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Emdirme ve Kimyasal Köpük Sistemi İle Buruşmazlık İşleminde Farklı pH Uygulamaları

Crease Recovery Treatment Via Pad and Chemical Foam System with Different pH Values

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Araştırma Makalesi / Research Article

CREASE RECOVERY TREATMENT VIA PAD AND CHEMICAL FOAM SYSTEM WITH DIFFERENT pH VALUES

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ABSTRACT: Textile fabrics are subjected to various treatments for required finishing effects by specific chemicals. Water / oil repellency and crease recovery are among the most applied finishing treatments which are also used for products defined under "easy-care". Regarding to improve crease recovery, most popular application has been to introduce cross-links between individual macromolecule chains. Cross-linking agents are usually small molecules containing several functional groups capable of reacting with some active groups in the polymer, such as hydroxyl groups in cellulose. N-methylol reagents such as dimethylol dihydroxylethyleneurea (DMDHEU) have long been used as durable press finishes producing crease-resistant fabrics. The drawbacks of DMDHEU application are the well-known formaldehyde problems and worsening some mechanical properties; thus there have been efforts to achieve non-formaldehyde alternative agents or reduce the amount of DMDHEU within treating recipes. Acidic media destroys cotton fabric samples as known.

Keywords: Chemical foam system, DMDHEU, crease recovery

EMDİRME VE KİMYASAL KÖPÜK SİSTEMİ İLE BURUŞMAZLIK İŞLEMİNDE FARKLI pH UYGULAMALARI

ÖZET: Tekstil kumaşları özel kimyasallarla istenen bitim işlemini elde etmek için çeşitli işlemlere maruz kalmaktadır. Su/yağ iticilik ve buruşmazlık işlemleri en çok uygulanan bitim işlemleridir ve bu işlemleri gören ürünler ''kolay bakımlı'' olarak adlandırılır. Buruşmazlık özelliğini artırmaya yönelik sıklıkla kullanılan yöntem makromolekül zincirleri çapraz bağlayıcı ile bağlanmaktadır. Çapraz bağlayıcılar selülozdaki hidroksil gruplar gibi polimer içindeki bazı aktif gruplarla reaksiyon veren birden fazla fonksiyonel grup içeren, genellikle küçük moleküllerdir. Dimetilol dihidroksietilenüre (DMDHEU) gibi N-metilol bileşikleri uzun zamandır buruşmazlık bitim işlemlerinde kullanılmaktadır. DMDHEU aplikasyonun dezavantajları çok bilinen formaldehit problemi ve mekanik özelliklerdeki düşüştür, dolayısıyla formaldehit içermeyen maddeler elde etmeye veya reçetede DMDHEU miktarını azaltmaya yönelik büyük çabalar gösterilmektedir. Ayrıca asidik ortamın pamuklu kumaşlara zarar verdiği bilinmektedir.

Anahtar Kelimeler: Köpük aplikasyonu, DMDHEU, buruşmazlık

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1. INTRODUCTION

Textile finishing is the most important and final stage of textile material production to impart high quality, good visual aspect, best touch and gain desirable properties to textile materials [1]. Cotton based textiles are always popular. The comfort to wear always enables popularity for cotton fabrics. However, creasing of cloth easily causes disadvantages. Crease recovery for appearance is very important [2,3]. Crease resistant finish is used commonly in textile industry to give crease resistant property to cotton fabrics and garments. Because un-treated cellulose has poor recovery, it is necessary to apply crease resistant finish [4,5]. Formaldehyde based N-methylol cross-linkers can enable advantages for mechanical properties such as crease resistance, anti-curl, dimensional stability, durable press. Besides these advantages, there are some drawbacks such as strength loss, high formaldehyde release (as known human carcinogen) [4,6]. Dimethylol dihydroxyethylene urea (DMDHEU) is the most applied durable press agent that gives crease resistance to textile material consists of cotton or cotton blends [7].

Recently, there has been a rapid growth on textile finishing process in the industry. The researches play a vital role on developing treatments to obtain significant (respectable) properties of fabrics as the result of finishing processes [2, 8]. The cross-linking process can be applied in different ways; pad treatment, humid process, wet process and newly chemical foam system.

A foam system could be the most logical alternative to the conventional pad-mangle system. The important point of foam processing is that the reagent is applied to the fabric in the form of foam in contrast to the conventional process of impregnating the fabric with a dilute solution of the reagents [9]. Air replaces water as the transport medium for the reagents, so it achieves energy-saving in the drying of fabrics, less waste disposal and enhanced quality of the product may be realised. “A foam is a substance that is formed by trapping pockets of gas in a liquid or solid” [10]. Most of them contain surfactants; i.e. complex molecules aggregating at the bubble surface [11]. The foam bubble is a flexing unit. Bubble rearranges constantly and flows like a liquid under enough pressure [12]. In this paper, 100% woven cotton fabric samples were treated with both pad system and chemical foam system. And the aim of this paper is to compare mechanical properties of crease resistant finish applied to 100% woven cotton fabric samples via pad and chemical foam applications with different pH values. Because chemical foam system is so different from pad system, for instance there is no need to treat two sides of fabric samples similar to pad system. In chemical foam system, it is possible to treat only one side and it is possible to adjust lower % of wet pick ups (% w.p.u.) than pad application. It enables benefits for large productions, for instance energy saving, water saving and etc.

1.1. Chemical Foam System

Chemical foam system (CFS) is unique in its ability to place chemicals into or onto substrates in a controlled manner. It offers so many benefits that many consider CFS technology to be the future of chemical application to open-width substrates. Foam application to woven and knitted fabrics and nonwoven substrates from a pressure plenum was developed in the early 1970s. The principle objective was to provide finite control over chemical application relative to uniform quality and controlled penetration. Foam was chosen as the preferred medium because it extends the surface area of the chemical to a more closely match to the surface area of the fibers. It has also produced significant cost savings due to reduced energy requirements for drying operations. Typical wet pickups vary from 3% to 50% on weight of dry substrates [13].

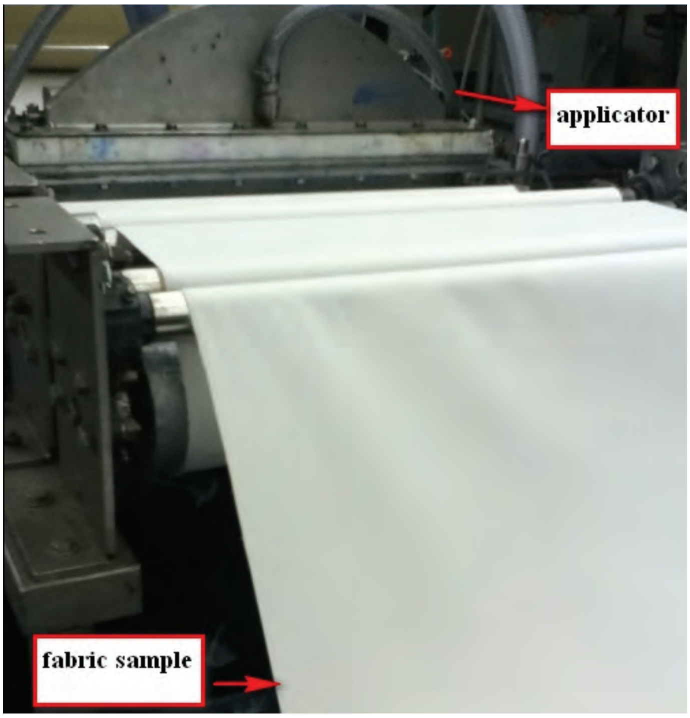

Figure 1. Laboratory Type Foam Applicator

1.2. Benefits and Characteristics

The technology of applying foam under pressure has several unique characteristics and important advantages:

- High concentrations of chemicals applied.
- Minimum need for thickeners.
- Precise and controlled liquid feed rates.
- Controlled, uniform and repeatable foam bubble size.
- Wide range in foam densities.
- Significant reductions in water and energy consumption.
- Flexibility in chemical applications.
- Measurable reductions in waste volumes with zero discharge possibilities.
- Reduced air pollution.
- Fast wetting and penetration rate into substrate.
- System speeds go as high as 1000 meters per minute in some specific applications [9,13]

1.3. The Difference Between CFS and Other Foam Applicators

Foam, which is expected to treat fabric uniformly in a flooded nip arrangement, will not be controllable and produces inferior results. Foam must be confined to do the expected work in a repeatable manner. With CFS, foam is under pressure and highly controlled [9,13].

1.4. Economic Benefits

Good economics are the result of payback conditions initiated by several different factors. Some of these factors have a greater impact than others because of the cost and value attached to each. Costs for waste, power, floor space, waste water treatment, air pollution, labor costs, chemical costs, better quality assurance, and market demands are all common factors, each of which can vary widely from one region to another.

In general, economic incentives to invest in CFS come from:

- Reduction in water consumption: up to 80%
- Reduction in energy use: depends on reduction of evaporation loads
- Reduction in chemical costs: results from precise chemical placement
- Range speed increases: the consequence of reduced wet pickups
- Better quality control: reduced seconds
- Greater application flexibility: producing higher margin specialty fabrics
- Range speed tracking, 80 standard programs, actual repeatability of applications [9,13].

2. MATERIAL and METHOD

2.1. Materials

100 % woven cotton fabric samples (50 warpxcm^{-1} x 24 weftxcm^{-1}, 250 g/m^2) were obtained from Gaston Systems Laboratory, North Carolina, USA. The fabric samples were cut into pieces of 50 cm of each width for crease recovery treatment via pad and foam application. The fabric samples were treated by 3 different recipes. The components used in treatment are as follows; Crosslinking agent which is produced by Rudolf Duraner was selected as Rucon Fan N-methylol dihydroxyethylene, Magnesium chloride hexahydrate 99% $MgCl_2$ produced by MERCK 1.05833.1000 was used as catalyst, macro silicone, a polysiloxane compound and cationic silicone, as softener was selected which is produced by Rudolf DuranerRucofin GSQ, and in the end, sodium hydroxide produced by Unichem Corporationwhich has 50% concentration and surfactant (Unifroth 0154, low molecular weight,anionic) was used for foaming.

Recipes were prepared in same manner for both applications with a slight difference. The solution used in foam application had less water when compared to pad application. For this study, the fabric samples were treated just by one side which resulted in a less wet pick up (w.p.u. %) of fabric samples. For pad application wet pick up of fabric samples was 73%, for foam application wet pick up of fabric samples was just 30%, so chemical solution on fabric samples after pad treatment was lesser than treatment with foam application. Three different pH values were studied in this paper, the aim of this paper was to obtain results with different pH values by means of different application types. Recipes for pad and foam applications were given in Table 1.

Table 1. Recipes for Crease Recovery Finishing Process of Cotton Fabric Samples

Recipes	Crosslinking agent (g/L)	Softener (g/L)	Catalyst (g/L)	pH	Drying	Curing
Recipe1	40	20	10	4.5-5	130 °C 5 min.	170°C 70 sec.
Recipe2	40	20	10	2	130°C 5 min.	170°C 70 sec.
Recipe3	40	20	10	11	130°C 5 min.	170C 70 sec.

2.2. Methods

After chemical applications, pyhsical tests (tensile strength, tear strength, abrasion resistance, crease recovery angle test and whiteness and yellowness indices measurement) were handled in Textile Engineering Department at University of Gaziantep. The fabric samples were tested under laboratory conditions with temperature 21±1 °C and with relative humidity 65±2 %RH. James H.Heal Titan Universal Strength Tester 2 with the standard of TS EN ISO 13934-1 'Tensile properties of fabrics- Part 1: Determination of maximum force and elongation at maximum force using the strip method (200 mm-100 mm)' was used to determine the tensile strength and elongation of fabric. 5 of warp direction, 5 of weft direction fabric samples (for each recipe) were tested.Tear strength was also measured by James H. Heal Titan Universal Strength Tester 2. TS EN 13937-2 'Tear properties of fabrics- Part II: Determination of tear force of trouser–shaped test specimens'.Similar to tensile strength tests, 5 trials warp and weft directions of fabric samples (for each recipe) were measured.

Crease recovery angles were measured according to AATCC Test Method 66 'Wrinkle Recovery of Woven Fabrics: Recovery Angle-1998' by James H. Heal & Co. Ltd. Crease Recovery Angle tester. 12 specimens for each recipe were cut into pieces of about 40x15 mm for each warp and weft direction of samples. The wrinkle recovery angles were recorded as the added total ofwarp and weft averages. In Table 2, crease recovery angle results were given.

Abrasion resistance values were measured by Martindale Abrasion Tester. TS EN ISO 12947-3 'Determination of the abrasion resistance of fabrics by the Martindale method- Part 3: Determination of mass loss' standard was used.4 specimens were prepared for each fabric samples. Test strokes of 2500, 5000, 7500 and 10000 cycles were studied according to TSE Standard.

Whiteness (WI) and yellowness (YI) indices were measured by Hunterlab Color Quest II. The device was adjusted D 65 daylight 10° angle field of vision. Fabric samples from each recipe were placed into sample clamp and the whiteness and yellowness indices were obtained.

3. RESULTS

In this study, 100% woven cotton fabric samples were treated with pad and chemical foam system (CFS). The results are as follows.

Tensile Strength: When pH values are discussed, in alkali media (pH 11) fabric samples have higher tensile strength (Figure 2). The highest value of tensile strength is obtained with Recipe 3 via pad application. But when results belong to Recipe 3 pad and Recipe 3 foam application are compared, values are similar to each other. This similarity shows that foam application is a significant alternative to pad application.

Tear Strength: According to results shown in Figure 3, the highest tear strength value is obtained with foam application. Three recipes belong to foam application enable highest results for tear strength. It shows pH values are effective for pad applications. When both Recipe 2 pad application and Recipe 2 foam application are examined, Recipe 2 by pad application (pH 2) has worst tear strength. It can be said that when pH value is low, in acidic media, fabric samples are affected negatively by pad application.

Crease Recovery Angle: If the angle is bigger, the fabric has less tendency to crease [12]. When we examine the Table 2**,** we can see the highest value for total angle is gained with both Recipe 2 pad application and Recipe 2 foam application. So it shows that pH 2 is more suitable value to get highest crease recovery angles with both pad and foam applications (Figure 4). According to results from Table 2 fabric samples are resistant to crease with pH 2, in acidic region, and it can be observed there is almost no difference between pad and foam application.

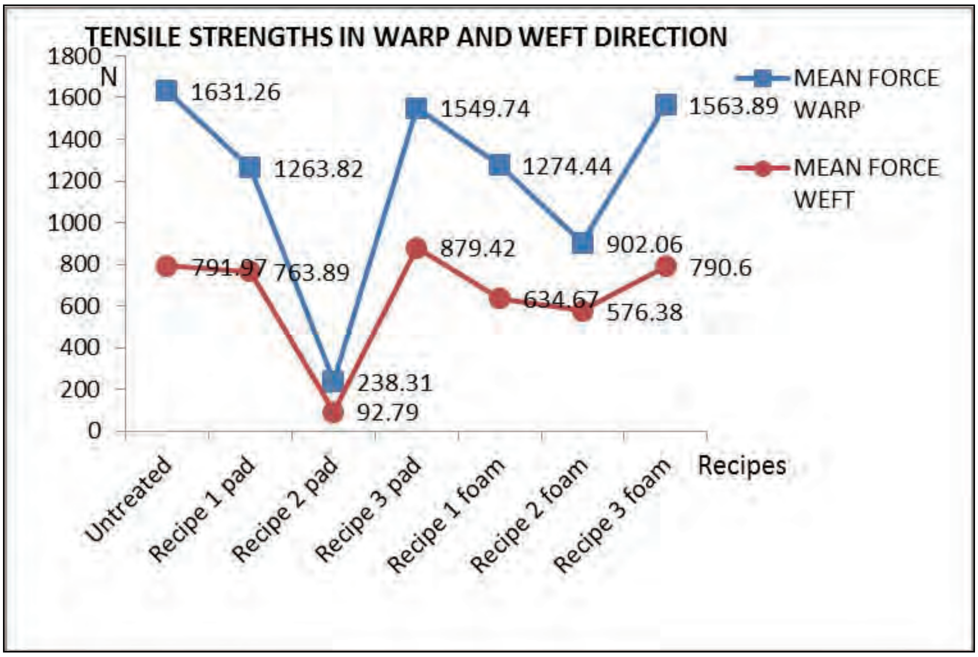

Figure 2. Tensile strength in warp and weft directions of samples

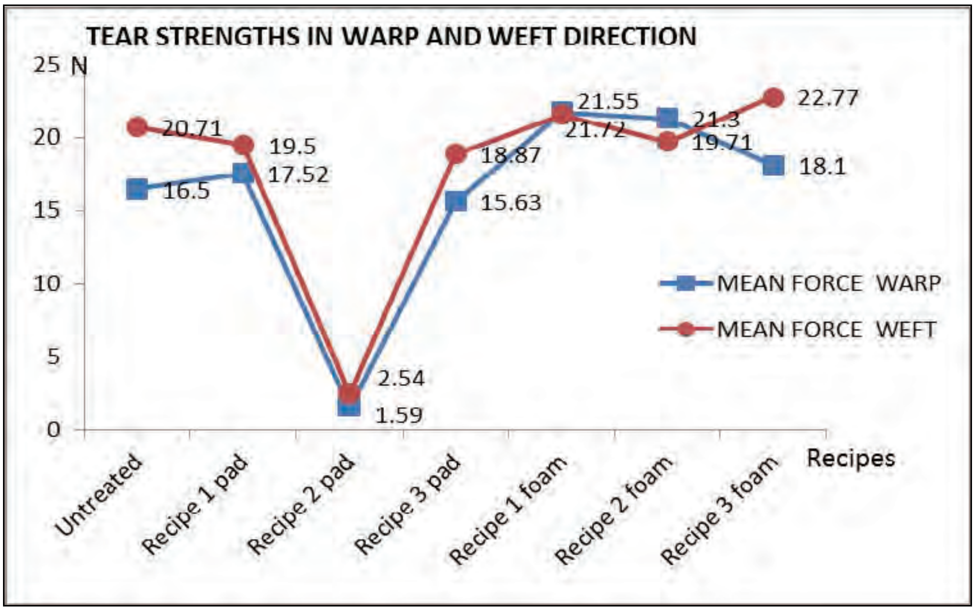

Figure 3. Tear strength in warp and weft directions of samples

Table 2. Crease recovery angles in warp and weft direction and total angle results

Samples	Warp (°)	Weft (°)	Total (°)
Untreated	56.50	94.00	150.50
Recipe 1 pad	62.70	114.00	176.70
Recipe 2 pad	85.00	117.50	202.50
Recipe 3 pad	66.80	100.30	167.10
Recipe 1 foam	74.80	120.70	195.50
Recipe 2 foam	77.00	129.80	206.80
Recipe 3 foam	63.30	99.70	163.00

Abrasion Resistance: Mass losses are shown in Figure 5. According to the figure, mass loss is maximum for Recipe 2 pad application. The mass losses are recorded at 10000 cycles (in Table 3), because the fabric samples are abraded with 10000 cycles. If Figure 5 is inspected fabric samples treated with Recipe 2 pad application are fully destroyed. This result shows that in acidic region, at pH 2, pad application damages 100% woven cotton fabric samples. When pad application and foam application results are discussed, foam application of all recipes is better than pad application.

Whiteness Yellowness Indices: According to Table 4, results except from Recipe 2 by pad application are acceptable. But in pad application with pH 2 (Recipe 2 pad application) fabric samples turn yellow. It shows that this recipe is not suitable, because treated fabric samples are so different from untreated samples.

According to test results, in both application methods, when pH value is low (pH 2), in acidic region, fabric samples show unfavourable results except crease resistant result. Of course to produce a crease resistant fabric sample, it is not possible to accept low values of tear strength, tensile stregth,abrasion resistance and also it is not acceptable to get yellowish fabric samples. These results show that in acidic region we cannot get reasonable values to produce crease resistant fabric samples for both pad application and foam application methods.

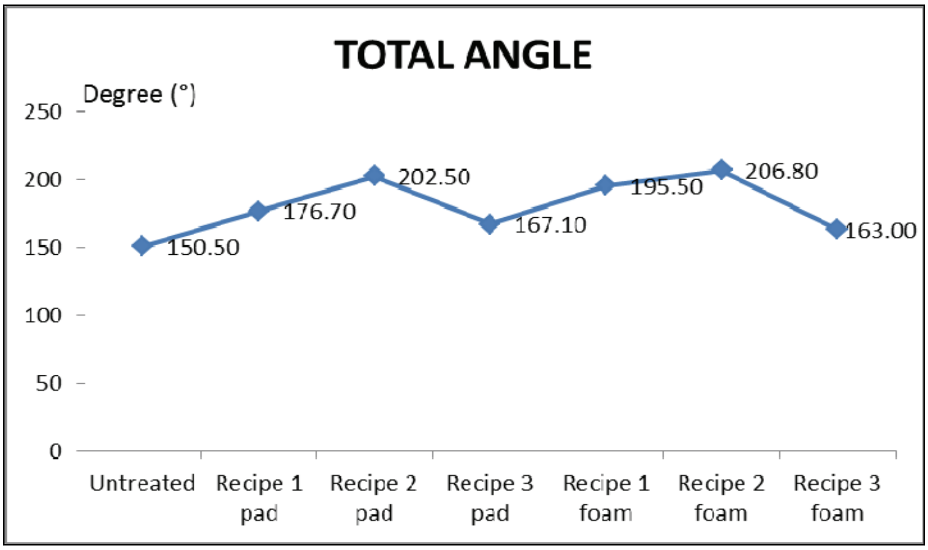

Figure 4. Total crease recovery angles of fabric samples in warp and weft directions

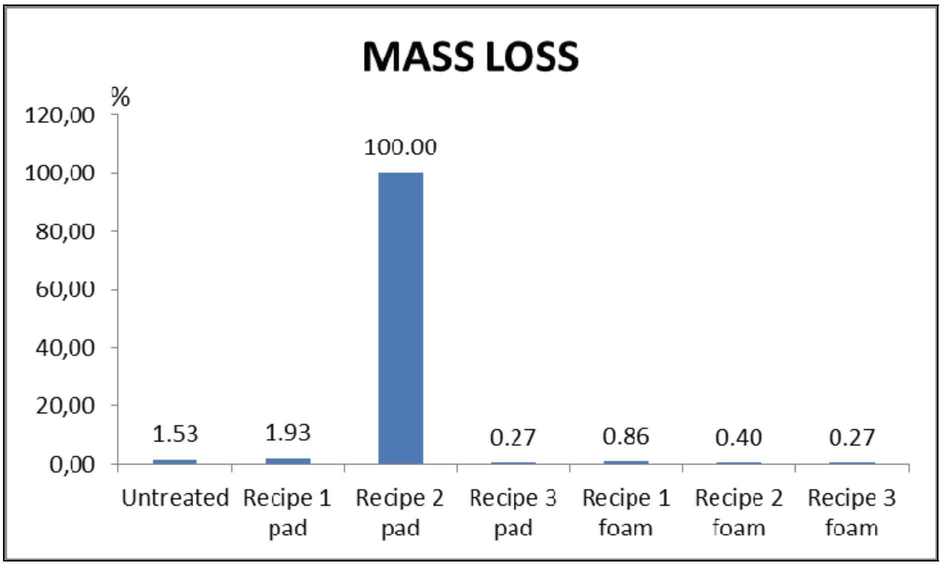

Figure 5. Total mass loss (%) of fabric samples at 10000 cycles

Table 3. Mass loss of fabric samples at 0,2500,7500 and 10000 cycles

Samples	0 cycle	2500 cycle	5000 cycle	7500 cycle	10000 cycle
Untreated	1.2170 g	1.2134 g	1.2046 g	1.2041 g	1.1984 g
Recipe 1 pad	1.2384 g	1.2348 g	1.2261 g	1.2198 g	1.2145 g
Recipe 2 pad	1.2693 g	0 g	0 g	0 g	0 g
Recipe 3 pad	1.2362 g	1.2416 g	1.2464 g	1.2392 g	1.2329 g
Recipe 1 foam	1.1534 g	1.1614 g	1.1573 g	1.1477 g	1.1435 g
Recipe 2 foam	1.2392 g	1.2593 g	1.2504 g	1.2403 g	1.2343 g
Recipe 3 foam	1.2362 g	1.2416 g	1.2464 g	1.2392 g	1.2329 g

Table 4. Whiteness and yellowness indices

Samples	**Whiteness Indices (WICIE)**	**Yellowness Indices (E 313)**
Untreated	73.08	2.97
Recipe 1 pad	71.18	3.62
Recipe 2 pad	25.31	16.51
Recipe 3 pad	70.06	3.75
Recipe 1foam	74.06	2.41
Recipe 2foam	72.21	3.15
Recipe 3foam	71.70	3.23

4. CONCLUSION

In conclusion when each property is evaluated, it is clearly seen that foam application with different pH values compared with pad application has never enable worst results. Pad application indicates good results in total crease recovery angle and total tensile strength. However pad application shows lowest results in total tear strength, abrasion and whiteness/yellowness indices. Foam application provides low water usage and it is possible to apply recipes just on the front side of the fabric sample, so the chemical usage decreases by this application and according to the results the optimal values for mechanical properties can be obtained by foam application. Results show that the highest value just for crease recovery angle is with pH 2. But it cannot be acceptable that it is the best recipe because other properties are optimal for other pH values.

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