

**2nd Interim Report on “Modification and efficacy study of wood protector,
the eco friendly wood preservative for glue line treatment during
manufacture of plywood”**

Sponsored By



M/s wood cure enterprise

Ashram Math, South Naldanga, Bandel

Hoogly, West Bengal-712123



IPIRTI, KOLKOTA, India

(An autonomous body of Ministry of Environment and Forests)

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EVALUATION OF WOOD PROTECTOR AS WOOD PRESERVATIVES

Summary

The study objective was to evaluate the wood protector, an eco-friendly wood preservative using naturally available plant by-products, CSNL with ant-termites, anti-fungus and anti-borer material having less toxicity to human being but high toxic to wood destroying organism, as a suitability as wood preservative in plywood industries. 12mm Plywood samples at different concentration (0.5 to 5%) preservative were manufactured randomly by using wood protector as a glue line preservative with combination of different species. These samples have been evaluated to find out the effectiveness as wood preservatives against decay fungi and termites. From the results obtained in this study it can be concluded that 1.5% or more concentration of the preservative can be utilized in plywood manufacture which can resist against wood destroying organism. Concentrations below 1.5% of preservative make the samples prone to termite and borer attack. Therefore, 1.5% to 2.5% are the feasible concentrations to be used for plywood manufacture. The result of MoE, MoR test at 1.5% to 3% concentrations also show satisfactory limit of acceptance. However, high decay activity in Borås and Hannover has been indicated. Soft, white and brown rot have been found in different samples from graveyard test. The decay assessment after 12 months exposure did not allow any clear conclusions to be drawn yet. To evaluate fully the wood protector as wood preservative study is continuing for another 24 months to get clear conclusion.

Synthesis of UF resin:-

230-250 parts by weight of formalin (Formaldehyde content 37%) was charged into resin kettle and made alkaline with 50% sodium hydroxide solution to pH 7.5 -8.0. 100 parts by weight of urea was gradually added to the kettle and stirring started. Stirring continued till the end of the reaction. Temperature was raised by passing steam and then set at $92^{\circ}\pm 2^{\circ}\text{C}$ and kept at this temperature under agitation for $1\frac{1}{2}$ - 2 hours. pH is checked time to time and maintained appx. 7.5.

In the second stage, the pH of the solution was lowered to 5.5 – 6.0 by adding 50% solution of acetic acid and reaction was continued under agitation at the same temperature. The progress of the reaction was followed by measurement of viscosity and water tolerance. For ready result, instead of viscosity, flow time of the reaction mixture was measured in B₄ cup IS: 3944/1982. Water tolerance was a measure of the number of times of weight of water which can be mixed with resin before incipient precipitate is formed. The resin was ready have a flow time of 16-17 seconds in B₄ flow cup and water tolerance of 3-4 times. The reaction was arrested by raising pH to 7.5 – 8.0 by adding 50% alkali and then resin was cooled and conditioned for whole night prior to use.

Synthesis of Modified PF resin :-

Novolac resin: 100 parts by weight of phenol and 60 parts by weight of formalin (37% formaldehyde) were charged into resin kettle. Stirring started and continued till the end of reaction. 2 parts by weight of oxalic acid in 33 parts by weight of water was added in case of acid catalyzed novolac resin. The reaction was carried out at $90^{\circ}\pm 2^{\circ}\text{C}$ for two hours. At the end of first stage reaction white insoluble product is formed which separates from aqueous layer on keeping. The resin was then cooled to 60°C .

Resol resin: 16 parts by weight of sodium hydroxide dissolved in 66 parts of water was added in case of acid catalyzed novolac resin. 120 parts by weight of formalin (37% formaldehyde) was added next. Exothermicity was carefully controlled at this stage.

Reaction is further continued at 85°C. When viscosity flow time have a flow time of 16-17 seconds in B₄ flow cup of IS: 3944-1982, the resin was cooled and discharged from the kettle and conditioned for whole night prior to use.

The resin was characterized by checking the parameters like pH, flow time, solid content etc.

Properties of synthesized Urea-formaldehyde resin

Gel Time at 100°C (seconds)	Flow Time (B4 cup) (seconds)	Solid content (%)	Water tolerance	pH	PH of Cured film	Free formaldehyde (%)
67	20	47.5	1:3	8.0	2.62	0.88

Properties of synthesized Phenol formaldehyde resin

Gel Time (minutes)	Flow Time (B4 cup) (seconds)	Solid content (%)	Water tolerance	pH	Free phenol (%)
21	22	48	1:4	10.14	0.20

Adhesive mix:

The adhesive mix (glue) was formulated by taking the above both PF resin and UF resin with additive conventionally used in plywood industries and wood protector with different concentration from 0.5 to 5 %.

Plywood manufacturing:

12 mm plywood was manufactured by taking Gurjan as face and simul, gurjan as alternate as core veneer and above glue incorporated with wood protector varying from 0.5 to 5 % in concentration. 4 plywood samples of 600 x 600 x 12 mm for each concentration was manufactured, total 24 samples were manufactured.

Preparation of samples:

- a) The samples for efficacy test were prepared according to IS: 4833:1993 for termite resistance. Test samples or plywood with 12 mm thickness were prepared from defect

free air dried veneers of semul wood (Bombaxceiba). Samples were of size 100 x 25 x 12 mm and were prepared for field test.

- b) The samples for efficacy test for borer were prepared according to IS: 4873 (Part-II);2008 for borer resistance. Test samples or plywood were of size 100 x 40 x 12.5 mm were prepared from defect free air dried veneers of semul wood (Bombaxceiba).
- c) The samples for evaluation of moisture content, density, water resistance, bond quality (glue shear strength), adhesion of plies and mechanical properties (Modulus of rupture and modulus of elasticity) were prepared according to IS: 1734:1986. Sample sizes were 150 x 75 mm, 150 x 75 mm, 250 x 250 mm, 150 x 25 mm, 250 x 250 mm and 338 x 50 x 12 mm respectively.

Physico-mechanical testing

The plywood samples made with glue incorporated with different concentration of wood protector were tested as per IS 1734: 1986.

Efficacy evaluation:

- a) Field test of preservatives against termites:-

Testing was performed according to IS: 4833:1993. Six replicates for each concentration along with control was taken. The treated/untreated samples were tied together to form a chain and buried in the high termite prone area at six different places. Observations were made till one year of exposure with inspections done once in every three months. Specimens were re installed at the same position after every inspection. Recording of results were as per the ratings given in the standard.

- b) Evaluation against powder post beetles (borers):-

Testing was performed according to IS: 4873 (Part II): 2008. For initiation of culture beetles are obtained from naturally infested wood stored outside which was maintained in the laboratory. Untreated timber of semul/mango/rubber or dry tapiocca chips were kept along with infested samples for continuous multiplication of beetles. The test samples were stored singly in glass containers with cambric cover, to reduce risk of mite infestation. Test samples (plywood) with each concentration were exposed individually.

The condition during test was 25-30 °C and 70-75 % RH. Number of exit holes were recorded and reported.

© Graveyard test

The graveyard test was carried out according to EN 252 (1990). The stakes (25 mm x 50 mm x500 mm) were buried half to their length (Image- 1). The stakes were put in rows with a distance of approximately 300 mm and the different materials were installed alternately. All specimens were free of cracks, decay and other obvious defects.

Table 1-Efficacy test against termites after 12 months of exposure.

Preservative Concentration, %	Numerical ratings	Condition of samples
0.0	2.0	Moderate attack, termite attack area between 20 % to 30 % of surface area.
0.5	0.5	Trace attack, termite attack area less than 15 % to 20% of surface area.
1.0	0.5	Trace attack, termite attack area less than 5 % to 10% of surface area.
1.5	0	No attack, samples free from termite attack
2.0	0	No attack, samples free from termite attack
2.5	0	No attack, samples free from termite attack

Table 2: Efficacy test against borer after 12 months of exposure.

Preservative Concentration, %	Damage
0.0	Exit holes present
0.5	Exit holes present
1.0	Exit holes absent
1.5	Exit holes absent
2.0	Exit holes absent
2.5	Exit holes absent

Table 2: Efficacy test against termites after 12 months of exposure.(IPIRTI)

Preservative Concentration, %	Damage
0.0	?
0.5	No termite attack
1.0	No termite attack
1.5	No termite attack
2.0	No termite attack
2.5	?

Table 3: Physico-mechanical properties of plywood prepared from preservative concentration

Preservative Concentration, %	Moisture Content, %	Density, kg/m³	Modulus of Elasticity, N/mm² (Perpendicular to the grain)	Modulus of Rupture, N/mm² (Perpendicular to the grain)
0.0	9.02	852		
0.5	8.98	863		
1.0	8.67	846		

2.0	8.89	838		
2.5	8.81	848		

CONCLUSION

The efficacy test of preservative against wood destroying organism like termite, borer was done after the exposure period of 12 months with inspection after every 3 months. The results have been given in table. It was observed that after 9 months of exposure the control samples got attacked moderately where termite attack area was between 20% and 30% of surface area. Attack was found on 0.5% of the preservative concentration with termite and borer attack on less than 15% of surface area and trace attack on less than 10% surface area of sample having concentration 1% , however concentrations above 1% shows no attack, samples were free from termite and borer attack. Concentrations below 2% of preservative make the samples prone to wood destroying organism like termite, borer attack Therefore, 1.5% and 3% are the feasible concentrations to be used for plywood manufacture. The decay assessment after 12 months exposure did not allow any clear conclusions to be drawn yet. However, high decay activity in Borås and Hannover has been indicated. Soft, white and brown rot have been found in different samples. To evaluate fully the wood protector as wood preservative study is continuing for another 24 months to get clear conclusion.

Image 2: Samples exposed to termite attack at IPIRTI, FS, Kolkata.



Image 2 : Exposed sample against termite attack

