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INVESTIGATIONS ON THE RESISTANCE OF MODIFIED WOOD TO BIOLOGICAL ATTACK

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The resistance of Scots pine wood (*Pinus silvestris* L.) impregnated with polystyrene to attack white, brown and soft rot fungi, by insects (*Hylotrupes bajulus* L.) and by marine organisms was investigated in laboratory and in field test.

The tests showed that the impregnation of wood with polystyrene increases its resistance to biological attack, chiefly to white rot fungi. The resistance against "soft rot" fungi and marine bores is lower.

INTRODUCTION

In the sixties wood-polymer combinations were developed based on impregnation of wood by vinyl monomers, which polymerized in the wood so that a polymer is obtained which is integrated inside the wood structure. Many tests were carried out on the physical and mechanical properties of polystyrene modified wood [5]. It has been shown that the treatment with vinyl benzene improves wood mechanical properties, such as static bending strength and perpendicular-to-grain compression, decreases its hygroscopicity and increases its dimensional stability [3]. Some laboratory and field tests have also shown that this material is resistant against biological deteriorating agents (fungi and insects) [2, 4, 6].

For these promising results we tought it interesting to test polystyrene modified wood in our environment for a possible utilization of this material out-of-doors. Preliminary tests were started to study the resistance of modified wood against attack by white, brown and soft rot fungi, by insects and by marine borers. The tests were performed in laboratory, test fields and marine stations.

MATERIAL AND METHODS

TREATMENT

Samples of Scots pine sapwood (*Pinus silvestris* L.) were treated with styrene monomer by the full-cell process. The termal catalytical polymerisation was carried out according to the patent technology (Patent N° PRL-81 908). The degree of impregnation with the polystyrene was about 85%. The wood samples were impregnated by Firm "STELLA S.p.A.", Cuneo, Italy.

BIOLOGICAL TESTS

RESISTANCE AGAINST FUNGI

Laboratory tests. The resistance of polystyrene impregnated wood against *Basidiomycetes* was determined according to European Standard Methods namely: EN 113 "Wood preservatives. Determination of toxic values of wood preservatives against wood destroying basidiomycetes cultured on an agar medium", EN 84 "Wood preservatives. Accelerated ageing of treated wood prior to biological testing. Leaching procedure" and EN 73 "Wood preservatives. Accelerated ageing tests of treated wood prior to biological testing. Evaporative ageing procedure" using a white rot

Table 1

Resistance of polystyrene modified wood against fungi
Odporność na działanie grzybów drewna zmodyfikowanego polistyrenem

Fungus species Gatunek grzyba	Average weight loss (%) Średni ubytek masy (%)			
	without ageing bez wymywania	after leaching po wymywaniu	after evaporation po odparowaniu	controls próbki kontrolne
Gloeophyllum trabeum (Pers. ex Fries) Murill	5.2	5.6	4.9	42.4
Coriolus versicolor (L.) Quélet	1.1	2.3	1.5	26.4
Soft rot fungi (test a) Grzyby rozkładu szarego (test a)	9.0	–	–	19.7
Soft rot fungi (test b) Grzyby rozkładu szarego (test b)	12.1	–	–	22.8

fungus *Coriolus versicolor* (L.) Quélet and brown rot fungus *Gloeophyllum trabeum* (Pers. ex Fries) Murill.

The fungicidal effectiveness against soft rot fungi was determined using unstandarised methods:

a) placing the samples in vessels containing 300 g of unsterilized garden soil. In preliminary tests it had been ascertained that the medium caused soft rot; the fungi

we isolated from such soil belonged chiefly to *Chaetomium, Phialophora* and *Humicola* species;

b) placing the samples in vessels containing 300 g of sterilized garden soil plus *Chaetomium globosum* Kunze.

The vessels were kept at a constant temperature of 30° ± 1°C and 75 ± 5% relative humidity for 16 weeks.

The results are presented in table 1.

These results show that the styrene treatment increases the resistance of wood against *Basidiomycetes*, in fact the weight loss caused by *Coriolus versicolor* (L.) Quélet is about 1% and the weight loss caused by *Gloeophyllum trabeum* (Pers ex Fries) Murill is about 5% which is a bit higher than the accepted weight loss of 3% in toxicity test (EN 113).

These preliminary data show that polystyrene modified wood becomes more resistant against decay fungi than against soft rot fungi.

Field tests. Treated stakes, 2.5 × 2.5 × 50 cm, were buried to approximately half their length in a testing field in Florence.

The stakes were inspected twice a year. The inspection starts with a light push on the stake when still in the ground, to find out whether its strength has been so

Table 2

Condition of stakes in field test

Stan próbek podczas badań poligonowych

Sample number Numer próbki	Time of inspection (months) – Czas obserwacji (miesiące)				
	6	12	18	24	30
	degree of attack – stopień zaatakowania				
1 - 10	0	0	0	0	0
Controls* Próbki kontrolne	1	1,8	2,6	4	–

* Mean of 5 stakes
Wartości średnie dla 5 próbek

reduced that it breaks. If this is not the case, the stake is cautiously drawn out from the ground and its condition is estimated according to the following grading system:

0 – no decay,
1 – slight and superficial decay,
2 – evident but moderate decay,
3 – severe decay,
4 – failure.

The results are presented in table 2.

After a period of 30 months, all treated stakes did not show any decay attack, while all control stakes have had to be removed after 24 months due severe damages (caused) mostly by the action of brown fungi.

RESISTANCE AGAINST INSECTS

The resistance of polystyrene modified wood against insects was determined according to EN 46 "Wood preservatives. Determination of the preservative action against recently hatched larvae of *Hylotrupes bajulus* L." and EN 47 "Wood preservatives. Determination of the toxic values against *Hylotrupes bajulus* L. larvae"

Table 3

Resistance of polystyrene modified wood against *Hylotrupes bajulus* L. according EN 47

Odporność na żerowanie larw spuszczela (*Hylotrupes bajulus* L.) w drewnie zmodyfikowanym polistyrenem (wg EN 47)

Sample number Numer	Larvae in category 1 – Larwy grupy 1			Larvae in category 2 – Larwy grupy 2		
	dead – martwe		live żywe	dead – martwe		live żywe
	not having tunnelled nie wydrążyły chodników	having tunnelled wydrążyły chodniki		not having tunnelled nie wydrążyły chodników	having tunnelled wydrążyły chodniki	
	number of larvae – liczebność larw					
Treated Impregnowane						
1	6	0	0	0	0	1
2	6	0	0	1	0	0
3	6	0	0	0	0	1
4	6	0	0	0	0	1
5	6	0	0	1	0	0
Control Kontrolne						
1	0	0	6	0	0	1
2	0	0	5	0	0	1
3	1	0	5	0	0	1
4	0	1	5	0	0	1
5	2	0	4	0	0	1

Table 4

Resistance of polystyrene modified wood against *Hylotrupes bajulus* L. according to EN 46

Odporność na żerowanie larw spuszczela (*Hylotrupes bajulus* L.) w drewnie zmodyfikowanym polistyrenem (wg EN 46)

Sample number Numer próbki	Larvae dead Larwy martwe		Larvae live Larwy żywe
	not having tunnelled nie wydrążyły chodników	having tunnelled wydrążyły chodniki	
	number of larvae – liczebność larw		
Treated Impregnowane			
1	10	0	0
2	10	0	0
3	10	0	0
4	10	0	0
5	10	0	0
6	10	0	0
Control Kontrolne			
1	1	1	8
2	1	0	9
3	0	0	10

The results are presented in tables 3 and 4.

The tests show that recently hatched larvae of *Hylotrupes bajulus* L. were not able to penetrate into the wood, while larvae of medium size survived and began to tunnel, in conclusion the impregnation of wood with polystyrene reduces the possibility of infestation and increases the resistance to larvae attack, but the wood is not completely protected.

RESISTANCE AGAINST MARINE BORERS

Treated samples 2.5 × 10 × 20 cm were submerged in the sea at Follonica, Italy. Untreated pine samples were submerged as controls.

Follonica, latitude 42°55′ North and longitude 10°45′ East, is situated on the Tyrrhenian coast. The recorded temperature varies from 13°C to 25°C, salinity 37 - 38‰ and pH about 8.

The borer observed were: *Nototeredo norvagica* Splenger, *Bankia carinata* Gray, *Limnoria tripunctata* Menzies and *Chelura terebrans* Philippi. Inspections were made every 6 months, taking the samples and scraping off the fouling organisms. The

Table 5

Degree of attack of polystyrene modified wood during 30 months of immersion in sea water
Stopień zaatakowania przez szkodniki drewna zmodyfikowanego polistyrenem, w czasie 30 miesięcy w wodzie morskiej

Sample number Numer próbki	*Teredines* Świdrakowate					*Crustacean* borers Skorupiaki				
	time of inspection (months) czas obserwacji (miesiące)					time of inspection (months) czas obserwacji (miesiące)				
	6	12	18	24	30	6	12	18	24	30
	degree of attack stopień zaatakowania					degree of attack stopień zaatakowania				
1	0	0	2	3	3	0	0	2	2	3
2	0	0	1	1	1	0	0	1	2	2
3	0	0	1	2	2	0	0	1	1	1
4	0	0	2	2	3	0	0	1	1	1
5	0	0	1	1	2	0	0	1	2	3
6	0	0	0	0	1	0	0	0	1	1
7	0	0	2	3	3	0	0	1	1	1
8	0	0	0	1	1	0	0	1	1	2
9	0	0	1	1	2	0	0	2	2	2
10	0	0	1	2	2	0	0	2	2	3

evaluation of the borer attack was made by visual estimation and by X-ray analysis. The grading categories of borer attack were:

0 – no detectable attack,
1 – slight attack,
2 – moderate attack,
3 – severe attack,
4 – destroyed and removed.

The results are presented in table 5.

All the untreated samples were destroyed by both *Teredines* and *Crustacean* borers after 6 months of submergence. The samples treated with polystyrene showed attacks by *Teredines* and by *Crustacean* borers. The treatment with polystyrene, even if increases wood resistance, is not enough effective to avoid the marine borer attack.

CONCLUSIONS

These preliminary trials reveal that the treatment of wood with polystyrene show a considerable promise as non toxic means of reducing damage caused by fungi and insects, chiefly by fungi.

This method does not assure the protection of wood in sea water.

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BADANIA NAD ODPORNOŚCIĄ BIOLOGICZNĄ DREWNA ZMODYFIKOWANEGO

Streszczenie

Biel sosny (*Pinus silvestris* L.) ulepszony polistyrenem, poddano badaniom odporności na działanie grzybów powodujących brunatny, jasny i szary rozkład drewna, na żerowanie larw spuszczela (*Hylotrupes bajulus* L.) oraz na działanie organizmów niszczących drewno zanurzone w wodzie morskiej. W wyniku badań stwierdzono dużą odporność badanego materiału na działanie grzybów, szczególnie rozkładu białego. Mniejszy wzrost odporności zauważono wobec grzybów rozkładu szarego. Larwy *Hylotrupes bajulus* L. niszczyły drewno ulepszone polistyrenem w znacznie mniejszym stopniu niż naturalne drewno sosny. Polistyren nie zwiększa odporności drewna na żerowanie szkodników występujących w wodzie morskiej.

ИССЛЕДОВАНИЯ В ОБЛАСТИ БИОЛОГИЧЕСКОЙ УСТОЙЧИВОСТИ МОДИФИЦИРОВАННОЙ ДРЕВЕСИНЫ

Резюме

Проведены испытания модифицированной полистиролом заболони сосны (*Pinus silvestris* L.) на устойчивость к действию грибов, вызывающих деструкционную, коррозионную и серую гниль древесины, личинок домового усача (*Hylotrupes bajulus* L.), а также к действию организмов, разрушающих погруженную в морскую воду древесину. В результате испытаний отмечена высокая устойчивость испытуемого материала к действию грибов, особенно вызывающих коррозионную гниль, меньшее повышение устойчивости отмечено в случае грибов, вызывающих серую гниль. Личинки домового усача разрушали модифицированную полистиролом древесину в значительно меньшей степени, чем естественную сосновую древесину. Полистирол не повышает устойчивости древесины к действию вредителей, обитающих в морской воде.

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