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Acetic acid pulp from jute stick, rice-straw and bagasse

M.S. Karim, H.P. Seal, M.A. Rouf, M.I Rahman, M.H.R. Talukder[1] and P.G. Karmaker[2]
Department of Chemistry, Bangladesh Agricultural University, Mymensingh, [1]Ananda Mohan College, Mymensingh, [2]Rajshahi University, Rajshahi

Abstract: Jute stick, rice straw and sugarcane bagasse have been subjected to acetic acid pulping. Optimum pulping conditions were established on the basis of unbleached yield and permanganate number of the pulps. Bleaching was adopted in case of jute-stick with a view to obtaining writing and printing paper. Evaluation of the pulp properties were done in details and results for breaking length, tear factor, burst factor and brightness of the pulp-sheets have been recorded. The freeness of the beaten pulps was also determined and reported. Studies on fibre dimension (fibre-length and diameter) of the individual pulps were made. From the present studies, it can be concluded that good quality writing and printing paper from 3 and 5 stage bleached acetic acid jute stick pulp and packing and wrapping paper from the unbleached acetic acid rice straw and bagasse pulp can be produced.
Key words: Jute-stick, rice-straw, bagasse, pulp

Introduction

The idea of acetic acid pulping is relatively a new one. The processes by which pulps are manufactured are generally closed pulping system type where pulps are produced in a big tank like-vessel called digester. In digesters pressure rises with the rise of temperature and vice versa. The present studies on jute-stick, rice-straw and bagasse includes the application of acetic acid alongwith a certain volume of suitable catalytic solution for quick delignification and it is done in a distillation flask. In the process of pulp making in acetic acid solution, there is no high rise of temperature as the pulping is done at atmospheric pressure at the boiling point of acetic acid in a distillation flask of different capacities. Attempts have been made for shorter cooking time than that required at our pulp mills existing in the country. Recovery of chemicals in soda and sulphate and other pulping processes is expensive and time consuming but in acetic acid pulping technique, almost all the acid is recoverable by simple distillation. The recovered acid is used and reused in cycles for years together. Similar is the case with acid catalyst. The process is also free from health hazard.

Due to deforestation, scarcity of woods and bamboos, the main cellulosic raw materials for paper pulp production in our country has begun. So the owners of the paper mills at home has given their attention for making pulp from non woody substances like rice-straw, jute, jute-stick, green and dry whole jute, sugarcane bagasse , etc. It is well known that Bangladesh is an agricultural country and rice is the main food of her people. She is also almost self sufficient in production of paddy and rice therefrom. So a huge quantity of rice-straw is obtained from rice plant. The major portion of rice-straw is mainly used as cattle feed and minor portion is used as fuel by the villagers. Similarly jute-stick and bagasse are also available in huge quantity in our country as agricultural wastes.

Therefore the present studies are made on rice-straw, jute-stick and sugarcane bagasse for their utilization in making good quality pulp for writing, printing, packing and wrapping paper with use of acetic acid and a suitable acid catalyst in minimum cooking time without polluting the environment. As there is no report in literature for making writing, printing, wrapping and packing paper from above agricultural wastes by acetic acid pulping process, so the present studies have been made somewhat in details.

Materials and Methods

Jute-stick, bagasse and rice-straw were cut into pieces of about one centimeter in length and then were sun dried. The moisture content was determined in an electric oven at 105^0C by keeping samples at least for 18 hours. A distillation flask of 3-5 litre capacity was taken and fitted on an oil-bath of wax. All solutions used for analysis of cooking liquor, bleach liquor and determination of permanganate number were prepared from analar grade samples and standardised by convential (TAPPI 1-3, 1969) methods. The unbleached pulp of individual samples was sustained with 0.1% sufranin in order to have distinct vision for 10-15 minutes. The sustained fibres were then washed thoroughly with water to remove the excess staining material and then diluted with distilled water. One or two drops of dilute suspension was mounted on a slide and then covered. The prepared slide was then examined under a PANPHOT universal microscope in a transmitted light. For determination of fibre length and diameter those elementary fibres tappered at both ends were taken into consideration. Two hundred fibres were taken for measurement of length and diameter. The maximum and minimum length and diameter of the 200 fibres were determined and their average was recorded. For determination of fibre length, micrometer eye piece 6X and objective 1 : 3 : 6 were used. About 200 gram (o.d) unbleached and bleached pulps were disintegrated (TAPPI-4, 1969) and beaten (TAPPI - 5, 1969) in a beater for a period of 60 minutes. Samples of pulp-slurry at 0 minute beating time and after each 10-15 minutes internal of time were collected. Standard pulp-sheets were made from collected samples (TAPPI-6, 1969). The sheets were then tested for breaking length, tear factor and burst factor (TAPPI 7-9, 1969). Brightness and freeness of the sheets were also tested (TAPPI 10-11, 1969).

Results and Discussion

The acetic acid jute-stick, rice straw and bagasse pulps were obtained with the use of optimum pulping conditions (Table-1). The bleached yields for jute-stick and unbleached yields for rice-straw and bagasse are higher

than those obtained by Karim (1987, 1988, 1989), Guha (1963) and Jain (1969) by the pulping techniques using soda, sulphate and soda-sulphur processes. The different yields indicated that there was no loss in alpha cellulose and hemicellulose due to right selection of optimum pulping conditions like time, temperature, chemicals of acetic acid, catalytic solution, material-liquor ratio, etc.

Table 1. Optimum pulping conditions for jute-stick, rice-straw and bagasse alongwith unbleached yield and permanganate number

Cellulosic raw material	Acetic acid (ml)	Catalytic solution* (ml)	Temp. ^{0}C	Time (min)	Material liquor ratio	permanganate number	Unbleached yield (%)
Jute-stick	600	25	116±2	30	1 : 6	21	58
Rice-straw	300	7.5	116±2	30	1 : 3	20	51
Bagasse	300	8.0	116±2	60	1 : 3	21	60

* concentrated HCl solution

Table 2. Yield and brightness of acetic acid jute-stick, rice-straw and bagasse pulp

Raw material	Type of pulp	Yield (%)	Brightness (%)
Jute-stick	Bleached HEH*	55	76
	HEHEH	53	79
Rice-straw	Unbleached	62	33
Bagasse	Unbleached	60	41

*E means caustic extraction and H means hypochlorite treatment.

Table 3. Maximum physical properties of the pulp sheets of acetic acid pulps of jute stick, rice straw and bagasse

Raw material	pulp	Maximum breaking length (metre)	Maximum tear factor	Maximum burst factor	Maximum freeness ^{0}SR
Jute-stick	Bleached HEH	5627	87	39	143
	HEHEH	5300	83	35	149
Rice-straw	Unbleached	2262	75	13	65
Bagasse	Unbleached	2827	78	19	73

Table 4. Fibre-length and diameter of jute-stick, rice-straw and bagasse pulp

Raw material	Type of pulp	Average fibre- length mm	Average fibre- diameter mm
Jute-stick	HEH	0.75	0.027
	HEHEH	0.73	0.026
Rice-straw	Unbleached	0.48	0.085
Bagasse	Unbleached	0.98	0.093

The surprising lowering of cooking time of 30 minutes is case of jute-stick from 4-5 hours obtained by Karim and others in soda and sulphate processes, 30 minutes from 2-3 hours by Karim and Islam in case of rice-straw by soda and soda-sulphar processes and 60 minutes from 3-4 hours in case of bagasse by soda process may be due to the use of an appropriate amount of suitable catalytic (HCl) solution which undoubtedly helped in quick delignification.

Permanganate number was found to be 21, 20, 21 respectively for jute stick, rice straw and bagasse pulps which are not high enough for writing and printing paper. This is also in favour of right selection of optimum pulping conditions as given in Table -1.

The unbleached and bleached pulps were beaten for laboratory evaluation of their properties from 0-60 minutes. It was observed from different experiments (Table 5) that the breaking length and burst factors for jute-sticks and bagasse pulps increased upto 60 minutes due to gradual increase in the area of fibres in optical contact. But those in case of rice-straw pulp decreased upto 60 minutes due to gradual decrease in fibre length. The tear factor in all cases increased from 0 to 45-50 minutes beating time after which it decreased all on a sudden also due to decrease in fibre length. The tear factor 87 in case of jute stick 3 stage HEH bleached pulps is higher than those obtained by Morby (1957) and Karim (1989).

The brightness of the acetic acid jute-stick pulp, rice-straw and bagasse pulps of the same origin was respectively 76-79, 33 and 41 for different categories of pulps including writing and printing , wrapping and packing paper (Table 2). The brightness value 76-79 of jute-stick pulp is sufficiently high enough for writing and printing paper whereas that for wrapping and packing paper is not matter of consideration at all.

Table 5 . Laboratory evaluation of acetic acid jute-stick, rice-straw and bagasse pulps.

Cellulosic Raw material	Type of pulps	Beating time (minute)	Breaking length (metre)	Tear factor	Burst factor	Freeness ^{0}SR
Jute-stick	unbleached	00	3516	60	16	100
		10	3609	67	17	104
		20	3717	73	18	111
		30	3823	76	19	116
		40	3914	81	20	122
		50	4010	83	21	128
		60	4112	80	22	134
	bleached	00	5000	68	27	104
	HEH	10	5096	73	29	110
		20	5200	77	31	117
		30	5295	81	33	123
		40	5397	85	35	130
		50	5503	87	37	137
		60	5627	84	39	143
	bleached	00	4730	63	25	108
	HEHEH	10	4803	67	27	115
		20	4897	72	28	121
		30	4893	76	30	129
		40	5092	80	32	135
		50	5207	83	34	142
		60	5300	80	35	149
	unbleached	00	2262	42	13	33
Rice-straw		15	2170	54	12	42
		30	1981	63	10	50
		45	1863	75	08	58
		60	1759	61	06	65
Bagasse	unbleached	00	2309	59	12	43
		15	2430	64	14	51
		30	2549	71	16	58
		45	2677	78	17	65
		60	2827	75	19	73

From Table 5, it is also observed that the freeness increased thoroughly during the beating time in case of acetic acid jute stick, rice straw and bagasse pulps. This is one of the characteristics of short fibre pulps. From the fibre length (Table- 4) and freeness value, jute-stick, bagasse and rice-straw pulps may be considered as short fibres. The results are in good agreement with those of Morby (1957) and Karim (1989).

Good quality writing and printing paper can be obtained from both 3 and 5 stage bleached acetic acid jute-stick pulps. Wrapping and packing paper may also be obtained from the unbleached pulp of the same origin.

Unbleached acetic acid pulp of rice-straw is suitable for wrapping and packing paper.

Wrapping and packing paper can be made from unbleached pulp of bagasse by using acetic acid pulping technique.

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