(REFEREED RESEARCH)

EFFECTS OF CAUSTICIZING ON CREASE RESISTANCE OF CELLULOSIC WOVEN FABRICS

SELÜLOZİK DOKUMA KUMAŞLARDA KOSTİKLEMENİN BURUŞMAZLIK ÖZELLİĞİNE ETKİSİ

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ABSTRACT

Cellulose and regenerated cellulose fibers are used widely in the world recently. In spite of many advantages of cellulosic fibers, they can wrinkle easily. Because of the performance enhancing finishes, the wrinkle property can be eliminated. In this study, it was aimed to investigate the effect of causticizing treatment before the crease resistance finishing on the crease resistance, breaking strength and abrasion resistance properties of the fabrics. The causticizing processes were applied to 100% mercerized cotton, 100% unmercerized cotton, 100% linen, and 100% viscose woven fabrics at different caustic-soda concentration. The fabric type, the caustic-soda concentration and the concentration of crosslinking agent parameters were evaluated independently. The obtained results were discussed.

Keywords: Cellulosic Fibers, Causticizing, WRA, Breaking Strength, Weight Loss

ÖZET

Selüloz ve rejenere selüloz lifleri, günümüzde dünyada çok yaygın bir şekilde kullanılmaktadır. Bu liflerin birçok avantajı olmasına rağmen kolay bir şekilde buruşmaktadırlar. Performans arttırıcı terbiye işlemleri sayesinde buruşma özelliği elimine edilmektedir. Bu çalışmada; buruşmazlık bitim işlemlerinden önce yapılan kostikleme işleminin kumaşların buruşmazlık, kopma mukavemeti ve aşınma dayanımı özellikleri üzerine olan etkisinin incelenmesi amaçlanmıştır. Kostikleme işlemleri; %100 merserize pamuk, %100 merserize yapılmamış pamuk, %100 keten ve %100 viskon dokuma kumaşlara farklı kostik konsantrasyonlarında uygulanmıştır. Kumaş tipi, kostik konsantrasyonu ve çapraz bağlayıcı konsantrasyonu parametreleri ayrı ayrı değerlendirilmiştir. Elde edilen sonuçlar tartışılmıştır.

Anahtar Kelimeler: Selülozik Lifler, Kostikleme, Buruşmazlık Açısı, Kopma Mukavemeti, Ağırlık Kaybı

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1. INTRODUCTION

Nowadays, cellulose and regenerated cellulose fibers are widely used in the world. They have many advantages; however, as they absorb large amounts of water and swell to a greater extent so, they can wrinkle easily. In order to stabilize woven and knitted cellulosic fabrics and to increase the easy usage and care, it is necessary to reduce the water absorption capacity of the fibers. On the other hand, linen fabric has strong, shiny and, breathable, linen fabric like cotton fabric creases easily. This can be achieved with the wrinkle resistance finishes (1-3).

The crosslinking of cellulose have previously been made mainly within the textile industry, in order to improve wrinkle resistance, wrinkle recovery, and dimensional stability. To obtain a cross-linked cellulosic material, at least two hydroxyl groups in a cellulose molecule or between adjacent molecules are combined. The cross linking agent is at least bifunctional, the reaction normally occurs in two chemical steps. The chemical reactions are typically initiated by heat and/or pressure. Nonetheless, an inevitable side effect of the cellulosic crosslinking finishes is a reduction in the elasticity and flexibility of the cellulose fibers. This produces a considerable decrease in abrasion resistance, tear, and tensile strengths on cellulose fibers (4).

Some researchers have investigated the effects of various crosslinking agents. Dimethyldihydroxyethylene urea (DMDHEU) is produced with the reaction of dimethylurea and glyoxal. It has two reactive hydroxyl groups and combines with cellulose by means of ether bonds. Fibers having great deals of amorphous regions and weak molecular bonds tend to crease more. The purpose of crease resist finish is to reduce swelling of fiber and to

improve crease resistance properties. If water hardly diffuses into the gaps among fiber crystallites, then swelling and consequently shrinkage values are reduced (1,5).

Figure 1 indicates the mechanism of crosslinking between cellulose and DMDHEU.

The causticizing is a useful process to enhance dimensional stability in addition to improve the crease resistance properties. Moreover it partly recovers the interior stress of the fibers and results in a better dimensional stability. In causticization treatment with sodium hydroxide, it is necessary to wash off unreacted sodium hydroxide from the fabric and then neutralize with some acids, such as acetic acid and sulphuric acid (6,7,1).

When the cellulose fibers are treated with caustic-soda solution, the molecule chains rearrange and reorient. The use of caustic-soda in regenerated cellulose fibers changes the crystallinity, accessibility, unit cell structure and orientation of fibrils. The causticizing process can increase crystallinity index, swelling tendency and color efficiency in viscose fibers. Moreover, this process can provide a positive effect on pilling tendency (8,5,9,10,11,12).

In this study, the purpose is to investigate the effects of the performance enhancing finishings on various cellulosic woven fabrics. For this purpose, the effect of causticization treatment before the wrinkle resistance finishing was investigated. Furthermore, the effect of causticizing was assessed in terms of crease resistance, breaking strength and abrasion resistance properties of the mercerized cotton, unmercerized cotton, linen, and viscose woven fabrics.

2. MATERIAL and METHOD

Material

Before the experimental study, firstly desized, scoured and bleached fabrics were supplied and then, the causticization processes at the laboratory conditions were applied to 100 % mercerized cotton, 100 % unmercerized cotton, 100 % linen, and 100 % viscose woven fabrics at four different caustic-soda concentration. Finally, the crease-resistance finishings at the laboratory conditions were applied to the fabrics at two different concentration. The physical characteristics of the fabrics were indicated in Table 1.

Method

Before the crease resistance treatments, the causticizing process was applied to the fabrics at laboratory conditions. In Figure 2, the steps of causticizing process were shown.

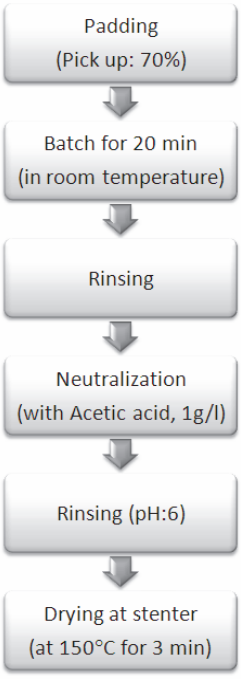

Figure 2. The steps of causticization process

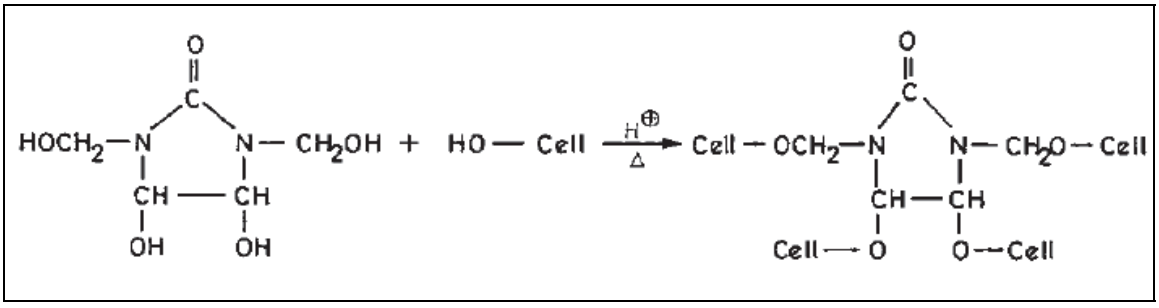

Figure 1. Mechanism of crosslinking with DMDHEU (5)

Table 1. The physical characteristics of the fabrics

Fabric type		**Mercerized cotton**	**Unmercerized cotton**	**Linen**	**Viscose**
Fabric construction		Plain	Plain	Plain	Plain
Fabric weight (g/m^2)		295	200	**190**	**125**
Yarn density (threads/cm)	Warp density	56	56	**24**	**44**
	Weft density	24	24	**18**	**30**

The applied recipes at the causticizing process were indicated in Table 2.

Table 2. The amount of NaOH solutions

Causticizing process	NaOH °Be			
For Unmercerized cotton, mercerized cotton and linen	10	15	20	25
For viscose	6	8	10	

After the causticization process, while one group fabric was prepared for the tests, another group fabric was applied to the crease resistance treatments by padding method.

The crease resistance treatments were realized with Rapid Model PA-1 (2004) marked laboratory padder for impregnation and Ataç GK 4 marked laboratory stenter for drying and curing at laboratory conditions. The recipes of experiments were given in Table 3. Modified DMDHEU, is a commercial chemical, was supplied from Bozzetto Group Company in this study. Two commonly chemical concentration (60 and 80 g/l) was chosen in applications.

Table 3. The structure of chemicals and recipes

Chemical Name	Recipe Code	
	WRT1	WRT2
Modified DMDHEU (Crease resistant chemical)	60 g/l	80 g/l
$MgCl_2$ (Catalyst)	15 g/l	20 g/l
Impregnation conditions :	pH 4.5 (with Acetic acid) Pick up: 70% Drying: 110°C for 3 min Curing: 160°C for 4 min	

Tests

Before the tests, the fabric samples were conditioned under standard atmosphere conditions (20°C±2°C temperature, 65%±4% RH). Then, the crease recovery angle, breaking strength and weight loss of the fabrics were measured. The obtained results were discussed.

Determination of Crease Recovery Angle

The dry crease recovery angles (WRA) of the samples were measured according to DIN 53890 standard. WRA° of the specimens in warp and weft directions was measured separately and total WRA° (warp+weft) values of specimens was calculated as well (13).

Determination of Breaking Strength

Breaking strengths (N) of all fabrics were measured according to EN ISO 13934-1 standard (strip method) at Lloyd LRX Plus marked tester (14).

Determination of Weight Loss

The abrasion resistances of the fabrics were done at Martindale abrasion and pilling tester (James H. Heal & Co Ltd) according to ISO 12947-2 standard. The samples were evaluated at 1000, 5000 and 10000 revolutions (15). After test, the weight losses of these samples were calculated using the following equation:

$$\text{Weight loss (\%)} = \frac{A2-A1}{A1}\ x\ 100$$

A1: Initial weight (before test)

A2: Last weight (after test)

3. RESULTS AND DISCUSSION

Crease Recovery

After the causticizing and crease resistance treatments, the wrinkle recovery angles (WRA) of the untreated and treated samples were measured. In Figure 2-6, total WRA values (warp+weft) of the fabrics were showed. In Figures, the following abbreviations were used:

C: Causticized; C+WRT1: Causticized+1st concentration of wrinkle resistant chemical; C+WRT2: Causticized+2nd concentration of wrinkle resistant chemical

In Figure 2, it was seen that there were no significant differences between WRA of untreated and causticized mercerized cotton fabrics. After the causticization and crease resistance treatments, WRA values of the fabrics were raised. However, while NaOH amount was 25°Be, WRA values decreased again (approximately 20-25°). The reason of this decrease could be the changing of the fiber structure caused by the intense caustic solution (NaOH 25°Be). As the concentration of crosslinking agent increased, WRA values increased (nearly 15°). Only crease resistance treatment increased WRA values considerably.

As seen in Figure 3, WRA values of unmercerized cotton fabrics enlarged after causticization and crease resistance treatments. WRA of unmercerised fabrics were higher than that of mercerized cotton fabrics. Especially, while NaOH amount was 10°Be, WRA values were at the highest level. The effect of concentration of crosslinking agent on WRA values was low. The causticizing process was effective because the influence of finishing on crease recovery was dependent on the degree of fiber swelling during crosslinking and fibers could have homogeneity structure due to the causticization process. Ultimately, crosslinking agents could be bonded to the fibers homogeneously and deeply. The similar results were obtained in literatures (16).

After the causticizing and crease resistance treatments, WRA of the fabrics was raised. While NaOH amount was 10°Be, WRA values increased significantly (nearly 15-20°). WRA was peak after the only crease resistance treatment. The effect of concentration of crosslinking agent was seen obviously (almost 25-30°). Compared with the other fabrics, WRA values of linen fabrics were lowest. Since linen fabric had higher stiffness, lower resilience and lower wrinkle recovery. Also, linen fibers could not swell enough during causticization process (Figure 4).

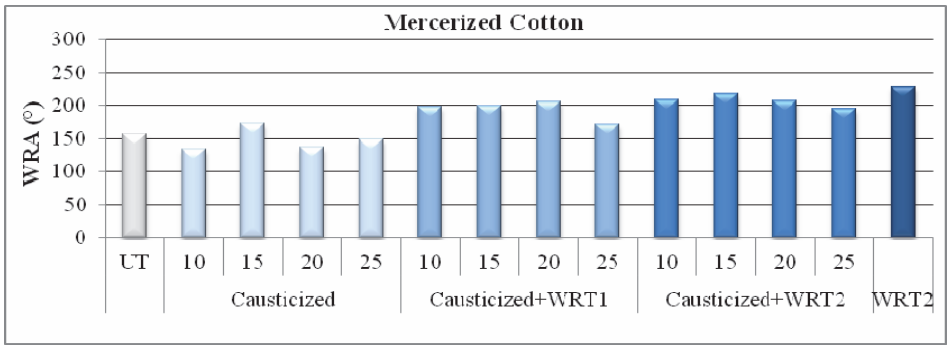

Figure 2. WRA of Mercerized Cotton Fabrics

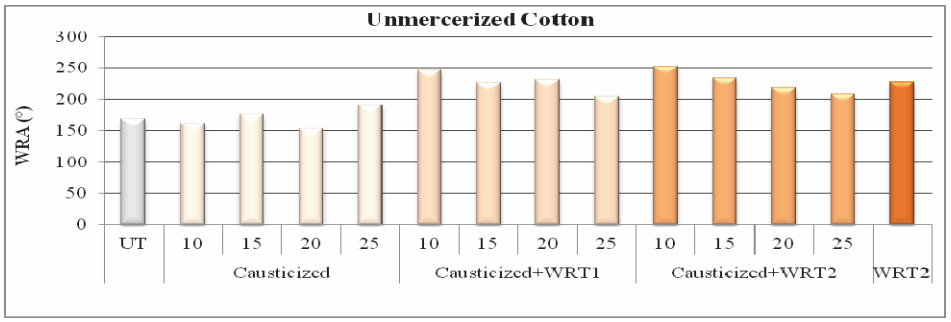

Figure 3. WRA of Unmercerized Cotton Fabrics

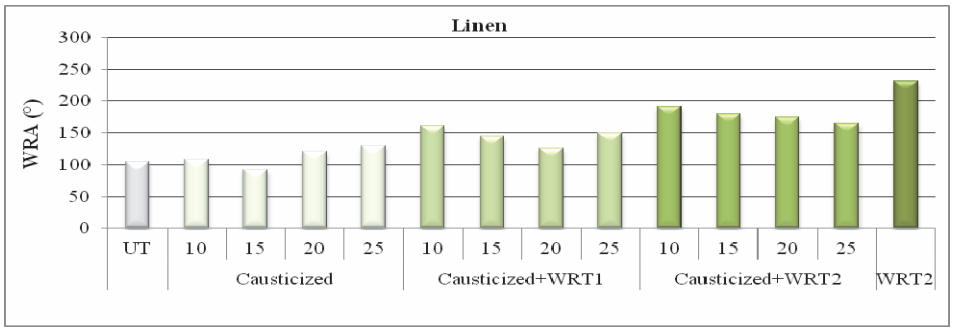

Figure 4. WRA of Linen Fabrics

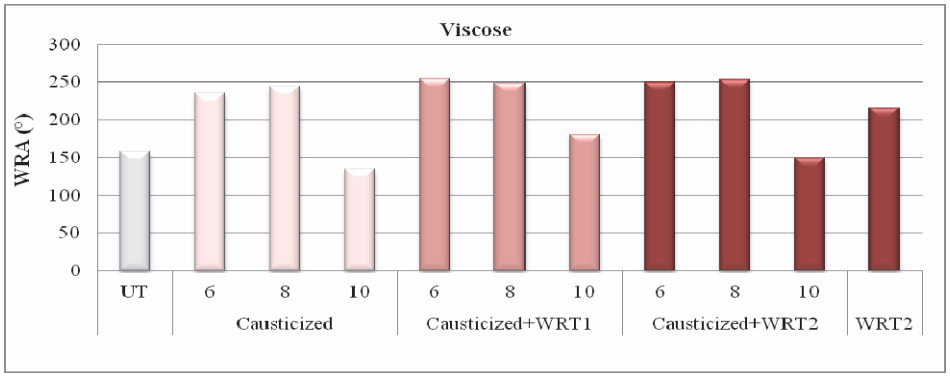

Figure 5. WRA of Viscose Fabrics

In literatures, it is recommended to apply NaOH at 6 and 8°Be concentration. Because, during the causticizing treatment the viscose fibers are more affected due to the degradation caused by the transformation of crystalline cellulose II to amorphous cellulose, to the point of total dissolution at high caustic concentrations for viscose (10,17). In this study, for viscose fabrics, the amounts of caustic solutions were changed and chosen as 6, 8 and 10°Be concentration. In Figure 5, WRA values of viscose fabrics were showed. While NaOH amount was 6 and 8°Be, WRA values increased notably. There was no important changes between untreated and treated samples at NaOH 10°Be. It can be stated that the causticization treatment improved WRA values. With the application of the

causticizing, the crystalline region of viscose increased and so, the macromolecular orientation increased.

Figure 6 showed the WRA of all fabrics treated with NaOH 10°Be solutions

The unmercerised cotton fabrics had highest WRA values. The increase on concentration of crosslinking agent was seen clearly except viscose fabrics. For viscose fabrics, while the concentration of crosslinking agent increased, there was no increase on WRA values. When compared to the fabric types, the highest WRA values were obtained as follows; unmercerized cotton>mercerized cotton>viscose>linen

Breaking Strength

After the causticization and crease resistance treatments, the breaking strength values (BS) of the untreated and treated samples were measured. In Figure 7-11, the breaking strength values (in warp and weft directions) of the fabrics were indicated.

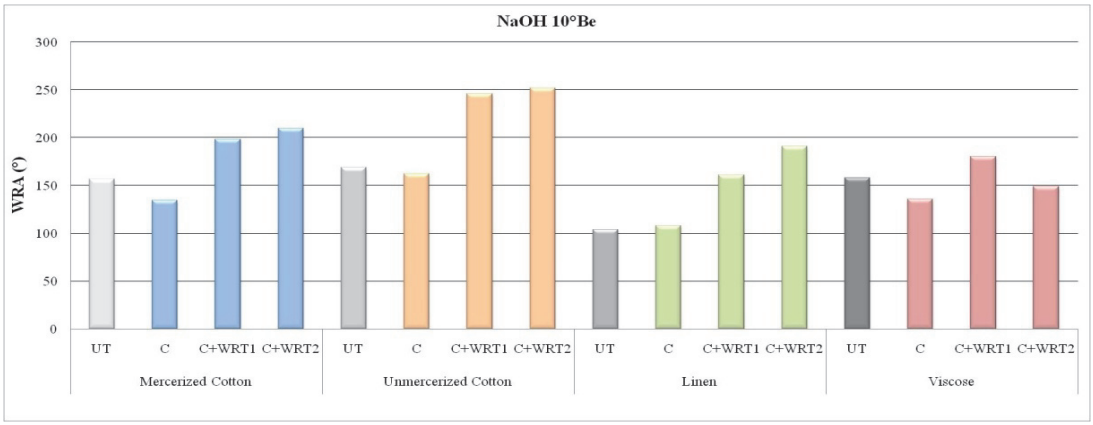

Figure 6. WRA of Fabrics with treated NaOH 10°Be solutions

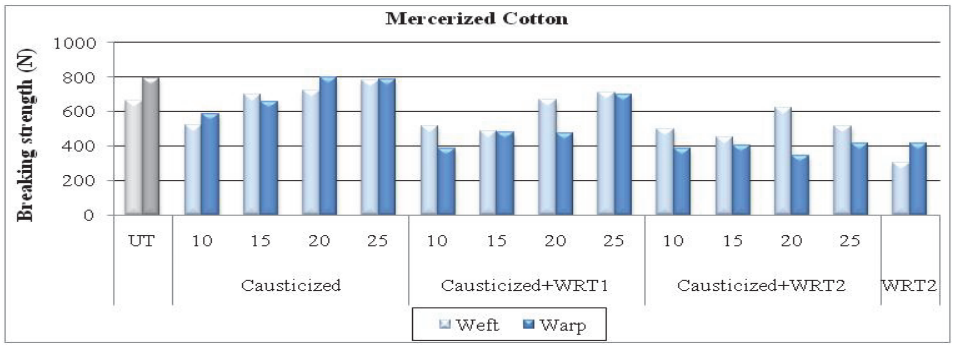

Figure 7. BS Values of Mercerized Fabrics

In Figure 7, the BS values of untreated fabrics and causticized fabrics at NaOH 20 and 25°Be were higher than that of causticized+wrinkle resistant fabrics. Particularly, after the causticized and crease resistance treatment at higher crosslinker concentration BS values had significant reductions. The reductions in BS values in warp directions were higher than the reductions in BS values in weft directions. BS values in weft directions of causticized fabrics at NaOH 20 and 25°Be concentration raised compared to the untreated fabrics. The reason of this interesting result could be the excessive swelling of fibers and so, fabric structure could become tight due to the causticizing process. While the concentration of crosslinker increased, BS values reduced. Only crease resistance treatment affected BS values negatively.

The tendency in the results of Figure 8 was the similar to that of Figure 7. In generally, BS values of causticized+wrinkle resistant fabrics reduced considerably. BS values in warp directions were higher than that of in weft directions.

Compared to the other fabrics, BS values of causticized+wrinkle resistant linen fabrics reduced considerably in both directions. On the other hand, the only causticization process brought about the vital increases in BS values of linen fabrics. For example, BS value in warp direction of the fabric only causticized at NaOH 25°Be was higher than that of untreated fabric. This difference between these two BS values was 140 N. It is predicted that the reason of large reductions in BS values of linen fabric can be curing process in high temperature (160°C)**.** The curing can make fibers more brittle and delicate. It is suggested the moist curing instead of dry curing (18-20).

Figure 10 showed that there were no big differences between BS values of viscose fabrics after all the finishings. The causticizing process did not affect the BS values markedly. But the high concentration of crosslinking agent and high NaOH amount reduced the BS values of viscose fabrics.

Figure 11 indicated the BS values of all fabrics treated with NaOH 10°Be solutions.

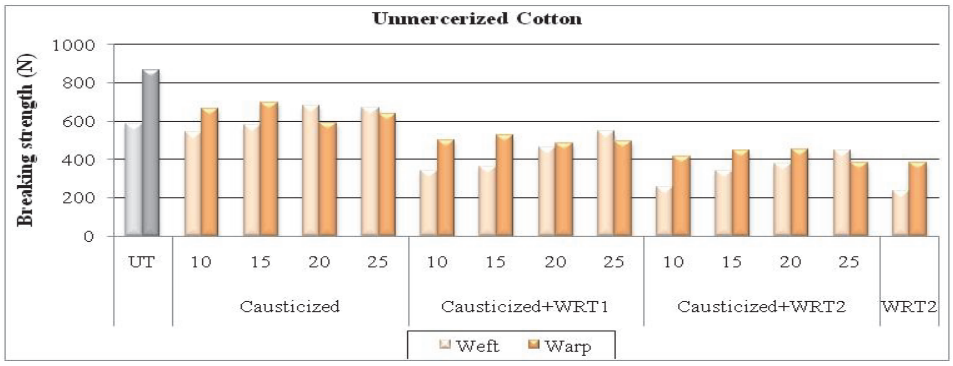

Figure 8. BS Values of Unmercerized Fabrics

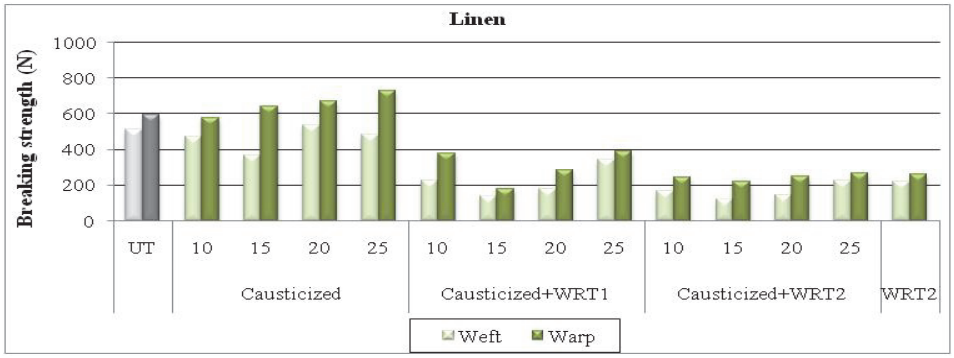

Figure 9. BS Values of Linen Fabrics

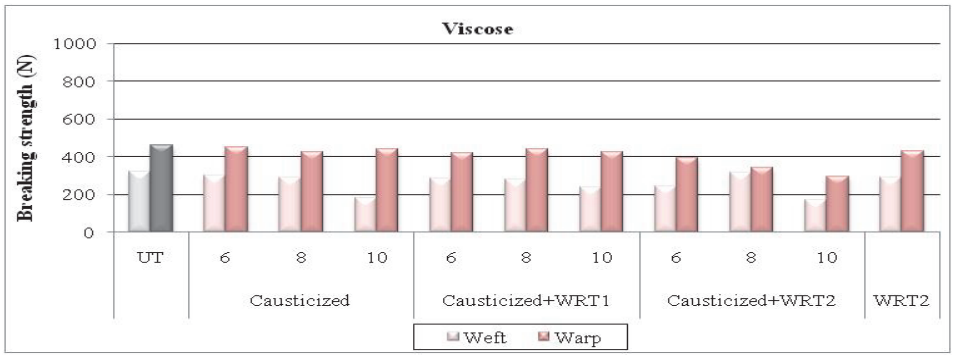

Figure 10. BS Values of Viscose Fabrics

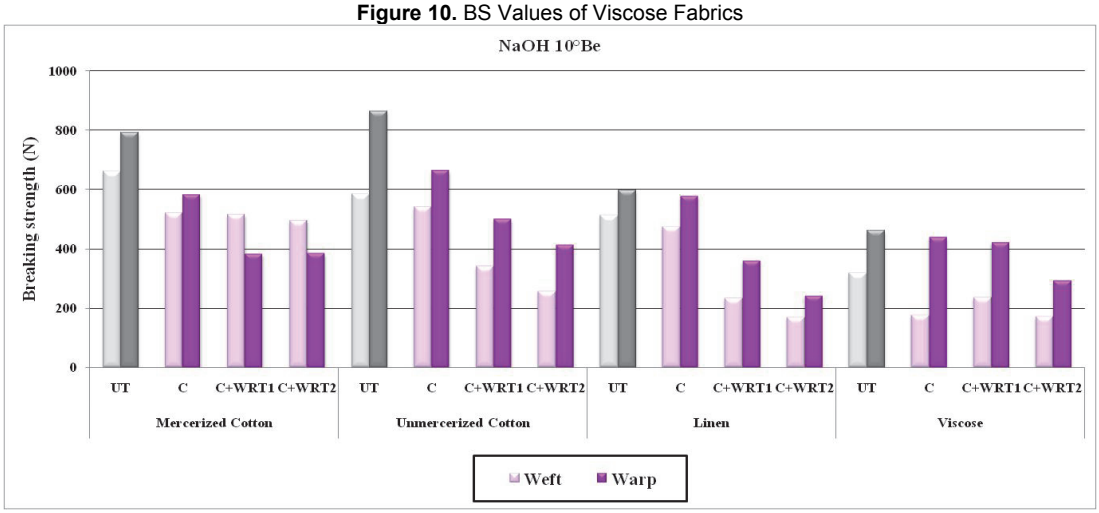

Figure 11. BS Values of All Fabrics

Whereas unmercerised cotton fabrics had highest BS values, linen fabrics had lowest BS values. The increase in concentration of crosslinking agent affected BS values negatively. In generally, the reductions in BS values in weft direction were higher than the reductions in BS values in warp direction.

Weight Loss

After the causticization and crease resistance treatments, the abrasion resistance tests were done at 1000, 5000 and 10000 revolutions and the weight losses of the untreated and treated samples were calculated. Figure 12 illustrates the weight losses of the fabrics.

In Figure, the following abbreviations were used: MC:Mercerized cotton; UC:Unmercerized cotton; L:Linen; V:Viscose

The weight losses of causticized and wrinkle resistant fabrics at high crosslinker concentration and only wrinkle resistant fabrics were highest. At 10000 revolutions, the weight losses were maximum. For all fabrics, the weight losses were following respectively; linen > viscose > unmercerized cotton > mercerized cotton.

4. CONCLUSION

The purpose of this study was determining the effect of causticizing treatment before the crease resistance finishing on the crease resistance, breaking strength and abrasion resistance properties of the fabrics.

The conclusions can be summarized as follows:

- The causticization treatment affected WRA values positively. But, it is important to determine the optimum NaOH concentration depending on the type of the cellulosic fiber. For example, for viscose fibers optimum NaOH concentration was found to be 8°Be. However, for mercerized cotton 20°Be is recommended. As the concentration of crosslinker increased, WRA values increased. When compared to the fabric types, the highest WRA values were obtained as follows; unmercerized cotton>mercerized cotton>viscose>linen

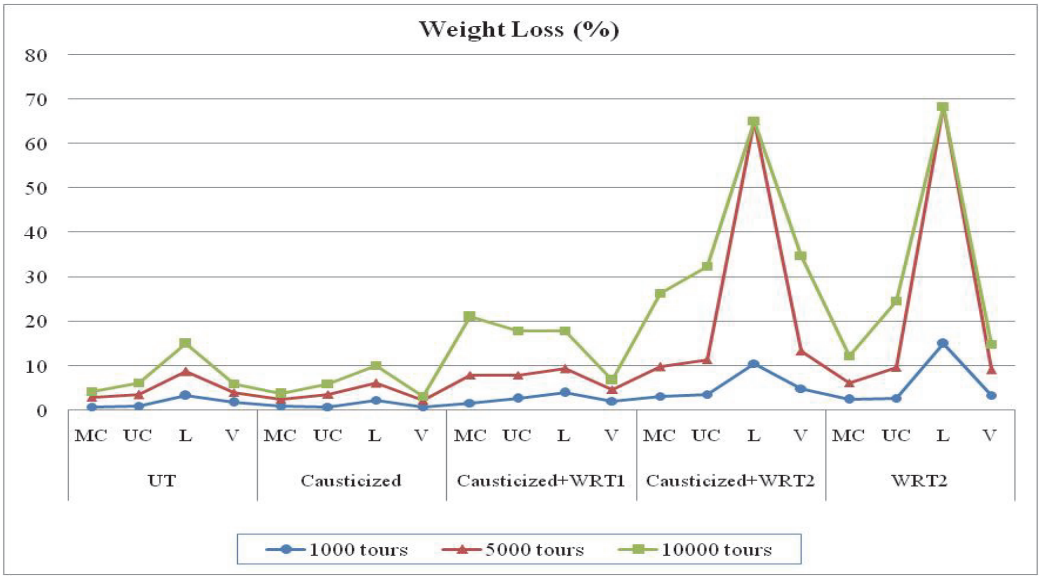

Figure 12. WL Values of The Fabrics

- The causticizing treatment affected BS values certainly. At higher crosslinker concentration, BS values had significant reductions. When compared to the fabric types, the highest BS values were obtained as follows; unmercerized cotton>mercerized cotton> viscose >linen
- The weight losses of causticized and wrinkle resistant fabrics at high crosslinker concentration and only wrinkle resistant fabrics were highest. When compared to the fabric types, the weight losses were given as follows; linen>viscose>unmercerized cotton>mercerized cotton.

As a result, it was recommended that the causticizing and crease resistance treatments together can be applied to the fabrics.

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