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Research Article

Investigation on the Physical Properties of 100% Cotton Knit Fabric by Treating with Crossslinking Agents

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Abstract

Application of crosslinking agent to impart wrinkle recovery property on cotton fabrics is very popular for textile industry. This paper represents the effect of different crosslinking agent on the physical properties and the wrinkle recovery of cotton knit fabric. Here five different types of crosslinking agent from three different chemical companies were used. The work was divided into two parts .At first; crosslinking agents were applied on cotton fabric than various related tests were done on the treated and untreated fabric. Better crease resistancy was found on the finishing agent having high formaldehyde content .The other important properties like tensile strength, dimensional stability, stiffness, abrasion resistance pilling resistance and areal density was studied here. Among them some properties were improved and some were fall down.

Keywords: *Cotton, Crosslinking agent, Formaldehyde content, Crease, Bursting strength*.

1. Introduction

Cotton is a natural fibre of great economic importance as a raw material for cloth. It is nearly pure cellulose, which is the most abundant organic polymer with the formula $(C_6H_{10}O_5)n$ on Earth and it is a polysaccharide consisting of a linear chain of several hundred to over ten thousand β(1→4) linked D glucose units (Saleemuddin 2013) .In textile industry, cotton is still one of the most preferred fibers because of its own natural and distinctive properties like strength, absorbency, comfortably, biodegradability and easy to wash and dye etc .But it has a inherent drawbacks such as tendency to crease formation and poor crease recovery. Cotton fabric is particularly prone to wrinkling because of the hydrogen bonding holds cellulose fibers together. But under stress these bonds can shift and hold fabrics in a new orientation, particularly when cotton is wet. Water molecules lubricate the cellulose chains and disrupt hydrogen bonding thus allowing them to shift more easily under stress. When the fabric is dried, the cellulose retains its new shape as the hydrogen bonds reform in a new configuration (Gary C Lickfield 2001). This problem has been overcome by covalently bonding the cellulose chains together, forming covalent bonds that are not disrupted by water. Treatment with crosslinking agent was mainly used for this purpose. Formaldehyde-based crosslinking agent is the dominant products used in industry. These products provide excellent wrinkle resistance and durable press performance. They also produce several adverse effects (H. Petersen 2008). They reduce the strength of the fabric. They increase the stiffness of the fabric and cause yellowing. These properties considerably reduce the wear and abrasive properties of treated fabrics. They also release formaldehyde over time, which is undesirable since formaldehyde is a suspected human carcinogen. There has been considerable effort to develop a product that could provide wrinkle resistant and durable press performance without these adverse effects. In previous time several research work has been done on crease resistance finishing by CLA (crosslinking agent) application, where several property changes has been investigated on treated fabric. On this work we selected cotton knit fabric to investigate the overall physical property after CLA application.

1.1 Crosslinking of resin with cottons

Wrinkles form in cotton fabrics due to the free hydroxyl groups. Cotton is a form of cellulose chains linked to form firm three-dimensional structures that offer both tensile strength and flexibility due to their carbon-carbon and carbon-oxygen bond-based backbone. Since cellulose is composed of glucose units, cyclic carbohydrate molecules, cellulose has free hydroxyl groups (-OH) projecting from each nonnumeric subunit (W D Schindler and P J). Hauser these hydroxyl groups tend form hydrogen-bonds to neighboring hydroxyl groups. When the fabric is

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stressed either by heat or pressure, the original hydrogen bonds in the cotton fabric break and reform with nearby atoms at random. This re-forming of the hydrogen bonds, known as cross linking, is the reason for wrinkles, or creases, in the fabric. Crosslinker works to prevent these wrinkles by covalently bonding to two free hydroxyl groups in the fabric through a dehydration reaction that is not as easily broken as the hydrogen bond before treatment.

2. Materials and Method

2.1 Fabric

Cotton fabric of knit structure was used for this work. 100% cotton knit fabric has been scoured, and bleached from Ahsan knit composite Ltd (Bangladesh) . Fabric specification is given below

Fiber content	100 % Cotton fabric
Fabric structure	Single jersey
Fabric weight	146 g/m^2
Yarn count	30Ne

2.2Chemicals

Five different crosslinking agents (CLA) from Archroma, Swiss colour and Oriont chem was used.

Table 1: Different cross linking agent

Name **of CLA**	**Manufacturer**
Arkofix ELF	Ultra-low formaldehyde CLA from Archroma
Arkofix NETLF	Low formaldehyde containing CLA from Archroma
Fixaprate CL	Low formaldehyde CLA from BASF
Melamin GO 6	Melamine formaldehyde CLA from Orient chem
Knitex FFRO	Zero formaldehyde easy care finish from Swiss colour

2.3Auxiliaries

- Catalyst NKC Liq
- Acetic Acid (CH_3COOH)

2.4 Equipments

The fabric was padded using a werner mathis AG padding machine. Batch drying was performed in a Werner Mathis AG forced air curing oven. Continuous drying was performed in a Werner Mathis AG dryer. Several machine was also used for testing purpose such as crease recovery angle tester, washing machine, martindale abrasion and pilling tester, Brustinng strength tester by james heal, GSM cutter and shierly stiffness tester.

2.5 Procedure

In this work five different type of Crosslinking agent was used according to below recipe. The resin was applying on fabric by pad dry and cures method. Then several qualitative and quantitative tests were carried out on untreated and treated sample. The untreated fabric was express by control .The other CLA treated sample was express by CLA 1 for Arkofix ELF, CLA 2 for Arkofix NETLF, CLA 3 for Fixaprate CL, CLA 4 for Melamin GO 6, CLA 5 for Knitex FFRO . Below recipe was used to prepare working solution by five crosslinking agents.

Table 2: Recipe for application

Cross Linking Agents	100g/l
Catalyst (Catalyst NKC Liq)	15g/l
Acetic Acid	1g/l
Pick up	75%,
Drying	120˚(2 min)
Curing-	170˚(1 min),
PH	4.5

Process sequence

- Sample preparation
- Recipe formulation
- Padding
- Drying(120^0 * 2min)
- Curing (170* 1min)
- Washing

3. Results and Discussion

3.1 Formaldehyde content

The formaldehyde content of used crosslinker (CLA) was measured by Dynamic Double Beam DB-20 UV-VIS Spectrophotometer in PPM and listed on below table. Formaldehyde not only causes respiratory inflammation by inhalation and skin inflammation by skin contact but also irritates the eyes. Furthermore, formaldehyde may cause allergies and cancer. So the crosslinker having high formaldehyde content is not safe to use. Melamine formaldehyde crosslinker shows higher formaldehyde content (151ppm) than other crosslinker .Sample one (CLA 1) and Four(CLA 5) give PPM below tolerable limit so it may called non formaldehyde CLA and safe to use.

Table 3: Formaldehyde content of different crosslinking agent

Sample	Formaldehyde Content(PPM)
Control	23
CLA 1	30
CLA 2	60
CLA 3	86
CLA 4	151
CLA 5	38

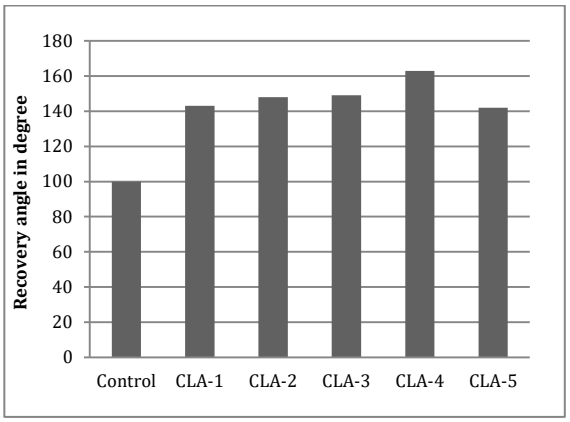
3.2Effect on Crease Recovery

Crease recovery property is expressed by means of

recovery angle (RA) and smoothness and appearance rating (SA).

i) Recovery Angle

The changes of the angle of recovery due to the treatment with CLA are shown on below figure (fig 1). Here we see that all fabric sample treated with CLA give higher recovery angle than untreated sample. Another thing is that the sample having high formaldehyde content shows high recovery angle that means CLA-4 offering more recovery angle (163^0).The maximum recovery shows by the sample having maximum formaldehyde content. So for better recovery from crease we should use melamine formaldehyde CLA. By comparing with the untreated fabric, all sample specimens had been treated by the CLA in any parameter had a significance improvement in the recovery angle.



Figurer 1: Recovery angle of control and treated sample

Table 4: Smoothness appearance rating of treated and untreated sample

	Smoothness Appearance	
Sample	3 wash	5wash
Control	2	1
CLA 1	4	3
CLA 2	4	3
CLA 3	4	3
CLA 4	4	4
CLA 5	4	4

ii) Smoothness and Appearance (SA)

The smoothness and appearance rating of control and treated fabric was assessed by AATCC standard test method and the obtain result are shown on the fowling

The assessment is done after three wash and after five wash by using AATCC standard replica with rating 1 to 5 .Where 1 means poor and 5 means excellent. All treated sample shows better SA rating where CLA 4 shows best result having grade-5 after 3 wash and 4 after wash.

3.3 Effect on Bursting Strength of fabric

Bursting strength test is an alternative method of measuring strength in which the material is stressed in all direction at the same time and is therefore more suitable for such material. It is expressed in unit kilopascal.

Table 5: Bending length and bursting strength of different sample

Sample	Bursting Strength(Kpa)	Bending length(cm)
Control	260	1.9
CLA 1	240	2.05
CLA 2	230	2.1
CLA 3	229	2.2
CLA 4	208	2.5
CLA 5	235	2.1

From table 5 it is shown that there was a significant reduction of strength after CLA application .CLA 4 gives worst result among others, it reduce 20% strength and others reduce around 10% strength.

3.4 Effect on the stiffness of fabric

Cloth stiffness is the resistance of the fabric to bending. Bending length is the length of the fabric that bends under its own weight to a definite extent. The bending length of un treated and treated fabric is measure by ASTM standard test method The three dimensional structure of crosslinking agent impart very stiff and firm handle to the fabric as well as increase the bending length .As bending length is the measure of stiffness so CLA finished fabric shows high bending length value [table 5] and become stiffer.

3.5 Effect on dimensional stability

Fabric dimensional stability is express by its shrinkage% and spirality angle (^{0}). At first shrinkage is discussed than spirality ismentioned.

iii) Shrinkage of fabric

The shrinkage of untreated and treated fabric was measure by AATCC standard test method and the obtain result are shown on the below table. [Table 3.3].Here shrinkage is improved for every CLA finished fabric. Ithappened due to the three dimensional network of CLA finished fabric, which make lower molecular movement and hinder the swelling. Another reason is the blockage of free hydroxyl group by cross linking

iv) Spirality

As like shrinkage the spirality of finished sample was also improved [Table 6]. So it is proved that Crosslinking agents may apply for better dimensional

stable of fabric besides its main purpose of crease resistance.

Table 6: Shrinkage % and Spirality angle of different sample

Sample	Shrinkage(%)		Spirality (⁰)
	Length wise	Width wise	
Control	7.6	3.5	6.5
CLA 1	3.2	0	0
CLA 2	3.9	0	2
CLA 3	3.8	1	0
CLA 4	3.5	0	0
CLA 5	3.6	0	2

3.6 Effect on abrasion resistance of fabric

For determining the abrasion resistance we followed to measure the weight loss % of the fabric sample. After certain amount of cycle higher weight loss indicate lower abrasion resistance. Here very small amount of weight loss was found .The table [Table 3] shows untreated fabric give lower weight loss than treated fabric sample. So it is clear that CLA treatment increase the weight loss of fabric at the same time the abrasion resistance is reduce.

Table 7: Weight loss of different sample due to abrasion

Sample	Weight loss in gram		
	500 cycle	1000 cycle	5000 cycle
Control	0.128	0.129	0.131
CLA 1	0.137	0.14	0.15
CLA 2	0.132	0.14	0.154
CLA 3	0.134	0.142	0.148
CLA 4	0.146	0.15	0.192
CLA 5	0.132	0.138	0.15

3.7 Effect on pilling property

Pills are the balls or bunch of tangled fibres that are held on to the surface of a fabric by one or more fibres. Pilling resistance is the resistance to form pills on a textile fabric. Pill formation is increase after crosslinking treatment, which is clearly observed by figure -3.

3.8 Effect on areal density of fabric

Areal density can be express by the GSM (Gram per square meter) of the fabric. Application of CLA increase the fabric GSM than it will be heavier than before. The five different CLA shows the same behavior of increasing GSM of cotton fabric [figure 2]. As GSM is the expression of areal density of fabric so the areal density is increase due to Crosslinking.

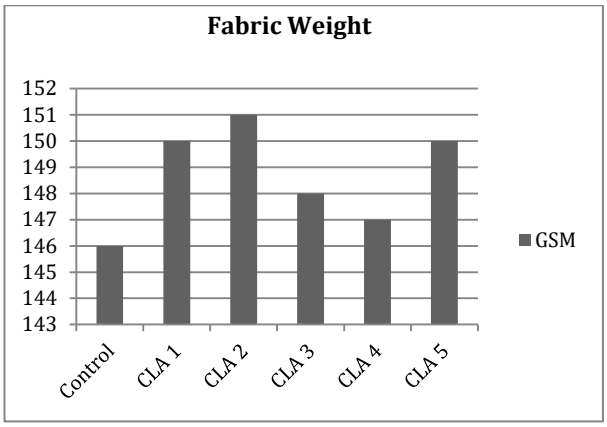


Figure 2: GSM of different sample

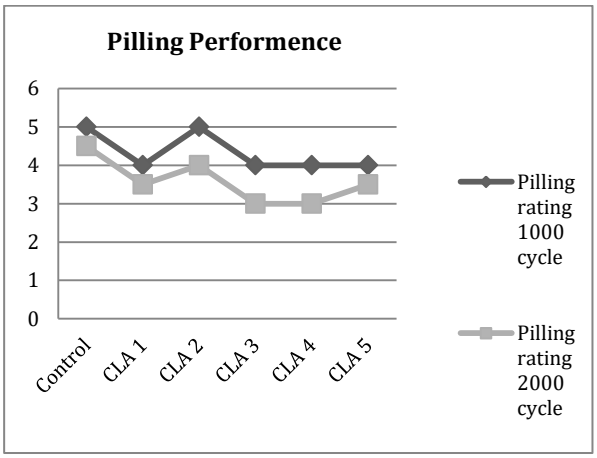


Figure 3: Pilling rating of treated and untreated sample

3.9 Wet ability of fabric

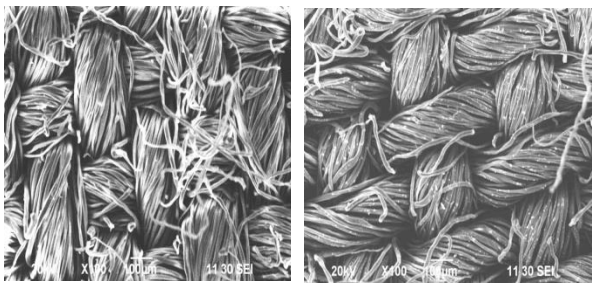
Wet ability of fabric is measure by wicking test. For wicking test the fabric sample is cut 18cm x 5 cm, then in a beaker 1% direct dye red color is taken after that a marker is drawn at 1cm above from the sample bottom. Now the sample is hung from a wood stick supported by immersing that 1cm portion of fabric in the dye liquor Then we measured the point up to which the colored solution in absorbed straight above way by the sample in 5 min time. Column test result is standard range of wicking 30-50 mm. For our five sample the wick ability were decrease. That means crosslinking treatments reduce wet ability(table 8).

3.10 SEM analysis

The SEM (Scanning Electron microscopy) technique was used to examine the surface morphology of fiber from untreated fabric and treated fabric. Here the untreated fabric and CLA 1 was toasted by SEM and the image of surface was given on figure 4.the treated fabric surface shows the presence of crosslinker.

Table 8: Wicking length of treated and untreated fabric after 1min, 3min and 5min

Sample	Length of Wicking (millimeter)		
	1 min	3min	5 min
Control	33	45	51
CLA 1	31	38	41
CLA 2	28	40	43
CLA 3	22	28	40
CLA 4	22	26	34
CLA 5	28	35	40



(a) (b)

Figure 4: SEM micrograph of (a) untreated cotton fabric and (b) treated cotton fabric with CLA-1

Conclusion

This work can be conclude that fabric finished with crosslinking agent shows better crease recovery and improved smoothness appearance (SA) rating. Better dimensional stability is also obtained by treating with crosslinking agents. That means shrinkage% and spirality angle was improved after CLA application. Crease resistancy and SA rating will more for crosslinker having more formaldehyde content. Here we found significant reductions of bursting strength, abrasion resistance and pilling performance. Another physical property like stiffness is increase due to crosslinking agents because it makes fabric harder. Crosslinker also make the fabric heavier.

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