Role of Biotechnology in Textiles Using Bioscouring Technique

By: M. Thenmozhi and
Dr. Rajeshwari Sivaraj

Role of Biotechnology in Textiles Using Bioscouring Technique

By: M. Thenmozhi and Dr. Rajeshwari Sivaraj

Biopreparation may be a valuable and environmentally friendly alternative to harsh alkaline chemicals for preparing of cotton. In bioscouring the removal of the noncellulosic substances can be achieved mainly by hydrolytic enzymes, such as pectinase, amylase, xylanases and cellulases. The bioprocess has several advantages over conventional chemical scoring. Enzymes operate under mild conditions (pH, temperature) with low water consumption and act only on specific substrates.

Modem society expects biotechnology to be the answer for many worldwide problems like depletion of energy sources, incurable illnesses and pollution, among other problems. Textile processing is a growing industry that traditionally has used a lot of water, energy and harsh chemicals starting from pesticides for cotton-growing to high amounts of wash waters that result in waste streams causing high environmental burdens. As textile fibers are polymers, the majority being of natural origin, it is reasonable to expect there would be a lot of opport1Jnities for the application of white biotechnology to textile processing. Enzymes nature's catalysts are the logical tools for development of new biotechnology based solutions for textile wet processing. The enzymes are selected based on their pH and temperature compatibility. The most effective conditions for this process are established in regard to the properties of the scoured goods.

In many industries, enzymes are used as biological catalysts to replace harsh chemicals or perform reactions under milder conditions. The textile industry is no exception. 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.

Enzymatic processing can simply be defined as the application of living organisms and their components to industrial products and processes. It is not an industry in itself, but an important technology that will have a large impact on many industrial sectors in the future. Enzymatic processing is the application of biological organisms, systems or processes to manufacturing industries. Enzymatic processing firms will rely mainly on inexpensive substrates for biosynthesis, processes that will function at low temperatures, and will consume little energy. In Textile Processing the Enzymatic removal of starch sizes from woven fabrics has been in use for most of this century and the fermentation vat is probably the oldest known dyeing process. What has given enzymatic processing a new impetus in the last few years has been the very rapid developments in genetic manipulation techniques which introduces the possibility of 'tailoring' organisms in order to optimize the production of established or novel metabolites of commercial importance and of transferring genetic material from one organism to another. Enzymatic processing also offers the potential for new industrial processes that require less energy and are based on renewable raw materials. Various applications which entail enzyme and colors broadly included fading of denim and non-denim, bio-scouring, bio-polishing, silk degumming, carbonsing of wool, peroxide removal, washing of reactive dyes, etc. incidentally enzymes were consumed to the tune of about 70%in detergents than in textile industry.

Scouring is a cleaning process that removes pectin and thereby assists with the removal of impurities such as waxes, mineral salts, etc. from cotton yarns and fabric before dyeing. Traditionally, scouring involves a number of high-temperature steps with a large consumption of chemicals such as sodium hydroxide, sodium carbonate and hydrogen peroxide. Enzymes provide a biological alternative with high specificity towards difficult to remove pectin compounds on the raw cotton. The problem with chemicals is that they do not just remove the impurities, but they attack the cellulose too, resulting in weight losses. Enzymes enable a faster and gentler scouring process with lower energy and chemical consumption.

Role of Biotechnology in Textile Processing

The major areas of applications of biotechnology in textile industry are,

- Improvement of plant varieties used in production of textile fibres and in fibre properties.
- Improvement of fibres derived from animals and health care of animals.
- Novel fibres from biopolymers and genetically modified microorganisms.
- Replacement of harsh and energy demanding chemical treatments by environment friendly routes to textile auxiliaries such as dyestuffs.
- Novel uses for enzymes in textile finishing.
- Development of low energy enzyme based detergents.
- New diagnostic tools for detection for adulteration and quality control of textiles.
- Waste managements.

Enzymes are large protein molecules made up of long chain amino acids which are produced by living cells in plants, animals and microorganism such as bacteria or fungi. Enzymes are secretions of living organisms, which catalyze biochemical reactions, without which no life in plant or animal kingdom can be sustained.

Combination of enzyme, sand blasting and bleach has been evolved as a fashion recently. Sand blasting are enzyme treatments which subject the denim fabric to sand at high pressure with consequent exposure of white area while blowing off surface colour followed by a treatment of the fabric again with enzyme, leading to a salt and pepper effect and bleached to reduce the colour value. Furthermore, after sand blasting, treatment with enzyme followed by over dyeing of the abraded areas produced typical effects on denim.

Bio-Polishing

It was perceived that bio-polishing and fading or bio polishing and wash down were two different operations. But both of them basically employed the same action. They degraded the cellulose due to abrasion or friction between fiber to fiber or fiber to metal resulting in removal first from cellulose and then surface bleeding. Bio-polishing gives cleaner appearance to the garment besides wash down effect.

Degumming of Silk

Silk is made up of two types of proteins like fibrin and ceresin. In the case of enzymatic treatment, a ceresin specific protein was used to degum the silk with out causing damage, impart softness and increase dye uptake of about 30%. If silk was degummed by alkaline treatment, there was damage to fibrin and heavy weight loss.

Life cycle assessments of enzymes used in the textile industry

Figure 1 indicates that there are considerable environmental advantages when using enzymes in the textile industry. It is, however, necessary to investigate the advantages in more detail by including all processes in the product chain. Two concrete studies in China, from textile mills that have changed to enzymes recently, are presented below. The assessments are comparisons of two different scouring processes and two different bleach removal processes. In each case, one of the processes was enzymatic and the other process was non-enzymatic. LCA has been used as an analytical tool and the two case studies presented here examined the changes that occur when enzymes are introduced in textile mills as an alternative to chemicals and hot water.

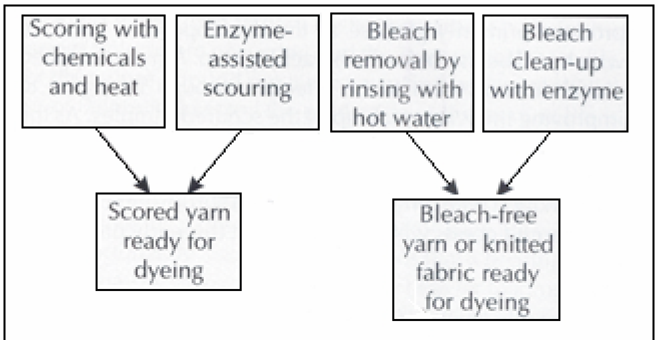

Figure 1: Two different scouring methods and two different bleach removal methods are compared from an environmental perspective

The industrial enzyme products used in the two case studies are from Novozymes and are produced by microorganisms in large fermentation tanks. Production relies to a large extent on inputs of agricultural products (sugar, protein, etc.), energy and water. The assessment of the environmental impact of enzyme production is based on data from Novozymes' production records in 2007. All processes in the production chain from the growing of agricultural products to the time the enzymes leave Novozymes' factory gate are included.

Bioscouring Prevent the global warming

The main factors behind the saved contributions to global warming are shown in Figure 2, which demonstrates that the heat saving in the bioscouring process is the main factor behind the reduced contribution to global warming, followed by electricity and yarn savings. Savings of water and chemicals in the process and the transport of chemicals from the manufacturers to Rongxin are less important.

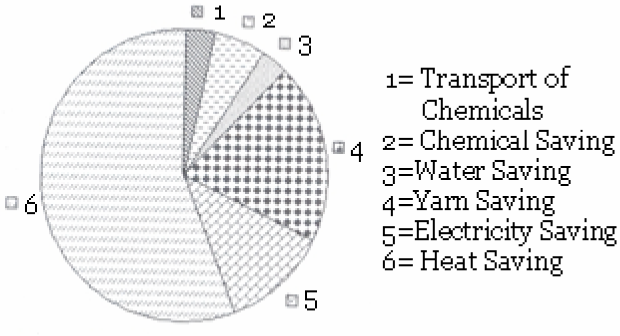

Figure 2: Main factors behind saved contributions to global warming

The present study of bioscouring process has used commercial available amylase enzyme. The activity was checked against the textile materials.

Result and Discussion

Desizing and Bioscouring

The desizing process can be performed with any type of amylase. These enzymes are commercially available with flexible pH and temperature ranges. Nowadays, even thermo stable amylases can be obtained. For this project, amyloglucosidases were applied since these enzymes produce primarily glucose as the decomposition product, which will be useful for the bleaching step. Amylase applied alone did not seem to be effective enough in regard to improving the water pick-up of the scoured samples. As the data in Table 1 show, the admixture of lipases clearly increased the water absorbency of the fiber. Cellulases in combination with amylase produced a surprising softness of the scoured goods which is an asset at this early processing stage.

However, in terms of water absorbency cellulases do not seem to be very effective. Also, as mentioned above, care has to be taken to avoid excessive fiber damage. Xylanases, enzymes advantageous during bio polishing of cellulosic fibers other than cotton especially, showed a moderate effect in this case. When all enzymes were applied in combination, the highest weight loss was observed and the water absorbency came close to the value of the commercially treated sample. This effect can most likely be attributed to the action of the lipases in the blend, probably in combination with some synergistic reactions of the other involved enzymes. It has been found that proteins in raw cotton have a very minor influence on the properties of the unscoured fiber and do not need to be specifically targeted. The treatment conditions are energy efficient because all the enzymes work well at temperatures of 50 to 60·C or even lower. Since enzymes are biocatalysts only minute amounts are necessary for the desired effects. The deactivation of the enzymes is achieved by simply raising the temperature or the pH.

Table 1: Weight loss and relative absorbency recorded after 1 hour enzymatic scouring process at 50°C (tumbling speed 42 rpm, % steel balls/g fabric).

Enzyme System	Weight Loss (%)	Rel. Absorbency (%)
Control*	-	100
Amylase	11.3	19
Amylase, cellulase	13.2	24
Amylase, lipase	11.5	66
Amylase, xylanase	11.4	51
Combination of all enzymes	14.2	89

* For reasons of comparison a conventionally scoured and bleached cotton 24 fabric was used as a control sample

Combinations of amylase and lipases not only yielded satisfying results concerning water absorbency. The tensile properties of the in this manner scoured samples were basically unchanged from the untreated control (2-3% strength loss on the average, based on the untreated greige sample). If, however, cellulase was present during the scouring process, tensile strength decreased by approximately 20%, suggesting the usual fiber damage observed during extensive bio polishing.

In the process of bioscouring with amylases, galacturonic acid, glucose and other sugars are generated. With mainly glucose as the degradation product it should be possible to combine and reuse the desizing and scouring treatment baths for bleaching with glucose oxidases in a closed loop. We are presently investigating whether sugars other than glucose inhibit this process.

A current problem encountered with reusing the treatment bath is the increasing contamination, especially if the scouring and the desizing process are combined. These contaminants could redeposit on the cotton material. It is also possible that some of the hydrogen peroxide is working on these contaminants and therefore remain unavailable for bleaching. We are at present trying filtration and centrifugation methods for purification.

Conclusion

The use of enzymes in scouring and bleach clean-up as alternatives to chemical treatment and rinsing with hot water, respectively, led to considerable environmental improvements at the two production lines at textile mills in China. The explanation is that a small amount of enzyme saves considerable amounts of energy and water in both cases and also chemicals in the case of scouring. Sensitivity analyses indicate that the general conclusion of the assessment holds up under different energy supply scenarios although the sizes of the reductions in environmental impacts are subject to much variation and uncertainty. The impact of the transport of enzymes from the manufacturer to the final user is insignificant even though the transportation distance is long. The main findings of the study are therefore applicable to other textile mills with similar production systems elsewhere in the world. The magnitude of the environmental improvements obtained by replacing the existing production methods with the enzymatic technologies are highly dependent on the type of fuel used and the actual production conditions. An estimation of environmental improvements at other factories must therefore rely on specific information on production processes and energy supply systems. The study has not addressed the removal of bleach with a reducing agent and further environmental assessments as required before any conclusions can be made about this method.

Originally published in the Textile Review, April, 2012