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Resistance of furfurylated wood on infection by *A. niger*

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Abstract: *Resistance of furfurylated wood on infection by A. niger.* The aim of this study was to determine the resistance of wood modified with furfuryl alcohol (FA) on infection by the fungus *A. niger*. Micological tests carried out after 3, 6, 8, 15, 22, 29, 36, 43 days. The bioresistance examination method of modified wood was used the criterion of visual macroscopic biodegradation. On basis of the results was found that concentration of FA mixture has an influence at products resistance to fungus activity *A. niger*. Wood modified with FA mixture of the highest concentration was characterized by the highest resistance to test micro-fungus activity. Resistance of modified wood with FA also depend on maleic anhydride. The highest resistance to activity of test fungus was demonstrate by wood samples modified with 15% FA with maleic anhydride.

Keywords: decay resistance, furfuryl alcohol, wood modification

INTRODUCTION

The first process for "furfurylation" of wood (wood modification with furfuryl alcohol) were developed several decades ago. Furfuryl alcohol is a renewable chemicals since it is derived from furfural, produced from hydrolysed biomass waste. Over the last decade modernized processes for furfurylation of wood have been developed. The new processes are based on completely new catalytic systems and process additives (Schneider 1995; Westin 1995). The properties of furfurylated wood depends on the retention of grafted/polymerized furfuryl alcohol in the wood (Lande et al. 2004).

Our research group has become interested with the process of wood furfurylation, because it allows to obtain wood with very good physico-mechanical properties and with high resistance to biotic factors (Lande et al. 2004; Lande et al. 2008; Esteves et. al. 2011). The products of modification also have aesthetic appearance. The golden-brown colour is durable and resembles teak wood. The products of modification with furfuryl alcohol are also resistant to the effects of atmospheric factors. Also, the ecological aspect of wood furfurylation should be emphasized. No solvents, heavy metals or other compounds that negatively affect the natural environment, are present in this process (Doczekalska et al. 2012; Bartkowiak et al. 2013).

The aim of this study was to determine the resistance of wood modified with furfuryl alcohol (FA) on infection by the fungus A. niger. The bioresistance examination method of modified wood was used the criterion of visual macroscopic biodegradation.

MATERIAL AND METHODS:

Wood: Ash wood - dimensions 10 x 50 x 124 mm - air conditioned at a temperature of 18˚C ± 1˚C and humidity 50% ± 2%.

Wood modification with furfuryl alcohol

The process of modification of wood with furfuryl alcohol consisted of two main stages: impregnation and curing. The modification mixture were consist of the following components: aqueous solution of furfuryl alcohol (FA) with concentration of 10, 15 and 20% w/w of furfuryl alcohol or aqueous solution of furfuryl alcohol (FA) at concentrations of 10, 15 or 20% with the addition of maleic anhydride in an amount of 4%.

Impregnation: Impregnation of wood was carried out under reduced pressure (7 bar). The vacuum was maintained for 45 min. and then raised to atmospheric pressure and were maintained for a further 2 hours.
Curing: In the second step, the samples were cured for 3 hours at 70˚C. Then wrapped them in aluminum foil. Curing of samples was performed at 105˚C for 12 hours.

Samples of modifies wood (30 x 50 x 10 mm) were placed in sterile conditions on the earlier prepared and sterilized Petri dishes filled with the agar substrate and infected with the aid of the aqueous solution of spores of test fungus (*A. niger*). The Petri dishes were placed in a thermostat maintaining constant temperature of 28ºC and air humidity of 95%. The study lasted 41 days. Readings of the degree of colonisation of the samples according to a 5-point scale (table 1) were performed regularly on day: 3, 6, 8, 15, 22, 29, 36 and 43 of the experiment.

Table 1. Scale used for the evaluation of the sensitivity of experimental samples to fungal infestation

Index	Degree of sample colonisation
3	No sign of mycelium growth on sample, there is a zone of inhibition on the medium between the sample and mycelium
2	No sign of mycelium growth on sample, there is no zone of inhibition on the medium between the sample and mycelium
1	Less than 1/3 of the sample surface colonised by the test fungus mycelium
0	More than 1/3 of the sample surface colonised by the test fungus mycelium
-1	Surface of the examined sample colonised more intensively than the surface of the control sample

RESULTS AND DISCUSSION:

The average results of the assessment of the degree of fouling by *A. niger* ash wood samples modified with FA are shown in Table 2.

Table 2. The average results of the assessment of the degree of fouling by *A. niger* ash wood samples modified with FA *

days / sample	3	6	8	15	22	29	36	43
control	2	2	2	1	1	0	0	0
10% FA	2	2	2	0	0	0	0	0
15% FA	2	2	2	1	0	0	0	0
20% FA	2	2	2	2	1	1	1	1
10% FA + MA	2	2	2	1	1	0	0	0
15% FA +MA	2	2	2	1	1	1	1	1
20% FA + MA	2	2	2	2	1	0	0	0

* the average of four measurements
FA – furfuryl alcohol MA – maleic anhydride

During the research it was found that the mycelium of *A. niger* grown over control samples after two weeks of the test. Less resistant to attack by the mycelium as compared to

control samples it was found for the modified ash, 10% FA. After 15 days from the date of commencement of studies found growth index 0. In most cases, fouling the surface followed gradually exception was the modification of 10% FA. The greatest resistance to the attack of *A. niger* was observed for modified wood with 20% FA and modified with 15% FA with maleic anhydride .

CONCLUSIONS

On basis of the results was found that concentration of FA mixture has an influence at products resistance to fungus activity *A. niger*. Wood modified with FA mixture of the highest concentration was characterized by the highest resistance to test micro-fungus activity. Resistance of modified wood with FA also depend on presence of maleic anhydride. The highest resistance to activity of test fungus was demonstrate by wood samples modified with 15% FA with maleic anhydride.

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Streszczenie: *Odporność drewna modyfikowanego alkoholem furfurylowym na infekcję A. niger*. Celem niniejszej pracy było określenie odporności drewna modyfikowanego alkoholem furfurylowym (FA) na infekcje grzyba *A. niger*. Badania poległy na zainfekowaniu drewna mikrogrzybem testowym, a następnie obserwacji stopnia porastania próbek. Odczyty prowadzono w określonych odstępach czasowych tj. po 3, 6, 8, 15, 22, 29, 36 i 43 dniach badań. Na podstawie przeprowadzonych badań stwierdzono, że stężenie roztworu FA wpływa na odporność produktów modyfikacji na działanie grzyba *A. niger*. Drewno modyfikowane roztworem alkoholu furfurylowego o najwyższym stężeniu tj. 20% odznaczyło się największą odpornością na działanie grzyba testowego. Na odporność drewna modyfikowanego FA miał także wpływ dodatek bezwodnika maleinowego. Największą odporność na działanie grzyba testowego wykazały próbki drewna modyfikowane mieszaniną 15% roztworu FA z bezwodnikiem maleinowym.

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