Technology Section

Pak. j. sci. ind. res., vol. 35, no. 5, May 1992

MANUFACTURE OF EXTERIOR GRADE PLYWOOD FROM LIGNIN BASED PHENOLIC RESIN

MANSOOR AHMAD AND TASLEEM AKHTAR

National Centre of Excellence in Physical Chemistry, University of Peshawar, Peshawar, Pakistan

(Received April 5, 1990; revised June 7, 1992)

A lignin based phenolic resin has been developed for the exterior grade plywood. In this resin lignosulfonate (LS) was isolated from sodium based spent sulfite liquor (SSL), a waste product of the paper mills in Pakistan, where different grasses (bagasse, kaigrass, rice straws) are being used as raw material for pulping. A series of resins were formulated in which up to 70% of phenol was replaced by LS, when condensed with formaldehyde under reflux. Plywood made with these resins was tested both in the dry and wet states {cold water resistance (CWR), warm water resistance (WWR), boiling water resistance (BWR) and mycological}. The glue shear load of the plywood, in all the states met the requirements imposed by Pak. Std. 871, 1970. Wood failure of the plywood was compared with commercial standard (CS) 35 - 45 and the results found were equally good.

Key words: Grassy pulp material, Phenol formaldehyde-lignosulfonate resin, Plywood.

Introduction

During the sulfite pulping process, only half of the raw materials is converted into pulp while the other half forms a black liquor (BL), which is also called spent sulfite liquor (SSL). The major constituents of SSL is lignosulfonate, which is a lignin derivative and highly water soluble.

Only a small portion of the black liquor from the paper mills in Pakistan is consumed as a fuel in the paper industries while the rest is discharged into the rivers and water ways causing serious chemical hazards to aquatic lives.

In other developed countries, most of the BL is burnt as a fuel and only a small portion of it is used for various purposes, viz. dispersants [1], oil well drilling muds [2], grinding aids [3], rubber additives [4], concrete additives [5], tanning binding agents [6] and emulsifiers and stabilizers [7].

In most of the paper industries of the world, wood is used as the raw material for pulping but in this country all the paper mills utilise grassy materials such as bagasse *(Saccharum officinarum)*, kaigrass *(Saccharum spontarum)* and wheat straws *(Triticum vulgare)*. The lignin from these grassy materials is composed of guaiacyl-syringyl units where syringyl has been found to be the dominant unit [8,9].

Since SSL obtained from wood pulp has already been used as a binder for the plywood industry [10-12] it is desirable to investigate the potential uses of the BL from grassy pulp as a binder for plywood industries in this country.

A single glue line was applied on both sides of the core layer and the veneers were assembled in plywood construction with grains of the face vaneers at right angles to the core layer. An initial glue setting time of 20 mins. was given to all the panel preparations with different glues. Plywood loose panels were pressed under a pressure of 14 kg/cm^2 at 150° for 12 mins. After conditioning for one week at 65% relative humidity (Rh) and temperature of 23 ± 2°, shear specimens were prepared according to the American Society of Testing Materials (ASTM) [14]. The following tests were performed according to PS.871 : 1970, (plywood for general purposes).

1. Glue shear load in dry state (at 65% Rh, 23 ± 2°).
2. Glue shear load in wet state. (a) Cold water resistance (CWR); soaking in water for 24 hrs. at room temperature. (b). Warm water resistance (WWR); soaking in water for 3 hrs at 70°. (c) Boiling water resistance (BWR); boiling in water for 8 hrs.
3. Test for resistance to micro-organism (Mycological testing).

The test specimens were submerged in saw dust (poplar) moistened with a sufficient amount of an aqueous solution of sugar cane for a period of two weeks at room temperature.

The average shear load of the specimens at failure and the average wood failure were calculated. Twenty shear specimens were used for each test per plywood prepared from different glues.

Experimental

Black liquor was collected from the Adamjee Paper and Board Mills, Nowshera, NWFP, Pakistan where sodium based sulfite pulping process is being used. They use bagasse, kaigrass and wheat straws as pulp material.

Lignosulfonate was isolated from BL by Willstatter's method [13]. Different resins were synthesized by replacing phenol (upto 70%) with lignosulfonate to form phenol formaldehyde- lignosulfonate in an alkaline medium. A neat phenol formaldehyde resin was also prepared for comparison purposes.

Glue formulation. The amount of glue required in the manufacturing of plywood was calculated on the basis of total solids of the glue and the glue spread of the veneers.

For 100 gms of glue (solid contents 52 - 65%) the following formulation was used.

Glue	=	82 gms.
Paraformaldehyde	=	10 gms.
Wheat flour	=	2 gms.
Walnut shell powder	=	4 gms.
Sodium hydroxide (50% Soln.)	=	2 gms.

Plywood manufacturing. Plywood was prepared from *Eucalyptus camaldulensis* having a density of 0.676 g/cm^3. Three plies of rotory cut veneers of dimensions 50 cm x 55 cm x 0.159cm and moisture content of 9% were used.

Result and Discussions

Figure 1 shows the effects of different glue compositions on the glue failing load of the plywood. The failing load decreases with the increasing amount of lignosulfonate in the resin. No significant difference was observed in the failing load of the plywood in dry and wet states at various ratios of phenol formaldehyde to lignosulfonate, where the two forms are almost overlaping each other. This indicates that these resins are water resistant and their strength properties are not affected by water under various wet conditions. According to PS 871:1970, the average dry glue failing load in respect of BWR grade is 135 kg, while our study shows the lowest glue failing load of 217 kg (WWR) even at a glue composition 70:30 of lignosulfonate to phenolformaldehyde. It was also noticed from Fig.1, that the failing load is constantly decreasing in all the states except CWR where it increases from 10 to 20% LS and then decreases with the increasing amount of lignosulfonate (upto 40%) in the resin. Further increase of lignosulfonate in the resin produced no deteriorating effects and the failing load remained almost constant, upto 70% replacement of phenol by lignosulfonate in the resin.

Figure 2 represents the effects of different glue compositions on the average wood failure of the plywood. A clear cut difference was observed in the wood failure between dry and wet states. The same difference was maintained in the dry and wet states of neat PF indicating that the PF-LS resins are affected by water to the same degree as neat PF. It was noted that in both states wood failure increases with the increase of lignosulfonate (10-20%) in the resin, then it decreases upto 50% addition while further addition of lignosulfonate (upto 70%) showed a constant behaviour.

BWR test for neat phenolformaldehyde showed a low wood failure value, (40%) but the wood failure increased by the addition of 10% lignosulfonate and remained constant by further addition of LS.

Wood failure values obtained from this study at the various glue compositions of phenolformaldehyde and lignosulfonate are compared with commercial standard [15] (Table 1). The results obtained from this study are better than those of the commercial standard even at a glue composition 70 : 30 of lignosulfonate to phenolformaldehyde.

TABLE 1. COMPARISON OF THE COMMERCIAL STD WITH WOOD FAILURE TO THE CORRESPONDING FAILING LOAD OF THE PLYWOOD.

Failing load kg	Av. wood failure (%)
114	50
114 - 159	30
Above 159	15
249*	53

* Results from this study at a glue composition 70:30 of lignosulfonate to phenolformaldehyde in dry state.

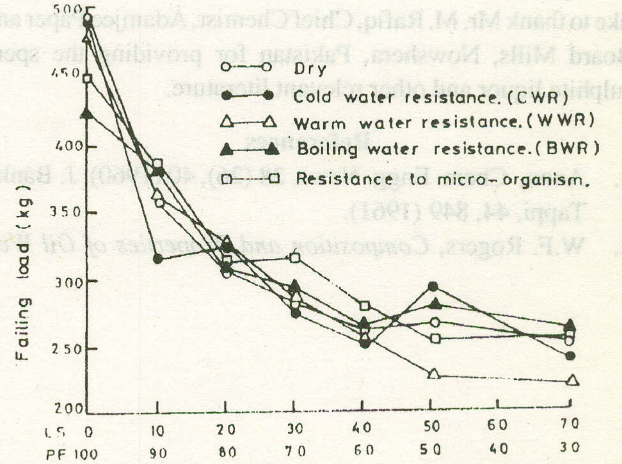

Fig. 1. Effect of glue composition on the failing load of the plywood in dry and wet states.

Note: According to PS 871: 1970, the average dry glue failing load in respect of BWR grade in 135 kg.

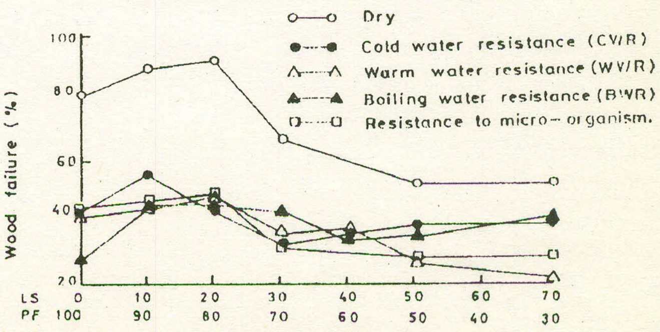

Fig. 2. Effect of glue composition on wood failure of the plywood in dry and wet states.

Note: According to CS 35 47 average wood failure is 50% for a failing load of 114 kg.

It is clear from the results that lignosulfonate modified resins are capable of producing water resistant bonds. This implies that lignosulfonate is actually participating in cross linking reactions to make it a part of the cured adhesive net- work.

Conclusions

It has been observed from this study that although the glue shear load of plywood decreases with the increasing amount of lignosulfonate (upto 40%) in the resin there was no significant difference in the glue shear loads of the dry and wet specimens. This could indicate that the plywood produced from various glue combinations of PF and lignosulfonate are water resistant. 70% of phenol could be successfully replaced by LS and even more substitution might still produce plywood of international standard (i.e. British Standard).

Acknowledgement. The authors are highly indebted to the Director, Pakistan Forest Institute, Peshawar for his generous provision of research facilities. The authors would also like to thank Mr. M. Rafiq, Chief Chemist, Adamjee Paper and Board Mills, Nowshera, Pakistan for providing the spent sulphite liquor and other relevant literature.

References

1. Anon, Chem. Engg. News, **38** (26), 40 (1960); J. Banki, Tappi, **44**, 849 (1961).
2. W.F. Rogers, *Composition and Properties of Oil Well Drilling Fluids* (Gulf Publishing Co., New York, 1971), 3rd ed., pp. 851.
3. K.V. Sarkanen and C.H. Ludwig, *Lignins* (Wiley Interscience, John Wiley and Sons, Inc., New York, 1971.), pp. 851.
4. West Virginia Pulp and Paper Co. (Westvaco) Poly Chemical Div., Technical Bull., 115.
5. W.J. Holstead and B. Cheiken, Public Road, **31**, 126 (1961).
6. H.B. Marshal and C.A. Shaw, U.S. Patent. 2, 929, 700 (1970).
7. A.J. Willey, M.F. Kummer, C.R. Faulkerider and Van Camp. B. Tappi, **34**, 556 (1951).
8. M. Ahmad and L. Khan, J. Chem. Soc. Pak., **10** (3), 299 (1988).
9. Lal Khan, Ph.D. Thesis , University of Peshawar (1985).
10. K.G. Forss and A.G.M. Fuhrmann, Brit. Pat. 1, 404, 536 (1975).
11. K.G. Forss and A. Fuhrmann, Prod. J., **29** (7), 39 (1979).
12. C.H. Ludwig and A.W. Stout, U.S. Pat. 3, 658, 638 (1972).
13. R. Willstatter and L. Kalb, Chem. Ber., **55**, 2637 (1922).
14. Standard Method of Test for Strength Properties of Adhesives in Plywood Type Construction in Shear by Tension Loading., ASTM Designation: D 906-64, (1965).
15. Comm. Std., CS-3547, Feb. 20 (1947).