SCOPE OF BIOTECHNOLOGY IN TEXTILES

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Textiles have been manufactured using various technologies since time immemorial. Human ingenuity and imagination, craftsmanship and resourcefulness are evident in textile products throughout the ages; We are to this day awed by beauty and sophistication of textiles sometimes found in archeological excavations.

After fabricating the mansions of fashion and comfort textiles are now moving towards high-tech era of performance which has brought up diversification and expansion of technologies.

This realization of technologists has coincided with rapid developments in technology and brought about a surge in research and development activities in textiles.

Biotechnology in Textiles is one of the revolutionary ways to advance the textile field. and this paper bring up this issue into lime light.

Key words: *Biotechnology, Fashion and comfort, Genetic and Tissue engineering.*

INTRODUCTION

Biotechnology is the application of living organisms and their components to industrial products and processes. In 1981 the European federation of bio-technology defined Biotechnology as "Integrated use of Biochemistry, Microbiology and Chemical Engineering in order to achieve the technological application of the capacities of microbes and cultured tissue cells".

The rapid developments in the field of genetic engineering have given a new impetus to biotechnology. This 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 (genes) from one organism to another. Biotechnology also offers the potential for new industrial processes that require less energy and are based on renewable raw materials. It is important to note that biotechnology is not just concerned with biology, but it is a truly interdisciplinary subject involving the integration of natural and engineering sciences. Defining the scope of biotechnology is not easy because it overlaps with so many industries, such as, the chemical industry or food industry being the majors, but biotechnology has found many applications in textile industry also, especially in genetic engineering, textile processing and effluent management.

GENETIC ENGINEERING

With an improved understanding of how different genes are responsible for the various characteristics and properties of a living organism, techniques have been developed for isolating these active components (in particular, the DNA which carries the genetic code) and manipulating them outside of the cell[1].

The next step has been to introduce fragments of DNA obtained from one organism into another, thereby transferring some of the properties and capabilities of the first to the second. For example, scientists working for the leading enzyme producer, Novo of Denmark, discovered that an enzyme produced in minute quantities by one particular fungus had very desirable properties for dissolving fats. The relevant genes where 'spliced' into another micro-organism which was capable of producing the desired enzyme at much higher yield.

Genetic engineering methods are being investigated for their potential to produce new kinds of textile fibres. The systems fall into two main groups. There are systems that can produce monomeric protein molecules in solution from appropriately engineered genes and include expression in bacteria, cell cultures or in the milk of transgenic animals such as goats or sheep. The protein monomers are then isolated from the chosen system and spun and drawn into fibres. The other approach is to modify keratin fibres such as wool by expressing other proteins in the internal components by trangenesis.

Biopesticides based on a strain of soil bacteria known as Bt are already being used for control of caterpillar and beetle pests in a wide variety of fruits, vegetables and crops. More stable, longer lasting and more active Bts are now being developed for the suppression of loopers, bollworms and budworms in cotton. The next stage will be to introduce greater insect and herbicide resistance by direct genetic engineering of the cotton plant itself.

Practical results achieved so far include development of a cotton fibre with 50% greater strength than its 'parent'. Coloured cottons are also being developed, not only by conventional genetic selection but also by direct DNA engineering to produce, for example, deep blue cotton for denim production. The prospect is even being held out of encouraging natural polyesters such as polyhydroxy butyrate (PHB) to grow within the central hollow channel of the cotton fibre, thereby creating 'natural' polyester-cotton[2].

APPLICATIONS OF BIOTECHNOLOGY IN TEXTILES

The use of enzymes in textile processing and after care is already the best established example of the application of biotechnology to textiles and is likely to continue to provide some of the most immediate and possibly dramatic illustrations of its potential in the near-to medium-term future.

● Fibre Preparation

Linen is a cellulosic fibre obtained from the flax plant. These fibres are formed in the cortex between the lignified core and the outer layers of the stem, they are separated from the stems by retting, in which matrix components, mainly pectin and lignin are removed and the fibres are separated. Recently, considerable efforts have been put to use enzymes in the retting process to control the process to produce linen fibres of consistent quality. Pre-treatment of the flax with sulphur dioxide gas brings about sufficient breakdown of the woody straw material to speed up enzyme retting whilst preventing excessive bacterial or fungal deterioration of the fibre.

The carbonization process in which vegetable matter in wool is degraded by treatment with strong acid and then subjected to mechanical crushing can, in principle, be replaced by selective enzyme degradation of the impurities.

● Fabric Preparation

Desizing using amylase enzymes has been well established for many years. However, there is still considerable scope for improving the speed, economics and consistency of the process, including the development of more temperature stable enzymes as well as a better understanding of how to characterize their activity and performance with respect to different fabrics, sizes, and processing conditions, e.g. for pad batch as opposed to jigger desizing.

The current application in the textile industry involves mainly hydrolases

Table 1: Application of Hydrolase Enzyme in Fabric Preparation

Sr. No	Enzyme Name	Substrate	Textile Application
1	Amylase	Starch	Starch desizing
2	Cellulase	Cellulose	1. Stone wash-Bio-polishing (Bio-singeing) 2. Bio finishing for handle modification 3. Carbonization of wool
3	Pectinase	Pectin	Bio scour replacing caustic
4	Catalase	Peroxides	In situ peroxide decomposition without any rinse in bleach bath
5	Lipases	Fats and oils	Improve hydrophilicity of PET in place of alkaline hydrolysis

Table 2: Application of Oxidoreductase in Fabric Preparation

Sr. No	Enzyme Name	Substrate	Textile Application
1	Laccase	Colour Chromophore and pigments	1. Discoloration of coloured effluent chromophore 2. Bio-bleaching of lignin containing and pigments fibres like kenaf and jute 3. Bio-bleaching of indigo in denim for various effects
2	Peroxidases	Colour chromophore and pigments	Bio-bleaching of wood pulp
3	Glucose	Pigments	In situ generation of H_2O_2 and bio-bleaching of cotton

and now to some extent is Oxidoreductase. The Tables 1 and 2 exemplify such textile applications.

An already established application is the use of catalase enzymes to breakdown residual hydrogen peroxide after, for example, pre-bleach of cotton that is to be dyed a pale or medium shade. Reactive dyes are especially sensitive to peroxide and currently require extended rinsing and/or use of chemical scavengers. The enzyme catalase is added after oxidative bleaching and allowed to react for 15 minutes at 30° C- 40° C. It degrades the residual peroxide in water and oxygen.

The results obtained were compared with the conventional process and it was found that the outcome of the enzymatic process was excellent. The best suitable conditions are the temperature range of 20° C- 60° C, pH 5-10 and the application time is 10 min to 15 min.

● Finishing

Bio-stoning and the closely related process of bio-polishing are perhaps attracting most current attention in the area of enzyme processing. They are also an excellent illustration of how different industry structural and market considerations can affect the uptake of enzyme technology.

Conventional stone washing uses abrasive pumice stones in a tumbling machine to abrade and remove particles of indigo dyestuff from the surfaces of denim yarns and fabric. Cellulase enzymes can also cut through cotton fibres and achieve much the same effect without the damaging abrasion of the stones on both garment and machine. Disadvantages can include degradation of the fabric and loss of strength as well as 'back staining'. A slight reddening of the original indigo shade can also occur. Now processors are learning to play more sophisticated tunes such as achieving a peach skin finish by use of a combination of stones and natural cellulase.

Bio-polishing employs basically the same cellulose action to remove fine surface fuzz and fibrils from cotton and viscose fabrics. The polishing action thus achieved helps to eliminate pilling and provides better print definition, colour brightness, surface texture, drapeability, and softness without any loss of absorbency.

Bio-polishing can be used to clean up the fabric surface after the primary fibrillation of a peach skin treatment and prior to a secondary fibrillation process which imparts interesting fabric aesthetics. A weight loss in the base fabric of some 3-5% is typical but reduction in fabric strength can be controlled to within 2-7% by terminating the treatment after about 30-40 min using a high temperature or low pH 'enzyme stop'. One area that still poses problems is that of tubular cotton finishing. Here, the fibre residues tend to be trapped inside the fabric rather than washed away.

● Wool Processing Applications

The international wool secretariat (IWS) together with, Novo, been developing the use of protease enzymes for a range of wool finishing treatments aimed at increased comfort (reduced prickle, greater softness) as well as improved surface appearance and pilling performance. The basic mechanisms are found closely parallel to those of bio-polishing. The improved enzyme treatments will allow more selective removal of parts of the wool cuticle, there by modifying the luster, handle and felting characteristics without degradation or weakening of the wool fibre as a whole and without the need for environmentally damaging pre-chlorination treatment.

● Other Protease Applications

Protease enzymes similar to those being developed for wool processing are already being used for the degumming of silk and for producing sand washed effects on silk garments. Treatment of Silk-Cellulosic blend is claimed to produce some unique effects. Proteases are also being used to wash down printing screens after use in order to remove the proteinaceous gums, which are used for thickening of printing pastes.

● Textile After-care

Enzymes have been widely used in domestic laundering detergents since the 1960s. Some of the major classes of enzymes and their effectiveness against common stains are summarized in Table 3.

Early problems of allergic reactions to some of these enzymes have now largely been overcome by the use of advanced granulation technology. Modern enzyme systems have reduced the use of sodium perborate in detergents by

Table 3: Types Of Enzymes and Their Effectiveness Against Various Stains

Enzyme	Effective For
Proteases	Grass, Blood, Egg, Sweat stains
Lipases	Lipstick, Butter, Salad oil, Sauces
Amylases	Spaghetti, Custard, Chocolate
Celluloses	Colour brightening, Softening, Soil removal

25% along with the release of harmful salts into the environment.

However, enzymes still have to make a corresponding impact upon the commercial laundering market. One of the problems here has been the level of investment in 'continuous-batch' or tunnel washers. These typically afford a residence time of 6-12 min which is not long enough for present enzyme systems to perform adequately. More efficient methods of 'enzyme kill' are also required because of the extent of water recycling in modern washers.

- **Role In Waste Treatment**

Natural and enhanced microbial process has been used to treat waste materials and effluent streams from the textile industry. Conventional activated sludge and other systems are generally well able to meet BOD and related discharge limits on most cases. The industry faces some specific problems like colour removal from dyestuff effluent and handling of toxic wastes including PCPs and heavy metals.

The synthetic dyes are designed in such a way that they become resistant to microbial degradation under the aerobic conditions. Also, the water solubility and the high molecular weight inhibit the permeation through biological cell membranes. Anaerobic processes convert the organic contaminants principally into methane and carbon dioxide and usually occupy less space, treat wastes containing up to 30 000 mg/l of COD, have lower running costs and produce less sludge.

- **New Fibre Sources**

Several possibilities exist for producing entirely new fibre materials, so called biopolymers, using biotechnological process routes, naturally occurring polyester etc. PHB is produced by bacterial fermentation of a sugar feed stock and commercially available as 'Biopol'. The polymer is stable under normal conditions but biodegrades completely in any microbially active environment. Other biopolymers with textile potential include polylactates and polycaprolactones, which are investigated for medical applications[3].

Bacterial Cellulose

The specialty papers and nonwovens are produced based on bacterially grown cellulose fibres. These are extremely fine and resilient and are used as specialized filters, odour absorbers and reinforcing blends with aramids.

Genetically Modified Micro-Organisms

Attempts have been made to transfer certain advantageous textile properties into micro-organisms where they can be more readily reproduced by bulk fermentation processes. The spider DNA is transferred into bacteria with the air of manufacturing proteins with the strength and resilience of spider silk for use in bulletproof vests.

- **Dyestuffs And Intermediates**

Attempts have been made to synthesize bacterial forms of indigo as well as fungal pigments for use in the textile industry. Certain micro fungi are capable of yielding up to 30% of their biomass as pigment. Potential non-textile applications include food industry colourants[2].

- **Biotechnology For Tissue Engineering and Medical Textiles**

The application of polymer materials in medicine for producing various implants such as vascular prosthesis, heart valves, sutures etc, is one of the most significant achievements in contemporary surgery[3].

Controlled revascularisation of the epidermal tissue is the key issues in tissue regeneration involving the use of porous and naturally occurring polymeric scaffolds on which cells are seeded. Textile structures gain importance as scaffolds to grow biological tissues in in-vitro[4]. Thus tissue engineering also forms the integral aspect of biotechnology.

CONCLUSION

These are just a few applications of Biotechnology to enunciate, however many such potentials are yet to be explored. Biotechnology finds wide application in textiles and it will prove to be a boon to the ever-changing conditions of the ecology as well as economy.

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