The Influence of Fabric Weight in the Enzymatic Process (Depilling) of Cotton Knitted Fabric

Moni Sankar Mondal[1], Md. Mahbubul Haque[1]

Abstract

Enzymes are gaining an increasingly important role as a tool in various wet textile pretreatment and finishing processes (Stanescu, 2002; Thiry, 2001; Cavaco-Paulo, et al. 1998; Heine and Höcker, 1995)[12]. Within 5 to 10 years, wet textile production processing will be shifted from conventional wet textile pretreatment and finishing procedures substantially towards sustainable processes, because of increasing governmental and environmental restrictions and the decreasing availability of fresh water. We analysed the influence of enzymatic treatment process(depilling) using an acid cellulase enzyme on the different weight of cotton knitted fabrics(single jersey) at different time duration and find that depilling effect vary with fabric properties such as density of the fabric which is related with GSM of fabric. The action of enzyme hydrolysis was studied by pilling grade and fabric strength loss percentage.

Keywords: *Cotton, depilling, acid cellulase, GSM, Fabric strength.*

1. Introduction

Cellulases are increasingly being used in cotton finishing. The most widely used application is the replacement of stone washing process to produce the fashionable aged appearance of denims. Other cellulase treatments are used to improve the appearance of cotton fabrics by removing fuzz-fiber and pills from the surface. (Cavaco-paulo, A., Almeida, L., and Bishop, D Report-1996, Cavaco-Paulo A. Report-1998), Such processes also modify the mechanical properties in ways that lead to the perception of improved handle. Cellulases comprise a group of different acting enzymes that, in coordinated action, degrade cellulose and their derivatives to glucose (endoglucanase, exoglucanase or (ß-1,4glucosidase) (Bisaria, V. S. Ghose, Report -1981, Boisset, Chanzy, H., Schulein, M., Henrissat Report-1997, Hoshino, E., Chiwaki, M., Suzuki, A, Murata Report-2000, Ito, S., Kobayashi, T, Ara, K, Ozaki, K, report-1998).

The complex interactions among endoglucanase, cellobiohydrolase and ß-1,4 glucosidase/cellubiase change substrate characteristics during the hydrolysis and these changes are represented in Fig. 1. Endoglucanases cut at random amorphous sites of the cellulose chain, producing oligosaccharides of various lengths and new reducing and non-reducing ends on the fibre surface. During the cellulose hydrolysis, the solid substrate characteristics vary, with the number chain ends changing due to the action of endoglucanase and exoglucanase.

1.1 Mechanism of Cellulolysis

The three types of reaction catalyzed by cellulases: 1.Breakage of the non-covalent interactions present in the crystalline structure of cellulose (endo-cellulase); 2.Hydrolysis of the individual cellulose fibers to break it into smaller sugars (exo-cellulase); 3.Hydrolysis of disaccharides and tetrasaccharides into glucose (beta-glucosidase). All these three enzymes act synergistically on cellulose to hydrolyse them.[9-11]

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[1] Lecturer, Department of Textile Enginerring BGMEA University of Fashion and Technology (BUFT), Bangladesh.

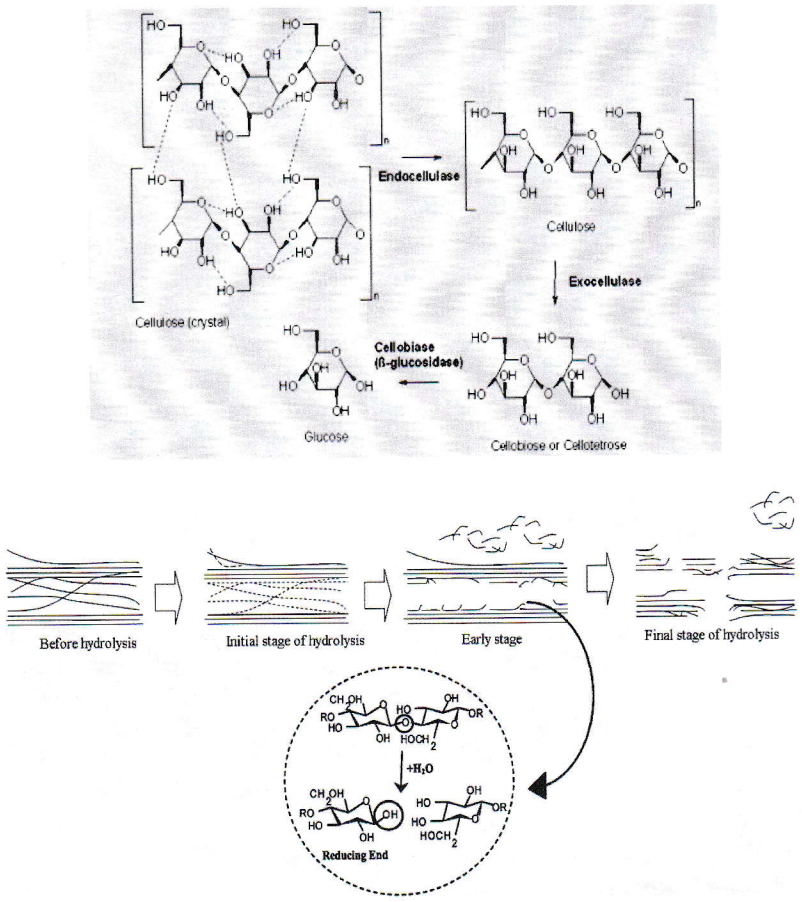

Figure 1: Main stages for degradation of cotton fibres by cellulase are presented. Endoglucanases cut at random amorphous sites of the cellulose.

Cellulolytic enzymes are applied in textiles proesses where mechanical action is always present such as in Jets or rotating drum washers (Cortez J.M., Ellis J. and Bishop D.P. (2001). A careful balance between cellulase activity and mechanical action is required to achieve efficient fuzz-fiber and pill removal without excessive fabric strength loss (Cavaco-paulo,A. and Almeida,Report-1994, Cavaco paulo,A. Morgado,j and Alice Rousselle, M., Report- 2000).These facts indicate that cellulase composition and mechanical action are key features during depilling process of cotton.

1.2 Diffusion of Enzymes and Fabric

The migration of the enzyme molecules into the inter-yarn pores is most important factor for good enzymatic treatment. This can be achieved by flowing an enzyme solution through the fabric. However, since the flow resistance in the intra-yarn pores is much higher than the resistance in the inter-yarn pores, the bulk of the liquid will flow along the yarns instead of through the yarns. This was found by Van den Brekel and later confirmed by Gooijer. In Fig.2 the flow pattern of a liquid flowing along a yarn is drawn schematically. Based on this Warmoeskerken and Boom (1999) introduced the concept of a stagnant core and a convective shell (M.M.C.G. Warmoeskerken, V. A. Nierstrasz, Agrawal P.B., Nierstrasz V.A. and Warmoeskerken M.M.C.G. Report-2002).

The stagnant core of the yarn is the area in which there is no flow at all. The convective shell is the outer area of the yarn in which the flow penetrates to some extent. The transfer processes in the stagnant core are based on molecular diffusion while the transport processes in the outer convective

shell are driven by convective diffusion. Since convective diffusion is much faster than molecular diffusion, the rate of mass transfer in the yarn will be determined by the size of the stagnant core. This means that the migration time of enzymes into the intra yarn pores is determined by molecular diffusion in the stagnant core, which is a relatively slow process. The main focus of this research was to study the performance of acid cellulase on the different GSM of cotton knitted fabric

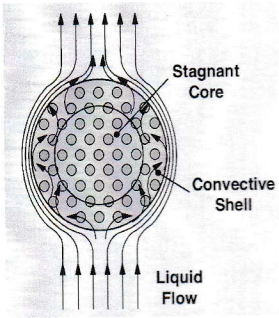

Figure 2: Liquid flow around and through a textile yarn. The dots represent the fibres in the yarn.

Figure 3: Structure of knitted fabric.

2. Experimental

2.1 Materials

Cellulosic fabrics which is used as the substrate in the enzymatic procedure had the following specifications:

100% cotton bleached and scoured fabrics. The weight per unit area of the fabric was 160 g/m^2, 180 g/m^2, 200 g/m^2, 220 g/m^2.

Mainly EG enriched cellulase enzyme (Fibrilase®GXM-ULTRA).,which is used in this study, was generously provided by IOGEN CORPORATION- Bangladesh Ltd.

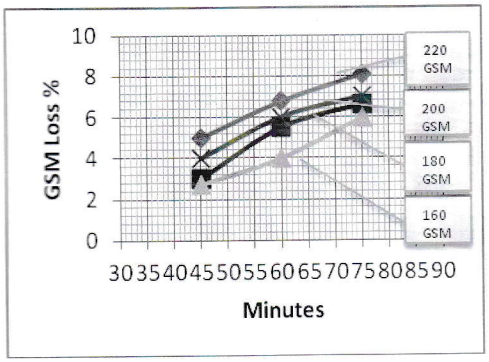

Figure 4: Fabric weight following cellulase treatment in jet dyeing machine with mechanical agitation. The fabric weight was taken as the average of several representative test fabrics after processing for 45, 60 & 75 minutes.

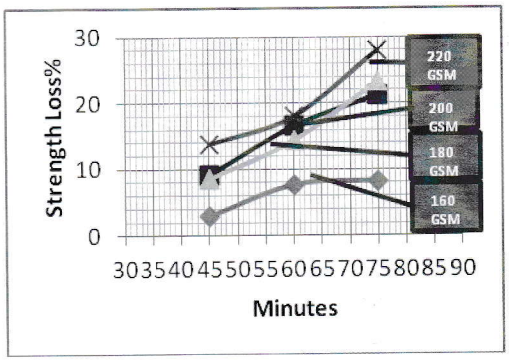

Figure.5: Tensile strength following cellulase treatment in jet dyeing machine without mechanical agitation. The tensile strength was taken as the average bursting strength of several representative test fabrics after processing for 45, 60 & 75 minutes.

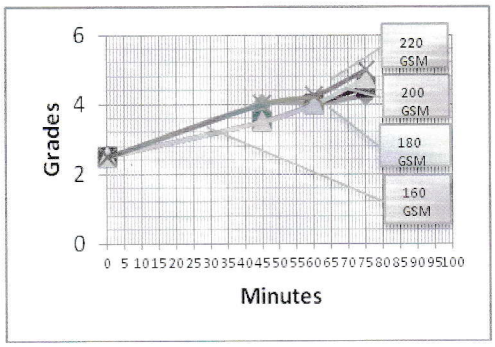

Figure 6: Pilling tendency following cellulase treatment in jet dyeing machine with mechanical agitation. The fabrics were panel scored (1= highly pilled to 5= no pills) after 60 minutes of tumbling in a random pill testing device.

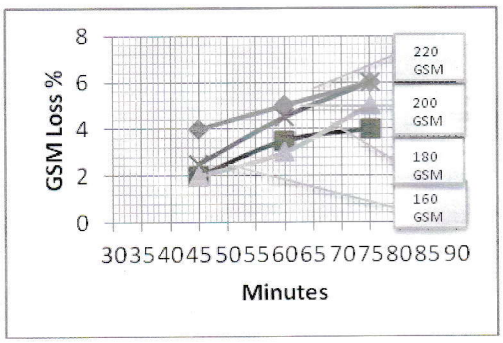

Figure 7: Fabric weight following cellulase treatment in lab machine without mechanical agitation. The fabric weight was taken as the average of several representative test fabrics after processing for 45, 60 & 75 minutes.

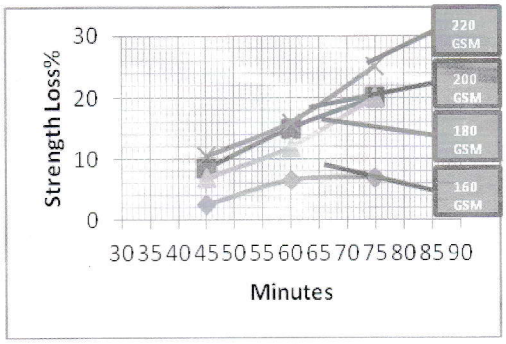

Figure8: Tensile strength following cellulase treatment in lab machine without mechanical agitation. The tensile strength was taken as the average bursting strength of several representative test fabrics after processing for 45, 60 & 75 minutes.

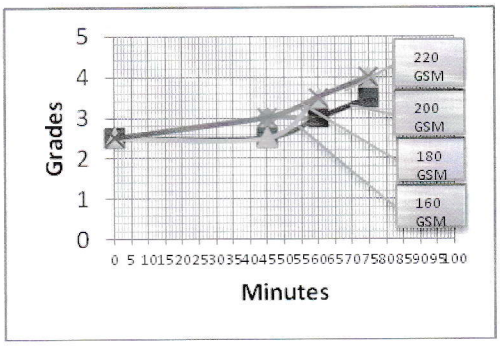

Figure 9: Pilling tendency following cellulase treatment in lab machine with mechanical agitation. The fabrics were panel scored (1= highly pilled to 5= no pills) after 60 minutes of tumbling in a random pill testing device.

2.2 Methods

Cotton fabrics in the appropriate size were prepared and 10 g of the fabrics was soaked in 200 ml buffer solution containing the appropriate concentration of the enzyme (1 gram of enzyme per liter of the buffer solution). Buffer had the following specification: acetate buffer, 0.02 M, pH 4.5.Temperature and time of the enzymatic treatments were 55°C, 45 min, 60min and 70min respectively. The experiment was carried out in Gyrowash m/c, James H. Heal, England with 20:1 liquor per gram of fabric, no agitation in the bath.

Fabrics were treated with high mechanical agitation in Jet dyeing machine (Fong's high temperature m/c) and dried in steam dryer in Rupa Fabrics Ltd. Gazipur, Dhaka. Fabrics were treated with 0.4 g/L enzyme, acetic acid at pH 4.5 for 45 min, 60 min and 75 min at 55°C.

2.2.1 Physical Parameters

Some of physical parameters of the fabrics measured in this study were: loss of strength, thickness and depilling effect.

Loss of strength was measured on Bursting strength Tester, James H. Heal, England, Pneumatic (AutoMode), Diaphram Pressure: 53.6 KPa, Pressure: 161-183 KPa, Test area (Dia): 50sq.cm

Variation in thickness was measured on Paramount GSM Cutter, India.

Pilling was measured on ICI Pilling Tester, James H. Heal and Co.Ltd, England, ISO-12945-1 (Comparison by BS5811:1979 paper standard), Rpm: 60, Rev: 7200.

3. Results and Discussion

3.1 Treatment with Mechanical Agitation

The effects of treating cellulosic fabrics with cellulase were measured and correlated well to results in commercial applications.

Enzymes work by cleaving surface fibers which results in some fabric weight loss. The weight loss is also highly dependent on which enzyme is used, the fabric construction, and the process used. Figure 4 shows the effect of cellulase treatment on the fabric weight loss percentage, which is more for high GSM fabric.
Fabric strength loss is a function of fabric weight loss for enzyme treatment.

Figure 5 indicates that for weight loss, there is noticeable loss in the fabric strength. As with fabric weight loss, the strength loss is dependent on the enzyme used, the fabric construction parameters- for example, yarn stitch length and the process or equipment used.

Figure 6 shows the tendency for pilling to occur-in fabrics that are prone to pilling-is reduced for high GSM. The cotton knitted fabric (Single jersey) treated with cellulase showed a significant reduction in the tendency to pill which became more pronounced after home launderings.

3.2 Treatment with no Mechanical Agitation

Figure 7 shows high weight loss percentage for high GSM in lab m/c.
We also try to find the effect of cellulase on the fabric strength without mechanical agitation in lab sample m/c where no steel disks are added. By Figure 8 this effect can be shown.

Figure 9 shows also same effect of enzyme for pilling tendency when fabric is treated with cellulase and no mechanical agitation in lab m/c.

4. Conclusions

The results of our work clearly show that the effect of acid cellulase in depilling process depends on the fabric GSM because when GSM increases strength loss percentage, weight loss percentage and pilling grade increased i.e enzyme worked preciously. If GSM of knitted fabric increases inter yarn pores i.e stitch length decreases (still difficult to flow of solution through intra yarn pores), so the flow of enzyme solution will be low whatever the process is mechanical agitation or not .As a result depilling process will be high. The main aim of this study was to analyse the effect of acid cellulase in depilling process on different GSM cotton knitted fabric (single jersey) that fabric is hugely produced and processed everyday for buyer demand, so this research will be effective in textile industry to take effective initiative.

5. Acknowledgements

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