Journal of Textile Science & Engineering
ISSN: 2165-8064

Ibrahim and Abd El-Salam, J Textile Sci Eng 2012, 2:3
DOI: 10.4172/2165-8064.1000113

Research Article
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Enzymatic Treatment of Polyester Fabrics Digitally Printed

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Abstract

100% polyester fabrics were digitally printed after merging the enzymatic treatment with lipase enzyme with the ink jet pretreatment bath. The color strength of the digitally printed polyester samples was clearly increased after the enzymatic treatment for about 10–30%. The presented work addresses a number of advantages over convention methods like time and energy saving through merging two stages of work in one bath, enzymatic and ink jet pretreatment. Several factors affecting the biotreatment process were studied in details and results were addressed.

Introduction

Concerns regarding health, energy and environment drove the improvement of enzyme technology in textile industry. Enzymatic processing of natural fibers covers a wide-range of operations, from cleaning preparations to finishing. In addition to natural fibers, enzymatic hydrolysis on synthetic fibers has been explored to enhance their hydrophylicity using lipases, polyesterases and cutinases Figure 1. Among these enzymes, lipases have been reported as hydrolyzing ester linkages in polyethylene terepHthalate, thus producing hydroxyl and carboxylic groups [1].

On the other hand, total global production of printed textiles is widely covering a wide range 25-30 billion meters per annum. Around 97% is screen printed and the remaining 3% is digitally printed. Over the next 5-years, a large percentage of production will shift to digital printing applications. Analysts predict that within 5-years, 15% of globally printed textiles will be digitally produced [2]. This interest has been fulfilled by the rapid advantages of digital printing technology.

Ink jet printing offers many advantages like fully integrated system with CAD, no screens needed, friendly to environment, easy change of design and no restrictions on repeats [3,4].

In spite of all these advantages, polyester fabric has a lower ability to hold water and inks due to the smooth morphology and chemical properties of polyester fibers [5].

In this present work polyester fabric was treated with lipase enzyme based on two different routes:

- First: In a separate bath before digital printing.
- Second: In the pretreatment bath of ink jet printing mixed with the bath components.

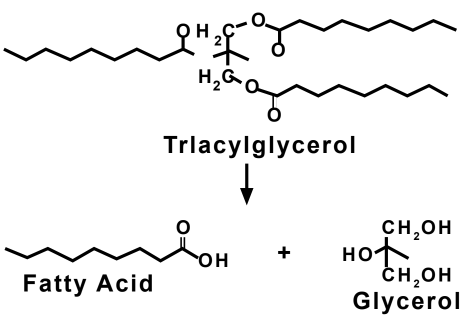

Figure 1: Lipase action on ester chains of polyester.

Another aim of work is that both techniques were going in the same line for environmentally friendly technology. Meanwhile with respect to all which has been addressed before, this research aims to:

- Improves digitally printing of polyester fabrics using disperse dyes.
- Applies a new technique in textile wet processing.
- Save energy, time and money (representing in merging two processes).
- Green production by using green substrates and technology.

Experimental Works

Materials and dyestuff

Throughout this research a 100% scoured and bleached polyester fabric, with fabric structure plain weave 1/1, 80 g/m^2 weight, supplied by Happy Tex. for Spinning & Weaving Company- Egypt, was used.

A hydrophobic disperse dye was used in the present study, supplied as original ink jet dyes of printing (CMYK to obtain red color), produced by Ink Tec. Co. Ltd, Korea. Lipase MP Enzyme supplied from biomedical LLC France, sodium alginate thickener and formic acid, with commercial grade.

Technical procedures

The two routes of treatment were sited in this work:

First: enzymatic treatment before ink jet pretreatment bath: Polyester samples were treated in a previous separate biotreatment bath of polyester fabrics using lipase enzyme with different concentrations:

X g/l lipase enzyme (0, 0.5, 0.9, 1.5 and 2 g/ l), at room temperature for 30 mins at pH level 7.

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Received March 29, 2012; **Accepted** April 16, 2012; **Published** April 18, 2012

Citation: Ibrahim DF, Abd El-Salam SH (2012) Enzymatic Treatment of Polyester Fabrics Digitally Printed. J Textile Sci Eng 2:113. doi:10.4172/2165-8064.1000113

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After enzymatic treatment, the temperature of the bath was raised to stop enzyme activity, and then the samples were rinsed with hot and cold water then dried. Polyester samples were then padded in ink jet pretreatment bath and finally digitally printed and fixed, as follows:

I. Pre-treatment bath: (Traditional pre-treatment bath of polyester)

Control sample

100 gm/l sodium alginate 4%

$$\frac{900\ \text{gm}/\text{l water}}{1000\ \text{gm}/\text{l}}$$

Adjust pH level to 6.2 using formic acid and then, padding is done approximately to 70% pick up. Allow the mixture to dry at room temperature [6].

Ink jet printing: The pretreated polyester samples, were digitally printed by ink jet technique machine using (Encad 1500 TX printer, produced by Encad Inc, USA) followed by air drying.

Fixation: After drying the printed samples were subjected to fixation at 180°C for 2 minutes, using thermo fixation machine, produced by (R.B. Electronic and Engineering PVT. LTD, India).

Washing off: Finally the fixed printed samples were washed off as follows:

- Rinsing with running cold water.
- Soaping at 60°C for 15 minutes using (4 gm/l soap)
- Rinsing with running cold water and finally the printed samples were dried at room temperature.

II. Second: Enzymatic treatment mixed with ink jet pretreatment bath: Polyester fabrics treated with different concentrations of lipase enzyme dispersed with the inkjet pretreatment bath components, including (sodium alginate and water, at different pH levels (4, 5, 7 and 8), accompanied with different storing time (1, 2, 3 and 4 hours) using plastic bags, at room temperature.

X g/l lipase enzyme (0, 1, 2, 3 and 4 g/l)

100 g/l sodium alginate 4%

$$\frac{900\ \text{g}/\text{l water}}{1000\ \text{g}/\text{l}}$$

After storing time the samples were dried with hot air to insure enzyme inactivation, and then ink jet printed with traditional steps (2, 3, and 4).

Measurements

Color fastness properties: The color fastness to washing, rubbing, and perspiration were determined according to AATCC test methods (61- 2010, 8- 2007, 15- 2009).

Color strength: K/S of the printed samples was evaluated by color reflectance technique at λ maximum (440). The used spectrophotometer was of model ICS-Texicon Ltd, Kennestside Park, Newbury, Berkshire RG 145TE, England.

Tensile strength: Tensile strength of control polyester fabrics and the biotretead ones based on optimum conditions were measured on Quant 5.37, tensile strength H5KT/130 – USA, according to ASTM: D 5034 - 2008 standards.

Results and Discussion

Separately previous polyester enzymatic treatment:

Effect of lipase enzyme concentration: Different concentrations of lipase enzyme were used (0, 0.5, 0.9, 1.5 and 2 g/l) in a separate bath for polyester fabrics biotreatment (before ink jet pretreatment and printing) in order to improve the fabric hydrophilicity and absorbance. As lipase catalyze the hydrolysis of ester bonds, regenerating water soluble glycerol and water insoluble fatty acid, which then can be converted to water soluble salts by the addition of the alkali [7].

The K/S values of the biotreated and printed fabrics are plotted in Figure 2. The results imply that the maximum color strength value was obtained using the enzyme concentration 0.5 g/l, since this concentration caused an increase in color strength for about 20%. As a result of this modification the fine structure of polyester fibers is opened leading to easier and greater dye penetration inside the fiber which is reflected on the color strength of the printed fabric. Then any increase in enzyme concentration will decrease K/S; according to the negative relation between disperse dye and the modified polyester surface which has a more hydrophylicity character Table 1.

Enzymatic treatment mixed in pretreatment bath of ink jet printing

Effect of enzyme concentration: For saving time and energy (conventional process stages), the enzymatic treatment was mixed in one bath with the pretreatment step of the ink jet printing.

Different concentrations of lipase enzyme were used with constant contents of pretreatment bath at pH 6.2. After treatment the polyester

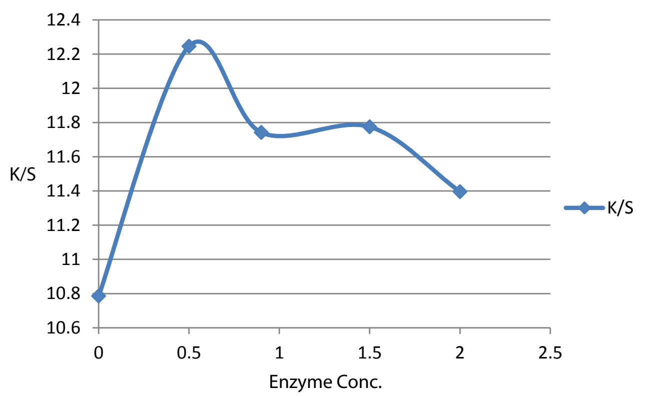

Figure 2: Effect of Enzyme concentration on color strength of digitally printed polyester fabrics with disperse dye.

Enzyme concentration g/l	K\S Value
0	10.7860
0.5	12.2464
0.9	11.7423
1.5	11.7747
2	11.3964

Table 1: Effect of Enzyme concentration on color strength of digitally printed polyester fabrics with disperse dye.

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samples were stored in plastic bags for 1 hour. As the treatment bath contains:

X enzyme (0, 1, 2, 3 and 4 g/kg) + 100 g/kg sodium alginate thickener with 900 cm water

From Figure 3 it is clear that increasing enzyme concentration, increase the K/S gradually, till it reaches maximum at 2 g/L concentration. As an effect of lipase enzyme on fiber surface modification according to the hydrolysis of great number of ester links reaches its maximum degree [8].

By comparing between the role of enzyme in fabric modification in (Figure 2,3) we can observe that enzyme has a more freely effect in the aqueous solution rather than in a viscous paste. This addresses the difference between the effect of lipase enzyme in separate solution and within the pretreatment bath of ink jet Table 2.

Effect of pH level: pH level is considered to be a very effective factor, affecting both enzyme treatment and pretreatment of inkjet printed polyester fabrics. Generally the lipase optimum pH is in the range 7-9 according to the substrate, and the presence of the activators, but it is decomposed by acids. On the other hand the optimum pH level of pretreatment bath of the ink jet printer polyester fabrics was 6.2–6.8 as mentioned in literature [6]. So the pH level in this experiment was adjusted at different pH levels (5, 6, 7 and 8) in order to reach the most suitable one for maximum color strength result.

From Figure 4, it obtained that changing the pH level from acidic to slightly alkaline medium made some gradually increasing in color strength of printed samples according to the presence of the suitable medium for enzyme activity and disperse dye fixation. pH level 6-7 could be the most suitable level in spite of the increasing color strength

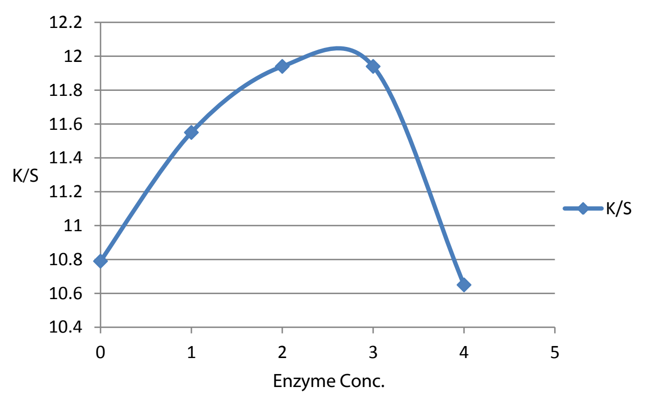

Figure 3: Effect of Enzyme concentration on color strength of digitally printed polyester fabrics with disperse dye.

Enzyme concentration g/l	K\S Value
0	10.7860
1	11.5513
2	11.9392
3	11.9392
4	10.6494

Table 2: Effect of Enzyme concentration on color strength of digitally printed polyester fabrics with disperse dye.

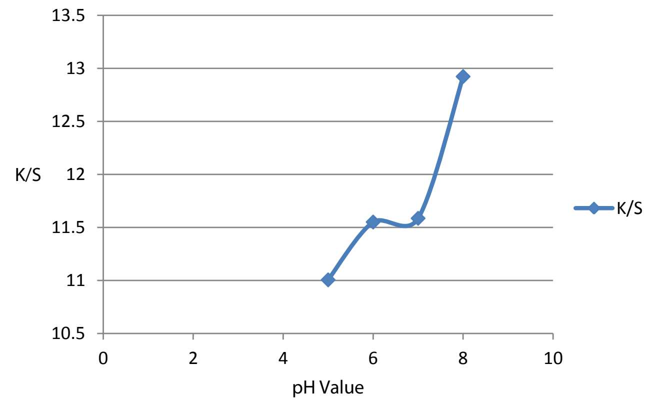

Figure 4: Effect of pH level of pretreatment bath on color strength of digitally printed polyester fabrics with disperse dye.

pH	K\S Value
5	11.0057
6	11.5513
7	11.5859
8	12.9227

Table 3: Effect of pH level of pretreatment bath on color strength of digitally printed polyester fabrics with disperse dye.

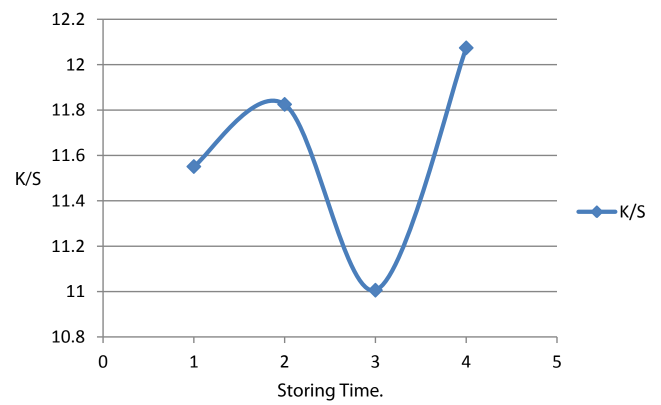

Figure 5: Effect of storing time on color strength of digitally printed polyester fabrics with disperse dye.

at pH 8, as reaching the alkaline medium may hydrolyze the polyester fibers due to alkali deweighing effect Table 3.

Effect of storing time

For offering the lipase enzyme an interval of time to make its action of hydrolysis polyester chains, the polyester samples were carefully stored in plastic bags after treatment in a bath contains.

100 g/l sodium alginate

$$\frac{2\ \text{g/l lipase enzyme}}{1000\ \text{g/l at pH } 6-7 \text{ at room temperature}}$$

Different storage times were applied (1, 2, 3 and 4 hours) in order to study the effect of storing time on the fabric merging pretreatment process.

Figure 5 shows increasing in color strength by extending the

Storing time / hour	K\S
1	11.5513
2	11.8250
3	11.0057
4	12.0742

Table 4: Effect of storing time on color strength of digitally printed polyester fabrics with disperse dye.

Color fastness	Fastness to rubbing		Fastness to perspiration		Fastness to washing
	Wet	Dry	Alkaline	Acidic	4-5
Control	4	4	4-5	4-5	
Separate Bio treatment	4-5	4-5	4-5	4-5	4-5
Mixed treatment	4-5	4-5	4-5	4-5	4-5

Table 5: Fastness properties of polyester digitally printed fabrics.

	Tensile strength kg/m^2	Tenacity cm
Control	226	24.8
Separate Bio treatment	210	26
Mixed treatment	192	23.6

Table 6: Tensile strength of bio treated and digitally printed polyester fabrics.

samples storing time, as a result for enzymatic effect on polyester samples. Two hours storing time was the most suitable time, as increasing time in spite of its positive effect on fabrics; it has also a negative effect of weakening the fiber tensile strength Table 4.

Color fastness properties

The results of fastness properties of the printed fabrics are listed in Table 5. The results show very good fastness to rubbing, from very good to excellent in case of perspiration and washing fastness properties, indicate that the prints have some improving after both enzymatic treatment .

Tensile strength: To insure limited tensile strength loss, the tensile strength of untreated polyester fabrics and both enzymatic treated polyester samples, were measured. It seems to be a minimal loss of fiber weight and strength (8–16%). As a result of fabric weight loss, according to enzyme modification and hydrolyze effect on polyester surface Table 6.

Conclusion

Ink jet printing of polyester fabrics was improved using biotreatment process either before ink jet pretreatment or merging with it in one bath. This treatment was considered as a new technique at which saving time and energy via, improving digital printing of polyester fabric with disperse inks. As well, color fastness of treated printed samples was improved and tensile strength not affected for great extent.

References

1. Rim KH, Soon SW (2010) Lipase treatment to improve hydrophilicity of polyester fabrics. International Journal of clothing Science and Technology 22: 25-34.
2. Digital textile printing: Inks & technology solutions. Indian Textile Journal 2012.
3. Bidoki M, Gorman DM, Lewis DM, Clark M, Horler G, et al. (2005) “ATCC Review”: 11.
4. Dawson TL, Ellis H (1994) Will ink jets ever replace screens for textile printing? Journal Society of Dyers and Colorist 110: 331-337.
5. Nilsson J (1997) “International Dyer: 18.
6. Catalog of Pretreatment of Textiles by Ciba Specialty Chemicals Co, Basel, Switzerland, 2000 3: 5.
7. Wilkinso JH (1976) Diagnostic enzymology. Edward Arnold Ltd London: 3-40.
8. Salem AA (2004) Improving of physical properties and printability of local polyester fabrics by using eco friendly technology- faculty of Applied Arts Helwan University.