Performance Of Non-Formaldehyde Crosslinking Agents Versus Formaldehyde-Based Crossing Agents

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Abstract

Result of studies in the application of a non-formaldehyde crosslinking agents, Natrium-CRA, under different conditions are reported and durability of the crease recovery on washing evaluated. Comparison has also been made of the performance of Natrium-CRA with that of other non-formaldehyde and formaldehyde based crosslinking agents. Enzymatic hydrolysis of the crosslinked cellulose obtained through application of Natrium-CRA was studied using a cellulase enzyme to indicate resistance to enzyme action due to the formation of crosslinks in the fiber substance.

Introduction

Due to the toxic nature of formaldehyde, use of crosslinking agents based on formaldehyde for imparing crease resistance to cellulosic textiles have been restricted in several countries. In recent years, several companies have commercialized non-formaldehyde or low-formaldehyde crosslinking agents to meet the specific requirements of the customer. Such products have been reported in the literature.

In a previous Publication[1] preliminary work on the application of two non-formaldehyde crosslinking agents Natrium-NFO and Natrium-CRA, for cotton and polyester-cotton blends has been reported while subsequent work deals with the effects of Natrium-CRA2 in combination with a booster on the crease recovery and other characteristics of treated fabrics, both undyed and dyed with reactive, vat and disperse dyes.

Table I : Properties of Natrium-CRA treated cotton fabrics in the absence and presence of Booster-CMW.

Conc. of Natrium -CRA g/l	Conc. of. Booster -CMW g/l	Before wash Crease-recovery angle			After Wash Crease-recovery angle			Before Wash Tear Strength kg	
		WP	WT	Total	WP	WT	Total	WP	WT
Control	–	89	93	182	82	88	170	1.13	0.96
50	–	102	106	208	95	93	188	1.13	0.86
50	3.75	113	114	227	92	99	191	1.13	0.96
100	–	110	113	223	94	104	198	1.13	0.93
100	7.50	111	119	230	102	101	203	0.96	0.74
150	–	114	113	227	97	104	201	1.02	0.80
150	11.25	127	126	253	109	111	220	0.64	0.54

Table II : Performance of Natrium-CRA and Booster CMW treated cotton fabric and other non-formaldehyde and DMDHEU-based crosslinking agents

Finish	Conc. of. Product g/l	Before wash Crease-recovery angle			After Wash Crease-recovery angle			Before Wash Tear Strength kg	
		WP	WT	Total	WP	WT	Total	WP	WT
Control	–	89	93	182	82	88	170	1.13	0.96
Natrium-CRA	50	102	106	208	95	93	188	1.13	0.86
Non-formaldehyde	50	97	103	200	95	96	191	1.13	0.96
Crosslinking agent									
DMDHEU (A)	50	96	99	195	88	91	179	1.02	0.86
DMDHEU (B)	50	98	105	203	94	95	189	0.99	0.70
Natrium-CRA	100	110	113	233	94	104	198	1.13	0.80
Non-formaldehyde	100	102	103	205	98	102	200	1.13	0.96
Crosslinking agent									
DMDHEU (A)	100	110	107	217	100	103	203	0.99	0.83
DMDHEU (B)	100	114	118	232	112	108	220	0.77	0.70
Natrium-CRA	150	114	113	227	97	104	201	1.02	0.80
Non-formaldehyde	150	105	105	210	98	103	201	1.13	0.96
Crosslinking agent									
DMDHEU (A)	150	101	111	212	94	102	196	0.86	0.80
DMDHEU (B)	150	124	118	242	116	123	239	0.64	0.48

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Table III : Effect of "Cellulase" enzyme on cotton fabric with combination of Natrium-CRA and Booster-CMW.

Conc. of Natrium -CRA g/l	Conc. of Booster -CMW g/l	Reducing sugars, ug/ml				
		Time of Enzyme action, min				
		60	120	180	240	300
Control		2060	3546	4766	4986	5223
50	–	1350	1745	2120	2398	2726
50	3.25	755	1065	–	1475	1680
100	–	1255	1700	2125	2335	3048
100	7.50	555	775	–	900	1050
150	–	1085	1415	1875	1975	2210
150	11.25	475	460	–	660	690

In the present study, investigation has been made in the application of Natrium-CRA in combination with a booster under different conditions to impart durable crease recovery to cotton fabric. Comparison has also been made of the performance of the product developed with other commercially available formaldehyde-based and non-formaldehyde crosslinking agents.

Experimental methods

Mill desized, scoured, bleached and mercerized cotton fabric was selected for the study.

Natrium-Cra along with Booster CMW both of Supertex (India) Corporation was applied to the fabric in different proportions by padding at 80% expression followed by drying at 100°C for 3 min. Similar procedures were adopted for the application of other formaldehyde based non-formaldehyde crosslinking agents commercially available.

Treated fabrics were evaluated for crease recovery determined according to AATCC Test No. 66-1968 before and after washing with 5 g/l anionic soap and 2 g/l soda ash at 60°C for 30 min. Tear strength of the treated fabric was determined as per ASTM Standard 1424-83 (falling pendulum tear strength test).

Enzymatic hydrolysis of control and treated fabrics was carried out with a cellulase enzyme "Cellusoft" manufactured by Novo Nordisk, Denmark at pH 4.8 and temperature 50 ± 1°C for different durations in "Polycolor" beaker-dyeing machine at liquor : material ratio of 15:1. Reducing sugars formed as a result of hydrolysis were determined according to the method suggested by somogly and Nelson[3].

Absorbency of the treated fabric was determined by the Drop Test Method-AATC-79-1975. The fabric was mounted on an embroidery frame (6" diameter) and water drops allowed to fall on the fabric from a distance of 2.cm. The stop watch is started as soon as the drop falls on the fabric and stopped as soon as the drop is completely absorbed by the fabric.

Results and Discussion

Action of Booster-CMW on properties of Natrium-CRA treated cotton fabric.

Natrium-CRA was applied to cotton fabric at different concentrations in the presence of optimum levels of Booster-CMW and crease recovery before and after wash as well as tear strength of the treated fabric have been determined (Table I). It is observed that the presence of Booster enhances crease recovery of the treated fabric. Retention of crease recovery is also better in the washed fabric when Booster-CMW is applied along with Natrium-CRA. Loss in tear strength is within a tolerance limit up to 100 g/l concentration of Natrium CRA applied to the fabric.

Comparison of properties of Natrium-CRA treated fabrics with commercially available non-formaldehyde and DMDHEU-treated fabrics.

When comparison is made of the performance of Natrium-CRA along with Booster-CMW (7.5% of Natrium-CRA) with another non-formaldehyde cross-linking agent commercially available and also with conventional DMDHEU type finishing agents, it is observed that equivalent crease recovery can be abtained with Natrium-CRA, and the effect is equally durable to washing as in the case with other products (Table II). Retention of tear strength of the treated is to some exetent better in the case of Natrium-CRA treated fabric for equivalent improvement increase recovery.

Action of cellulase enzyme on fabrics treated with Natrium-CRA in the absence and presence of Booster-CMW.

It is known that enzyme action on cellulosic fabric treated with crosslinking agent is considerably reduced due to intermolecular crosslinking of cellulose chains. When comparison is made of the amount of reducing sugars formed as a result of cellulase enzyme action on the substrate for different duration, it is observed that Natrium-CRA treated fabrics show a reduction in enzyme action, and when this product is applied along with Booster-CMW there is a substantially further reduction in the extent of enzyme action (Table III).

This is mainly due to effective crosslinking of adjacent cellulose chains in the fabrics by the combined action Natrium-CRA and Booster-CMW. Further, the extent of resistance to enzyme action is almost similar in the case of this combination as compared with formaldehyde-based crosslinking agents and better than commercial non-formaldehyde crosslinking agent (Table IV). Natrium-CRA crosslinked fabric shows better water absorbtivity (12.92. Sec.) when tested by the spot test method as compared with the other non-formaldehyde product tested (More than 10 min.) (Table V).

Table IV : Effect if "Cellulase" enzyme on cotton fabric treated with Natrium-CRA and other non-formaldehyde and DMDHEU -based crosslinking agent.

Composition of Product	Reducing sugars, ug/ml			
	Time of enzyme action, min			
	60	120	240	300
Control	2060	3546	4986	5223
Natrium-CRA (100 g/l) +Booster-CMW (7.5 g/l)	555	775	900	1050
Non-formaldehyde crosslinking agent (100 g/l)	1035	1765	2375	2933
DMDHEU (A) (100 g/l)	600	620	730	750
DMDHEU (B) (100 g/l)	295	320	380	430

Table V : Absorbency test results.

100 gpl - Finished fabric	Drop Absorbency Time, Sec	ph of 100 gpl sol'n pH paper	pH- meter
Control (No-Finish)	2.50	–	–
DHDHEU (A)	8.25	4-5	3.59
DMDHEU (B)	1.13	4-5	3.80
Natrium-CRA	7.80	4-5	3.17
Natrium-CRA +Booster CMW (7.5 gpl) Non-formaldehyde Crosslinking agent	12.92	2-3	2.22
	More than 10 min	4-5	3.23

Conclusions

Treatment of cotton fabrics with combination of a non-formaldehyde cross-linking agent, Natrium-CRA along with Booster-CMW imparts to cotton fabrics improved crease-recovery which is sufficiently durable to washing. Losses in tear strength suffered by the treated fabrics is within the acceptable limits for creaseresistent fabrics. Performance of fabrics treated with this combination is comparable to that of fabrics treated with some non-formaldehyde and formaldehyde-based product commercially available. Action of cellulase enzyme is considerably reduced in the case of treated fabrics due to the formation of intermolecular crosslinking of cellulose chains in the fabric substance.

References

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