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Biotechnology: A review on it's role in textile applications

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Abstract
Biotechnology is defined as application of living organisms and their components to industrial products and processes. It is an important technology that have a large impact on many different industrial sectors. In textile processing the enzymatic removal of starch from woven fabrics has been in use and the fermentation vat is probably the oldest known dyeing process. Biotechnology a new impetus in the last few years has been the very rapid developments in genetic manipulation techniques (Genetic engineering) which introduces the possibility of 'tailoring' organisms 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. Cheese production, golden rice, the manufacture of insulin and interferon, biosensors, enzymes in detergent are examples of biotechnology. Textile industry is a key sector where immense possibility exist for applications of biotechnology but the current awareness of about it is less. Therefore the application are yet limited. So, it can be predicted that in the long term, more cumbersome and polluting chemical procedures employed by the textile industry will be substituted by the biotechnological processes.

Keywords: biotechnology, textile application

Introduction

Biotechnology, as the word suggests, is combination of biology and technology. Biotechnology is the use of technology to use, modify or upgrade the part or whole of biological system for industrial and human welfare. The name biotechnology was given by Hungarian engineer Karoly Ereky in 1919 to describe a technology based on converting raw materials into a more useful product. of course, biotechnology is not new; traditional products include bread, beer, cheese, wine, and yoghurt. 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. Genetic manipulation techniques has given biotechnology a new impetus in the last few years by introducing the possibility of 'tailoring' organisms in order to optimise the production of established or novel metabolites of commercial importance and of transferring genetic material (Genes) from one organism to another.

Biotechnology is the use of living things such as cells and bacteria for production of various products for benefiting human beings. It is a combination of various technologies. Its application ranges from agriculture to industry, medicine, nutrition, environmental conservation, Cell Biology, making it one of the fastest growing fields. Biotechnology is to modify genetic structure in animals and plants to improve them in desired way for getting beneficial products.

Definition of biotechnology: Biotechnology can be defined as the application of living organisms and their components to industrial products and processes is not an industry in itself, but an important technology that will have a large impact on many different industrial sectors in the future.

According to European Federation of Biotechnology “Biotechnology is the integrated use of biochemistry, microbiology, and engineering sciences in order to achieve technological

(Industrial) application of the capabilities of micro-organisms, cultured tissue cells."

United State Congress's Office of technology Assessment defined biotechnology as any technique that used living organisms to make or modify a product to improve plants or animals or to develop microorganisms for specific use.

History: The ancient Egyptians made wine using fermentation techniques based on an understanding of the microbiological Egyptians also applied fermentation technologies to make dough rise during bread-making. Due in part to this application, there were more than 50 varieties of bread in Egypt more than 4,000 years ago. Yogurt was made at homes but the reason of the conversion of milk into yogurt was unknown to old people. Later researches showed that yogurt is made due to the action of yeast added to milk; which is also biotechnology as it uses a micro-organism for benefiting human.

Fig 1: Processes that occur in the absence of oxygen. In 1680 Antony Van Leeuwenhoek first observed yeast cells with his newly designed microscope.

In 1857 Louis Pasteur highlighted the lactic acid fermentation by microbe.

By the end of 19thcentury large number of industries and group of scientists were involved in the field of biotechnology and developed large scale sewage purification system employing microbes were established in Germany and France. Biotechnology has also led to the development of antibiotics. In 1928, Alexander Fleming discovered the mold *Penicillium*. His work led to the purification of the antibiotic compound formed by the mold by Howard Florey, Ernst Boris Chain and Norman Heatley – to form what we today know as penicillin. In 1940, penicillin became available for medicinal use to treat bacterial infections in humans.

Modern biotechnology: The Second World War became a major impediment in scientific discoveries. After the end of the second world war some, very crucial discoveries were reported, which paved the path for modern biotechnology and to its current status. In 1953, JD Watson and FHC Crick for the first time cleared the mysteries around the DNA as a genetic material, by giving a structural model of DNA, popularly known as, 'Double Helix Model of DNA'. This model was able to explain various phenomena related to DNA replication, and its role in inheritance.

Dr. Hargobind Khorana was able to synthesize the DNA in test tube, while Karl Mullis added value to Khorana's discovery by amplifying DNA in a test tube, thousand times more than the original amount of DNA. Using this technological advancement, other scientists were able to insert a foreign DNA into another host and were even able to monitor the transfer of a foreign DNA into the next generation.

In 1997, Ian Wilmut an Irish scientist, was successful to clone a sheep and named the cloned sheep as 'Dolly'. In 2003, the Human Genome Project completes sequencing of the human genome.

In 1978, Boyer was able to isolate a gene for insulin (a hormone to regulate blood sugar levels) from human genome using biotechnology. He then inserted it into bacteria, which allowed the gene to reproduce a larger quantity of insulin for diabetics

Modern biotechnology provides breakthrough products and technologies to combat rare diseases, reduce our environmental footprint, feed the hungry, use less and cleaner energy, and have safer, cleaner and more efficient industrial manufacturing processes. Currently, there are:

- More than 250 biotechnology health care products and vaccines available to patients, many for previously untreatable diseases.
- More than 13.3 million farmers around the world use agricultural biotechnology to increase yields, prevent damage from pests and reduce farming's impact on the environment.
- More than 50 biorefineries are being built across North America to test and refine technologies to produce biofuels and chemicals from renewable biomass, which can help reduce greenhouse gas emissions.

Fields in biotechnology: Following are famous biotechnological fields.

1. Genetic engineering: Genetic engineering, also called genetic modification, is the direct manipulation of an organism's genome using biotechnology. Genes are the chemical blueprints that determine an organism's traits. Moving genes from one organism to another transfers those traits. Through genetic engineering, organisms can be given targeted combinations of new genes, and therefore new combinations of traits that do not occur in nature and, indeed, cannot be developed by natural means. Such an approach is different from classical plant and animal breeding, which operates through selection across many generations for traits of interest. Genetic engineering is the technique of removing, modifying or adding genes to a DNA molecule in order to change the information it contains. By changing this information, genetic engineering changes the type or amount of proteins an organism is capable of producing. Genetic engineering is used in the production of drugs, human gene therapy, and the development of improved plants. For example, an "insect protection" gene (Bt) has been inserted into several crops - corn, cotton, and potatoes - to give farmers new tools for integrated pest management. Bt corn is resistant to European corn borer. This inherent resistance thus reduces a farmers pesticide use for controlling European corn borer, and in turn requires less chemicals and potentially provides higher yielding Agricultural Biotechnology.

2. Tissue culture: Tissue culture, a method of biological research in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function. The cultured tissue may consist of a single cell, a population of cells, or a whole or part of an organ. Cells in culture may multiply; change size, form, or function; exhibit specialized activity (Muscle cells, for example, may contract); or interact with other cells.

3. Cloning: Cloning describes the processes used to create an exact genetic replica of another cell, tissue or organism. The copied material, which has the same genetic makeup as the original, is referred to as a clone. The most famous clone was a Scottish sheep named Dolly.

There are three different types of cloning

1. **Gene cloning:** Gene cloning is the type of cloning in which copies of genes or segments of DNA was created.
2. **Reproductive cloning:** Reproductive cloning is the type of cloning in which copies of whole animal was created.
3. **Therapeutic cloning:** Therapeutic cloning is the type of cloning in which embryonic stem cells was created. Researchers hope to use these cells to grow healthy tissue to replace injured or diseased tissues in the human body.

Areas of biotechnology

1. **Red biotechnology:** deals with health, medical field and diagonastics.
2. **Green biotechnology:** deals with agricultural and environmental biotechnology.
3. **Blue biotechnology:** deals with aquaculture, coastal and marine biotechnology.
4. **Yellow biotechnology:** deals with food biotechnology and nutrition science.
5. **Brown biotechnology:** deals with desert biotechnology.
6. **Dark biotechnology:** deals with Bioterrorism and biowarfare.
7. **Purple biotechnology:** deals with patents, publications and inventions.
8. **White biotechnology:** deals with industrial biotechnology. Using biotechnology, the desired enzyme can be manufactured in commercial quantities.
9. **Gold biotechnology:** deals with Bioinformatics and Nano biotechnology.

Impact of biotechnology

1. Reducing rates of infectious disease.
2. Tailoring treatments to individuals to minimize health risks and side effects.
3. Creating more precise tools for disease detection Combating serious illnesses and everyday threats confronting the developing world.
4. Improving manufacturing process efficiency.
5. Reducing use of and reliance on petrochemicals.
6. Using biofuels to cut greenhouse gas emissions.
7. Decreasing water usage and waste generation.
8. Generating higher crop yields with fewer inputs.
9. Lowering volumes of agricultural chemicals required by crops-limiting the run-off of these products into the environment.
10. Using biotech crops that need fewer applications of pesticides.
11. Developing crops with enhanced nutrition profiles that solve vitamin and nutrient deficiencies.
12. Producing foods free of allergens and toxins.
13. Improving food and crop oil content to help improve cardiovascular health.

Improvement in natural fiber

Biotechnology can play a crucial role in production of natural fibers with highly improved and modified properties besides providing opportunities for development of absolutely new polymeric materials.

Cotton: Cotton continues to dominate the market of natural fibers. Cotton plant is currently directed by a two pronged approach

i. Solving the major problems associated with the cultivation of cotton crop, namely the improved resistance to insects, diseases an herbicides leading to improved quality and higher yield.
ii. The longer term approach of developing cotton fiber with modified properties such as improved strength, length, appearance, maturity and colour.

Transgenic cotton

Cotton growers fight to produce a product using chemical sprays, natural controls, cultural practices and monitoring. Use of excessive pesticide is posing a serious threat to the green image of cotton.

A new tool is available for cotton growers to ward off the pink bollworm, one of the major cotton pests. Monsanto scientist obtained a toxin gene from the soil bacterium called Bt (*Bacillus thuringiensis*) and inserted it into cotton plants to create a caterpillar-resistant variety. The gene is DNA that carries the instruction for producing a toxic protein. The toxin kills caterpillars by paralyzing their guts when they eat it. Plants with the bt toxin gene produce their own toxin and thus can kills caterpillar throughout the season without being sprayed with insecticide. Because the toxin is lethal to caterpillar but harmless to other organism, it is safe for the public and the environment. Bt gene technology for transgenic cotton under the trademark Bollgard.

Fig 2: Coloured cotton

b. Coloured cotton

Coloured cotton is also being produced by direct DNA engineering. Although several naturally coloured cotton varieties have been obtained by traditional breeding methods no blue variety exist. As blue is in great demand in textile industry, particularly for jeans production, synthetic fabric dyes used. However the ingredients of these synthetic dyes are often hazardous and their wastes are polluting. Additionally they take time and energy to work into the cloth. Natural blue cotton does not have these disadvantages and therefore has great market potential.

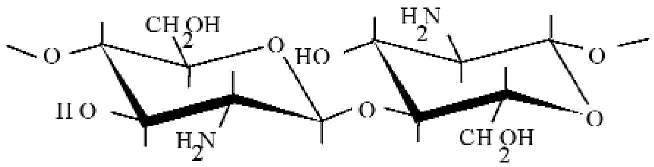
2. Wool

A revolutionary bio wool harvesting process became available. The technique relies on an artificial epidermal growth factor which when injected into sheep interrupts hair growth. A month later, breaks appear in the wool fiber and the fleece can be pulled off whole, without the use of a mechanical hand piece, in half the normal shearing time. Wool harvested using it will be free of second cuts and skin pieces contaminating the fleece.

3. DNA profiling of animal hair fibers

British textile technology group has developed a novel technique based on DNA hybridisation analysis to objectively confirm the type of animal fibers present in an unknown sample or blend. This technique can be used to demonstrate the presence of adulterants in commercial samples of exotic cashmere fibers and other specialty fibers.

1. **Novel fibers**
   The use of biotechnology has the potential of control and specify in polymer synthesis which is difficult. New materials produced using advanced biologically based approaches represent the textiles of the future. Two of the tools of the molecular biology namely recombinant DNA and genetic engineering technique now make it possible to construct highly specific polymers. Eg. Polyamides and polyester produced in this manner.
2. **Protein fiber:** Efforts in biosynthesis have been directed towards the preparation of precisely defined polymers of three kinds: Natural protein such as silk, elastins, collagens and marine bio adhesives, modified version of these biopolymer and Synthetic protein designed de novo that have no close natural analogue.
3. **Spider silk:** Spider dragline silk is a versatile engineering material that performs several several demanding functions. The mechanical properties of dragline silk exceed those of many synthetic fibers. Dragline silk is at least 5 times as strong as silk.
4. **Other new fiber soures:** It includes bacterial cellulose and the polysaccharides such as chitin, alginate, dextran and hyaluronic acid.
5. **Chitin and chitosans:** Both can form strong fibers. Chitin is found in the shells of crustaceans such as crab, lobster shrimp etc. Fabric woven from them are antimicrobial and serve as wound dressing products and antifungal stockings. Chitosan also has promising application in the field of fabric finishing, including dyeing and shrink proofing of wool. It is also useful in filtering and recovering heavy and precious metal and dyestuff from the water streams.



6. **Bacterial cellulose:** Cellulose produced for industrial purpose is usually obtained from plant source or it can be produce by bacterial action. *Acetobacter xylinum* is one of the most important bacteria for cellulose production. Cellulose produced by *Acetobacter* which has the ability to synthesize cellulose from a wide variety of substrate is chemically pure and free lignin and hemicelluloses.
7. **Corn fiber:** Lactron, the polylactic acid fiber is produced from the lactic acid fiber obtained through the fermentation of corn starch. Lactron is compatible with human body, it is being used for sanitary and household application. Its non clothing application includes paper making, auto seat cover and household use.
8. **Polyester fiber:** Polyhydroxybutyrate (PHB) is an energy storage material produced by a variety of bacteria in response to environmental stress, which has the properties comparable to polypropylene. It is commercially produced under the trade name Biopol. PHB is biodegradable, it is use for packaging purposes. Due to its immunological compatibility with human tissue PHB also has utility in antibiotics, drug delivery, medical sutures and bone replacement applications.

Biofabrics: Biofabrics aimed at producing fabrics containing genetically engineered bacteria and cell stress to manufacture the chemicals within the textiles thereby making chemical stores within the fabrics the self replenishing materials.
Niche applications for bio active fabrics exist in the medical and defence industries. eg. drug producing bandages or protective clothing with highly sensitive cellular sensors. Commercial products eg. fabrics that eat odours with genetically engineered bacteria, self cleaning fabrics and fabrics that continually regenerate water and dust repellents.

Dyes and intermediates from microorganisms: Textile auxiliaries such as dyes can be produced from the plants or by the fermentation. It is known that some microbial species can produce, up to 30% of their dry weight, pigment or a mixture of pigments. These includes Napthoquinon, Anthraquinones, Indigo

Treatment of textile waste water: Biotechnological techniques are also being employed for the elimination of toxic waste from textile effluents. Some major environmental problems faced by the textile industry include the removal of colour from the dye bath effluent and handling of toxic wastes such as insecticides heavy metals. Some of these waste are toxic enough to poison the systems used to treat them.
In response to this, several waste treatment systems based upon aerobic and anaerobic bacterial action have been developed. It has been found that only biotechnological solutions can offer complete destruction of the dyestuff with reduction in BOD and COD.

Fungi for discolouration: Azo dye constitutes the largest group of synthetic dyes being used by the textile industry. They do not occur in nature and are resistant to aerobic bacterial degradation. However the azo linkage is susceptible to reduction and the anaerobic bacteria can yield potentially carcinogenic aromatic amines. Eg. Wood degrading white rot fungus *P. Chrysosporium* can completely degrade a number of azo dyes.

Metal and toxin removal: Fungi are also being employed to absorb heavy metals from effluent streams.

Application in Finishing

i. Amylase enzymes for the desizing of woven cotton and man-made fabrics.
ii. The use of proteases, cellulases, and lipases as additives to textile after-care detergents also developed since the 1960s.
iii. Remove stains proteins based & starch-based stains

Bio finishing of cotton

Conventional stone washing uses abrasive pumice stones that abrade the fibers and remove particle of indigo dyestuff. Cellulase enzyme same effect without involving the damaging abrasive action of stones on both the garment and the machine.

Finishing on wool

Wool fabric has tendency to felt and shrink on wet processing. Papain was used to shrink proof wool by involving the partial hydrolysis of the scale tips and gave wool a silky lustre.

i. Papain used for boiling off cocoons and degumming of silk.
ii. For bio scouring, pectinase, lipase and cellulase are used.

Rapid bleaching with laccase

Laccase and hydrogen peroxide causes less fiber damage.

Waste management

Biotechnology can be used in new production processes that are themselves less polluting than the traditional processes and microbes or their enzymes are already being used to degrade toxic wastes. Waste treatment is probably the biggest industrial application of biotechnology. Specific problems pertaining to the textile industry include colour removal from dye house effluent, toxic heavy metal compounds and pentachlorophenol used overseas as a rot-proofing treatment of cotton fabrics but washed out during subsequent processing in the UK. Research was being carried out to resolve these problems and biotechnology would appear to offer the most effective solutions.

Drawbacks of biotechnology

1. **Ethics:** Debates over the ethics of biotechnology have been ongoing for decades. The question mostly lies in the morality of various practices employed in research and development. Ethics-related concerns include cloning, xenotransplantation, stem cell research, fetal tissue use, and genetic modification of organisms have been ongoing for decades. The question mostly lies in the morality of various practices employed in research and development. Ethics-related concerns include cloning, xenotransplantation, stem cell research, fetal tissue use, and genetic modification of organisms.
2. **Uncertainty:** The biggest concern over biotechnology is the uncertainty in its long term effects. The immediate advantages are clear in many circumstances, but they may directly or indirectly impact the future in unforeseen ways.
3. **Cost:** Balancing benefits of biotechnology with cost, especially in the field of medicine, can be one tricky aspect. In terms of investment, the value of biotech products is often miscalculated with failure to include the factors of risk and product development periods, which can ultimately lower the return on profit. Thus far, biotech products are often more expensive and less practical than alternatives.
4. Too much altering of crops is destroying the soul of natural farming
5. Genetically modified species can damage the natural ecosystem.

Conclusion

Biotechnology has already led to the development of new product, opened new markets, speeded up the production of pure products and helped reduce the pollution load. Textile industry is a key sector where immense possibility exists for biotechnological applications but the current awareness of biotechnology is less. Therefore the application are yet limited. So, it can be predicted that in the long term, more and more of the cumbersome and polluting chemical procedures employed by the textile industry will be substituted or supported by the biotechnological processes.

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