the poplar heat-treatment, the higher the Phenol emissions. Phenol and Furfural are typical chemicals, which are resulting in thermal degradation of wood components.

The finished surface by the water borne lacquer does not decrease the amount of emissions escaping from heat-treated spruce wood. Surprisingly, water borne lacquers even elevated the amount of VOCs.

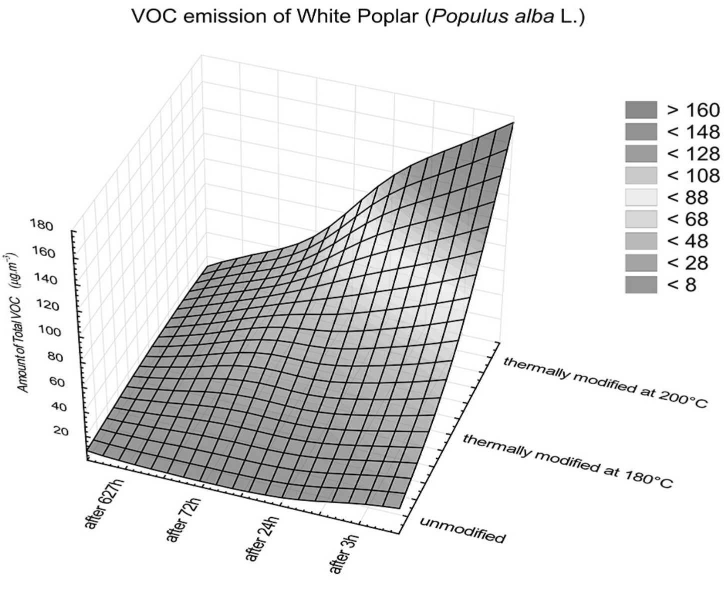

Fig. 1 Amount of VOC emitted by heat-treated Poplar (Populus Alba L.) after 3, 24, 72 and 672 hours

Figure 1 shows the influence of the wood modification temperature and of the time between the VOC measurement and wood modification. The amount of VOC emission decreases with the decreasing temperature of wood modification. The amount of emitted VOC declines with the increasing time between the wood modification and the measurement of VOC emissions emitted by tested samples.

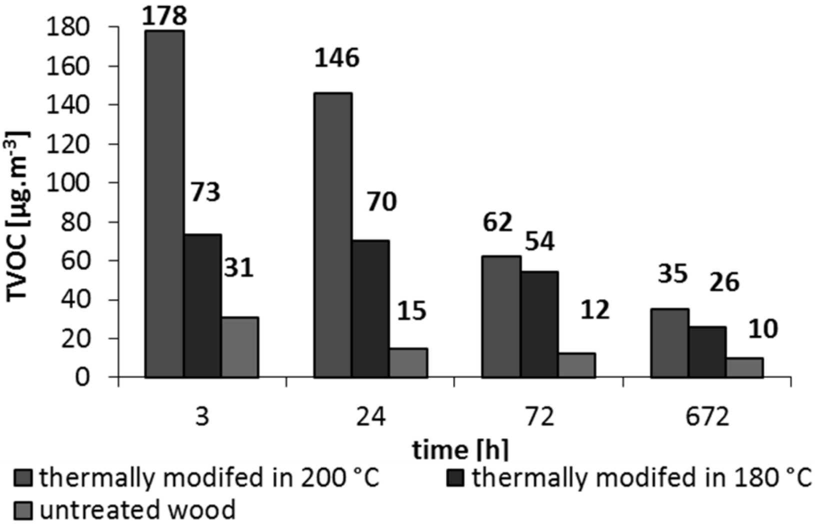

Fig. 2 Comparison of TVOC emissions from White Poplar (Populus Alba L.) „thermally modified wood" in 200 °C and 180 °C and untreated wood

Figure 2 shows a comparison of TVOC from „thermally modified wood" (Populus Alba) in 200 °C and 180 °C and untreated wood in dependence on time. The highest concentration of TVOC emitted by thermally modified wood in 200 °C.

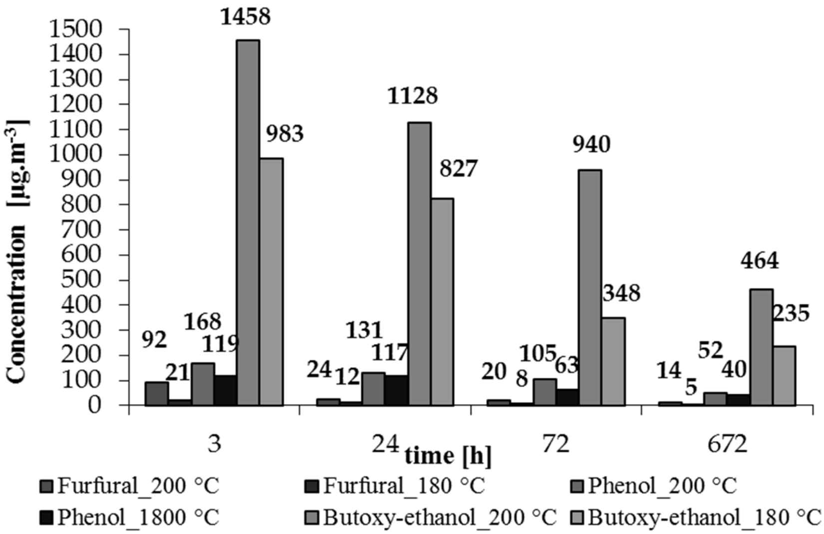

Fig. 3 Comparison of VOC emissions from White Poplar (Populus Alba L.) in 200 °C and 180 °C „thermally modified wood" after finishing by water borne lacquer

Figure 3 shows a comparison of VOC emissions from White poplar „thermally modified wood" in 200 °C and 180 °C after finishing by water borne lacquer. We can see very high concentration of buthoxy ethanol, while this compound is obtained in water borne lacquer. Phenol and furfural are substances resulting from thermal decomposition of lignin. Concentration of furfural is moved in the hundreds of $\mu g \cdot m^{-3}$, while concentration of phenol is moved only to units of $\mu g \cdot m^{-3}$.

CONCLUSIONS

1. Based on the obtained results (figure 1, 2) it is concluded that the heat-treatment of wood increases the quantity of VOC emissions emitted by tested samples. The main difference was found in the amount of emitted phenol and furfural in the blend of gaseous evaporated by heat-treatment poplar in normal conditions.
2. The temperature of heat-treatment has a great influence on the amount of emitted phenol and furfural by tested heat-treated wood. The higher the temperature during the poplar heat-treatment, the higher is the phenol emissions. Furfural and phenol are typical chemicals, which are resulting in thermal degradation of wood components.
3. The finished surface by the water borne lacquer does not decrease the amount of emissions escaping from heat-treated poplar wood. Surprisingly, water borne lacquers even elevated the amount of VOCs.

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Streszczenie: *Porównanie emisji lotnych związków organicznych LZO z naturalnego (nieprzetworzonego) drewna topoli oraz drewna poddanego obróbce cieplnej.* W pracy opisano emisję lotnych związków organicznych LZO z nieprzetworzonego drewna topolowego oraz drewna modyfikowanego w temperaturze od 180°C do 200°C. Skupiono się na wpływie temperatury, na jakość i ilość lotnych związków organicznych, zwłaszcza na ilość emitowanego fenolu i furfuralu. Emisję analizowano w funkcji czasu po obróbce cieplnej. Zbadano również wpływ wykończenia powierzchni drewna lakierem wodorozcieńczalnym na emisję LZO.

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