POLYSTYRENE POLAND WOODS RESISTANCE TO BIO-DETERIORATION

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Submitted to
The Tanabe South East Asia Nations Friendship Foundation
Matsue City, Japan

FOREST PRODUCTS TECHNOLOGY DEPARTMENT
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FORWARD

The experiment was successfully done, and it was an international joint research. The polystyrene Poland wood was done in Poznan Poland by Prof. M. Lawniczak before he passed away, and we did the research for bio-deterioration test in Faculty of Forestry Bogor Agricultural University, in Bogor, Indonesia. The test was done for *Cryptotermes cynocephalus* dry wood termite, *Macrotermes gilvus* subterranean termite, and *Schizophyllum commune* fungi.

For the bio-deterioration test purpose, the researchers got sponsorship from The Tanabe South East Asia Nations Friendship Foundation, Matsue City, Japan. We are highly appreciate to the foundation for the sponsorship.

We hope this research will be useful for science and technology development, and the technique can be applied to preserve wood with environment friendly.

Bogor, December 1997

Team Leader,

Prof. Yusuf Sudo Hadi

Chemical modification of wood originally involved any chemical reaction between the hydroxyl groups of principal wood components and a single chemical reagent. In recent years, chemical modification has also included several chemical systems that affect the cell wall and fill the void spaces in wood. Some of these modifications of wood that have been studied to improve hygroscopic, mechanical, viscoelastic, and fire-retardant properties are interesting for wood preservation techniques too. The effectiveness of chemical modification in enhancing biological resistance has been assumed to be mostly due to crosslinking, bulking, or a combination of both for dimensional stabilization. Hydroxyl groups in the cell wall polymers are not only the water adsorption sites but also biological enzymatic reaction sites (2).

Polystyrene wood with thermal polymerization process has been verified in the industrial scale in Poland (3). Properties of palm wood from inside zones are characterized by the low quality could be valorized above properties of wood from external zone characterized by high density and good quality with polystyrene impregnation (4). The polystyrene content affected the wood properties, a higher polystyrene content in wood gave higher dimensional stability, modulus of rupture, and hardness (5). Liese (6) stated that impregnation of monomer styrene to bamboo and rattan for the production of polystyrene composites improved technical properties and biological resistance, and Hadi *et al.* (7) mentioned that polystyrene bamboo with weight gain of 11 % had more resistant to dry wood termite, powder post beetle, and fungal attacks than the control bamboo.

The purpose of this experiment was to find out the resistance of four Poland woods to bio-deterioration, in this work the control was compared to polystyrened woods. The woods were tested to *Cryptotermes cynocephalus* dry wood termite, *Macrotermes gilvus* subterranean termite, and *Schizophyllum commune* fungi.

METHODS

Preparation of Wood

The sample woods for the tests were obtained from Poland, the wood species were *Alnus glutinosa* Gartn, *Populus maximowiczii* x trichocarpa, *Salix alba* Krobielewko, and *Pinus silvestris* L. The sample dimension was 2.5 cm by 3.5 cm by 30 cm, and it were prepared into twin samples which were assigned for impregnation treatment and control with four replication respectively.

Polymerization of Styrene

The sample woods were put into heating apparatus and then it were impregnated by styrene monomer using N-metylolmetacrilamide as initiating agent with quantity of 0.5 weight part to styrene mass respectively. The polymerization process based on thermal treatment by using water with addition of salt to increase boiling temperature. The processing time at temperature of 90-110 oC was one hour, and the continued process at temperature of 110-120 oC was two hours. The polymerization level was indicated by weight percent gain (WPG) based on the oven dried weight of wood.

Bio-deterioration Tests

Dry wood termite test

Wood samples sized 2.5 cm by 3.5 cm by 5 cm were put in glass boxes. Fifty healthy and active nymphae of the dry wood termite (*Cryptotermes cynocephalus* Light) were put into each box. The boxes were put in a dark room at average temperature of 20-32 oC and 80-90 % relative humidity for one month. During the test period every died termite was taken out to prevent canibalistic phenomena, and at the end of the test nymphae mortality and weight loss of wood were determined. The weight loss was determined using the following formula:

$$WL = \frac{Wp - Wa}{Wp}$$

Where,

WL = weight loss percentage
Wp = oven dried wood weight prior to the test
Wa = oven dried wood weight after the test

For comparison, the boxes containing dry wood termite only and containing dry wood with tissue paper were also observed to know how much the mortality level.

Subterranean termite test

Wood samples sized 2.5 cm by 3.5 cm by 20 cm were vertically buried with 15 cm of the wood in the ground for three months. At the end of the test, the protection level and weight loss percentage of the samples were determined. The weight loss percentage determination of the wood used the formula previously described. The protection level of polystyrene wood to bio-deterioration was observed using the rating system as shown in Table 1.

Table 1. Rating system for protection level (8)

Wood condition	Rate
Sound	100
Light attack	90
Moderate attack penetration	70
Heavy attack	40
Failure	0

Fungal test

Schizophyllum commune fungi was inoculated in the glass boxes using malt extract agar media until it grew adequately. Wood samples sized 2.5 cm by 2.5 cm by 3.5 cm were put in the glass boxes of fungal culture. The condition of inoculation at temperature of 20-32 oC and 80-90 % relative humidity. After six weeks of inoculation, the moisture content and weight loss of wood were.

RESULTS AND DISCUSSIONS

After polymerization process, the average weight gain of the Poland woods could be described as follows, *Alnus glutinosa* got 106 %, *Populus maximowiczii* got 135 %, *Salix alba* got 123 %, and *Pinus silvestris* got 88 %.

Regarding to bio-deterioration test, the comparisons between control and polystyrened Poland woods resistance to dry wood termite, subterranean termite, and fungal attacks were shown in Table 2. From the table it could be mentioned that polystyrene Poland woods had much better resistant to termites and fungal attacks, but wood species did not affect resistance to bio-deterioration, on the other words the four wood species had the similar wood durability class.

Dry Wood Termite Test

After one month test period, termite mortality reached 98 % for termite population without any feed, so the test for one month was adequate period. For termite population with tissue paper available in the box test, the termite mortality got 17 % and the average termite mortality with wood available got 26 %, and if polystyrene wood available the average termite mortality was 55 %, it means the highest value.

Polystyrene Poland wood had more resistance to dry wood termite which was indicated by termite mortality, weight loss, and protection level of polystyrene wood were 72 % higher, 95 % less, and 58 % higher than control wood respectively regarding to data based on the control wood. Furthermore, it could be mentioned that polystyrene wood were mostly not attacked by dry wood termite which was indicated by weight loss and protection level were 0.1 % and 98 % respectively.

Table 2. Results from dry wood termite, subterranean termite and fungal tests of Poland woods

Subject	*Salix* sp	*Alnus* sp	*Populus* sp	*Pinus* sp
DRYWOOD TERMITE TEST				
Mortality (%)				
Control	26.3	26.3	25.5	25.8
Polystyrene	43.8	46.5	45.3	44.0
Weight loss (%)				
Control	2.87	2.60	3.50	2.00
Polystyrene	0.08	0.05	0.08	0.17
Protection level (%)				
Control	62.5	62.5	55.0	70.0
Polystyrene	95.0	100	100	100
SUBTERRANEAN TERMITE TEST				
THREE MONTHS TEST				
Weight loss (%)				
Control	43.4	49.0	55.4	50.6
Polystyrene	5.67	4.07	2.07	4.47
Protection level (%)				
Control	40.0	37.5	40.0	20.0
Polystyrene	90.0	95.0	92.5	100
SIX MONTHS TEST				
Weight loss (%)				
Control	100	100	100	100
Polystyrene	14.7	15.2	12.2	8.3
Protection level (%)				
Control	0	0	0	0
Polystyrene	80.0	90.0	82.5	90.0
FUNGAL TEST				
Moisture content (%)				
Control	67.7	59.2	51.2	53.4
Polystyrene	39.6	37.2	44.2	24.7
Weight loss (%)				
Control	3.26	3.00	3.24	2.38
Polystyrene	2.98	2.73	3.14	2.31

Subterranean Termite Test

Polystyrene wood had much more resistance to subterranean termite attack than the control wood which was indicated from three months field test, the weight loss of polystyrene wood was 4 % comparing to control wood which having weight loss of 50 %. In the continuing field test for six months, the control woods were failure or all of the control woods were disappeared, but the polystyrene wood got weight loss of 13 %. From these data it could be mentioned that polystyrene wood had more resistance to subterranean termite especially for the longer test time.

Furthermore, the protection level of the woods had the same tend to weight loss results. After three months field test, the protection level of polystyrene wood got rate of 94 comparing to the control wood got 34 only, and after six months field test, the protection level of polystyrene wood got rate of 85 but the control wood had been failure.

Fungal Test

Moisture content of control wood was 57 %, and it was higher than the polystyrene wood which reached 36 % only. This case indicated that control wood was more susceptible to attacked by *Schizophyllum commune* fungi. But in the weight loss observation, the control wood was not so much different from polystyrene wood, this case was happened for six weeks test, it is hoped that the longer time test will give more different data between the two woods test.

CONCLUSIONS

From discussions above, it could be concluded that :

1. The average weight gain of *Alnus glutinosa, Populus maximowiczii, Salix alba,* and *Pinus silvestris* were 106 %, 135 %, 123 %, and 88 % respectively.
2. The four Poland wood species had the similar resistance to bio-deterioration.
3. Polystyrene wood had more resistance to dry wood termite, subterranean termite, and fungal attacks.
4. For the longer test time, the polystyrene wood had much more resistance to bio-deterioration.

From this experiment, it could be suggested that the testing period could be longer to find out how long the polystyrene wood could be resistant to bio-deterioration. To minimized the polymerization cost, the weight percent gain level must be determined efficiently.

REFERENCES

1. Rowell, R.M., B.A. Cleary, J.S. Rowell, C. Clemons, and R.A. Young. 1993. Results of chemical modification of lignocellulosic fibers for use in composites. *In:* M.P. Wolcott (Editor). Wood-fiber/polymer composites: Fundamental concept, process, and material options. Forest Products Society, USA.

2. Takahashi, M. 1996. Biological properties of chemically modified wood. *In:* D. N.-S.Hon. Chemical modification of lignocellulosic materials. Marcel Dekker, Inc. New York.

3. Lawniczak, M. 1993. Method of production of the composite bamboo-polystyrene elaborated in Poland. Paper presented on International Bamboo Festival and National Bamboo Convention 1, Bandung, Indonesia, 25-28 November 1993.

4. Lawniczak, M. 1995. Effect of the density of *Cocos nucifera* L. wood on the quality of produced wood-polystyrene composite. Folia Forestalia Polonica, Seria B, Zeszyst 25, p. 29-41.

5. Lawniczak, M. 1994. Influence of Aspen wood density and stem position on selected properties of wood polymer composites. Holz als Roh- und Werkstoff 52: 19-27.

6. Liese, W. 1995. Biological aspects of bamboo and rattan for quality improvement by polymer impregnation. Folia Forestalia Polonica, Seria B, Zeszyst 25, p. 43-56.

7. Hadi, Y.S., I Wahyudi, F. Febrianto, E.N. Herliyana, and M. Utama. 1997. Efect of radiation doses and position in the culm on polystyrene betung bamboo properties. Paper presented at XI World Forestry Congress, Antalya, Turkey, 13-22 October 1997.

8. American Wood Preservers' Association. 1972. Standard method for laboratory evaluation to determine resistance to subterranean termites. AWPA, Woodstock, Md.