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The susceptibility of poplar and alder wood to mould fungi attack

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Abstract: *The susceptibility of poplar and alder wood to mould fungi attack*
In the conditions of high air humidity and moisture content mould fungi are able to grow very easy on many building materials because of very poor nutritious requirements. During short time growing the fungi cause mainly disfigurements of wood and wood based materials, but in the case of strong prolongation of their growth the mould, i.e. filamentous fungi belonging to *Ascomycetes, Deuteromycetes* group, may cause even soft rot of lignocelluloses materials. One of the ways to enhance the wood resistance to fungi is its impregnation with fungicide; however, fungicides may have an unfavourable effect on health and environmental conditions and in many situations cannot be used. The thermo- and thermo-oil modification of wood is considered another and more accepted, in terms of ecology, method of improving some unfavourable physical properties of wood and enhancing its resistance to fungi (particularly to *Basidiomycetes*). Determination of the effect of thermo-modification, thermo-oil modification or impregnation with linseed or rapeseed oil of poplar (*Populus nigra*) and alder (*Alnus glutinosa*) wood on its resistance to fungi causing wood moulding (test with fungi mixture and apart *Chaetomium globosum*) was the aim of the research. Modification and impregnation of wood were carried out in semi-technical conditions. In most cases mould fungi covered the surface of samples of thermally and thermal-oil modified poplar and alder wood stronger, easier and to a greater extent compared to wood treated only with oils (it was especially visible in the case of a fungi mixture growing on poplar wood). The growth of fungi on treated wood was similar to that on control wood. The wood subjected to thermal modification, thermal-oil modification or impregnation with oils was still susceptible to the growth of mould fungi, and thus it cannot be classified as resistant to mould fungi in terms of requirements of building material evaluation.

Keywords: poplar, alder, thermo, thermal-oil modification, impregnation, natural oils, moulds fungi

INTRODUCTION AND AIM OF THE STUDIES

The mould fungi that belong to *Ascomycetes*, *Deuteromycetes* group growing on wood and wood based materials, cause mainly disfigurements of materials; however, fungi of that group may cause even soft rot of lignocelluloses materials if they are allowed to grow for a longer time and have good conditions, including high enough air humidity and moisture content of ground. Many of these fungi can decay cellulose because they have the capacity to produce large quantities of cellulitic enzymes (cellulases and hemicellulases), e.g. *Trichoderma* spp. [Montealegre et al. 2009]. The nutritious requirements of fungi are very poor so they appear universally all over the world [Fojutowski at al. 2009, Skyba et al. 2008, Wiszniewska at al. 2004]. The spores and mycotoxins, which are emitted by mould fungi during their growth, may pose a threat to the environment and health, e.g. cause people and animals different allergies and/or infections [Zawisza and Smoliński 1998, Wiszniewska et al. 2004]. Wood covered with mould fungi is classified as a material of lower quality class and, in consequence, of lower trade value. Poplar and alder wood may be attacked by the mould fungi very easily as other natural, native soft- and hardwood when freshly cut or secondary moistened. The fungicide treatment is one way of mould fungi control, but in some situations it is not recommended, because of possible unfavourable effect on health and environmental conditions. Thermo-modification and thermo-oil modification of wood is considered another, more accepted, in terms of ecology, method of improving some physical properties of wood and enhancing its resistance to fungi, thus extending the scope of wood use, especially in higher use classes. Thermally or thermo-oil modified wood usually is less hygroscopic, more dimensionally stable, more durable and resistant to fungal decay caused by *Basidiomycetes* fungi than natural wood [Kollman 1936, Mazela et al. 2004, Rep et al. 2004, Schwarze and Spycher 2005, Welzbacher et al. 2006, Zaman et al. 2000]. Thermal treatment of wood reduces the amount of hydroxyl groups of cellulose and hemicelluloses that are involved in oxidative degradation, fungal decay and processes of water absorption and desorption by wood [Militz 2002]. The good results achieved in relation to *Basidiomycetes* fungi attack control are not so obvious in relation to mould and soft rot fungi control [Fojutowski at al. 2009, Skyba at al. 2008]. Some positive effects concerning mould fungi control were observed as an effect mainly of oil treatment of wood, but they were insufficient to change the class of wood in terms of resistance to mould fungi. We continue our work to obtain improved wood, in semi-technical conditions, by thermal modification carried out also as heat-oil treatment and individual impregnation of wood with natural oils. The effect of thermo-modification, thermo-oil modification or impregnation with natural oils of poplar (*Populus nigra*) and alder (*Alnus glutinosa*) wood on its resistance to fungi causing wood moulding was the aim of our research. Thermal modification and oil impregnation of wood susceptible to fungi attack may broaden possibilities of practical use of wood that as a native material is not durable enough.

MATERIALS AND METHODS

The materials used in the tests consisted of poplar (*Populus nigra* L.) and alder wood (*Alnus glutinosa* (L.) Gaertn.). Little beams of wood prepared to treatment were planed on four surfaces and had sharp edges – 40R(thickness)x145Tx650Lmm. The wood was of 1st and 2nd quality class acc. to a standard requirements [PN-D-96002]. Besides control wood (C – native wood, not treated) the beams were subjected to:

- OL – vaccum-pressure impregnation with technical linseed oil of the temperature of 65°C and density of 0.927 g/cm^3, oil body at 60°C and 17 mPa·s that contained 75% of linoleic ($C_{18}H_{32}O_2$) and linolenic ($C_{18}H_{30}O_2$) acids, or
- OR – vaccum-pressure impregnation with technical rapeseed oil of the temperature of 65°C and density of 0.916 g/cm3, oil body at 60°C and 19 mPa·s that contained 78% of oleinic ($C_{18}H_{34}O_2$) and linoleic ($C1_8H_{32}O_2$) acids, or
- T – thermal modification at the nominal temperature of 195°C in steam as protective atmosphere, or
- TOL – thermal modification and following impregnation with technical linseed oil, as mentioned above, or
- TOR – thermal modification and following impregnation with technical rapeseed oil, as mentioned above.

Samples cut out of the little beams were conditioned for testing in normal conditions (20°C/65%) till equilibrium moisture content was reached. Determinations of the hygroscopic characteristics were carried out by testing by oven dry method, at equilibrium moisture content, samples conditioned till a constant mass in normal conditions (20ºC/65%RH) was reached [PN-EN 13183-1]. The Scots pine native sapwood (*Pinus sylvestris* L.) samples were used as activity control of fungi. The growth of fungi on salt-agar nutrient was observed as virulence control. The samples for mycological tests were used in state of equilibrium moisture content in normal conditions (20°C/65%RH).

A method adapted from building procedures [Instrukcja ITB....1995] was used for mycological testing. Test and control samples were exposed to the following fungi: set I = mixture of: *Aspergillus niger*, *Penicillium funiculosum*, *Paecilomyces varioti*, *Trichoderma viride*, and *Alternaria tenuis* or set II: *Chaetomium globosum* fungus; incubation at the temperature of 27$\pm$1^{o}C and relative humidity of 90%. After 4 weeks the growth of mycelium on the surface of test samples was evaluated using the following scale:

0 – no visible under microscope growth of fungi on a sample,

1 – trace growth of fungi on a sample, hardly visible with the naked eye but well visible under

microscope or growth visible with the naked eye limited to the edges of a sample,

2 – visible with the naked eye growth of fungi on a sample, but less than 15% of the surface is covered with fungus,

3 – over 15% of the surface is covered with fungus visible with the naked eye.

A standard evaluation was completed with estimation of the percentage of a sample surface overgrown by mycelium. The test samples of the dimensions of 60x20x3(thickness)mm were individually placed on Petri dishes of the diameter of 100mm and outside height of 15mm. For each variant of tested wood 6 samples were used.

RESULTS AND DISCUSSION

Equilibrium moisture content of natural poplar and alder wood after conditioning at (20 ± 2)°C and (65 ± 5)% (Table 1) was around 11% and at least 100% higher than that for thermally modified and thermo-oil modified wood. The equilibrium moisture content of wood impregnated only with oils also was smaller than that of natural wood, but decreased not so distinctly as in the case of thermally and thermo-oil treated wood. The level of equilibrium moisture content achieved by wood treated only with oils was in the range of 8.4-9.5%, i.e. decreased to about 80-90% of that of natural wood. It indicated strong hydrophobization of wood by thermo-oil modification and thermo-modification (Table 1).

Table 1. Equilibrium moisture content [%] of wood at normal conditions: 20^{o}C, 65% RH

Tested wood	Before modification - C[a]	After modification				
		OL[b]	OR[c]	T[d]	TOL[e]	TOD[f]
Poplar	10.7	8.7	9.5	4.4	4.1	5.1
Alder e	10.6	8.4	9.4	4.8	3.9	5.3

[a] Control, [b] OL – impregnation with oil – retention of line oil: poplar 116 kg/m^3; alder 143 kg/m^3, [c] OR – impregnation with rapeseed oil – retention of rape oil: poplar 69 kg/m^3; alder 108 kg/m^3, [d] T – Thermal modification, [e] TOL – Thermal-line oil modification – retention of oil: poplar 80 kg/m^3; alder 131 kg/m^3, [f] TOR – Thermal-rape oil modification – retention of oil: poplar 56 kg/m^3; alder 120 kg/m^3,

The strains of mould fungi used in the test were of very high virulence. The virulence check showed that they completely covered the whole surface of nutrient medium in Petri dishes after 3 days from infection. The test of fungi activity also demonstrated well activity of the fungi used, because the surface of Scots pine sapwood samples also were grown over with mycelium at grade 3 and 100% of the surface was covered with growing mycelium. The results of visual assessment of wood resistance to mould fungi presented in Table 2 and 3 show that the growth of fungi mixture and the growth of *Chaetomium globosum* reached mostly the highest 3. degree on native poplar and alder wood as well as on tested (modified, oil treated) and control specimens. On poplar wood treated only with oils the growth of the fungi mixture was smaller and not so abundant, i.e. up to grade 1.2 when wood was treated with rape oil and up to grade 2.3 when line oil was used. However, the assessment of fungi growth measured in % indicated that tested wood treated only with oils was also very susceptible to fungi growth, because 100% of the surface was coverd with fungi. Mean growth of the fungi mixture or *Chaetomium globosum* fungus on thermally and thermo-oil modified or oil treated poplar and alder wood was 100%. The fungal growth on thermally and thermo-oil treated wood seemed to have been even more abundant than on the control wood and wood treated only with oils. The kind of oil did not have a very important effect, except for the fungi mixture on poplar wood treated only with oils.

All tested materials should be classified as not resistant to mould fungi according to basis criteria used in buildings. The results were repeated twice in separate tests.

Thermal treatment and thermal-oil treatment had rather stimulating effect on the growth of the fungi mixture and *Chaetomium globosum* fungus on wood in comparison to control wood and wood treated only with oils.

Table 2 The resistance to mould fungi of thermally modified and thermo-oil (linseed or rapeseed oil) modified or impregnated with linseed or rapeseed oil poplar and alder wood – test acc. to Building Research Institute Instruction [Instrukcja ITB 355/98] using the mould fungi mixture of – Set I

Wood	Mean grade of fungi growth	Mean[g] fungi growth on sample surface [%]
Poplar C[a]	3.0	100
Poplar OL[b]	2.3	100
Poplar OR[c]	1.2	100
Poplar T[d]	3.0	100
Poplar TOL[e]	3.0	100
Poplar TOD[f]	3.0	100
–	–	–
Alder C[a]	3.0	100
Alder OL[b]	3.0	100
Alder OR[c]	3.0	100
Alder T[d]	3.0	100
Alder TOL[e]	3.0	100
Alder TOD[f]	3.0	100

Legend for [a] to [f] as for Table 1, [g] number rounding to 10%

Table 3 The resistance to mould fungi of thermally modified and thermo-oil (linseed or rapeseed oil) modified or impregnated with linseed or rapeseed oil poplar and alder wood – test acc. to Building Research Institute Instruction [Instrukcja ITB 355/98] using *Chaetomium globosum* fungus – Set II

Wood	Mean grade of fungi growth	Mean[g] fungi growth on sample surface [%]
Poplar C[a]	3.0	90
Poplar OL[b]	3.0	60
Poplar OR[c]	3.0	100
Poplar T[d]	3.0	100
Poplar TOL[e]		
Poplar TOD[f]		
–	–	–
Alder C[a]	3.0	100
Alder OL[b]	3.0	100
Alder OR[c]	3.0	100
Alder T[d]	3.0	100
Alder TOL[e]	3.0	100
Alder TOD[f]	3.0	100

Legend for [a] to [d] as for Table 1, [g] number rounding to 10%

It may be connected with the possibility of a small increase in nutrient agent in wood as a side effect of thermo treatment, not of importance for *Basidiomycetes*, but perhaps useful for mould fungi. Regardless of that, the hygroscopicity of modified wood was distinctly lower than that of control wood. The effect of impregnation of wood with oil in terms of its resistance to mould seemed to have been better than in the case of thermo and thermo-oil modification of wood; however, the resistance of all tested wood variants to mould generally seemed to have been not good. The relation between the retention of oil and the grade of fungi growth on oil or thermo-oil treated wood was not very clear, but there were no evident signs of inhibiting effects of the treatments. The treatment of poplar and alder wood did not distinctly decrease the intensity of fungi growth on the wood surface in the case of the fungi mixture as well as in the case of *Chaetomium globosum* fungus.

CONCLUSSIONS

1. Thermal modification or thermo-oil modification of poplar and alder wood using line or rape oil should increase the hydrophobicity of wood even twofold; however, individual impregnation with the oils can increase the hydrophobicity only by 20%.
2. Mould fungi under favourable conditions for their growth may grow very easily on native (natural) poplar and alder wood and even on the surface of thermally modified or thermo-oil modified or impregnated with natural oil poplar and alder wood. The growth of mould fungi on thermally modified or thermo-oil modified surfaces may be even more abundant than in the case of control wood or wood treated only with oils. It may create an environmental and health hazard similar to the hazard observed in the case of control wood.
3. Poplar and alder wood that was thermally modified and thermo-oil modified or impregnated with line/rape oil should not be considered resistant to the growth of mould fungi on its surface, thus it should be classified as not resistant to mould fungi in terms of building material evaluation requirements; however, in comparison to natural wood and thermally and thermo-oil treated wood the grade of mould growth on the surface of wood treated only with oil was not so abundant.
4. Poplar and alder wood subjected to thermal modification or thermo-oil modification or impregnation with natural oil, when used in conditions favourable to mould fungi growth, should be protected with anti-fungal preparations to safeguard wooden elements against the anticipated fungi attack.

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Streszczenie: *Podatność drewna topoli i olchy na działanie grzybów pleśni.* Grzyby pleśniowe w warunkach wysokiej wilgotności powietrza i zawartości wilgoci w podłożu mogą łatwo rosnąc na wielu materiałach budowlanych, z uwagi na niewielkie wymagania troficzne. Ich krótkookresowy wzrost powoduje głównie zeszpecenie drewna i materiałów budowlanych, lecz dłuższy rozwój tych pleśniowych – strzępkowych grzybów należących do *Ascomycetes*, *Deuteromycetes* może powodować nawet szary rozkład materiałów lignocelulozowych. Jednym z sposobów zwiększenia odporności drewna wobec tych grzybów jest impregnacja fungicydami. Fungicydy mogą mieć jednak niekorzystny wpływ na zdrowie i warunki środowiska, a w wielu sytuacjach nie mogą być stosowane. Termiczna i termo-olejowa modyfikacja drewna jest uważana za inną, bardziej proekologiczną metodę poprawy niektórych niekorzystnych właściwości fizycznych drewna i zwiększenia jego odporności na działanie grzybów (zwłaszcza *Basidiomycetes*). Celem badań było określenie wpływu termomodyfikacji, termo - olejowej modyfikacji lub impregnacji olejem lnianym lub rzepakowym drewna topoli (*Populus nigra*) i olszy (*Alnus glutinosa*) na ich odporność wobec grzybów powodujących pleśnienie drewna (badanie wobec mieszaniny grzybów i osobno *Chaetomium globosum*). Modyfikację i impregnację drewna wykonywano w warunkach półtechnicznych. Grzyby pleśniowe częściej, silniej, łatwiej i w większym rozmiarze porastały powierzchnię próbek drewna topoli i olchy modyfikowanego termicznie lub termo-olejowo, niż drewna tylko impregnowanego olejami (zwłaszcza mieszanina grzybów rosnąca na drewnie topoli). Wzrost grzybów na drewnie poddanym obróbce był zbliżony do wzrostu na drewnie kontrolnym. Drewno modyfikowane termicznie, termo-olejowo lub impregnowane olejami było nadal podatne na porośnięcie przez grzyby pleśniowe. W sensie wymogów budowlanych nie może być ono sklasyfikowane jako odporne na grzyby pleśniowe.

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