

Table 1 Effects of single acid and alkali pre-treatments on important textile related properties of jute-cotton (J/C) union fabric

Treatments	Weight loss (-) or gain (+) %	Treatment shrinkage %		Initial modulus N/mm		Tenacity cN/tex		Breaking extension %		Total CRAa (Warp+ Weft) degree	Bending length cm		Surface appearance properties			K/S value at λmax			
		Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)		Warp (Cotton)	Weft (Jute)	WI ^b	YI ^c	BI ^d	Before dyeing	After dyeing with		
																	Acid dye	Reactive dye	Basic dye
Nil (Raw control J/C Fabric)	-	-	-	30	98.6	5.04	8.42	12.24	4.02	145	1.7	4	52.1	34	25.4	1.2	13.26	12.84	10.84
Treatment with dilute aqueous solution of different acids at 30° C for 30 min using MLR 1:10.																			
1% HCl	(-) 2.10	7.2	3.6	26.4	81.4	4.84	7.94	11.2	3.58	122	1.3	3.3	51.8	36.4	29.6	1.3	-	-	10.96
1% Acetic Acid	(-) 1.52	9.5	2.6	27.6	82.6	4.78	8.14	11.62	3.9	124	1.4	3.4	50.4	37.2	26.9	1.36	-	-	10.89
1% Formic Acid	(-) 2.25	10.4	2.9	25.6	83.4	4.68	7.86	11.62	3.72	124	1.3	3.4	50.9	37.5	26.2	1.34	-	-	11.04
1% Citric Acid	(+)0.48	10.5	3.7	29.2	90.2	4.52	7.74	10.64	3.54	154	1.4	3.6	52	36.1	27.4	1.38	-	-	11.88
Treatment with aqueous solution of NaOH at 30° C for 30 min using MLR 1:20.																			
1% NaOH	(-) 3.02	9.4	0.85	30.5	80.8	4.82	7.46	13.64	6.08	140	1.6	3.8	49.4	37.6	23.2	1.3	13.42	12.96	-
5% NaOH	(-) 6.14	11.2	2.9	32.1	70.8	4.6	6.9	15.04	9.26	136	1.5	3.6	45.1	42.4	21.6	1.46	13.98	13.24	-
10% NaOH	(-) 8.64	13.2	7.54	35	65.8	4.34	5.64	17.24	15.04	130	1.4	3.4	38.2	45.5	18.6	1.82	14.64	13.62	-
18% NaOH	(-)12.46	15.6	14.68	40.04	60.4	4.84	5.04	19.27	18.8	125	1.2	2.8	34.4	49.4	16.4	1.98	15.08	14.14	-

^aCrease recovery angle, ^bWI-whiteness index, ^cYI-yellowness index, ^dBI-brightness index

Table 2 Effects of different dosages of citric acid pretreatment on important textile related properties of jute-cotton (J/C) union fabric

Treatments	Weight loss (-) or gain (+)	Treatment Shrinkage %		Initial modulus N/mm		Tenacity cN/tex		Breaking extension %		Total cra a (Warp+ weft) degree	Bending length cm		Surface appearance properties			K/S value at λmax			
		Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)		Warp (Cotton)	Weft (Jute)	WI ^b	YI ^c	BI ^d	Before Dyeing	After Dyeing		
																		Acid dye	Reactive dye
Nil (Raw control J/C fabric)	-	-	-	30	98.6	5.04	8.42	12.24	4.02	145	1.7	4	52.1	34	25.4	1.2	10.84		
Treatment with dilute aqueous solution of Citric acid using varying concentrations of citric acid and varying treatment time as follows :																			
0.5% Citric Acid Treatment at 30°C for 30 min.	0.24	10.2	3.4	29.9	94.2	4.81	7.98	11.12	3.84	148	1.5	3.7	50.2	37.3	27.1	1.26	11.46		
Treatment with 1% Citric acid solution at 30°C for varying treatment period as follows :																			
- 15 min	+ 0.32	10.3	3.6	29.6	92.4	4.74	7.9	11.02	3.68	152	1.4	3.6	51.9	36.3	27.3	1.32	11.65		
- 30 min	+ 0.48	10.5	3.7	29.2	90.2	4.52	7.74	10.84	3.54	154	1.4	3.5	52	36.1	27.4	1.36	11.88		
- 60 min	+ 0.62	10.8	3.8	28.6	86.4	4.44	7.62	10.62	3.24	158	1.3	3.4	52.4	37.8	27.7	1.4	11.94		
- 120 min	+ 0.74	11.2	4	26.9	84	4.28	7.64	10.49	3.06	164	1.2	3.3	52.6	37.6	27.8	1.42	12.28		
1.5% Citric Acid Treatment at 30°C for 30 min.	0.54	11	4.1	27.2	80.2	4.26	7.6	10.48	3.32	156	1.3	3.3	51.4	37.4	27.9	1.44	12.64		
2% Citric Acid Treatment at 30°C for 30 min.	0.82	11.4	4.2	26.8	79.4	4.2	7.12	10.34	3.14	160	1.2	3.2	50.4	37.6	28	1.46	13.18		

^aCrease recovery angle, ^bWI – whiteness index, ^cYI-yellowness index, ^dBI-brightness index, ^eusing MLR 1:10, ^fAfter dyeing with 1% basic dye (Auramine-O, C.I. Basic yellow 2)

Table 3 Effects of treatment with single cellulase enzyme on important textile related properties of alkali pretreated and bleached or sequentially or both alkali pretreated and bleached jute-cotton (J/C) union fabric

Treatments	Weight loss (-) or gain (+)	Initial modulus N/mm		Tenacity cN/tex		Breaking extension %		Total cra a (Warp +weft) degree	Bending length cm		Surface appearance properties			K/S value at λmax)		
		Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)		Warp (Cotton)	Weft (Jute)	WI ^b	YI ^c	BI ^d	Before dyeing	After dyeing with	
																Acid dye
Nil (Raw Control J/C fabric)	-	30	98.6	5.04	8.42	12.2	4.02	145	1.7	4	52.1	34	25.4	1.2	13.26	12.84

5% NaOH at 30°C for 30 min.	(-) 8.14	32.1	70.8	4.6	6.9	15	8.01	135	1.5	3.6	45.1	40.4	21.6	1.46	14.78	13.24
2% H2O2 Bleaching at 85°C for 2h	(-) 5.25	28.4	48.4	4.77	7.27	13.5	4.7	150	1.6	3.8	72.4	18.6	44.2	0.42	12.64	10.4
Sequential Pretreatment with 5% NaOH at 30°C for 30 min. followed by 2% H2O2 Bleaching at 85°C for 2h.	(-) 14.54	29.5	42.5	4.31	6.42	16.2	8.4	140	1.3	3.4	68.3	25.2	39.6	0.61	13.85	13.46
Treatment with specified doses of single cellulase enzyme on dilute alkali (5% NaOH) pretreated J/C fabric																
4% (owf) cellulase Enzyme (35 unit/ml)	(-) 2.2	28.7	60.3	4.4	6.3	16.1	8	142	1.4	3.4	46.8	38.2	24.8	1.52	14.62	13.64
Treatment with specified doses of single cellulase enzyme on conventional 2% H2O2 bleached J/C fabric																
4% (owf) cellulase Enzyme (35 unit/ml) on 2% H2O2 Bleached J/C Fabric	(-) 3.6	24.8	40.8	4.54	6.94	14.6	5.1	155	1.5	3.5	71.6	16.6	44.7	0.48	12.78	10.18
Treatment with specified dosages of single cellulase enzyme on sequentially pretreated J/C fabric using 5%NaOH pretreatment followed by conventional 2% H2O2 bleaching																
4% (owf) Cellulase Enzyme (35 unit/ml)	(-) 2.5	26.4	37.5	4.11	6.2	17.1	8.6	145	1.2	3.3	70.6	24.1	41	0.65	13.4	13.01
Treatment with specified doses of single cellulase enzyme on sequentially pretreated J/C fabric using 1% HCl pretreatment followed by conventional 2% H2O2 bleaching																
4% (owf) Cellulase Enzyme (35 unit/ml)	(-) 2.0	21.2	41.4	4.2	6.42	13	5.64	134	1.2	3.2	69.3	22.8	46.5	0.6	13.77	11.45
Treatment with specified doses of single cellulase enzyme on sequentially pretreated J/C fabric followed by conventional 1% citric acid pretreatment followed by conventional 2% H2O2 bleaching																
4% (owf) Cellulase Enzyme (35 unit/ml)	(-) 1.8	24.4	49.6	4.1	6.34	12.7	7.1	165	1.3	3.3	68.4	25.2	43.5	1.26	13.03	10.92

Specified condition of treatment with all type of enzymes: Temp-55±5°C, time-2h, pH-4.8-5.0 adjusted with Na-acetate and acetic acid buffer

^aCRA-Crease recovery angle, ^bWI- whiteness index, ^cYI-yellowness index, ^dBI-brightness index

Table 4 Effects of treatment with single and mixtures of cellulase enzyme and mixture of cellulose enriched mixed enzymes on important textile related properties of alkali pretreated and bleached or sequentially or both alkali pretreated and bleached jute-cotton (J/C) union fabric

Treatments	Weight Loss (-) or gain (+)	Initial modulus N/mm		Tenacity cN/tex		Breaking extension %		Total CRAa (warp +weft) degree	Bending length cm		Surface appearance [properties]			K/S Value at λmax		
		Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)	Warp (Cotton)	Weft (Jute)		Warp (Cotton)	Weft (Jute)	WI ^b	YI ^c	BI ^d	Before dyeing	After dyeing with Acid dye Reactive dye	
Nil (Raw control J/C Fabric)	-	30	98.6	5.04	8.42	12.2	4.02	145	1.7	4	52.1	34	25.4	1.2	13.26	12.84
Treatment with 4% (owf) overall dosages of a mixture of cellulase (C), xylanase (X) and pectinase (P) in the following ratios (Gradually increasing cellulase content) on conventional 2% H2O2 bleached jute-cotton union fabric																
C: X: Pe																
35:96:136	(-)3.9	23.4	35.8	4.4	6.82	14.9	5.6	158	1.4	3.5	72	15.2	47.9	0.46	12.78	9.68
70:96:136	(-)4.1	22.5	30.1	4.32	6.65	15.2	6	160	1.3	3.4	72.5	14.5	48.1	0.46	12.82	9.06
105:96:136	(-)4.4	20.8	26.3	4.26	6.48	15.8	6.2	165	1.2	3.2	72.8	14.2	48.2	0.45	12.88	9.28
140:96:136	(-)4.6	18.2	21.6	4.13	6.26	16	6.4	166	1.1	3.1	73.1	13.6	48.4	0.44	12.96	9.32
175:96:136	(-)5.0	16.4	21.5	4.05	6.1	16.5	6.5	170	1	3	73.5	13.1	48.5	0.46	13.06	9.37
210:96:136	(-)5.1	16	20.2	3.95	6.02	16.6	6.5	172	1	3	73	13.9	48.6	0.52	13.1	9.4
Treatment with specified dosages of cellulase enriched specified mixed enzyme on 5% NaOH pretreated J/C union fabric with mixed enzyme having C:X:P ratio of enzyme as follows																
C : X : P 175 : 96 : 136	(-) 3.8	24.2	54.4	4.23	6.2	16.5	7.6	150	1.2	3.2	48.2	37.1	26.2	1.44	14.86	13.84
Treatment with specified doses of cellulase enriched specified mixed enzyme on 5% NaOH pretreated followed by conventional 2% H2O2 bleaching of J/C union fabric with mixed enzyme having C:X:P ratio of enzyme as follows:-																
C : X : P 175 : 96 : 136	(-) 5.1	24.2	33.2	4.02	6.1	18.1	9	155	1	3	70	21.2	43.1	0.6	13.1	12.9
Treatment with specified doses of cellulase enriched specified mixed enzyme on 1% HCl pretreated followed by conventional 2% H2O2 bleaching of J/C union fabric with mixed enzyme having C:X:P ratio of enzyme as follows:-																
C : X : P 175 : 96 : 136	(-) 3.5	23.4	44.34	4.1	6.25	14.5	6.2	140	1.1	3.1	71.1	21.2	47.5	0.56	14.45	11
Treatment with specified doses of cellulase enriched mixed enzyme on 1% citric acid pretreated followed by conventional 2% H2O2 bleaching of J/C union fabric with mixed enzyme having C:X:P ratio of enzyme as follows:-																
C : X : P 175 : 96 : 136	(-) 3.0	22.2	46.8	4.02	5.9	13.5	7.8	170	1.3	3.3	69	23.6	41.2	1.12	13.5	10.7

Specified condition of treatment with all type of enzymes: Temp-55±5°C, time: 2h, pH4.8-5.0 adjusted with Na-acetate and acetic acid buffer

^aCRA - Crease recovery angle, ^bWI-whiteness index, ^cYI-yellowness index, ^dBI-brightness index, ^eC, X, P-cellulase : xylanase : pectinase

