Bleaching of Kraft Pulp Using Enzyme - Laboratory Investigations

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ABSTRACT: *Xylanase enzymes have been widely reported to improve the effectiveness of conventional bleaching chemicals in removing lignin from the pulp. The laboratory trials were carried out on bleaching of captive unbleached kraft pulp with xylanase called BLEACHZYME-F. It is found that treatment of unbleached pulp with Bleachzyme-F, prior to bleaching, is effective in bringing up the brightness of bleached pulp and reduction in chlorine consumption in the conventional bleaching. 1 kg. of Bleachzyme-F per metric tonne of unbleached pulp helped to acheive 79% brightness pulp with reduction of 25% of chlorine in the chlorination stage of conventional bleaching. The strength properties of enzyme treated bleached pulps are better than untreated bleached pulps of similar brightness level.*

INTRODUCTION

There is a growing interest in the enzymatic treatment of unbleached kraft pulp to improve bleachability and reduce chemical consumption in the conventional bleaching process. Enzymes are proteins with catalytic properties. They are the catalysts with a very specific action. Each kind of enzyme will only catalyse reactions involving one particular type of chemical bond. Other bonds are unaffected.

Xylanase enzymes have been widely reported to improve the effectiveness of conventional bleaching chemicals in removing lignin from kraft pulp. Xylanase enzymes partially hydrolyse the hemi-cellulose portion of pulp. The enzyme treatment is presumed to hydrolyse xylan into smaller fragments allowing lignin associated with these short hemi-cellulose chains to be more easily removed through subsequent chlorination and alkali extraction stages.

BLEACHZYME-F is essentially a xylanase and a bleach boosting agent which is the product of M/s. Biocon India Ltd., Bangalore. The laboratory trials were taken up on bleaching of captive kraft pulp using Bleachzyme-F. The optimum pH level of unbleached pulp for enzyme treatment, optimum enzyme requirement for brightness gain and the strength properties of bleached pulps are studied in the laboratory trials.

RESULTS AND DISCUSSION

A. The test results in Table no. 1 reveal that--

1. Bleachzyme-F acts as a bleach boost and effective in increasing brightness of pulp in comparison with untreated bleached pulp.
2. The activity of Bleachzyme-F is more effective when unbleached pulp is treated at a pH of 6.0.

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3. There is brightness gain of 3 points for enzyme bleached pulp compared to the control test.
4. There is not considerable change in the strength properties of enzyme bleached higher brightness pulps compared to the blank run lower brightness pulp.
5. There is a marginal increase in viscosity of enzyme bleached pulp, compared to the control test pulp.

Table-1.

Bleaching of Unbleached Kraft Pulp using Bleachzyme-F by Varying pH.

		Control	Expt.1	Expt.2	Expt.3
I PRETREATMENT STAGE:					
Unbleached pulp,	g.	50	50	50	50
pH of unbleached pulp		8.6	7	6	5
H_2SO_4 addition,	%	-	0.2	0.35	0.51
ENZYME	%	-	0.1	0.1	0.1
II. CHLORINATION STAGE:					
Chlorine,	%	6	6	6	6
Residual chlorine	%	0.08	0.05	0.045	0.034
Kappa Number		14.7	14.0	13.7	13.4
III. CAUSTIC EXTRACTION STAGE:					
Caustic,	%	2	2	2	2
IV. HYPOCHLORITE STAGE:					
Hypochlorite,	%	5	5	5	5
A. BRIGHTNESS OF BLEACHED PULP,	%	80.7	82.4	83.2	83.7
B. STRENGTH PROPERTIES OF BLEACHED PULPS:					
PFI rev.		2000	2000	2000	2000
Freeness, ml.		290	290	300	285
Burst Factor		37.5	37.8	37.3	37.8
Breaking length, m.		7030	7070	6920	7075
Tear Factor		50.6	49.3	49.5	48.5
Double Folds		52	50	48	45
C. VISCOSITY, cp.		5.76	5.97	6.47	6.02

B. Test results in Table No. 2 show that--

1. With the increased addition of enzyme, there is increase in brightness of pulp. The optimum enzyme dosage required can be inferred as 0.1% or 1 Kg. per tonne of unbleached pulp.

Table-2.

Bleaching of Unbleached Kraft Pulp by Varying Addition of Bleachzyme-F.

		Control	Expt.1	Expt.2	Expt.3	Expt.4
I PRETREATMENT STAGE:						
Unbleached pulp,	g.	50	50	50	50	50
Unbl. pulp pH		8.6	6	6	6	6
ENZYME	%	Nil	0.05	0.075	0.1	0.15
II. CHLORINATION STAGE:						
Chlorine,	%	6	4.5	4.5	4.5	4.5
Kappa Number		14.5	15.5	15.2	14.9	15.0
III. CAUSTIC EXTRACTION STAGE:						
Caustic,	%	2	2	2	2	2
IV.HYPOCHLORITE STAGE:						
Hypochlorite,	%	4	4	4	4	4
A. BRIGHTNESS OF BLEACHED PULP,%		79.2	77.2	78.1	79.1	79.3
B. STRENGTH PROPERTIES OF BLEACHED PULPS:						
PFI rev.		2500	3200	3200	3100	3100
Freeness, ml.		320	310	325	315	300
Burst Factor		43.1	46.9	47.0	46.9	47.3
Breaking length, m.		6860	7750	7610	7960	7930
Tear Factor		71.7	74.9	73.7	73.6	74.1
Double Folds		278	386	405	294	310
C. VISCOSITY, cp.		7.5	8.3	8.5	8.4	8.3

General Parameters maintained for Bleaching Expts. given in Table No. 1 and No. 2:

	Consistency	Temp. degree C	Retention time min.
Pretreatment stage	8	40	120
Chlorination stage	4	Amb.	45
Extraction stage	8	60	60
Hypochlorite stage	8	40	90

KAPPA NUMBER OF EXPERIMENTAL UNBLEACHED PULP USED FOR ALL THE BLEACHING EXPTS. = 25.9

RAW MATERIAL: USED FOR UnBLEACHED PULP
BAMBOO + HARDWOOD (40 : 60)

2. When enzyme treated and untreated pulps of similar brightness are compared, enzyme treated pulps indicate lower chlorine requirements to reach the same brightness level.
3. 25% less chlorine is required in chlorination stage for enzyme treated pulps to reach the same brightness level of untreated pulps.
4. The viscosity and strength properties of enzyme treated pulps are better than the untreated pulps of similar brightness (Fig. 1).

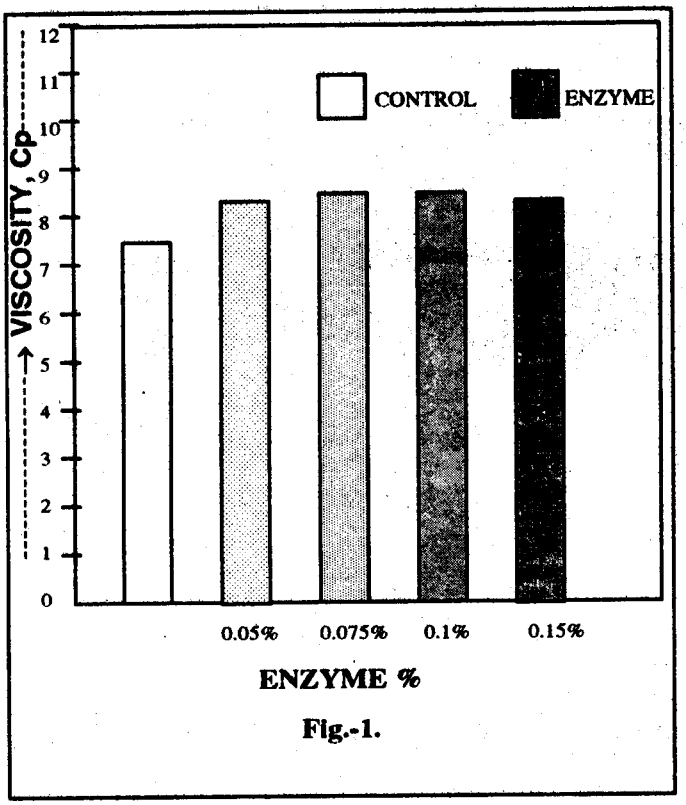

Fig.-1.

CONCLUSION

a- Pretreatment of unbleached kraft pulp with Bleachzyme-F prior to bleaching is effective in bringing up the brightness of bleached pulp, reducing chlorine consumption in the chlorination stage of bleaching.

b- 25% less chlorine is required in chlorination stage of bleaching by pretreating the unbleached pulp with Bleachzyme-F.

c- The Bleachzyme-F requirement for the pretreatment of unbleached pulp prior to bleaching is 0.1%.

d- The viscosity and strength properties of Bleachzyme-F treated pulps are better than untreated bleached pulps of similar brightness level. There is 9% increase in Burst Factor, 16% increase in Tensile strength, and 12% increase in viscosity for enzyme treated pulps.

EXPERIMENTAL WORK

For the purpose of laboratory bleaching experiments, captive unbleached pulp from final brown stock washer of kraft mill was collected. A representative portion from this pulp was tested for Kappa number, Brightness, consistency and remaining portion was used for the bleaching experiments. Two sets of experiments were carried out.

Set-I To find out the optimum pH level of unbleached pulp for better activity of enzyme.

Set-II To find out optimum enzyme requirement to obtain required brightness level pulp.

I. Bleaching of pulp to find out the optimum pH level of unbleached pulp for better activity of enzyme

As the activity of enzyme varies with the pH of pulps, experiments were carried-out to find out the optimum pH level of unbleached pulp for better activity of enzyme. 50 g. of unbleached pulp for each experiment was taken in a double layer polythene bag. The consistency of pulp in the bag was adjusted to 8%. Dilute sulphuric acid was added to pulp samples to obtain pH of 7, 6 and 5. Desired amount i.e. 0.1% (1 Kg/t) Bleachzyme - F was added to each experimental pulp sample and mixed well. A retention time of 2 hours at 40 degree C was allowed. The pulp after enzyme treatment were taken for bleaching without washing. Further, bleaching was carried-out following conventional CEH sequence.

For comparison, a blank / control bleaching experiment was carriedout maintaining all the parameters identical but without pretreatment of unbleached pulp with enzyme. The experimental parameters, the test results obtained in the control and other bleaching experiments are given in Table No.1

II. Bleaching of pulp to find out the optimum enzyme requirement to obtain required brightness

It was observed in the I-set of bleaching experiments that the enzyme activity was optimum at 6 pH of unbleached pulp. It also indicated that the chlorine requirement was less for enzyme bleached pulps. Hence, further bleaching experiments were carriedout on unbleached pulp with 6 pH to find out optimum enzyme requirement for obtaining required brightness level bleached pulp.

Series of bleaching experiments were carriedout by treating unbleached pulp with varying dosages of enzyme, and then bleaching with the conventional CEH bleaching sequence. For comparison a control bleaching experiment following CEH sequence was also carriedout but without the enzyme treatment of unbleached pulp.

The experimental conditions, the test results obtained for all the experiments are given in Table No. 2.

ACKNOWLEDGEMENT

The authors express their gratitude to the Chairman & Managing Director, Sri Vijay Gore, who initiated and inspired to take up this study to find the usefulness of enzyme in bleaching of Kraft pulp.

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