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The resistance of Scots pine wood protected with ammonium ionic liquids to attack by mould fungi

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Abstract: *The resistance of Scots pine wood protected with ammonium ionic liquids to attack by mould fungi.* In this paper the protective action of ionic liquids with environmentally friendly bio-cations, obtained from natural plant oils, and nitrate(III) anion against mould fungi was determined. The experiments were carried out using a mixture of pure cultures of moulds or a culture of fungus *Chaetomium globosum* Kunze. The results of the study fail to show the inhibition of mould coverage on the surface of Scots pine sapwood protected with ammonium ionic liquids.

Keywords: ionic liquids, biocidal activity, mould fungi, inhibition

INTRODUCTION

Ionic liquids are a group of organic compounds, built of synthetically obtained organic cation, as well as of natural resources of plant or animals origin. The anion is most frequently inorganic. Lately, ionic liquids structures with an organic anion were also developed [Pernak et al. 2006, Walkiewicz and Pernak 2006, Stasiewicz et al. 2008]. Recently, Owing to the synthesis of modified structures and the discovery of their new properties, the ionic liquids are use for multiple purposes [Lee 2006]. After launching the production of cheap ionic liquids in the form of didecydimethylammonium, nitrate(V) and benzalkonium nitrate in Poland, with high efficiency towards a wide spectrum of microorganisms and low toxicity for animals [Pernak et al. 2006], the research work was directed towards obtained compounds from natural substrates, from vegetable or animal oils easily biodegradable in environment [Zabielska-Matejuk and Pernak 2009]. The developed ionic liquids were characterized of the effectiveness action against three species of fungi decaying softwood and a species causing blue stain of softwood.

The presented study determined the effect of the structure of ammonium ionic liquids with environmentally friendly bio-cation, obtained from natural plant oils, on the biological activity. The aim of the investigations was to the determine the influence of nitrate(V) anion exchange [into nitrate(III)] on the resistance of Scots pine wood protected by these compounds to attack by mould fungi. The object of the performed experiments included ionic liquids developed in cooperation with the Institute of Chemical Technology and Engineering of the Poznań University of Technology.

RESEARCH METHODS

The resistance to mould fungi was tested using a method based on the instruction of the Building Research Institute Instruction No 355/98 [1998]. The test specimens of Scots pine sapwood *Pinus sylvestris* L. were of the dimensions of 40x40x4mm. Before the exposure to fungi, the wood samples were conditioned in KBF 720 chamber at 20^{o}C and 65% relative humidity , until the moisture content of. 12±1% was obtained. Next, on the surface of wood were applied 15, 25 i 50 g/m2 of investigated ammonium nitrate(III) were applied, presented in table 1. After seasoning, samples were exposed for 4 weeks to the action of a mixture of pure cultures of the following fungi: *Aspergillus niger* v. Tieghem,

Penicillum funiculosum Thom, *Pecilomyces varioti* Bainer, *Trichoderma viride* Persoon ex Fries, *Alternaria tenuis* Link ex Fries (mixture) or to the action of a pure culture of fungus *Chaetomium globosum* Kunze. The growth of mycelium on the surface samples was measured after 4 weeks of incubation, at the temperature 27±1^{o}C and 90% relativity humidity, using the following scale:

0- no growth of fungi on the sample, visible under the microscope,
1- trace growth of fungi on a sample, hardly visible with the naked eye but well visible under the microscope or growth limited to the edge of a sample, visible with the naked eye,
2- growth of the fungi on a sample , visible with the naked eye, but less than 15% of the surface is covered with fungus,
3- over 15% of the surface is covered with fungi visible with the naked eye.

The results of activity study of ammonium nitrate(III) were compared with action of ammonium nitrate(V) against mould fungi.

Table 1. The investigated ionic liquids

Ionic liquids	Active substance content [%]	Solvent	Description
[DDA] [NO_2]	99	isopropanol/ water	didecyldimethylammonium nitrate(III)
[Arq1230][NO_2]	72	water	dodecyltrimethyloammonium nitrate(III)
[Arq C35] NO_2]	95	water	nitrate(III) with cation obtained from coconut oil
[Eth C/12][NO_2]	98	isopropanol/ water	nitrate(III) with cation obtained from natural plant products (etoxylates of coconut oil)

RESULTS AND DISCUSSION

Table 2 presents the results of fungicidal activity of ammonium nitrates(III) against a mixture of moulds. The average degree of mould coverage on the surface of protected wood with ammonium nitrates(III), to the amount of 15 g/m^2, were from 0,2 to 0,5. In the case of application of those compounds in the amount of 25-50 g/m^2 all-out inhibition of the growth of moulds mixture on the wood surface was shown.

Table 2. The growth of moulds fungi mixture on the surface of Scots pine sapwood, protected with ionic liquids

Ionic liquids	Amount of ionic liquids applied on the surface of wood		
	15 [g/m^2]	25 [g/m^2]	50 [g/m^2]
	Average degree of mould coverage		
[DDA] [NO_2]	0,3	0,0	0,0
[Arq1230][NO_2]	0,5	0,2	0,2

[Arq C35][NO_2]	0,5	0,0	0,0
[Eth C/12][NO_2]	0,2	0,0	0,0

The results of wood resistance protected whole being with ionic liquids against *Chaetomium globosum,* were presented in Table 3. Also the application of ammonium nitrate(III) in the amount of 15 g/m2 , caused an insignificant growth of fungi on the surface of Scots pine wood.

Table 3. The growth of *Chaetomium globosum* on the surface of Scots pine sapwood, protected with ionic liquids

Ionic liquids	Amount of ionic liquids applied on the surface of wood		
	15 [g/m^2]	25 [g/m^2]	50 [g/m^2]
	Average degree of mould coverage		
[DDA] [NO_2]	0,7	0,5	0,2
[Arq1230][NO_2]	0,5	0,2	0,2
[Arq C35][NO_2]	0,7	0,3	0,3
[Eth C/12][NO_2]	0,7	0,3	0,2

The comparison of biotic activity of ionic liquids with cation of natural origin, obtained from plant oils of diverse anion structure was show in Fig. 1-2. It was stated that the antifungal properties of new ammonium nitrate with environmentally friendly bio-cation, depend upon the anion structure. Ionic liquids with nitrate(III) anion better protect the Scots pine wood surface against moulds action (attacking), than those with nitrate (V) anion.

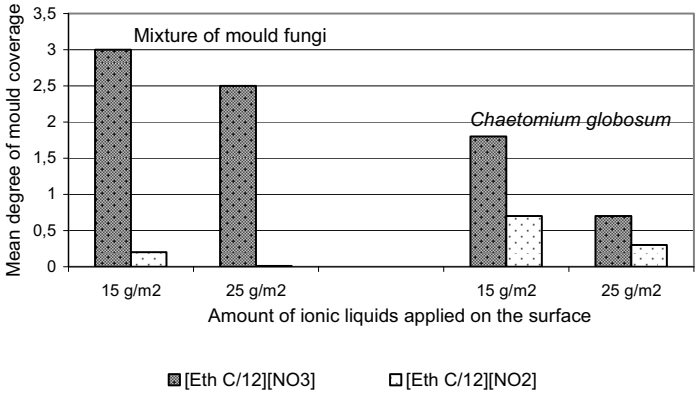

Fig.1. Comparison of average degree of mould coverage by tested fungi on the surface of wood protected with [Eth C/12] nitrate(III) and nitrate(V)

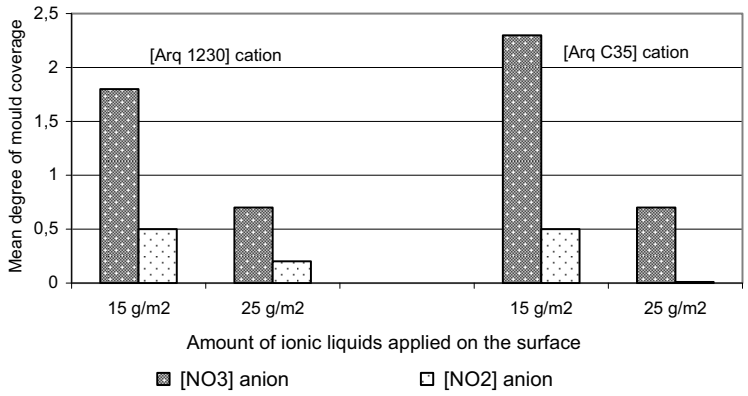

Fig.2. Comparison of average degree of mixture of mould coverage on the surface of wood protected with ammonium nitrates(III) and nitrates(V)

CONCLUSIONS

The protective effectiveness of ammonium nitrates against the tested moulds fungi depends on the anion structure of ionic liquids. It was comparable with the efficacy of copper-chromium-boron preparations. The compounds with nitrates(III) anion were characterised by strong fungitoxic properties, stronger than ammonium nitrates(V). The tested compounds inhibited the growth of moulds fungi on the Scots pine sapwood surface The additional advantage of these compounds from the point of view of environmental protection requirements was their biodegradability.

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