Project code: - SP/97/Preservative/2013

"Modification and efficacy study of WOOD PROTECTOR SCAPO ™, the eco - friendly wood preservative for glue line treatment during manufacture of plywood"

Sponsored By

M/s wood cure enterprise

Ashram Math,SouthNaldanga,Bandel

Hooghly, West Bengal-712123

Executed By

भारतीय प्लायवूड उद्योग अनुसंधान और प्रशिक्षण संस्थान

INDIAN PLYWOOD INDUSTRIES RESEARCH AND TRAINING INSTITUTE

फील्ड स्टेशन, कलकत्ता / **FIELD STATION, KOLKATA**

(भारत सरकार, पर्यावरण एवं वन मंत्रालय का स्वायत्त निकाय) **(Autonomous Body of the Ministry of Environment & Forests, Govt. of India)**

2/2, बीरेन राय रोड, वेस्ट, सरसुना, कलकत्ता **-700 061**

2/2, Biren Roy Road West, Sarsuna, KOLKATA – 700 061

Ph : 033-24983120 ,Fax :033-24983120,E-mail –ipirtikolkata@gmail.com

PROJECT BRIEF

1. Project Code :- **SP/97/Preservative/2013**

2. Title of the project : - "**Modification and efficacy study of WOOD PROTECTOR SCAPO ™, the eco -friendly wood preservative for glue line treatment during manufacture of plywood.**"

3. Principal Investigator : - Mr. S. C. Sahoo, Scientist-D, IPIRTI, F. S, Kolkata

4. Associates : - Mr. AmitavaSil, Scientist,-D,IPIRTI, F. S, Kolkata
   Ms.RiyaTuduSolanki, Scientist-C,IPIRTI, F. S, Kolkata
   Mr.Narshimurty,Scientist--D IPIRTI, ,Bangalore

6. Date of commencement of the Project : - Sept. 2013

7. Date of completion of the Project : - june 2018

8. Total Sanctioned amount : - Rs. 1.227 lacs

____________________ xxxxxxxx ____________________

Acknowledgment

The Institute expresses its deep sense of gratitude to Shri Chandrakant Kumar Deo and Shri Prosenjit Ganguly, Director, M/S- Wood Cure Enterprise, kolkatta.. for funding the sponsored project .Thanks to Dr B.N.Mohanty, IFS Director IPIRTI, Bangalore for continuous support for the project, from initial advice & contacts in the early stages of conceptual inception & through on-going advice & encouragement to end of the project. We would like to express our greatest gratitude to the staffs who have helped & supported for project.

Content

EVALUATION OF WOOD PROTECTOR SCAPO ™ AS GLUE LINE PRESERVATIVES (GLP) FOR MANUFACTURE OF PLYWOOD.

Summary

The study focused on the effectiveness of using Wood protector scapo ™as glue line preservatives (GLP) as a controlling measure to bio-defoliation from borer and termite for plywood in service.Termites are the most troublesome pest of agricultural crops and wooden structures, causing billions of dollar damage annually throughout the world. Most popular and widely used prevention measure to reduce the infestation of termites is the use of synthetic termiticides. Present study deals with field level results of work done at IPIRTI,Kolkata by taking wood protector plus made by certain plant extract and selected plant biomass for controlling termites.The study objective was to evaluate the Wood protector scapo ™, a wood preservative made by naturally available plant by-products, CSNL with some anti-termite, anti-fungus and anti-borer chemicals as a suitability as a glue line preservative (GLP) in plywood industries.12mm Plywood samples at different concentration (from 0.5% upto 5%) preservative were manufactured randomly by Wood protector scapo ™ as a glue line treatment method with combination of different wood species These samples have been evaluated to find out the effectiveness as toxicity against borer and termites for 36 months after exposed in field for graveyard test. Termite and borer tests was carried as per IS 4833:1993 and IS 4873(Part-II):2008 respectively. From the field trial results obtained in this study it is concluded that 1.5% or more concentration of the preservative can be utilized in plywood manufacture which can resist against wood destroying organism like termite and borer. Concentrations below1.5% of preservative make the samples moderate termite attack and plywood samples treated with Wood protector scapo ™ shown resistance to borer attack even after exposed for 36 months. Therefore, 1.5% is the feasible concentrations to be used for plywood manufacture to resist borer and maximum level termite attack . The results of MoE, MoR,Glue shear strength test at 1.5% to 3% concentrations also showed satisfactory limit of acceptance as per Indian standards.

2.0 INTRODUCTION

Termites are the most troublesome pest of agricultural crops and wooden structures, causing billions of dollar damage annually throughout the world. Most popular and widely used prevention measure to reduce the infestation of termites is the use of synthetic termiticides. These are very harmful chemicals. Several termiticides are registered for termite control across the world under various brand names like spinosad, disodium octaborate tetrahydrate (DOT), calcium arsenate and chlorpyriphos. Although, chemical control is an effective measure of protection by termites but their excessive use is harmful for our environment and the results are not sustainable. Many researchers are trying to develop new methods of termite control. Plant derived natural products, entomopathogenic fungi, nematodes and bacteria are some of the alternative methods of termite control. Some plant biomass contains insecticidal activity which can be exploited for termite control.

Throughout the course of history, wood has remained one of the most important renewable natural resources available to mankind. It is-a natural, cellular, renewable resource, has excellent strength-to-weight properties, a relatively low price and is easily produced composite material of botanical origin-possesses unique structural and chemical characteristics that render it desirable for broad variety of end uses (Hingston et al., 2001). On the other hand, one of the major objections of the use of wood for many purposes is of course the question of its long-term resistance to the natural processes of degradation (Yalinkilic, 2000; Richardson, 1978). When timber is used as a construction material, it is generally treated with a chemical preservative to prevent damage by these aggressive biodeteriogens (Craig et al., 2001). A large number of preservative compounds have been introduced on to the market; however many of them has not gained acceptance either because of chemical toxicity, low efficacy, high cost, or corrosiveness (Murphy, 1990). Some contaminants are potentially included in wood preservatives such as chromated copper arsenate (CCA), arsenic, creosote consisting of various polycyclic aromatic hydrocarbons (PAHs), chlorophenols (CPs), pentachlorophenol (PCP), heavy metals including Hg, Cu and Ni, polychlorinated dibenzo-*p*-dioxins and dibenzofurans

(PCDD/DFs) as impurities in CPs, and organochlorine insecticides such as drin compounds and chlordane compounds (Sakai et al., 2001; Yasuhara et al., 2003; Asari et al., 2004;

Baldrian, 2003). The persistence of these chemicals in the environment has resulted in a widespread existence throughout the food chain (Wang et al., 2001; Margaret et al., 1999; Hingston et al., 2001).

Wood preservatives are also subject to increasingly stringent environmental legislations, particularly within the European Union where they fall under the control of the new Biocidal Products Directive.

There is an increasing awareness of the potential of natural products, which may lead to the development of much-needed new preservatives (Tagboto and Townson, 2001). As a consequence, various environmentally friendly treatments or naturally durable plant species are being evaluated (Yalinkilic et al., 1998).

3.0 REVIEW OF LITERATURE

Wood is a lignocellulytic material and liable to degradation due to wood destroying organisms. The improved utility of wood has been the sole purpose of wood preservation. Wood preservation can increase greatly the serviceability of wood and with the supply of wood being limited, it has become necessary to protect wood from biological deterioration. Many workers have made numerous attempts to impart durability to wood by treating it with natural and synthetic chemicals.(Purushotham, 1970) The conventional wood preservative found to be very effective against wood destroying organisms, but they are said to cause environment pollution and are hazardous to animals and human being (Fisher,1968).Over the past few decades there is much global awareness to develop eco friendly wood preservatives which does not impose any kind of health hazards to mammals. Green plants act as reservoirs of natural preservatives which are environment friendly and easily degradable than synthetic chemicals. To develop eco-friendly wood preservatives, many studies have been conducted. Work has been reported on extractives from heartwood (Onurah, 2000; Soni, 1975; Gupta and I.Dev, 1999), work has also been reported on extractives from leaves of *Ipomeacarnea* (Saxena et al. 2002), bulb and leaves of *Sternbergiacandidum* (Goktas*et al.* 2007), leaves of Neem (Swathi et al. 2004). These extracts possess a number of toxic constituents exhibiting high toxicity against wood destroying microbes. Efforts have been made by many workers to use these plant products with toxic metals and tested for durability against termites and fungi (Jain and Virendra Narayan, 1991; Jain et al. 1989 & 1997; Purushotham & Tewari, 1961; Indra Dev & Nautiyal, 2004)

Cashew nut shell liquid (CNSL) is a by-product of cashew industry. It is obtained either by extraction in hot oil or in solvents or by mechanical expulsion from the shells. Cashew nut shell liquid is chiefly used in the preparation of synthetic resins. In addition to its main application in brake lining of motor vehicles, it is used for manufacturing heat and waterproof paints, corrosion-resistant varnishes, insulating enamels and different types of surface coatings. CNSL consists chiefly of naturally produced phenolic compounds-Anacardic acid (about 90%) and Cardol (about 10%). Anacardic acid is a derivative of salicycylic acid, which readily decarboxylates on heating, to obtain anacardol or cardanol. The cardol is a resorcinol derivative having a long unsaturated hydrocarbon chain (Cornelius, 1996). In its natural form, CNSL is reported to accord protection against termites and has water repellency (Lepage and Delelis, 1980). The fishermen are also reported to be using this for protection of boat and fishing nets (Anon, 1948). Such protection is however temporary, as CNSL as such, has not been found effective for the purpose of wood preservation (Purushotham and Tewari 1961). Bagchee (1950) in his toxicity studies of CNSL against wood rotters reported that the activity of fungus and also weight loss was less in CNSL-treated blocks than in untreated ones. Activity of the fungus was decreased with the increase of concentrations of CNSL. Due to its phenolic nature, this product can be used directly as an outstanding preservative for timber and textile against insect and fungus attack (Ohler, 1979).

The application of organic preservative is limited due to their high price, single spectrum, low solubility, leachability, high toxic to human life & not easy to handle during plywood production**,** That’s why the need of an eco-friendly wood preservative is required to meet the demand for plywood industries so that it would be less toxic to human being & more toxic to wood destroying organism.On the other hand preservative must provide an adequate protection without sacrificing mechanical & physical properties to the wood panel.

4.0 SCOPE AND OBJECTIVE

With the synthetic heavy metal based preservative being banned these days the necessity and urgency of developing new eco-friendly preservative increases. In order to address increased public concerns about demand for the environment friendly wood preservative system need to be developed that go beyond the scope of the traditional wood preservation. In addition to being effective against fungus, termites and borers wood preservative chemical must be non volatile environmentally acceptable safe to handle and possess low leachebility. Hence less toxic to human beings and more toxic to wood destroying organism and effectively utilization of bio materials from abundantly available natural sources is in the scope of the use of this wood preservative. The objectives of this study are as follows:

1. Efficacy study of the Wood protector scapo ™of different concentration and climate against wood destroying organism.

2. Chemically compatibility evaluation in phenolic and amino resin and thermal degradation study of the preservative.

3. Optimization of minimum and maximum concentration dosage.

4. Evaluation of bond quality and mechanical properties.

5.0 MATERIALS AND METHODS

For the experimental work under this project following materials were used

1. Wood protector scapo ™ supplied by sponserer
2. Phenol.urea,formalin etc. purchased from local market for resin synthesis.
3. Veneers
   Gurjun face veneer(Dipterocarpus spp.)
   Semul (Bombax ceiba)
   Eucalpataus
   Poplar

5.1 Evaluation of compatibility of resin (Phenolic and amino) with preservative :-

The preservative was added at six different concentrations starting from 0.5%, 1.0%, 1.5%, 2.0%, 3.0%, 4.0%, 5.0% to both conventional phenol formaldehyde and urea formaldehyde resin to asses the suitability in resin without any advese effect . Colour, odour, PH, Potlife of the glue was studied .Observations were made after every one hour to see the consistency of the resin quality.

5.2 Glue line treatment of the plywood

12mm plywood samples having size 2’ X 2’were prepared by using both phenolic and amino resin by taking simul,poplar and ecucalpattaus as core veneer and gurjan sp. as face veneer. Wood protector scapo ™ was added in glue as glue line poison starting from the range 0.5%, 1.0%, 1.5%, 2.0%, 3.0%, 4.0%, 5.0% to both conventional phenol formaldehyde and urea formaldehyde for adhesive mix preparation.

5.3 Plywood manufacturing:

12 mm plywood was manufactured by taking Gurjan as face and simul, poplar and eucalyptus as a core veneer and above glue incorporated with Wood protector scapo ™ varying from 0.5 to 5 % in concentration. 4 plywood samples of size 600 x 600 x 12 mm for each concentration were manufactured, total 24 samples were manufactured.

5.4 Preparation of samples:

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.

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).

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.

5.75 Physico-mechanical study

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

5.8 TOXICITY STUDY

TERMITES

Field test/Gravy yard 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.© 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 distanceof approximately 300 mm and the different materials were installed alternately. All specimens were free of cracks, decay and other obvious defects.

Sample exposed in graveyard test

BORERS

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 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 ºC and 70-75 % RH. Number of exit holes were recorded and reported.

5.9 Thermal Degradation Study:-

Thermal degradation of polymers is molecular deterioration as a result of overheating. Degradation of material is extensive loss of useful properties. To carry out the thermal degradation study of the wood protector as glue line poison, 1% wood protector sample was mixed with resin and DSC – TGA study carried. The mass loss (%) vs temperature graph was plotted to assess the degradation study of the wood protector.

6.0 RESULT AND DISCUSSION

12mm plywood samples by using various concentration of preservative starting from 0.5%, 1%, 2%, 3% and 5% were prepared by using species like- *simul, kadam, poplar and eucalyptus* were exposed for termite and borer attack for period of 36 months along with control samples. Observations were made by monthly intervals and results were recorded.

6.1 Physical and chemical Profile of wood Protector Plus:-

The appearance of the wood protector plus is Deep Brown Viscous Liquid having some characteristic smell . It has been observed physically no etching or adverse effect on the humanbeing during handling, however use of gloves during handling is advisable. When Wood protector scapo ™ was mixed with starting from the entire range from 0.5% to 5.0%, it was observed that there was no adverse effect on the adhesiveness of the resin. It is fully compactible with both phenolic and amino resin .

6.2 Adhesive mix and pot life

Studies on pot life and pH of both UF and PF resin after addition of Wood protector scapo ™ from 0.5% to 5% based on the weight of liquid resin were studied. Addition of wood protector plus was not changed the viscosity and pH of the resin up to 6 to 8 hours. From the study data reveals the incorporation of Wood protector scapo ™ in both amino and phenolic resin in glue line no adverse effect on the pot life and pH of the adhesive mix.

6.3 Glue shear strength and resistance to microorganism

Bonding strength of plywood made by using UF resin and PF resin mixed with wood protector plus at various concentration were tested for glue shear strength in dry, wet and mycological conditions along with control samples. Average and minimum individual of the sample were tabulated in Tab 1. From the table, it is indicated that the addition of Wood protector scapo ™starting from concentration 0.5% to 5.0% in both amino and phenolic resin does not have significant adverse effect in glue shear strength of the plywood.

Table 1 : Results of glue adhesion test for dry, wet and mycological state

Test Parameter	Requirement as per IS 710	Concentration of Preservative (%)						
		0.0	0.5	1.0	2.0	3.0	4.0	5.0
Glue Shear Strength, (N)		Control sample						
(a) Dry State	1350 1100	Avg: 1460 Min: 1270	Avg: 1440 Min: 1250	Avg: 1380 Min: 1170	Avg: 1350 Min: 1110	Avg: 1270 Min: 1100	Avg: 1185 Min: 980	Avg: 1170 Min: 940
(b) Wet State	1000 800	Avg: 1230 Min: 1070	Avg: 1260 Min: 1020	Avg: 1210 Min: 1010	Avg: 1180 Min: 980	Avg: 1040 Min: 810	Avg: 940 Min: 780	Avg: 880 Min: 750
(c)Mycological	1000 800	Avg: 1250 Min: 1040	Avg: 1200 Min: 1020	Avg: 1200 Min: 1010	Avg: 1150 Min: 970	Avg: 1030 Min: 930	Avg: 920 Min: 860	Avg: 890 Min: 660

The resistance of microorganisms tests of the plywood samples made by using UF and PF resin by addition with Wood protector scapo ™ for the entire range of dosses starting from 0.5% to 5.0% were carried as per IS 1734:1983. From the study data reveals that there was no attack of microorganism on the surface or at the edges on the plywood samples. The details results were given in Tab 2.

6.5 Effect on mechanical and bonding properties

Static Bending Strength i.e. modulus of rupture and modulus of elasticity both along and across the grain of the plywood samples made by using UF and PF resin by addition with wood protector plus for the entire range of dosses starting from 0.5% to 5.0% were carried as per IS 1734:1983 along with control samples. From the study data shows the there was no adverse effect on the mechanical strength of the plywood sample were observed after using Wood protector scapo ™ samples in both amino and phenolic resins. The details of the results are in Tab 3.

The knife test conducted on preservative concentrations 0.5%, 1%, 2%, 3% shows pass standard whereas concentrations above 3% shows poor glue bonding in resistance to water test. Plywood sample shows pass standard results when tested for resistance to micro-organism for all concentrations of preservative. (Ref. Tab 2).

Physico-mechanical properties were also studied as per IS: 1734-1986 and it was observed that as preservative concentration increases modulus of elasticity and modulus of rupture results are satisfactory. (Ref. Tab 3).

Table 2 : Results of adhesion of plies, resistance to water and resistance of micro-organism test.

Preservative Concentration, %	Adhesion of plies	Resistance to water after 72 hrs	Resistance to micro-organism
0.0	Excellent	Pass Standard	Pass Standard
0.5	Pass Standard	Pass Standard	Pass Standard
1.0	Pass Standard	Pass Standard	Pass Standard
2.0	Pass Standard	Pass Standard	Pass Standard
3.0	Pass Standard	Pass Standard	Pass Standard
4.0	Pass Standard	Poor	Pass Standard
5.0	Pass Standard	Poor	Pass Standard

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

Preservative Concentration, %	Moisture Content, %	Density, kg/m^3	Modulus of Elasticity, N/mm^2 (Across the grain)	Modulus of Rupture, N/mm^2 (Across the grain)
0.0	8.91	916	6105	65.72
0.5	8.65	893	5406	61.38
1.0	8.50	872	5135	59.71

2.0	8.43	864	4904	58.83
3.0	8.30	847	4792	55.24
4.0	8.27	832	4368	33.71
5.0	8.16	815	4162	52.84

6.6 Toxicity study

Toxicity of the plywood samples in terms of both termite and borer were carried as per respective IS method to assess the resistance of the plywood made after using Wood protector scapo ™ starting ranges 0.5% to 5.0% against wood destroying organism. The details are as follows:

Termite

The efficacy test of preservative against termites was done after the exposure period of 12 and 24 months with inspection after every 3 months. The results have been given in table (4,5,6). 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. Trace attack was found on 0.5% of the preservative concentration with termite attack on less than 5% of surface area, however concentrations above 0.5% shows no attack, samples were free from termite attack

Data on toxicity test for exposure periods of 6, 12, 18, 24, 30 and 36 months are in Tab (4,5,6). From the data, it has been shown that plywood samples were showing moderate termite attack in between 0.5 to 1.5% concentration level.However, control sample has shown the measure attack.

Fig 1 : Samples after exposure to termite test

Table 4-Efficacy test against termites after 12 months of exposure.

Preservative Concentration, %	Numerical ratings	Condition of samples
0.0	3.0	Moderate attack, termite attack area 20% to 30% of surface area.
0.5	2.0	Trace attack, termite attack area between 20% and 30% of surface area.
1.0	2.0	Trace attack, termite attack area between 20% and 30% of surface area.
1.5	1.0	No attack, termite attack area between 5% and 20% of surface area
2.0	1.0	No attack, termite attack area between 5% and 20% of surface area
3.0	0.5	No attack, termite attack area less than 5% of surface area

Table 5- Efficacy test against termites after 24 months of exposure.

Preservative Concentration, %	Numerical ratings	Condition of samples
0.0	3.0	Heavy attack, termite attack area 35% to 40% of surface area.
0.5	2.0	Moderate attack, termite attack area between 20% and 30% of surface area.
1.0	2.0	Moderate attack, termite attack area between 20% and

		30% of surface area.
1.5	1.0	Light attack, termite attack area between 5% and 20% of surface area
2.0	1.0	Light attack, termite attack area between 5% and 20% of surface area
2.5	0.5	Trace attack, termite attack area less than 5% of surface area

Table 6 -Efficacy test against termites after 36 months of exposure.

Preservative Concentration, %	**Numerical ratings**	**Condition of samples**
0.0	3.0	Heavy attack, termite attack area is more than 50% of surface area.
0.5	2.0	Moderate attack, termite attack area between 35% to 30% of surface area.
1.0	2.0	Moderate attack, termite attack area between 35% and 40% of surface area.
1.5	1.0	Moderate attack, termite attack area between 20% and 30% of surface area
2.0	1.0	Moderate attack, termite attack area between 20% and 30% of surface area
3.0	0.5	Moderate attack, termite attack area less than 20% to 30% of surface area

Borer

Plywood samples were prepared using 0.5 to 5.0% concentration by glue line treatment method are exposed to borer attack at laboratory conditions. The results of toxicity tests for exposure periods of 6, 12, 18, 24, 30 and 36 months are in Tab (7,8,9,10). Borer holes were appeared within 6 months of exposures in the untreated control samples. However, in case of plywood samples treated with Wood protector scapo ™ starting from range 0.5% to 5.0%

concentration levels no borer infestation was observed for the entire duration of the study up to 36 months.

Table 7: 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
3.0	Exit holes absent
5.0	Exit holes absent

Table 8: Efficacy test against borer after 24 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
3.0	Exit holes absent
5.0	Exit holes absent

Table 9: Efficacy test against borer after 36 months of exposure.

Preservative Concentration, %	Damage
0.0	Exit holes present

0.5	Exit holes present
1.0	Exit holes present
1.5	Exit holes absent
2.0	Exit holes absent
3.0	Exit holes absent
5.0	Exit holes absent

Table 10 : Plywood samples treated with wood protector plus for borer (powder post beetle) Attack

Preservative Concentration (%)	06 months	12 months	18 months	24months	36 months	Remarks
0.5	No attack	No attack	No attack	attacked	attacked	
1.0	No attack	No attack	No attack	No attack	attacked	
1.5	No attack	No attack	No attack	No attack	No attack	
2.0	No attack	No attack	No attack	No attack	No attack	
3.0	No attack	No attack	No attack	No attack	No attack	
5.0	No attack	No attack	No attack	No attack	No attack	
Control Sample	Attacked	Attacked	Severe Attack	Severe Attack	Severe Attack	

6.7 Thermal degradation study

From the DSC-TGA data plotted weight (%) vs temperature (^{o}c) of the Wood protector scapo ™ added 1.5% in PF resin, shows that the loss of mass occurs about 300^{0}C. Hence, thermal degradation study of the preservative sample signifies that on heating the preservative molecule had not lost his original properties (Ref Fig 2 and Fig 3)

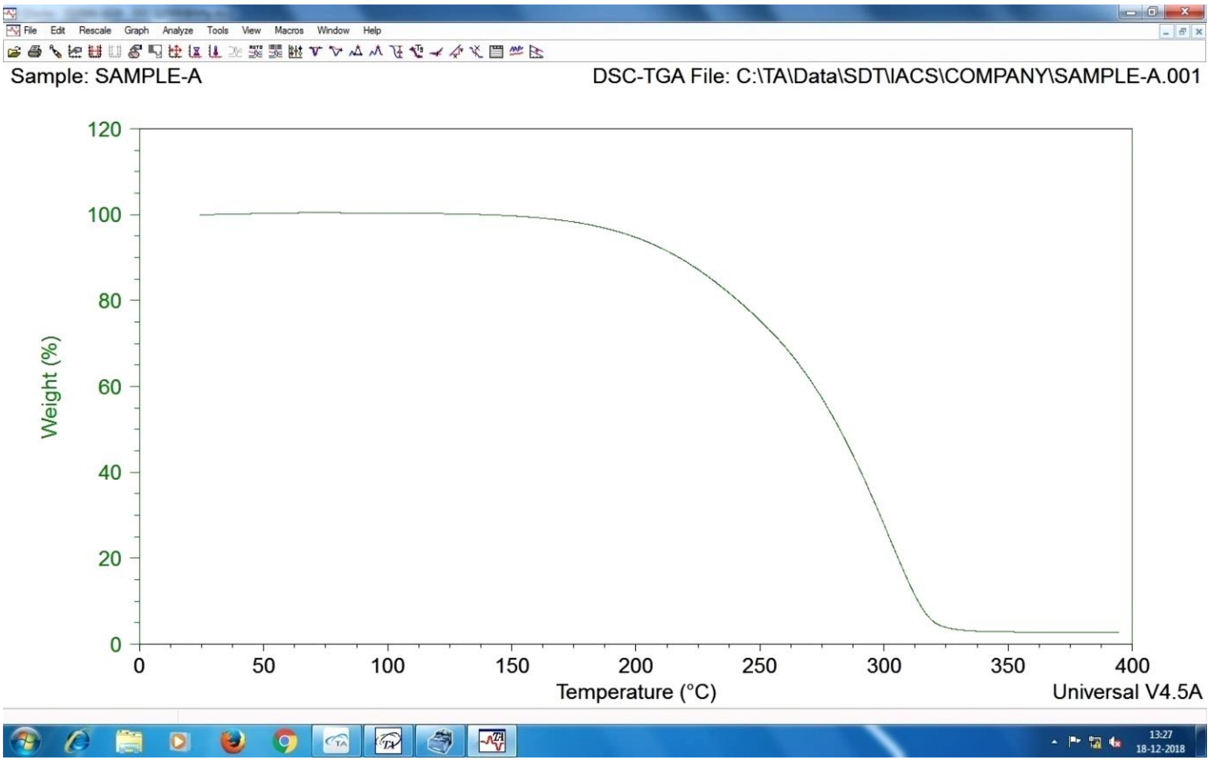

Fig 2 : Thermal degradation study of Wood protector scapo ™ **sample**

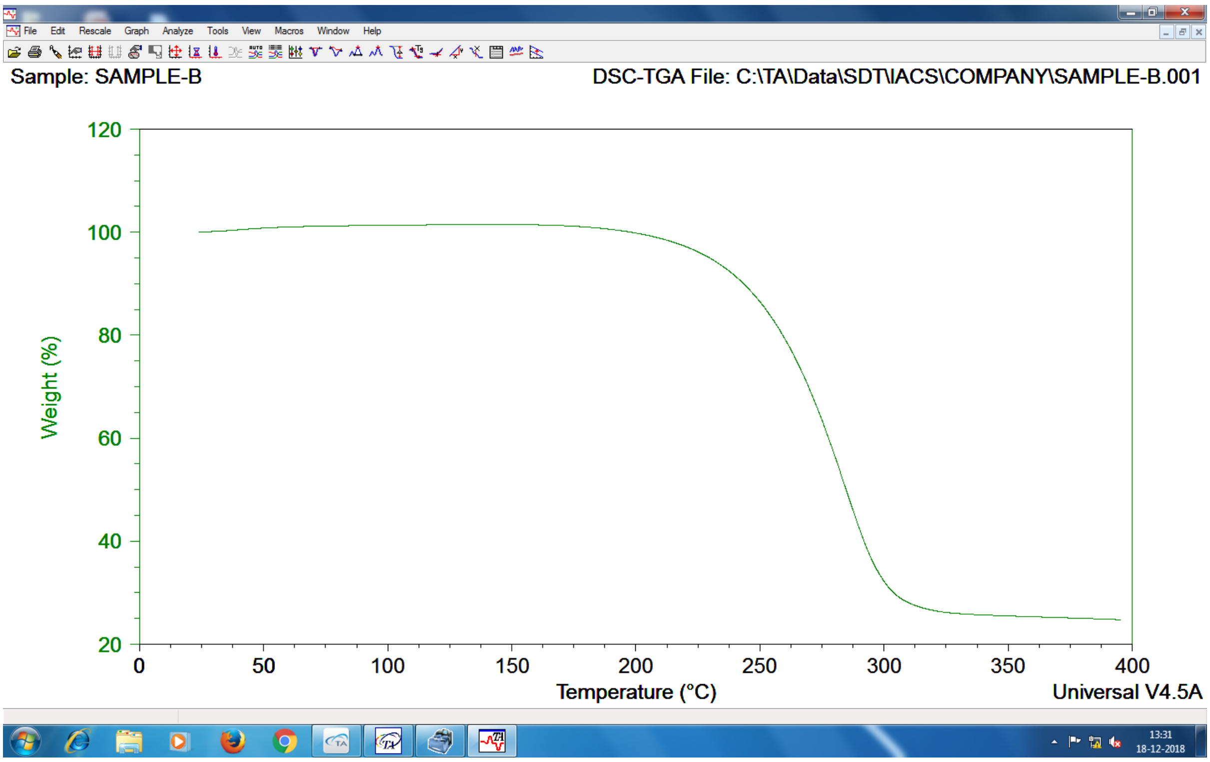

Fig 3 : Thermal degradation study of Wood protector scapo ™ **sample**

7.0 CONCLUSION

From the present studies of the wood preservative"The Wood protector scapo ™",it is concluded that the plywood samples treated with preservative indicates resistance to borer attack after 36months field exposure study,however moderate termite attack was observed at the surface area 20 to 30% instead of heavy attack.

On the basis of the experimental studies and result & discussion the following recommendation/conclusion are proposed.

(i) The wood protector plus GLP incorporated at in the glue line at different concentration have no imparted any change in the potlife and the bonding strength of the adhesive .

(ii) Results from the water resistance test revealed that the chemical is suitable for use of BWP grade plywood without effecting any bonding quality.

(iii) The above GLP can be used in both amino (UF,MUF,MF) & Phenolic resin (PF,MPF) at 1.5% to protect the plywood and other wood based panel products from fully borer attack and moderate attack from termites, concluded from after 36 months field exposer studies .

(iv) Lack of any adverse effect. environment and human being is the additional benefit by using the above GLP to protect from wood destroying organism.

(v) From the DSC-TGA studies of the Wood protector scapo ™ sample added 1.5% in PF resin, shows that the loss of mass occurs about 300^0C. Hence, thermal degradation study of the preservative sample signifies that on heating the preservative molecule had not lost his original properties upto 300^0C.

ACKNOWLEDGEMENT

This report is being published with the kind permission of the Director, IPIRTI, Bangalore

REFERENCE

1. Anonymous. 1983. IS: 1734. Methods of testing for Plywood. Bureau of Indian Standards.

2. Anonymous. 1993. IS: 4833. Methods for field testing of preservatives in wood (First Revision). Bureau of Indian Standards.

3. Anonymous. 2008. IS: 4873 (Part II). Methods of laboratory testing of wood preservatives against fungi and borers (powder post beetles)(Second Revision). Bureau of Indian Standards.

4. Gupta, P and I.Dev 1999. Studies on the fungal toxicity of Sal (*Shorearobusta)* heartwood extractive. J. Timb. Dev. Assoc. (India) 45 (1-2) :939

5. Indra Dev and S.N. Nautiyal 2004. An eco-friendly wood preservative formulation (CRCNSL). J. Timb. Dev. Assoc, India 50 (1-2) :19-25.

6. Onurah, E.O.2000. Short Communication. The wood preserative potential of heartwood extracts of *Miliciaexcelsa* and *Erythrophleumsuaveolens.Bioresources Technology*,75:171-173.

7. Purushotham , A. 1970. Protection of pulp wood (timber, bamboo) from deterioration due to biological agencies (fungies and insects etc.) during transit and storage. *J. Timb.Dev. Assoc. India.* , 16 (2); 51-53.

8. Purushotam, A and M.C. Tewari 1961. A preliminary note on the preparation of copper and zinc preservative from cashew nut shell liquid.J.Timb.Drryers preservers Assoc, India, 16 (2):51-53.

9. Saxena P and I. De 2002. Preliminary studies on termite resistance of water soluble phenolics fraction of Western Red Cedar, Canadian Journal Botany, 32 (1):308-309.

10. Soni, Goktas, O., Mammadov, R., Duru, E.M., Ozen, E., Colak, M.A., Yilmaz, F. 2007. Introduction and evaluation of the wood preservative potentials of the poisonous *Sternbergiacandidum* extracts.African Journal of Biotechnology Vol. 6 (8), pp. 982-986.

11. Soni, P.L. 1975. The chemistry of extractive of Dalbergiasissoo, Part I, The occurance of 3,5 Dihdroxy-trans-stilbene in the heartwood. J. Ind.Acad. Wood Sci., 6 (2) : 57-58.

12. Swathi Dhyani, SadhanaTripathi and Indra Dev 2004.Preliminary screening of neem (Azadirachtaindiaca) Leaf extractive against poriamonticola- A wood destroying fungus.J.Ind.Acad.WoodSci, (N.S.) 1 (1 &2) :103-112.

PACKING OF WOOD PROTECTOR **SCAPO** ™