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

UTILISATION OF SPENT SULFITE LIQUOR FROM GRASSY PULP MATERIALS AS A BINDER FOR PARTICLEBOARD

MANSOOR AHMAD AND TASLEEM AKHTAR

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

(Received April 5, 1990; revised June 15, 1992)

Spent sulfite liquor (SSL), obtained from the paper industry based on the grassy pulp material was concentrated to 50% total solids and polymerised with conc. H_2SO_4 at pH 2 and 3. The modified SSL was used as a binder for exterior grade particleboard. Medium density (0.7gm/cm^3) poplar boards (1.27 cm) were manufactured from 6-12% SSL based on the ovendry (O.D) weight of board material. Boards of highest strength were obtained at SSL concentration of 8-10% with pH 3, while high water resistant properties were observed in the board at pH 2. SSL bonded poplar and bagasse boards were also prepared at different press times. Boards prepared during this study met the requirements of American Standard CS 236 for urea formaldehyde (UF) bonded particle boards, even at a press time of 8 mins. The results were also compared with UF bonded poplar and bagasse boards, prepared during the present investigations. It has been noted that the strength property of the SSL bonded poplar board is comparable to the UF based poplar board, but its water resistance is comparable only at a press time of 20 mins. Strength property of the SSL bonded bagasse boards is not comparable to that of UF bonded bagasse boards but its water absorption is comparable even at a press time of 12 mins. The properties of the boards were also compared with the UF bonded commercial poplar and bagasse boards and were found to be equally good.

Key words: Grassy pulp materials, SSL, Particleboard.

Introduction

Lignosulfonate (LS) is the major constituent of spent sulfite liquor (SSL), a waste product of the paper industries. It consists of both aliphatic and aromatic hydroxyl groups, which provide active sites for polymerization and further condensations.

During the last few decades the rapid rise in the prices of petrochemicals, from which the synthetic resins (Phenol formaldehyde (PF) and urea formaldehyde (UF) are derived has brought a dramatic change in the economic picture of these industries. This has induced the scientists all over the world to carry out research on nonpetrochemical phenolic compounds, such as lignin and tannin, which have structural similarities with phenol and have a potential to produce a resin for binding particleboard, fiberboard and plywood. A lot of work has been done by Shen *et al.* [1-5] on preparing SSL based adhesive for particleboard and at present, there are a few patents in united states and Canada, describing methods of preparing a resin binder for particleboard from SSL [6-9]. However, none has so far been put to commercial use. Although most of the work was carried out with SSL obtained from softwood, while no such studies were conducted in Pakistan, where hard wood [10,11] is used as a pulping material in the paper and board mills. So the present investigation is focused at the utilisation of SSL as a binder for particle board industry, not only to compete the high prices of the synthetic resin but to solve the problem of water pollution and formaldehyde emission from the wood products.

Experimental

SSL used in this investigation was supplied by Adamjee Paper and Board Mill, Nowshera, NWFP, Pakistan, where sodium based neutral sulfite pulping process is being used. The pulping material is mainly composed of bagasse (*saccharum officinarum*), kai grass (*saccharum spontarum*) and wheat straws (*triticum vulgare*). The black liquor from the industry in question goes to the river Kabul.

Condensation of SSL. SSL was concentrated to 50% total solids at 50° under reduced pressure. Condensation was carried out with conc. H_2SO_4 and pH of the liquor was adjusted to 2. The condensed liquor was used as a binder for the board.

Board manufacturing. Medium desnity boards were prepared from poplar chips and depithed bagasse, a waste of sugar mills. Glue was sprayed at an air pressure of 2 kg/cm^2. The moisture contents of the glued chips was found to be 12-16% after 4 mins blending time.

Different types of boards having a size of 50 x 55 x 1.27cm were prepared by using poplar chips at various concentrations of SSL (pH 2), based on O.D. weight of chips, boards were pressed on a preheated hydraulic press at 30kg/cm^2, at temperature of 210° for 12 mins. Boards were also prepared from SSL with pH 3 under identical conditions.

Poplar and bagasse boards were prepared at different press time by using a fixed ratio (1:9) of the SSL and board material. Temperature and pressure of the press were kept constant at 210° and 30kg/cm^2 respectively.

Poplar and bagasse boards were also made with UF at a ratio (1:9) of UF and board material. Urea formaldehyde was provided by Pakistan Forest Institute, Peshawar. It was in liquid form with 60% solid content. The boards were pressed at 30kg/cm², 150° for 10 mins. UF bonded poplar and bagasse commercial boards were purchased from the local market and its various properties were tested for the comparison purposes. Results of the present investigations were also compared with UF bonded poplar board prepared in Pakistan Forest Institute (PFI) under standard conditions.

Properties of the boards were evaluated according to the ASTM methods for particle boards [12].

Results and Discussion

Table 1 represents various properties of the poplar boards prepared at different concentrations of SSL binder with pH 2 and 3. It is clear from the Fig. 1(a,b) that boards prepared at SSL concentration of 8-10% have high strength properties and this effect is even more pronounced in the boards at pH 3, which is in accordance with the findings of Shen [2]. Figure 1(c) represents the amount of hours at ambient temperature. It is noted that boards made at pH 2 are more water resistant as compared to the boards with pH 3 which is supporting the Shen [2] findings i.e. the boards prepared in more acidic conditions absorb less water. The results obtained from thickness swelling (T-S) after soaking the specimens in water for 24 hrs and linear expansion (L-E) after keeping the specimens in the humidity chamber at 90% relative humidity (Rh) for 24 hrs are not much conclusive, however, the results produced at pH 2 are comparatively better than those at pH 3.

Properties of SSL bonded boards were compared with different standard commercial boards made with UF (Table 2). It is obvious from this Table that SSL bonded boards meet the requirement of Am. Std. CS. 236 Static bending and LE at 90% Rh are comparable to other UF bonded poplar boards (Table 2), but their water resistance is poor. So, to overcome this problem, boards were prepared at higher press times (Table 3). It can be seen from Fig. 2(a) that modulus of rupture (MOR) is not much influenced by the press time, which is in accordance with the finding of Shen [2], while modulus of elasticity (MOE) shows increase for longer press time. It is

TABLE 1. PROPERTIES OF THE SSL BONDED POPLAR BOARD AT DIFFERENT CONCENTRATIONS OF SSL WITH pH 2 AND 3.

SSL	pH	MOR kg/cm²	MOE kg/cm²	%L-E 90%Rh	%T-S 90%Rh	%W-A 24hr. soaking
6	4.39	207	43791	0.1520	4.309	107.0
	(4.62)	(285)	(53110)	(0.1727)	(8.94)	(148)
8	4.03	285	56096	0.1747	12.00	116.0
	(4.52)	(302)	(69481)	(0.1225)	(12.11)	(139)
10	3.92	272	58120	0.1237	13.625	129.0
	(4.12)	(298)	(70926)	(0.1663)	(8.21)	(135)
12	3.84	180	48364	0.2600	3.42	106.0
	(4.15)	(290)	(60278)	(0.1537)	(7.99)	(115)

Notes: (a) Values in the paranthesis represents various properties of the board with SSL concentration at pH 3. (b) The values not in the paranthesis are those from SSL prepared at pH 2. (c) pH of particle board.

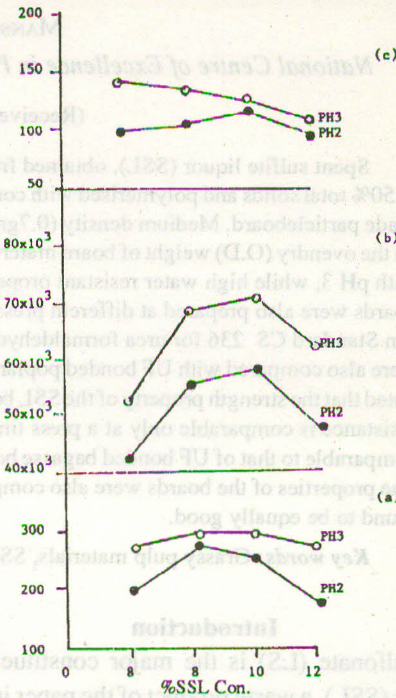

Fig. 1. Effect of SSL Conc. on (a) MOR, (b) MOE, (c) Water ABS. (24 hrs. soaking) of poplar boards.

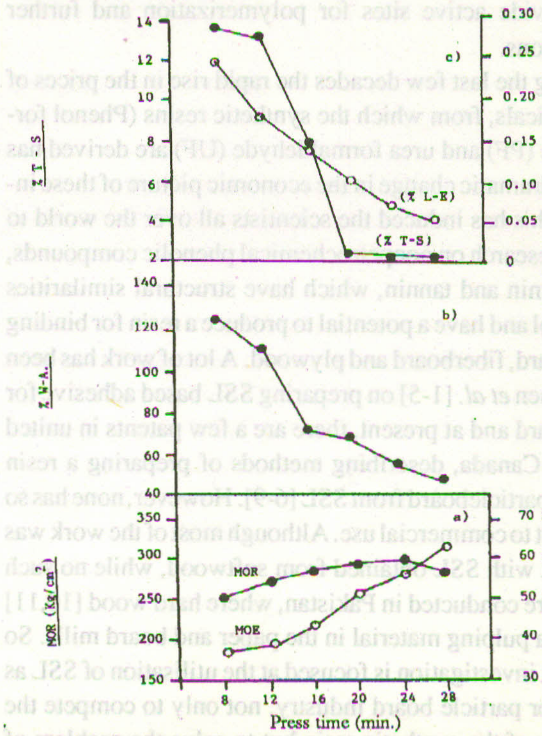

Fig. 2. Effect of press time on (a) MOR and MOE, (b) Water absorption and (c) Thickness swelling and linear expansion (90% Rh, 24 hrs.) of poplar boards.

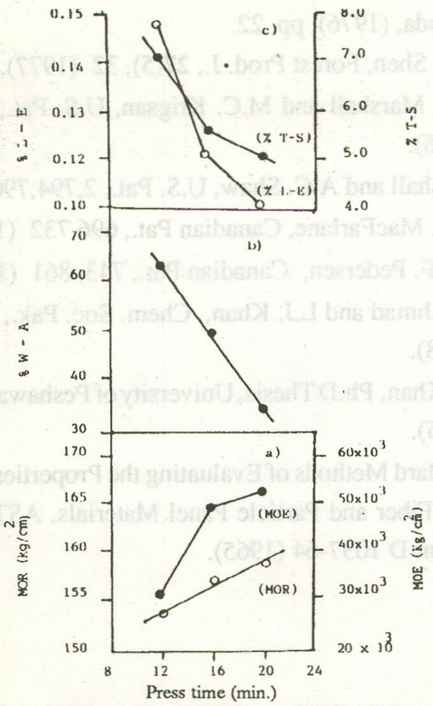

Fig. 3. Effect of press time on (a) MOR and MOE. (b) Water absorption (24 hrs. soaking) and (c) Linear expansion and thickness swelling (90% Rh, 24 hrs.) of bagasse board.

clear from Fig. 2(b,c) that water resistance of the SSL bonded boards increases with the increase of press time.

Table 3 also shows the properties of the SSL bonded boards prepared from depithed bagasse at different press times. We were unable to prepare boards at press times of 24 and 28 mins, which may be due to non-resistance of the bagasse weak fibers to high temperature for longer press times. Here as well, the MOR is not much affected by the press time but MOE increases with the increase of press time (Fig. 3a) water absorption after soaking the board specimens in water for 24 hrs, thickness swelling and linear expansion after keeping the specimens in humidity chamber at 90% relative humidity for 24 hrs (Fig. 3b,c) show a downward trend with the increase of press time.

Results obtained from SSL bagasse boards, met the requirements of Am. Std. CS. 236 for UF bonded particle board (Table 2). It was also observed that water intake was small as compared to the UF bonded bagasse board even at a press time of 12 mins.

Conclusions

Sodium sulfite liquor which is a waste product of paper mills can be modified with mineral acid, and can be utilized as a binder for particle board industry. SSL bonded poplar and bagasse boards met the requirement of Am. Std. CS 236. It is concluded that SSL bonded bagasse boards are more water resistant as compared to the bagasse board prepared from UF. Therefore modified SSL can be used as such to prepare bagasse boards of exterior grades. Water absorption property of SSL bonded poplar board, comparable to UF bonded poplar boards could only be achieved at a longer press time, of 20 mins and above.

Further more since SSL is considered at present as a waste material, by using it in particle board manufacturing, the industry may ultimately free itself from its dependence on petrochemicals.

TABLE 2. COMPARISON OF STANDARD AND COMMERCIAL BOARD WITH THE SSL BONDED BOARDS OBTAINED FROM THIS STUDY.

Board properties	Urea formaldehyde						SSL	
	Am.Std.CS 236,1966	Poplar(c) (from PFI)	Poplar(b) (conmm)	Poplar(d)	Bagasse(b) comm	Bagasse(d)	Bagasse(a)	Poplar(a)
pH	–	–	5.30	6.27	–	6.21	4.21	4.62
MOR(kg/cm²)	112	297	229	305	159	271	156	298
MOE(kg/cm²)	17577	–	26412	42074	23681	24415	27516	70926
%LE(90% Rh)	0.35	0.458	0.169	0.147	0.260	0.102	0.1483	0.1663
%T-S(90% Rh)	–	4.014	1.317	2.962	2.190	2.25	7.2024	8.21
%W-A(24 hr. soaking)	160 (hr)	–	118.76	69.69	60.710	86.95	64.59	135

a. The result obtained from this study, at SSL conc. of 10% with pH 3. (b) Commercial boards tested during this study. (c) Boards prepared in Pakistan Forest Institute. (d) Boards prepared from neat UF and tested for comparison purposes.

TABLE 3. PROPERTIES OF SSL BONDED POPLAR AND BAGASSE BOARDS AT DIFFERENT PRESS TIMES.

press time (min.)	MOR (kg/cm²)	MOE (kg/cm²)	%LE 90% Rh	%TS 90% Rh	%WA 24 hrs. soaking
8	250	35416	0.2513	13.62	126
12	272	38375	0.128	13.33	114
	(156)	(27516)	(0.1483)	(7.20)	(64)
16	285	47887	0.1753	8.09	74
	(157)	(49754)	(.1219)	(5.68)	(51)
20	280	61231	0.1005	2.14	70
	(159)	(52548)	(0.1133)	(5.17)	(35)
24	296	71193	0.0705	2.09	57
28	284	85332	0.0549	2.16	50

Note: Value in the parantheses represent properties of SSL bonded bagasse boards.

Acknowledgement. The authors are grateful for the generous supply of black liquor by Adamjee Paper and Board Mill, Nowsherea, NWFP, Pakistan. The authors are also thankful to the Director, Pakistan Forest Institute who has kindly allowed us to use the Laboratory facilities for this work.

References

1. D.P.C. Fung and K.C. Shen, In the Abstract of Forest Products Research Society, 30th Annual Meeting, Toronto, Canada, July 11-16, (1976), pp. 22.
2. K.C. Shen, Forest Prod. J., **24**(2), 38 (1974).
3. K.C. Shen, In the "Proceedings of Eight Washington State University Symposium on Particleboard" Pullman, Wash, (1974) pp. 231-246.
4. K.C. Shen, In the "Abstract of the Forest Products Research Society, 30th Annual Meeting, Toronto, Canada, (1976), pp. 22.
5. K.C. Shen, Forest Prod. J., **27**(5), 32 (1977).
6. H.B. Marshall and M.C. Krigsan, U.S. Pat., 2,772,139 (1956).
7. Marshall and A.C. Shaw, U.S. Pat., 2,794,790 (1957).
8. H.M. MacFarlane, Canadian Pat., 696,732 (1964).
9. A.H.F. Pedersen, Canadian Pat., 743, 861 (1966).
10. M. Ahmad and L.J. Khan, Chem. Soc. Pak., **10**(3), 299 (1988).
11. Lal Khan, Ph.D Thesis, University of Peshawar, Pakistan (1985).
12. Standard Methods of Evaluating the Properties of Wood-base Fiber and Particle Panel Materials, ASTM Designation: D 1037-64 (1965).