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COMPARISON BETWEEN CONVENTIONAL CHEMICAL PROCESSES AND BIO-PROCESSES IN COTTON FABRICS

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Scientific paper

Abstract: *Textile processing is a growing industry that traditionally has used a lot of water, energy and harsh chemicals. They are also not easily biodegradable. Biotechnology in textiles is one of the revolutionary ways to promote the textile field. Bio-processing were accompanied by a significant lower demand of energy, water, chemicals, time and costs. Due to the ever growing costs for water and energy worldwide investigations are carried out to substitute conventional chemical textile processes by environment-friendly and economically attractive bioprocesses using enzymes. Enzymes are known for their specificity, high efficiency and ability to work under milder conditions and thus inexorably provide a promising solution to those problems. So it has advantages as well in terms of ecology as in economy.*
This research paper focuses on a comparison analysis between the conventional pre-treatment processes with bio-preparation of textile-based enzymes.

Keywords: enzyme, conventional process, bio-process, eco-friendly characteristics.

POREĐENJE IZMEĐU KONVENCIONALNIH HEMIJSKIH PROCESI I BIO-PROCESA U PAMUCNE TKANINE

Apstrakt: *Tekstilna obrada je rastuća industrija koja tradicionalno koristi dosta vode, energije i jake hemikalije. Oni takođe nisu lako biorazgradive. Biotehnologija u tekstilnoj industriji je jedan od revolucionarnih načina da se unapredi oblast tekstila. Bio-obrada je praćena značajnog smanjenja potražnje energije, vode, hemikalija, vremena i troškova. Zbog sve veće troškova za vode i energiju u svetu se sprovode istraživanja da zameni konvencionalne hemijske tekstilne procese sa ekološki i ekonomski atraktivnim bioprocesima pomoću enzima. Enzimi su poznati po svojoj posebnosti, visoke efikasnosti i sposobnosti za rad pod blažim uslovima i na taj način neumoljivo obezbedi rešenje za te probleme. Tako da ima prednosti, kao u ekologije, tako i u ekonomiji.*
Ovaj istraživački rad se fokusira na komparativne analize između konvencionalnim pred - tretmanski procesi sa bio- pripreme u tekstilu na bazi enzima.

Ključne reči: enzim, konvencionalni proces, bio-proces, ekološke karakteristike.

1. INTRODUCTION

In many industries, enzymes are used as biological catalysts to replace harsh chemicals or perform reactions under milder conditions. Not only do enzymes make good economic sense by saving energy, water and chemicals or by improving quality, they also
give valuable environmental benefits. These benefits are becoming more and more important at a time of increasing awareness about sustainable development and climate change.

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Enzymes are used in a broad range of processes in the textile industry: scouring, bleach clean-up, desizing, denim abrasion and polishing. Enzymes are specifi c and fast in action and small amounts of enzyme often save large amounts of raw materials, chemicals, energy and/or water.

The progress of industrial biotechnology in the last twenty years, especially in molecular biology, protein engineering and fermentation technology, enhanced the development of new uses of enzymes in textile industry. Today enzymes offer a wide variety of alternative, to substitute conventional chemical textile processes by environment-friendly and economically attractive bio-processes.

Utilization of highly specific enzymes for various textile-processing applications is becoming increasingly popular because of their ability to replace harsh organic/inorganic chemicals currently used by the textile industry. Thus, a significant decrease in the amount and toxicity of textile wastewater effluents is achievable.

Cellulases, proteases, amylases, catalases, pectinases, peroxidases and lactases are the enzymes that can replace aggressive chemicals [1]

One of the most negative environmental impacts from textile production is the traditional processes used to prepare cotton fibre, yarn or fabric. In the conventional preparatory process concentrated sodium hydroxide solution and hydrogen peroxide are applied for removing the impurities from raw cotton. On the other hand cellulose is susceptible to oxidation damage under these treatment conditions [2], which might result in decreased tensile strength of the fabrics. Alkaline scouring may also cause fabric shrinkage and changes in physico-mechanical properties of fabrics, e.g. their handle [3].

Bio-preparation may be a valuable and environmentally friendly alternative to harsh alkaline chemicals for preparing cotton. Selected enzymes can be used to prepare cotton under very mild conditions. It will result in improvements: lower BOD, COD, TDS, process time, cotton weight loss and harshness to handle.

The next step, following scouring in textile processing is the bleaching process. The greyness of cotton is due to the natural pigments and matter present in the fibres. The most common bleaching agent nowadays is hydrogen peroxide, which is dosed in excess to the fibres. Alternatively, the peroxide could be produced in situ by enzymatic system glucose oxidase/glucose [4].

Results of dyeing of cotton fabrics with a bifunctional reactive dye were significantly improved when the fabric after bleaching with hydrogen peroxide was treated with catalase for the elimination of hydrogen peroxide residues from the fabrics [5].

Many review [6, 7] and scientific [8, 9] papers describe the use of different enzymes for textile finishing. Pectinases are an efficient alternative to sodium hydroxide in the removal of non-cellulose substances from the cotton fibre surface [10].

Also, it has been observed that after enzymatic treatment, baths are less polluted than baths after scouring with sodium hydroxide [11].

Dye uptake is often higher with bioscouring than with conventional scouring owing to the resulting differences in the yarn and therefore dyestuff savings can be expected. Furthermore, bioscouring maintains more of the natural softness of the yarn than conventional scouring and less softener is needed at the end of the dyeing process [12].

The textile industry is also looking for new ways to deal with current problems on fibres other than cotton. This includes finding ways to improve the quality of the so-called bast fibres (hemp, linen, etc.), wool and even synthetic fibres. The search is on for industrial enzymes that are commercially viable for use on these substrates. With all these opportunities and the need to move towards sustainable development, industrial enzymes could provide some of the solutions the textile industry is looking for in the future.

2. EXPERIMENTAL

2.1. Materials

- Enzyme- alkaline pectinase Bioprep from Novozymes;
- Grey woven cotton fabric;

- The different pre-treatment chemicals from Sigma Aldrich;
- Desizing enzyme from BASF;
- Basilen rot M5B from BASF

2.2. Treatment methods

At first the woven grey cotton fabric was desized using amylase enzymes at 70°C for 20 minutes in the laboratory dyeing. Then this fabric was subjected to single bath scouring-bleaching processes using, strong alkali and H_2O_2 at boiling temperature as in conventional method, and alkaline pectinase with H_2O_2 in a neutral pH and at a temperature of 65°C as in the bio-process. The amount of H_2O_2 used in both cases was 5 g/l and 10 g/l.

2.3. Analytical methods

- **Weight loss (%) -** The weights of un-scoured and scoured samples were determined by weighing the fabric samples before and after pretreatment and was expressed in percent.
- **Rising height (cm) -** The water absorbency was measured according to DIN 53 924 (the velocity of the soaking water for textile fabrics, the method for determining the rising height).
- **Absorbency test -** The absorbency of the pre-treated fabrics were assessed by the drop test method using 0.1% direct dye solution.
- **Whiteness index -** The degree of whiteness was measured using a spectrophotometer using the CIE method according to EN ISO 105-J02: 1997(E) standard.

3. RESULTS AND DISCUSSIONS

3.1. Weight loss

Table 1 represent the loss of weight in conventional process compared to the bio-process. From the results we see that the weight loss (%) is higher in conventional alkaline process compared to the bio-process. The loss of weight demonstrates that scouring with NaOH is more intensive and removes more impurities than enzymatic scouring.

Table 1.- *Weight loss in conventional process compared to the bio-process*

Process	Substrate	Weigt before (g)	Weigt after (g)	Weigt loss (%)
Conventional 5 g/l H_2O_2	Cotton	45.60	44.66	2.06
Bio 5 g/l H_2O_2	Cotton	44.80	44.04	1.69
Conventional 10 g/l H_2O_2	Cotton	46.2	44.14	4.46
Bio 10 g/l H_2O_2	Cotton	43.95	42.18	4.02

3.2. Rising height

Table 2 represent rising height in warp direction of differently preatreated cotton fabric samples. It is known from various studies that high temperature and high pH are conditions that contribute decisively to the removal of non-cellulosic impurities. Specifically, waxes cannot be removed completely when all processes are conducted at low temperatures and neutral pH, as is the case for bioscouring and bleaching. The remained substances influence on the water absorbency and consequently alkaline scoured samples had the highest absorbency. Bleaching improved the absorbency of the scoured fabrics, particularly of enzymatically scoured. However, the difference in rising height was so small, that all the samples could be considered absorbent.

Table 2.- *Rising height in conventional process compared to the bio-process*

Process	Substrate	Rising height (cm)
Desized only cotton fabric sample	Cotton	0
Alkaline scouring	Cotton	3,0
Scouring with enzyme	Cotton	2.6
Alkaline scouring + Bleaching with H_2O_2 at boiling temperature as in conventional method	Cotton	3.1
Scouring with enzyme + Bleaching with H_2O_2 in a neutral pH and at temperature of 65°C as in the Bio-process.	Cotton	2.9

3.3. Absorbency test

The absorbency of the pretreated cotton fabrics were compared in conventional process to the bio-process. The amount of H_2O_2 used in both cases was 5 g/l and 10 g/l. The best absorbency was obtained with conventional process using 10 g/l H_2O_2. Bio-process using 5 g/l H_2O_2 on cotton shows good absorbency relative to conventional process using 5 g/l H_2O_2.

3.4. Whiteness index

Table 3 represent the whiteness values for the cotton fabric in conventional process compared to the bio-process. Alkaline scoured samples are whiter than enzymatically scoured ones. The whiteness values increased significantly after bleaching with H_2O_2 as in conventional process as and in bio-process. The whiteness values are higher for the fabric processed with 10 g/l H_2O_2. The differences from previous scouring disappeared. So we can conclude that bio-process can give excellent whiteness to cotton fibers.

Table 3.- *Whiteness index in conventional process compared to the bio-process*

Process	Substrate	whiteness
Desized only cotton fabric sample	Cotton	12.3
Alkaline scouring	Cotton	20.5
Scouring with enzyme	Cotton	10.2
Alkaline scouring + Bleaching with H_2O_2 at boiling temperature as in conventional method (5 g/l H_2O_2)	Cotton	85.4
Alkaline scouring + Bleaching with H_2O_2 at boiling temperature as in conventional method (10 g/l H_2O_2)	Cotton	86.5
Scouring with enzyme + Bleaching with H_2O_2 in a neutral pH and at temperature of 65°C as in the Bio-process. (5 g/l H_2O_2)	Cotton	86.6
Scouring with enzyme + Bleaching with H_2O_2 in a neutral pH and at temperature of 65°C as in the Bio-process. (10 g/l H_2O_2)	Cotton	87.7

4. CONCLUSIONS

Enzymes can be used in order to develop environmentally friendly alternatives to chemical processes in almost all steps of textile fibre processing. New enzymes with high specific activity, increased reaction speed, and tolerance to more extreme temperatures and pH could result in development of continuous processes.

The use of various enzymes is in the early stages of development but their innovative applications are increasing and spreading rapidly into all areas of textile processing. The textile industry can greatly benefit from the expanded use of these enzymes as non-toxic, environmentally friendly compounds.

The necessity for the development of enzymatic solutions to pretreatment has never been as overwhelming as it is today. Scouring is a process that specifically targets non-cellulosic impurities with pectinases. Bioscouring can be recommended as an adequate process for scouring of cotton. Sodium hydroxide is removed from the textile treatment procedures or its use is considerably lowered. Bleaching improved the absorbency of the scoured fabrics, particularly of enzymatically scoured ones.

However, bioscouring has a few disadvantages. Waxes cannot be removed completely when all processes are conducted at low temperatures and neutral pH. The remained substances influence on the water absorbency and consequently alkaline scoured samples had the highest absorbency. The attained degree of whiteness is lower compared to alkaline scoured. Another factor limitting bioprocess as a pretreatment is use only for the dark shades.

The use of enzymes not only make the process less toxic (by substituting enzymatic treatments for harmful chemical treatments and waste waters are less polluted) and eco-friendly, they reduce costs associated with the production process, and consumption of natural resources (water, electricity, fuels).

There is still considerable potential for new and improved enzyme applications in future textile processing. It seems that in the future it will be possible to do every process using enzymes.

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