Effect of various types of enzymatic treatment on Textile Materials and Optimize the process

Md. Eman Talukder[1*], Md. Kamruzzaman[1], Monoroma Hossain[2] , Mithon Majumder[2], Md. Shakhawat Hossain Rony[2], Santanu Das[1]

College of Textile Chemistry & Chemical Engineering Wuhan Textile University, Hubei, China[1].
College of Textile Science & Engineering, Wuhan Textile University, Wuhan, Hubei, China[2].
Corresponding Author: Md. Eman Talukder, emant92@gmail.com, Cell No: +86-13237127416

Abstract

In this study, main focus on enzyme treatment in textile materials dyeing processing. Environment-friendly uses of assorted enzymes in numerous textile process steps are mentioned. It's determined that enzymes will replace harsh chemicals, catalyze reaction and operate beneath delicate conditions. The finishing process of cellulosic textile materials with celluloses has reached enormous industrial importance over the past decade. Nontoxic and environmentally benign, these biocatalysts are capable of improving hand and appearance properties of cellulosic goods at very low concentrations.The use of accelerator technology is engaging as a result of enzymes square measure extremely specific and economical, and work below delicate conditions. Moreover, the employment of enzymes leads to reduced method times, energy and water savings, improved product quality and potential method integration. The aim to supply the textile engineer with an understanding of enzymes and their use with textile materials.

Keywords

Enzyme, Textile materials, Bio-polishing, Eco-friendly, Bio-degradable

Introduction

The use of enzymes in the textile business is associate example of white/industrial biotechnology that permits the event of environmentally friendly technologies in fibre process and ways to enhance the ultimate product quality [1].The enzymes utilized in the textile field area unit amylases, catalase that area unit accustomed removing the starch, degrading excess oxide, bleaching textiles and degrading polymer.[2]. The enzymes within the textile chemical process is speedily gaining globally recognition attributable to their non-toxic and eco-friendly characteristics with the progressively necessary necessities for textile manufactures to scale back pollution in textile production[3]. The appliance of celluloses for denim finishing and lactases for decolourization of textile effluents and textile bleaching area unit the foremost recent industrial advances. Enzyme treatments became one amongst the foremost normally used wet-processing techniques within the textile trade. The catalyst technology has been applied to enhance handle, appearance, and alternative surface characteristics of cotton and cotton blends [4].

Bio-polishing enzyme finishing method during which a material is treated with associate as a catalyst to impart properties like anti-pilling, softness and smoothness[5].Bio-polishing process results in substantial saving in process rinsing water and cellulose structure of fabric stays intact which improves strength

properties and process ability. By replacing harsh chemicals Bio-polishing reduces pollution load drastically[6].

Enzymes are biological catalysts that accelerate the rate of chemical reactions [7]. All enzymes are created of super molecule and them every have a terribly specific three dimensional form. The shape is completely different for every catalyst and every catalyst solely works on one substance or form of chemical process. Catalase speed up the breakdown of hydrogen peroxide. The reason for this is often that the substrate fits into a special region of the enzyme known as the situation. When in the situation the catalyst will change state the reaction. The active site may be a special form and can thus solely enable molecules of a definite form within. The reaction happens with lower activation energy which is reached by forming associate degree intermediate catalyst substrate. The enzyme substrate molecule is converted into the product and then the catalyst also is regenerated by own self[8].

Biological element Demand (BOD) and Chemical element Demand (COD) of accelerator bio-polishing method square measure 20-45 resembling compared to a calescence scouring (100 %). Total Dissolved Solid (TDS) of accelerator scouring method is 20-50% as compared to a calescence bio-polishing (100%) [9].Hand feel is extremely soft in accelerator bio-polishing compared to al coalescence scouring method. Accelerator scouring and bleaching make it doable to effectively scour material while not negatively touching the material or the setting. It additionally minimizes health risks therefore operators don't seem to be exposed to incursive chemicals[10].

The main objective of this study work is to spot the result of various catalyst in textile wet process. To find out the enzyme is good for textile materials and shorter process time, nontoxic, cost effective and eco-friendly for environment.

Experimental

Materials and Methods

Single jersey knit cotton fabrics are collected from our lab for performed this experiment. Caustic Soda (NaOH), Hydrogen peroxide (H_2O_2), sequestering agent, Detergent, Acetic acid (CH_3COOH), Bio-Scouring agent (pectinase enzyme), Bio-Polishing agent (Celluloses enzyme)is used in this experiment. Reactive Dye Salt, Soda Ash (Na_2CO_3), wetting agent are also used, which are collected from our lab.
We used the several number of machines in this experiment.
Sample Dyeing M/C: used for scouring and dyeing of cotton fabrics. Machine Capacity is 50kg.
Bursting Tester: Used for measuring the fabric strength.
Washing M/C : Used for measuring the color fastness to wash.
Crock meter: For rubbing fastness.

Alkali scouring process

The following recipe is used to alkali scouring process.

Table 1: Recipe for alkali Scouring

Ingredients	Amount
NaOH	4 gm/L
Wetting Agent	1 gm/L
Sequestering Agent	1 gm/L

Detergent	2gm/L
pH	10.5-11.0
Temp.	95-100^{0}C
Time	40min
M:L	1:50

Neutralization

Hot wash(Temp-60^{0}C Time-10min)

↓

Cold wash

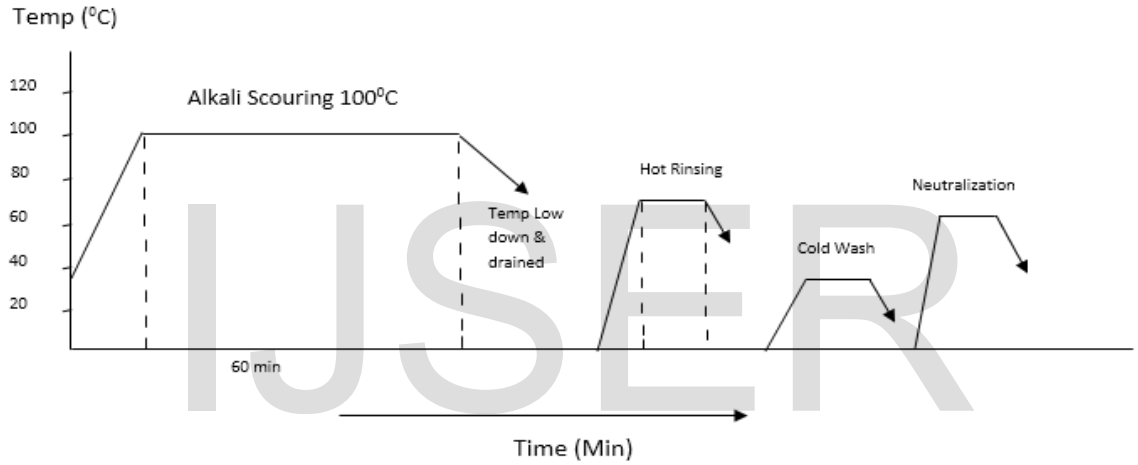


Figure 1: Scouring Curve with alkali.

Description of the scouring process

Firstly the fabric was prepared for processing and it was taken in dye bath. The process run with fabric at room temperature with required amount of water. Then Sequestering agent and detergent are added in the dye bath. After few min. alkali is added and raised the temperature to 95-100° C. The process run in this temperature for 60 minutes. After completing scouring drain out the liquor from the dye bath. Rinse twice with hot (around 70°C) and cold water. Neutralize the fabric with acetic acid treatment and carry out next process.

Bio-scouring process

The following recipes are used to bio-scouring process

Table 2: Recipe for Bio-Scouring

Ingredients	Amount
Bio-scouring enzyme	5gm/L
Acetic Acid	1gm/L

pH	4-5
Temp.	60-70^{0}C
Time	15-20min
M:L	1:50

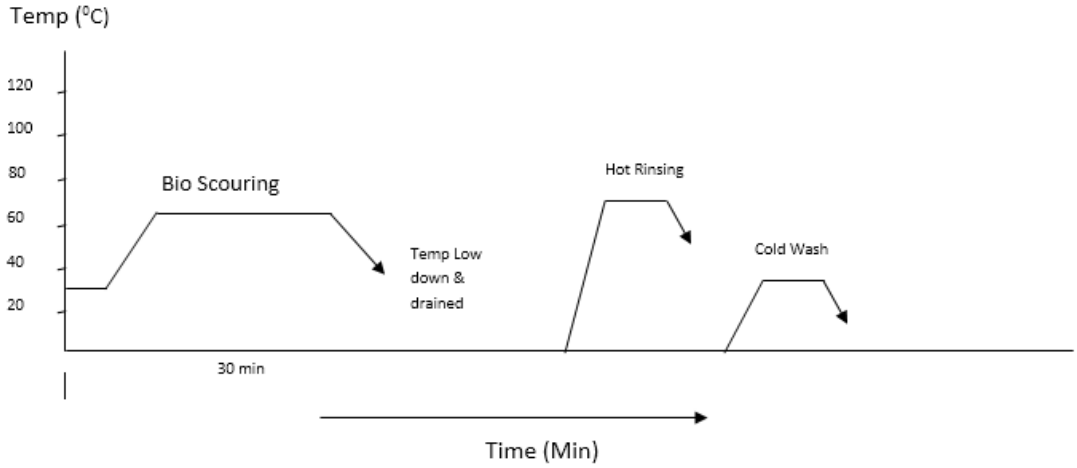


Figure 2: Scouring curve with enzyme

Description of bio-scouring process

The dye bath was set with fabric at room temperature with required amount of water. The temperature set at 40°C and kept it about 15 minutes. Then the Bio-Scouring agent added and raises the temperature to 60°C, kept it for 20 minutes. Cool down the bath temperature and drain out the liquor from the dye bath. Washed in 80°C for 5 minutes. Then the samples were rinsed with cooled water and dry it by using dryer. Then it's prepared for next process.

Bio-polishing

Table 3: Recipe for bio-polish

Ingredients	Amount
Bio-polishing enzyme	4gm/L
Acetic Acid	1gm/L
pH	4-5
Temp.	60-70^{0}C
Time	10-15min
M:L	1:50

Working Procedure for Bio-polishing

At first the weight of the sample was taken and the required amount of chemical was calculated.Then the required amount of chemicals were taken into a bowl. After that the fabric was impregnated in the bath. Then the temperature was slowly raised until 60-70 degree centigrade. During this process the PH of the bath and temperature was checked very frequently. The process continued for 10-15 minutes. Then drain and hot wash, cold wash.

Drop test

In a pipette a solution of 0.1% direct red is taken and is dropped on the fabric sample. Then the absorption of the colored drop is observed visually. There required some second to spread the drop. We noted the time taken to spread the drop.

We also captured some image to differentiate the shape of the drop and compare them to the standard shape. It is important to the same amount of color dropped on the fabrics; otherwise the result may be changed. So extra care should be taken to drop color solution on the fabric.

Scoured Fabrics Strength Test

Bursting tester is used to measure the strength of scoured fabric. At first insert the specimen under the tripod, drawing the specimen taut across the plate, and clamp specimen in place by bringing the clamping lever. At the instant of rupture of the specimen, swing the latch as far as it will go to bring the operating handle to a neutral position. Record the total pressure required to rupture the specimen. After rupture, and in rapid succession, release the clamping lever over the specimen.

Dyeing of bio-polish & without bio-polish fabric with Reactive Dye

Table 4: Recipe for dyeing

Ingredients	For .5% shade	For 1.5% shade	For 3% shade
Dye	0.5%	1.5%	3%
Gluebar salt	30gm/L	40	60
Soda Ash (Na_2CO_3)	6	8	12
Wetting agent	1	1	1
Sequestering agent	1	1	1
pH	9-11	9-11	9-11
Temp.	40^0C	40^0C	40^0C
Time	40min	40min	40min
M:L	1:50	1:50	1:50

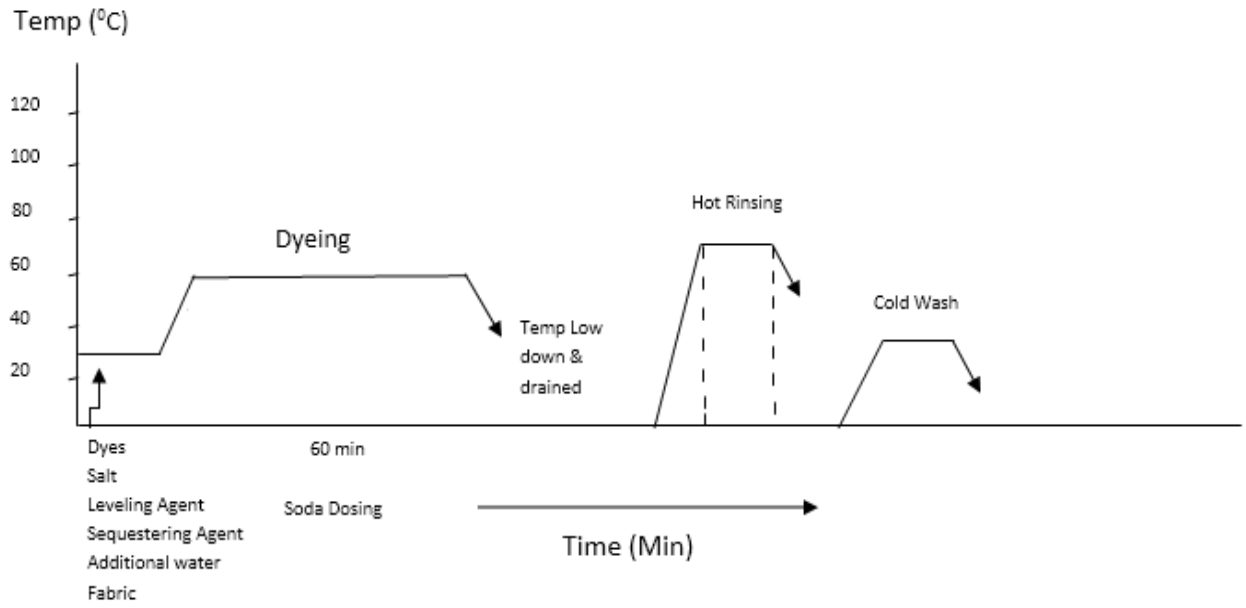


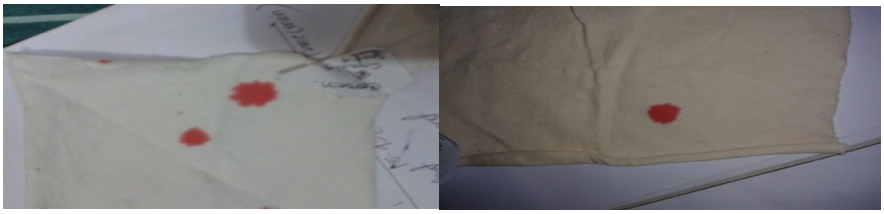
Figure 3: Process curve for dyeing of cotton fabric with reactive dye

Color fastness to Rubbing/crocking Test Procedure

IS0 test method 766-1988 was followed to measure the rubbing fastness. For dry rubbing, a test specimen of 15x5 sq. cm was placed on the base of the crock meter so that it rests flat with its long dimension in the direction of rubbing. 5x5 sq. cm undyed bleached cotton was mounted on the tip of the finger. A spherical spiral wire clip holds the test cloth in place. The crock meter is operated to rub the specimen in a straight line along a track of 10cm long for 10 times in 10 seconds with a downward force of 9N. After rubbing, the degree of staining on the undyed fabric is evaluated using grey scale.

Results and Discussion

Result of drop test



A B

Here, A= Conventional scouring, B= Bio-scouring

Figure 4: Result of drop test

It has been seen that the absorbed area by conventional scouring fabric is larger than the bio-scouring fabric, but absorbed area of bio-scoured fabric is more uniform. It is also found that the result of bio-scoured fabric is better than alkali scoured fabric. Again we observed that bio scoured fabric has more absorbency than alkali scoured fabric .So above the discussion, we can say that bio-scoured fabric is more hydrophilic than alkali scoured fabric and it will takes lowest time to absorb liquor.

Result of spot test

According to spot test we observed that bio scoured fabric has more absorbency than alkali scoured fabric.So, we can say that bio-scoured fabric is more hydrophilic than alkali scoured fabric and it will takes lowest time to absorb liquor.

Result of Fabric strength

Table5: Measurement of scoured fabric strength

Treatment Name	Strength (lb/inch^2)
Conventional scouring	160
Bio-scouring	165

Table 6: Measurement of bleached fabric strength

Graphical Representation of Fabric Strength

Figure 5: Graphical Representation of Fabric Strength

Table 7: Measurement of colored fabric strength

Treatment Name	Shade%	Strength (lb/inch^2)
Conventional scouring without bio-polish	0.5%	155
	1.5%	150
	3%	155
Conventional scouring with bio-polish	0.5%	145
	1.5%	150
	3%	150
Bio-scouring without bio-polish	0.5%	155
	1.5%	150
	3%	155
Bio-scouring with bio-polish	0.5%	145
	1.5%	155
	3%	145

Graphical Representation of Dyed Fabric Strength

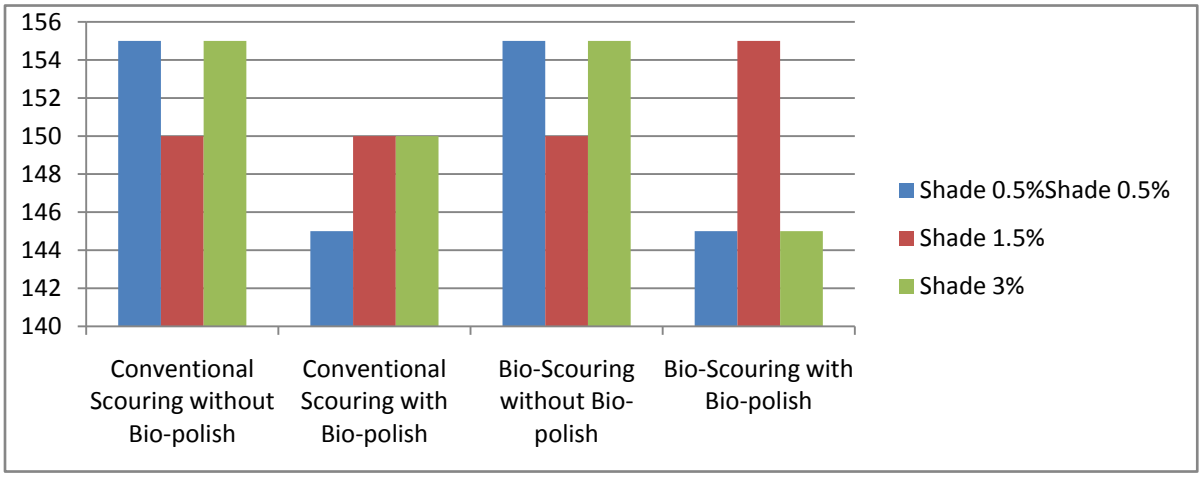


Figure 6: Graphical Representation of Dyed Fabric Strength

It could said that the strength of all fabric is decreased after different treatment. In scouring & bleaching the strength loss is more than the others process. Because the fabric degradation is occurred due to use of alkali & hydrogen peroxide.

Fastness Properties

Wash Fastness Test

Table 8: Wash fastness for color staining

Treatment Name	Shade%	Result	Comments
Conventional scouring without bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4	Good
Conventional scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4	Good
Bio-scouring without bio-polish	0.5%	4-5	Very good
	1.5%	5	Excellent
	3%	4-5	Very good
Bio-scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4	Good

Table 9: Wash fastness for color change

Treatment Name	Shade%	Result	Comments
Conventional scouring without bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4-5	Very good
Conventional scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good

	3%	4	Good
Bio-scouring without bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4	Good
Bio-scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4	Good
	3%	4	Good

From the table 8 & 9 it could said that the result of staining & change value of all fabric is nearly same, which is shown very good result for staining value of 0.5%, 1.5%, 3% shade, and from the table 13 it can be said that the result of change value of all fabric is same , which is shown very good result of Conventional scouring without bio-polish for 0.5%, 1.5%, 3% shade, Conventional scouring with bio-polish for 0.5%, 1.5% shade is very good and for 3% shade, which shown a good result.

Rubbing Fastness

Table 10: Rubbing fastness to dry

Treatment Name	Shade%	Result	Comments
Conventional scouring without bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	3-4	Average
Conventional scouring with bio-polish	0.5%	5	Excellent
	1.5%	5	Excellent
	3%	4	Good
Bio-scouring without bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	3	Moderate
Bio-scouring with bio-polish	0.5%	5	Excellent
	1.5%	4	Good
	3%	4-5	Very good

Table 11: Rubbing fastness to wet

Treatment Name	Shade%	Result	Comments
Conventional scouring without bio-polish	0.5%	3-4	Average
	1.5%	3	Moderate
	3%	4-5	Very good
Conventional scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4-5	Very good
	3%	4	Good
Bio-scouring without bio-polish	0.5%	3-4	Average
	1.5%	3-4	Average

	3%	4	Good
Bio-scouring with bio-polish	0.5%	4-5	Very good
	1.5%	4	Good
	3%	4-5	Very good

From the table 10 it can be said that the result of rubbing fastness for dry of all fabric is nearly same, which is shown excellent, very good result. From the table 15 it can be said that the result of rubbing fastness to dry of Conventional scouring with bio-polish for 0.5%, 1.5% shade, excellent and for 3% is good. And for Bio-scouring with bio-polish 0.5% is excellent, 1.5% is good and for 3% is very good. So above the discussion, we can say that bio-scoured and bi polish fabric has very good rubbing fastness to dry.

From the table 11 it can be said that the result of rubbing fastness to wet of Conventional scouring with bio-polish for 0.5%, 1.5% shade, very good and for 3% is good. And for Bio-scouring without bio-polish 0.5%, 1.5% is average and for 3% is good. So above the discussion, we can say that Conventional scouring with bio-polish fabric has very good rubbing fastness to wet.

Conclusion

Bio-polishingof cotton is the process for removing the fiber impurities to make the fiber absorbent for textile wet processing in commercially and bleaching is used for destructing of natural coloring matters to impart a pure permanent and basic white effects suitable for the production of white finishes, level dyeing and desired printed shade.After completing bio-polishing process, all sample result is exceptive good and we can say bio-polishing process is good than condensational textile materials' process. It has decreased the process flow and consume/save the time, water, and energy. All of that, enzyme based bio-polishing process completed textile materials dyeing and finishing properties is best.

References

1. R, A., C. M, and C.-P. A, *Application of enzymes for textile fibres processing.* Biocatalysis and Biotransformation, 2008. **26**(5): p. 332-49.
2. Patel, A.K., R.R. Singhania, and A. Pandey, *Production, Purification, and Application of Microbial Enzymes*, in *Biotechnology of Microbial Enzymes*. 2017, ScienceDirect: Academic Press. p. 13-41.
3. Rita, A., M. Casal, and A. Cavaco-Paulo, *Application of enzymes for textile fibres processing.* Biocatalysis and Biotransformation, 2009. **26**(5): p. 332-349.
4. Hebeish, A. and N.A. Ibrahim, *The impact of frontier sciences on textile industry.* Colourage 2007. **54**(4): p. 41-55.
5. L, A. and V. T, *Softening and polishing of cotton fabrics by cellulase treatment Dyeing/Printing/Finishing.* Int. Textile Bull, 1990. **2**: p. 5-8.
6. K, M., *Enzyme scouring of cotton fabrics: A review.* International Journal of Marketing and Technology (IJMT), 2012. **2**(9): p. 256-75.
7. A., C.-P. and G.G. M., *Woodhead Publishing, Textile processing with enzyme.* Cambridge, 2003: p. 17-169.
8. C, V., *Biovision in textile wet processing industry-Technological Challenges.* Journal of Textile and Apparel, Technology and Management, 2011. **7**(1).

9. Hebeish, A., et al., *New Development for Combined Bioscouring and Bleaching of Cotton-Based Fabrics.* Carbohydrate Polymers, Elsevier 2009. **78**(4): p. 961-972.
10. K, A., et al., *Pretreatment of Bleached Cotton Fibers with Whole and Mono component Cellulases for Nonwoven Applications.* Textile Research Journal, 2007. **77**: p. 734-742.