Biotechnological Developments in Textile Field

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Abstract: The textiles industry has impact of biotechnology through the development of more efficient and more environment friendly manufacturing processes, as well as through the modified design of textile materials. Some of the major key roles of biotechnologyare implementation, production, and modification of enzymes for the improvement of textile manufacturing processes.Other contributions are related with thegeneration of textile auxiliaries. Biotechnology has also facilitated the production of novel and biodegradable fibres from biomass feedstock.Biological means of Waste management and some analytical tools have come up and widely accepted. In this paper these few textile industrial uses are focused.

***Key Words**- Biotechnology, Biopolymers, Enzymes, Waste management*

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I. INTRODUCTION

Biotechnology offersthe potential for new industrialprocesses that require less energyand are based on renewable rawmaterials. It is important to note thatbiotechnology is not just concernedwith biology, but it is a trulyinterdisciplinary subject involvingthe integration of natural andengineering 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 geneticengineering, textile processing and effluent management.

The biotechnology has made rapid developments in genetic engineering with a possibility of ‘tailoring’ organisms in order to optimize production of established or novel metabolites of commercial importance and of transferring genetic material (genes) from one organism to another. It has economized developing industrial processes with less energy and renewable raw materials thus it is an effective interdisciplinary and integrate natural and engineering sciences [1].

Textile industry is a conventional and pillar industry in India, which possesses a considerable proportion of the national economy. In recent years, special attention has been paid to the application of biotechnology in textile industries in India. This paper summarizes current developments and highlights those areas where biotechnology might play an increasingly important role in different sectors of textile industry.

II. FIBERS AND BIOPOLYMERS

Biotechnology can play a crucial role in production of natural fibres with highly improved and modified properties besides providing opportunities for development of absolutely new polymeric material. Cotton, wool and silk natural textile fibers are an asset but biotechnology producing unique fibers and improve yields of existing fibers. Cotton is leading worldwide textile fiber with ca 20 million tons grown/year by about 85 countries but it is vulnerable to many insects, and to maintain yields, large amounts of pesticides are in use [2]. Cotton is prone to infestation by weeds under intense irrigation conditions and needs throughout its growth cycle, and has poor tolerance to any of the herbicides. Hence biotechnologists have put forward short-term objectives on genetically engineering insect, disease and herbicide resistance into cotton plant along with modification of fiber quality and properties to have high performance cottons. Naturally colored cottons are attracting the world market hence transgenic intensely colored cottons (blues and vivid reds) is dream of the day that can replace bleaching and dyeing [2].

Biotechnology has largely influenced animal fiber production, in vitro fertilization and embryo transfer, diagnostics, genetically engineered vaccines and therapeutic drugs are other catchments of it. CSIRO, Australia’s national research organization is put up efforts for genetic modification of sheep to resist attack from blowfly larvae by engineering a sheep that secretes an insect repellent from its hair follicles and ‘biological wool shearing’’. And is expected to artificial epidermal growth factor which on injection into sheep interrupts hair growth, within a month, it breaks up in wool fiber and fleece can be pulled off whole in half the time it takes to shear a sheep.

Fermentation is developing biopolymers at largescale. One of the bacterialstorage compound, PHB polyhydroxybutyrate is developed by Zeneca bioproducts and is produced as ‘Biopol’ [3]. It is a high molecular weight linear polyester and thermoplastic (melts at 180°C) and can be melt spun into biocompatible and biodegradable fibers suitable for surgical use where human body enzymes slowly degrade sutures. Biopol is being used as conventional plastics for shampoo bottles but it is not economic [3], research is on to produce Biopol from plants, probably from genetically engineered variety of rape. Polysaccharides chitin, alginate, dextran and hyaluronic acid biopolymers are of interest in wound healing as chitin and its derivative chitosan are important components of fungal cell walls, at present manufactured from sea food (shellfish) wastes [4]. Patents taken out by Japanese Unitika cite a use of fibers made out of chitin in wound dressings. At BTTG, research has been directed for use of intact fungal filaments as a direct source of chitin or chitosan fiber to produce inexpensive wound dressings and other novel materials. Tests are carried out at Welsh School of Pharmacy indicate that these products have wound healing acceleration properties. Wound dressings based on calcium alginate fibers have already been developed by Courtaulds and are marketed as 'Sorbsan'. Present supplies of this polysaccharide rely on its extraction from brown seaweed's. However, a polymer of similar structure can also be produced by fermentation from certain species of bacteria. Dextran, which is manufactured by fermentation of sucrose by Leuconostoc mesenteroides or related species of bacteria, is also being developed as a fibrous non-woven for specialty end-uses such as wound dressings. Additional unique biopolymers are now coming onto market thanks to biotechnology e.g. hyaluronic acid a polydisaccharide of D-glucuronic acid and N-acetyl glucosamine found in connective tissue matrices of vertebrates and is also present in capsules of some bacteria. The original method of production by extraction from rooster combs was very inefficient requiring 5 kg of rooster combs to provide 4 g of hyaluronic acid. Fermentech, a British biotechnology company, is now producing hyaluronic acid by fermentation. The same amount of high quality purified hyaluronic acid can be obtained from 4 liters of fermentation broth as opposed to 5 kg of rooster combs.

Different biotechnological routes for cellulose production are being worked out globally, cellulose is produced as an extra cellular polysaccharide by several bacteria in form of ribbon-like micro fibrils, and can be used to produce moulded materials of relatively high strength. Sony, a Japanese electronics company has patented a way of making hi-fi loudspeaker cones and diaphragms from bacterial cellulose. An alternative route to cellulose, still at a very early stage of development, concerns in vitro cultivation of plant cells. Culturing cells of various strains of Gossypium can produce cotton fibers in vitro include a more uniform product displaying particularly desirable properties. Plant tissue culture can provide a steady, all year supply of products without climatic or geographic limitations free of contamination from pests. Proteins are interesting biopolymers for utilizing new genetic manipulation techniques where animal and plant proteins genes (e.g. collagen, various silks) can now be transferred into suitable microbial hosts and proteins produced by fermentation. US army is taking up spider silk as a high performance fiber for bulletproof vests.

III. ENZYMES

Chemical reactions by catalytic proteins (enzymes) are a central feature of living systems, living cells makes enzymes although the enzymes themselves are not alive and we can encourage living cells to make more enzymes than they would normally make. Or to make a slightly different enzyme (protein engineering) with improved characteristics of specificity, stability and performance in industrial processes and operate under mild conditions of pH and temperature. Many enzymes exhibit great specificity and stereo selectivity. With a notable exception of starch-size removal by amylases, however, scant attention is given to application of enzymes in textile processing for preparation textile fibers e.g. flax and hemp by dew retting involves action of pectolytic enzymes from various microorganisms, which degrade pectin in middle lamella of these plant fibers. Yet no attempts appear to be taken to use isolated enzyme preparations for desired effects although their effectiveness has been demonstrated in the laboratory.

Textile finishing sector requires different chemicals, which are harmful to the environment. Sometimes they may affect the textile material if not used properly. So instead of using such chemicals we can use the enzymes. The finishing of denim garments has been revolutionized by application of enzymes. Enzymes are very specific in action when they are used under the required conditions [5]. The processes in which enzymes can be used are desizing, scouring, bleaching, biowashing, degumming etc. Amylase, pectinase, and glucose oxidase are enzymes used for desizing, scouring, and bleaching respectively in enzymatic preparation processes. Use of isolated enzymes to remove fats and waxes, pectin's, seed-coat material and colored impurities from loom state cotton and cotton/polyester fabrics, leading to a novel, low-energy fabric-preparation process, (replace scouring and bleaching). Only partial success is made using existing commercial enzyme preparations due to the recalcitrant nature of some of components and process was found to be too slow and therefore uneconomic for current applications. Enzyme that is being applied in textile processing for removal of hydrogen peroxide prior to dyeing is catalase. Undoubtedly, use of microbial enzymes can be expected to expand into many other areas of textile industry replacing existing chemical or mechanical processes in not too distant future.

Contrary to textile processing enzymes are used in detergents since their inception in 1960's, and washing powders are referred to as 'biological', and degrade stains with milder washing conditions at lower temperatures saving energy and protects fabric. Cellulose enzymes could replace pumice stones used to produce 'stone-washed' denim garments, stones can damage clothes, particularly the hems and waistbands, and most manufacturers are now using enzyme treatment. Cellulose enzymes are in biopolishing, a removal of fuzz from surface of cellulosic fibres, which eliminates pilling making fabrics smoother and cleaner looking. Similarly protease enzymes are developed for wool.

Interesting uses of enzymes are in biotransformation with biocatalytic transformation of one chemical to another. In practice, either intact cells, an extract from such cells or an isolated enzyme may be used as the catalyst system of a specific reaction. Concentration of individual enzymes in cells is typically less than 1 per cent this can now be increased using gene amplification techniques. Bulk chemical production by oil-based processes is being replaced by biotransformation, biotechnology competes with chemical synthesis. For example, optical activity of chemicals as of polymer precursors is likely to grow and biotransformation has a particular edge over traditional chemical methods.

Enzymes are used in detergents e.g. protease removes stains caused by proteins such as blood, grass, egg and human sweat. Amylase removes starch-based stains such as those made by potatoes, pasta, rice and custard. Lipase breaks down fats, oils and greases removing stains based on salad oils, butter, fat-based sauces and soups, and certain cosmetics such as lipstick. Cellulase brightens and softens the fabric, and release particles of dirt trapped in the fibers.

IV. TEXTILE AUXILIARIES

These are dyes produced by fermentation or from plants in future. In the nineteenth century many of colors used to dye textiles came from plants e.g. woad, indigo and madder. Many microorganisms produce pigments during their growth, which are substantive as indicated by permanent staining and associated with mildew growth on textiles and plastics. Some species produce up to 30% of their dry weight as pigment, such microbial pigments are benzoquinone, naphthoquinone, anthraquinone, and perinaphthenone and benzofluoranthenequinone derivatives, resembling in some instances the important group of vat dyes. Microorganisms offer great potential for direct production of novel textile dyes or dye intermediates by controlled fermentation techniques replacing chemical synthesis. Production and evaluation of microbial pigments as textile colorants is currently being investigated at BTTG. Another biotechnological route for producing pigments for use in food, cosmetics or textile industries is from plant cell culture, e.g. red pigment shikonin (cosmetics) is being commercially produced since 1983 in Japan. Shikonin was extracted from roots of five-year-old Lithosperum erythrorhiz plants where it makes up about 1 to 2 percent of dry weight of roots. In tissue culture, pigment yields of about 15 percent of dry weight of root cells have been achieved.

NEW ANALYTICAL TOOLS

Work on molecular biology at BTTG has led to development of species-specific DNA probes for animal fibers to detect adulteration of high value specialty fibres such as cashmere by much cheaper fibres e.g. wool and yak hair. Rapid methods are being evolved to assist in early detection of biodeterioration of textile and other materials. BTTG have shown that presence of viable microorganisms on textiles can be assessed using enzyme luciferase isolated from firefly (Photinus pyralis), which releases light (bioluminescence) in combination with ATP produced by the microorganisms.

WASTE MANAGEMENT

Microbes or their enzymes are being used to degrade toxic wastes instead of traditional processes, thus waste treatment is useful industrial asset of biotechnology. 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, usually occupy less space, treat wastes containing up to 30 000 mg/l of COD, have lower running costs and produce less sludge [4]. Azo dyes are susceptible to anaerobic biodegradation but reduction of azo compounds can result in odour problems. Biological systems, such as biofilters and bioscrubbers, are now available for the removal of odour and other volatile compounds. The dyes can be removed by biosorption on apple pomace and wheat straw [5]. The experimental results showed that 1 gm of apple pomace and 1 gm of wheat straw, with a particle size of 600μm, were suitable adsorbents for the removal of dyes from effluents. Apple pomace had a greater capacity to adsorb the reactive dyes taken for the study compared to wheat straw.

The use of lignin degrading white-rot fungi has attracted increasing scientific attention as these organisms are able to degrade a wide range of recalcitrant organic compounds such as polycyclic aromatic hydrocarbons, chlorophenol, and various azo, heterocyclic and polymeric dyes [6,7]. The major enzymes associated with the lignin degradation are laccase, lignin peroxidase, and manganese peroxidase. The laccases are the multicopper enzymes, which catalyze the oxidation of phenolic and non-phenolic compounds [8].

V. CONCLUSIONS

Biotechnology is being treated as upcoming science with enormous commercial implications for many industrial sectors in years to come. In the textile arena, it has successfully developed new products, opened up new doors, expedited production and helped to clean up environment. Notably, biotechnology improves plant varieties used in production of textile fibers and in fiber properties, and derives fibers from animals and health care of the animals along with novel fibers from biopolymers and genetically modified microorganisms. Biotechnology plays a major role to maintain eco standards and save the environments. In this way, biotechnology is contributing a lot to textile industries.

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