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Comparative study for Improving Printing of Cotton/Polyester Blended Fabrics

Ibrahim DF*

Textile Printing, Dyeing and Finishing Department., Faculty of Applied Arts, Helwan University, Giza, Egypt

Abstract

Pre-treated Cotton/polyester blended fabrics were printed with kayacelon reactive/disperse dyes in one step process using slightly acidic medium (pH 6). The blended fabrics were introduced to enzymatic and alkaline treatment, (each separately). Several factors affecting both treatments were studied in details. The results addressed a remarkable improvement in both color strength and fastness properties for printed blend fabric; as well a comparison was obtained concerning the environmental impact.

Keywords: Bio-treatment; Cotton/polyester blended fabrics; Brewer yeast; Alkali treatment

Introduction

Recently polyester and cotton blends have become very important and wide spreading, especially polyester/cotton mixtures in the ratios 50:50 and 67:33. The popularity of these blends comes out from the desirable balance of both physical and comfort properties for clothes, such as shirts, blouses and other outer clothing. Several techniques, dyes and dye combinations can be used for the printing of polyester/cotton blends fabrics. Many variations and combinations have been applied and good results were obtained, but always there were some difficulties or undesirable complication.

The application of disperse and reactive dyes in textile printing has met with worldwide interest. This combination of two dyes can be fixed in a single process. Problems faced are fewer than with other dyes as this combination offers more color range that may be produced. Ready-mixed dye blends are used and recommendations are also made for the mixing [1].

The application of enzymes in the textile industry is an example of white/industrial biotechnology, which allows the development of environmentally friendly technologies and strategies to improve the final product quality. The consumption of energy and raw-materials, as well as increased awareness of environmental concerns related to the use and disposal of chemicals into landfills. Water or releases into air during chemical processing of textiles are the major reasons for the application of enzymes in finishing of textile materials [2].

Applying bio-treatment process before printing will ease the way for achieving desirable properties, especially improving the dye uptake by different fabrics. Nowadays special enzymes are created for textile applications, meanwhile discovering new sources of natural enzymes containing a variety of enzymes such as: lipase, amylase, protease and others is opening a new era for enzymatic applications in the fields of textiles. Brewer yeast having a mixture of enzymes, adhering to very simple preparation steps accompanied with a very low price [3].

On the other hand, the treatment of cotton/polyester blended fabric in alkali media is a common modification process for producing a fabric with desirable qualities and better performance. Weight reduction is an alkali treatment role for (PET) fabric with the aim of improving drape, handle and touch. For cotton fibers, NaOH is exclusively used in variable processes such as, scouring and mercerization [2,4,5].

In the present work, cotton/polyester blended fabrics were pretreated with two different separated treatments; Brewer's yeast filtrate enzymes and caustic soda, as a way of improving cotton/polyester blended fabrics post printing with kayacelon reactive/disperse dyes.

Experimental Work

Materials and dyestuff

• Fabric: 31/69% cotton/polyester blended fabrics plain weave 1/1, 135 g\m^2 fabric weight, was used in this study (Table 1).

• Enzyme: Brewer's yeast filtrate, contains different enzymes (protease, lipase and amylase), supplied from starch and yeast company-Cairo, Egypt, was prepared by a method that described elsewhere [3] and used throughout this study.

Dyes: Two dyes were used

• Reactive dye (kayacelon reactive red CN3B TM130)-USA.

• Disperse dye (Disperse Red S-5BL)-China.

Chemicals: Caustic soda (NaOH), acetic acid (CH_3COOH), urea ($CO(NH_2)_2$), dispersing agent, polyethylene glycol 400 and sodium alginate thickener (high viscosity), from all supplied by El Nasr Pharmaceutical Chemicals.

Technical Procedures

Bio treatment of blended fabrics with enzymes: The cotton/polyester blended fabrics were treated with brewer's yeast filtration at

Fabric parameters	Warp	Weft
Yarn Material	100% Polyester	100% cotton
No. of yarns/cm	72	36
Yarn count	150 Denier	133 Denier (40 NE)

Table 1: Fabric parameters.

***Corresponding author:** Ibrahim DF, Textile Printing, Dyeing and Finishing Department., Faculty of Applied Arts, Helwan University, Giza, Egypt, Tel: 002-02-33380965; E-mail: drdaliafekry@hotmail.com

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different concentrations (0, 100, 200, 300 and 400 ml/l) at L:R 1:50 using pH level which adjusted at different degrees (6-7-8-9) .The enzymatic treatment was also applied at different treatment temperatures (40-50-60-70°C) for different intervals of time (0-15-30-45-60 min).

After bio treatment time, the temperature was raised to 80°C to stop the enzymatic activity, and then the blended fabrics were rinsed with cold water and printed using the optimum printing paste as mentioned later in (2.2.3).

Alkali treatment of cotton/polyester blended fabrics: Cotton/polyester blended fabrics were treated with caustic soda in a different bath at different concentrations (0, 2, 4, 6 and 8% owf), using L: R 1:30, and different treatment temperatures (70-80-90-100°C) for different durations (0-15-30-45-60 min.). After treatment time the samples were neutralized using acetic acid to remove any remains of caustic soda, then rinsed with cold water. Afterwards, the blended samples were printed using the optimum printing paste mentioned later in (2.2.3).

Printing of cotton/polyester blended fabrics: Treated cotton/polyester blended fabrics were printed with kayacelon reactive and disperse dyes by flat screen printing method in order to determine the most suitable printing paste contents and pH level for fixing both dyes, in addition to adjusting the optimum steaming temperature and time.

Printing paste contents were:

50 g/kg dye (both reactive and disperse dyes according to blending ratio)

70 g/kg urea

10 g/kg dispersing agent

(0, 10, 20 and 30 g/kg polyethylene glycol)

650-700 g/kg sodium alginate thickener (4%)

X g/kg water/1000 g

Different concentrations of polyethylene glycol were added to the printing paste , as well , pH level was adjusted at different levels (5-6-7-8), in order to determine the most suitable pH degree for fixing both kayacelon reactive and disperse dyes on both cotton and polyester fibers. Fixation step was also done at different steaming temperatures (120 and 130°C) and different intervals of time (10, 20, 30 and 40 min.) to reach the optimum fixation conditions.

Measurements

Color strength: The color strength (K\S) of the printed samples was evaluated by color reflectance technique at λ maximum. The used spectrophotometer was of model ICS-Texicon Ltd., Kennestside Park, Newbury, Berkshire RG 145TE, England.

Color fastness properties: The color fastness to washing, rubbing, and perspiration were determined according to AATCC test methods (61, 8, 15-1989 respectively).

Tensile strength: The testing was done according to the ASTM: D 5034 (standard test method for breaking strength and elongation of textile fabrics (grab test method).

All measurements were done in National Research Centre, Cairo, Egypt.

Results and Discussions

Treatment of cotton/polyester blended fabrics with Brewer's yeast filtration

The cotton/polyester blended fabrics were treated with brewer's yeast filtration in order to study the effect of different enzymes available in this natural source.

Effect of yeast filtrate concentration: The blended fabrics were treated with different concentrations of yeast filtration (0,100,200,300 and 400 cm/l) at pH 8 using L:R 1:50, at 60°C for 30 min (Table 2). Analysis of brewer's yeast filtration illustrated the presence of protease, lipase and amylase enzymes [3,6]. Amylases are commercialized for completely removing the size without any harmful effects on the fabric. Proteases are enzymes that catalyze the hydrolysis of proteins. Different kinds of proteases have a slight effect on improving wettability. Lipases catalyze the hydrolysis of fats. Common fats are esters of glycerol and fatty acids. Lipases attack the ester bonds regenerating water-soluble glycerol and water-insoluble fatty acid.

K/S values improvement confirm that carboxyl and hydroxyl groups are produced on the surface of PET fabrics by lipase hydrolysis [2,7,8]. From the summation of all the improvement actions, color strength for printed blended fabrics was to be an expected result.

Effect of pH level: The cotton/polyester blended fabrics enzymatically treated at different pH levels to reach the suitable pH level for enzymes activity. In general enzymes are quite stable over a wide range of pH from 4 to 11 [2]. From (Table 3), it is clearly shown that pH 9 was the most suitable pH level for the activity of this mixture of enzymes. Increasing alkaline medium may affect the fibers, tensile strength.

Effect of treatment time: Concerning treatment time, which affects the treatment efficiency, different treatment time were applied (0, 15, 30, 45 and 60 min.) for treating cotton/polyester blended fabrics with brewer's yeast filtrate.

Brewer s yeast filtrate concentration (ml/l)	K/S
0	15.67
100	17.74
200	18.62
300	18.09
400	17.12

Table 2: Brewer s yeast filtrate concentration (ml/l) via K/S values.

pH level	K/S
6	17.00
7	16.92
8	18.05
9	18.60

Table 3: pH level adjustment for enzymes activity via K/S values.

Treatment time (min.)	K/S
0	16.13
15	17.83
30	18.85
45	19.57
60	18.63

Table 4: Treatment time adjustment for enzyme activity via K/S values.

From (Table 4) it can be investigated that enzymatic treatment time affect the action of enzymes by increasing the color strength according to the improvement of printability properties; absorbency, hydrophilicity and surface character.

Effect of treatment temperature: From the different bio-treatment temperatures were used (40, 50, 60 and 70°C), (Table 5) shows the increasing of enzyme activity represented in increasing of color strength as reactions speed up until reaching the maximum at 60°C , then the k/s decreased according to the denaturation of enzyme by raising the temperature [8].

Treatment of cotton/polyester blended fabrics using sodium hydroxide

In this research cotton/polyester blended fabrics were treated with NaOH different concentrations, at different temperatures and times. The results show that alkali treatment at the optimum temperature and time with NaOH could hydrolyze the polyester fiber surface and remove some of the impurities from the cotton fiber at the same time, may also improve some of the fabric properties, such as absorbency, and fabric pilling [4,9].

Effect of NaOH concentrations: Different concentrations of NaOH were used as shown in (Table 6) to determine the most suitable concentration which gives the desirable effect without affecting fabric physical properties.

The mechanism of hydrolytic degradation of polyester fibers (warp yarns) shows that alkali gradually degrades polyester by saponification of its ester linkages and results in a loss in weight of the fabric. By alkaline hydrolysis, surface hydrophilicity and feel of the fabric are considerably improved [10]. Considering cotton yarns (weft yarns) NaOH may extend to the release impurities and un-mature fibers which can affect absorbency of the fibers [5,11].

Effect of treatment temperature and time: In order to set up the suitable conditions for alkali treatment, cotton/polyester blended fabrics were treated with NaOH for different intervals of time at different temperatures. Tables 7,8 shows that 90°C is the optimum temperature for treatment for 30 min. Any increase in treatment time and temperature results in fabric weakness and k/s decrease.

Treatment temperature °C	K / S
40	17.36
50	17.46
60	19.45
70	17.64

Table 5: Treatment temperature adjustment for enzymes activity via K/S values.

NaoH concentration % (owf)	K/S
0	16.79
2	17.51
4	18.23
6	19.09
8	18.65

Table 6: NaOH concentration for blended fabric treatment via K/S values.

Treatment temperature °C	K/S
70	17.45
80	17.81
90	18.23
100	17.58

Table 7: Alkali treatment temperature via K/S.

Treatment time (min.)	K/S
15	17.07
30	18.23
45	17.17
60	16.25

Table 8: Alkali treatment time via K/S.

Polyethylene glycol concentration(ml/kg)	K/S
0	16.04
10	17.38
20	18.00
30	16.87

Table 9: Polyethylene glycol concentration via K/S values.

pH level	K/S
5	16.31
6	16.76
7	15.27
8	14.87

Table 10: pH level for printing paste via K/S values.

Steaming time	K/S
10	14.07
20	15.60
30	16.37
40	16.22

Table 11: Steaming time via K/S values.

Printing treated cotton/polyester blended fabrics with reactive/disperse dyes

Both enzymatic and alkali treated cotton/polyester blended fabrics were printed with one printing paste in one step, using flat screen technique. The printing paste containing both dyes, kayacelon reactive one and the disperse dye. Factors affecting the efficiency of printing paste were studied in dilates.

Effect of polyethylene glycol concentration: Different concentrations of polyethylene glycol were added, which is used as a solvent agent, helping in dissolving reactive dye and spreading of disperse one , as well as swelling of cotton fabrics [12]. Table 9 shows the different results for polyethylene glycol concentration used.

It is clearly shown that using polyethylene glycol results in a remarkable improvement in the depth of printed fabric samples due to the gradual increase of dye penetration to reach the maximum by using 20 ml/kg, [13] while color strength decreased due to the increasing of polyethylene glycol conc. which may be due to the inverted action on disperse dye.

Effect of pH level: Different pH levels 5,6,7 and 8 were used in adjusting the printing paste medium in order to determine the most suitable pH for fixing both reactive dyes on cotton fabric and disperse dye on polyester in the same time. pH 6-7.5 is considered to be the suitable level for fixing kayacelon reactive dyes on cotton fabrics [14], where the most suitable level for printing polyester fabrics with disperse dyes as recommended in literature is slightly acidic medium from 5.5 to 6 .

From Table 10, it can be concluded that pH 6 is the most suitable pH level for both dyes to be fixed on cotton/polyester blended fabrics, achieving maximum color strength.

Substrate Status cotton/ polyester blended fabrics	weight (g)	K/S	Rubbing		Washing		Perspiration				Tensile strength	
							Acidic		Alkaline		Tenacity Kg	Elongation %
			Dry	Wet	St.	Alt.	St.	Alt.	St.	Alt.		
Blank printed without pre-treatment	33.65	16.05	04-May	4	4	03-Apr	03-Apr	4	03-Apr	4	110	62
Pre-treated with Brewer's yeast filtrate	32.9	19.5	04-May	4	4	03-Apr	03-Apr	4	4	4	106.5	67
Pre-treated with NaOH	32.95	19.56	04-May	4	4	03-Apr	03-Apr	4	4	4	105.5	73

Table 12: Fabrics properties.

Points of comparison	Brewers yeast filtrate treatment	Alkaline treatment with NaOH
Optimum condition of treatment	200 ml/l brewer's yeast filtrate	6% NaOH
	L:R 1:50	L:R 1:30
	pH 8-9	
	for 45min	for 30 min.
	at 60 °C .	at 90°C
Environmental impact	Environmentally friendly	Chemical treatment is hard to control, leading to unacceptable loss of weight and strength. Besides, this is not an environmentally appealing process since it requires large amounts of energy and chemicals.
Energy and water consumption	Save energy (60°C) and water	Need high energy (90°C)–need more rinsing water
Decrease in tensile strength	3%	4%

Table 13: Comparison between enzymatic & alkaline treatment on cotton/polyester blended fabrics.

Effect of Steaming temperature and time: Concerning fixation temperature, it shows that decreasing steaming temperature only 10 degrees from 130 to 120°C decrease color strength of the printing samples for about 50% from (16.37 to 8.46). Thus 130°C was setted to be the most suitable steaming temperature.

Table 11 shows the result of studying the steaming time effect on color strength of printed blended fabrics. By increasing steaming time the fixation of both dyes increased gradually until reaching the maximum at 30 min.

So, it can be illustrated that the optimum printing paste contents and steaming conditions were:

50 g/kg Dye (both reactive and disperse dyes according to blending ratio)

70 g/kg Urea

10 g/kg Dispersing agent

20 g/kg Polyethylene glycol

650-700 g/kg Sodium alginate thickener (4%)

At pH 6

X g/kg water/1000 g

After air drying, the samples were fixed using saturated steam at 130°C for 30 min.

Color fastness properties

The results of fastness properties of un-treated and treated printed cotton / polyester blended fabrics are listed in Table 12. The results show good to very good fastness to wash, from good to very good in case of alkaline and acidic perspiration fastness. The results of rubbing fastness indicate that the prints have from very good to excellent fastness to dry and wet rubbing.

Tensile strength

A Linear correlation exists between strength loss of the fabric and its weight loss [8]. From Table 12, it was illustrated that decreasing in tensile strength after treating the blended fabrics with brewer's yeast filtration reached about 3% loss in substrate tensile. While decreasing in tensile strength after treatment with NaOH lose about 4%. In General, the effect of both treatments did not reach the accepted limit.

Comparison between enzymatic & alkaline treatment on cotton/ polyester blended fabrics is shown in table 13.

Conclusion

Comparative study between enzymatic treatment with brewer's yeast filtrate and alkaline treatments with NaOH for Cotton/polyester blended fabrics which were printed with kayacelon reactive/disperse dyes in one step method, shown an improvement in color strength for printed areas. Although the gained improvement in printability was relatively closed, the environmental impact for both treatments differs in the way to green technology. In addition the printing paste used with nearly neutral medium for fixing both dyes on the blended fabrics insures the research aim.

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