International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Enzymatic Finishing of Textiles

Khushboo Shrimali[1], Ela Dedhia[2]

[1]Ph.D. Scholar, Shrimati Nathibai Damodarji Thackersaey University, Mumbai, India

[2]Guide, Professor, Nirmala Niketan College of Home Science, Mumbai, India

Abstract: ***Enzymes are generally globular proteins consisting of long linear chains of amino acids that fold to produce a three-dimensional product. Each unique amino acid sequence produces a specific structure possessing unique properties. Enzymes are extremely efficient and highly specific biocatalysts. The primary sources of enzymes for commercial use are animal tissue, plants and microbes. Enzymes are naturally occurring substances and are often not readily available in sufficient quantities for industrial use. Although to facilitate industrial use, desired enzyme can be produced by isolating microbial strains and optimizing the conditions for growth. There is a large number of microorganisms which produce a variety of enzymes (Boyer, 1971; Fersht, 2007).***

Keywords: Enzymes, Bio-enzymes, Textile finishing, Textile wet processing

1. Why Enzymes?

The rise in the level of various kinds of pollutions has created a major awareness among the consumers for using eco-friendly products. Governments of many countries have also imposed limitations on release of pollutants. This in turn has resulted in a rise in demand for green and clean processes. One of the sectors of industry that holds a major share in the global pollution is textile industry. Therefore use of enzymes on textiles play a key role as an alternative process for textile processing and have become an integral part of the textile processing industry.

The process of use of enzymes is energy saving and does not require any special equipment for heat resistance, pressure or corrosion. Their efficiency, high biodegradability and the mild conditions of working mark their use in a wide range of industrial applications. Enzymes work only on renewable raw materials. Fruit, cereals, milk, fats, cotton, leather and wood are some typical candidates for enzymatic conversion in industry (Uhlig, 1991; Ruttloff, 1994). Out of the 7000 enzymes known, only about 75 are used in the textile industry (Quandt&Kuhl 2001).

2. Enzyme Classification

Enzymes are biocatalyst and can speed up the chemical process without even being consumed in the process. Usually most enzymes are not reusable after a reaction but some enzymes can be released again and mark their use in another reaction also. For each type of reaction in a cell there is a different enzyme and they are classified into six broad categories namely hydrolytic, oxidising and reducing, synthesising, transferring, lytic and isomerising.

The specificity of enzymes is more when compared to other inorganic catalysts such as acids, bases, metals and metal oxides. The molecule that an enzyme acts on is known as its substrate, which is converted into a product or products. Originally, enzymes were classified on the basis of functions they perform. But later, in 1956 an International Commission on Enzymes (EC) was established by the International Union of Biochemistry (IUB), in consultation with the International Union of Pure and Applied Chemistry (IUPAC), to classify hundreds of enzymes that had been discovered by that point. A standardized terminology was also formed to name the newly discovered enzymes systematically.

The commission divided the enzymes into six categories depending on their basic function (Uhlig, 1991; Ruttloff, 1994):

- EC1 Oxidoreductases: catalyze oxidation/reduction reactions.
- EC2 Transferases: transfer a functional group.
- EC3 Hydrolases: catalyze the hydrolysis of various bonds.
- EC4 Lyases: cleave various bonds by means other than hydrolysis and oxidation.
- EC5 Isomerases: catalyze isomerization changes within a single molecule.
- EC6 Ligases: join two molecules with covalent bonds.

Enzymes used in Textiles

Mainly two types of enzymes are used in textile processing industry. The desizing process includes the use of Amylases and in the finishing area cellulases are used for softening, bio-stoning and reducing of pilling propensity for cotton goods. The other enzymes used in the processing of textiles are pectinases, lipases, proteases, catalases, xylanases etc.

Application of enzymes on textiles

In textile industry, there is a wide use of enzymes because of their beneficial nature(Uhlig, 1991; Ruttloff, 1994):

- They accelerate reactions,
- Act only on specific substrates,
- Operate under mild conditions,
- Safe and easy to control,
- Can replace harsh chemicals
- Are biologically degradable i.e. biodegradable
- Save water, energy and chemicals
- Increase productivity
- Produce high quality textile products

The various applications of enzymes in textile area includes the effect of fading of denim and non-denim, bio-scouring, bio-polishing, wool finishing, peroxide removal, decolourization of dyestuff, etc. (Cavaco-Paulo and Gubitz, 2003; Chelikani et al., 2004; Barrett et al., 2003; Sharma, 1993; Nalankilli, 1998; Shenai, 1990).

3. Enzymes in various textile processes

A wide variety of enzymes have been used on textiles since ages. The current application of enzymatic processing in the textile industry revolves mainly around hydrolases and now to some extentoxidoreductase. The enzymatic desizing of cotton with α-amylases is state-of-the-art since many decades (Marcher et al., 1993). The other cotton pre-treatment and finishing process includes the use of cellulases, pectinases, hemicellulases, lipases and catalases (Meyer-Stork, 2002). The enzymatic degumming of silk is done withsericinases (Gulrajani, 1992), the felt-free-finishing of wool with proteases (Fornelli, 1994) and the softening of jute with cellulases and xylanases (Kundu et al., 1991).

When compared with the conventional processing, the enzymatic processing has been proved advantageous like its use in catalytic concentrations at low temperatures and at pH-values near to neutral (Uhlig, 1991; Ruttloff, 1994).

4. Enzymatic Desizing

One of the various steps of textile processing is weaving which includes the interlacing of warp and weft yarns. This process results in the exposure of warp threads to considerable mechanical strain. Therefore, to prevent the warp threads from breaking during weaving, a gelatinous substance is used to coat them. This process is known as Sizing and the substance is known as Size. In the weaving of cotton blend fabrics, the commonly used material to size the yarn contains starch in native or modified form, sometimes in combination with other polymers such as polyvinyl alcohol (PVA), polyacrylic acid (PAA) or carboxymethyl cellulose (CMC). Small amounts of fats or oils may be also added to the size, with the aim of lubricating the warp coat surface. Because of this process, the sized warp yarns of the fabrics are unable to absorb water or finishing agents to a sufficient degree. This in turn necessitates the removal of the size before dyeing or finishing of the fabric. In most cases, the Desizing treatment given to the fabric to get the desired effect consumes huge amount of water & different types of hazardous chemicals resulting in large amount of effluent and high pressure on environment (Mojsov K. 2014).

The widely used enzyme for desizing process is a hydrolytic enzyme called Amylase. It catalyses the breakdown of dietary starch to short chain sugars, dextrin and maltose which gives uniform wet processing. The advantage of these enzymes is that they are specific for starch, removing without damaging to the support fabric. An amylase enzyme can be used for desizing processes at low-temperature (30-60ºC) and optimum pH is 5,5-6,5 (Cavaco-Paulo and Gübitz, 2003).

This enzyme works by converting the starch mixture to soluble dextrin and then more slowly convert this to reducing substances and sugar, such as maltose. The two types of amylase enzymes used for removing size materials from warp yarn of woven fabric are α-amylase and β-amylase.The α -Amylases are produced by a variety fungi, yeasts and bacteria, butenzymes from filamentous fungal and bacterial sources are the most commonly used in industrial sectors (Pandey A et.al. 2000).

Enzymatic Scouring (Bioscouring)

Scouring means the removal of non-cellulosicmaterial, which is responsible for water repellency of cotton, present on the surface of the cotton. Enzymescellulase and pectinase are combined and used for Bioscouring. Pectinase destroy the cotton cuticle structure by digesting the pectin and removing the connection between the cuticle and the body of cotton fibre whereas Cellulase destroys the cuticle structure by digesting the primary wall cellulose immediately under the cuticle of cotton.This is done by using a specific degradation process in delicate pH and temperature and then removing the natural impurities with a successive hot wash and rinse. The traditional scouring of cotton includes the use of hazardous chemicals that increase biological oxygen demand (BOD), chemical oxygen demand (COD) & total dissolved solid (TDS) in waste water increasing overall cost & pollution of environment (BahrumA. M. K &Mojsov K. 2012). Enzymatic scouring results in very soft handle compared to harsh feel in alkaline scouring process. It also minimizes health risks hence operators are not exposed to aggressive chemicals (Pawar et al., 2002).

5. Enzymatic Bleaching

Cotton bleaching is done to decolourise natural pigments and give a pure white appearance to the fibres. Mainly flavonoids are responsible for the colour of cotton (Hedin et al., 1992; Ardon et al., 1996). Generally for bleaching, H_2O_2 is used and its residues must be removed in order to obtain the most efficient dyeing & to reduce the complexity of treatment. The traditional processing of cotton requires high amounts of alkaline chemicals and generates huge quantities of rinse water. Therefore, the conventional bleaching agent hydrogen peroxide can be replaced by an enzymatic bleaching system which would result in a better product quality due to less fibre damage and savings on washing water needed for the removal of hydrogen peroxide. With the use of enzymes, dyeing can be carried out in the same bath resulting in reduced water consumption which in turn requires less power to dye fabric eventually lowering the amount of effluent produced. Therefore, we can save on the use of water, energy and chemicals.

For this procedure, Amyloglucosidases, pectinases, and glucose oxidases are used as they are compatible concerning their active pH and temperature range.

6. Bio polishing

A finishing process to improve fabric quality and reduce fuzziness and pilling property of the cellulosic fibre is called Bio polishing. This process involves the action of cellulose enzyme in order to discard micro fibrils of cotton (Stewart, 2005; Cavaco-Paulo, 1998; Cavaco-Paulo et al., 1996; Lenting and Warmoeskerken, 2001).

Bio polishing is a finishing process to obtain a cooler, cleaner, lustrous, soft fabric.

7. Enzymatic treatment to denim

A fading effect is given to the denim in its finishing process. The conventional method of giving this finish was done using sodium hypochlorite or potassium permanganate was used called as pumice stones (Pedersen and Schneider, 1998). Denim is heavy grade cotton and the dye is mainly adsorbed on the surface of the fibre due to which fading can be achieved without considerable loss of strength. The use of pumice stone carries some disadvantages with it like:

- Pumice stones cause large amount of back-staining.
- Pumice stones are required in very large amount.
- They cause considerable wear and tear of machine.

The enzymatic finishing of denim fabric is done with cellulase enzyme as it loosens the indigo dye on the surface of denim. This process is known as “Bio-Stonewashing”. A small dose of enzyme can replace several kilograms of pumice stones. This process results in less damage to garment, machine and less pumice dust in the laundry environment.

More recently, some authors showed that laccase was an effective agent for stone-washing effects of denim fabric with and without using a mediator (Campos et al., 2001; Pazarloglu et al., 2005).

8. Enzymes for wool and silk finishing

The bio blasting of cotton and other fibers based on cellulose came first, but in 1995 enzymes were also introduced for the bio blasting of wool. Wool is made up of protein and requires a treatment to modify the fibres known as Bio-blasting which uses protease enzyme. The enzymatic treatment reduces "Facing up" (a trade term used for the ruffling up of the surface of wool garments by abrasive action during dyeing) resulting as increased softness and improved piling performance. As reported, the enzymatic finishing of wool also improves shrink resistance, tensile strength retention, handle, softness, wettability, dye uptake, reduced felting tendency and protection from damage caused by the use of common detergents (Cortez J. et. al. 2004).

Proteases are also used to treat silk. The finishing of silk includes the removal of sericin, a proteinaceous substance that covers the silk fiber. This process is called degumming of silk fibers. The traditional method of degumming of silk is a harsh treatment that destroys fibrin as it is done in an alkaline solution containing soap (Araujo R. et. al. 2008).On the other hand, the proteolytic enzymatic finishing is a better method as it removes the sericin without attacking the fibrin. Tests with high concentrations of enzymes show that there is no fiber damage and the silk threads are stronger.

9. Conclusion

Use of enzymes not only provides us with eco-friendly environment but also saves a lot of money by reducing water and energy consumption thus reducing the cost of production. Enzyme producing companies are also coming up with more new technologies and products in this area.

The major limitation in the use of enzyme processing is the high cost of enzymes. This technology can still become a widely and extensively used technology if its cost could be managed. In textile processing the enzyme can be successfully used for preparatory and finishing process like desizing, scouring and bleaching and is appropriate to create a cleaner and greener environment and product too.

References

[1] M. K. Bahrum Prang Rocky (August-2012).Comparison of Effectiveness between Conventional Scouring & Bio-Scouring On Cotton Fabrics.*International Journal of Scientific & Engineering Research Volume 3, Issue 8*. pp. 1-5.

[2] Ardon, O., Kerem, Z., Hadar, Y.(1996). Enhancement of laccase activity in liquid cultures of theligninolytic fungus *Pleurotusostreatus*by cotton stalk extract, *J. Biotechnol., 51*, 201-207

[3] Barrett, A.J., Rawlings, N.D., Woessner, J.F.(2003).*the handbook of proteolytic enzymes*, 2nd ed. Academic Press .ISBN 0-12-079610-4

[4] Boyer, P.D. 1971, *The enzymes*,3rd ed., *Academic Press, Inc., New York, Vol.5*

[5] Campos, R., Kandelbauer, A., Robra, K.H., Cavaco-Paulo, A., Gubitz, G.M. (2001). Indigo degradation with purified laccases from *Trameteshirsuta*and *Sclerotiumrolfsii*. *J. Biotechnol.89*.131-139

[6] Cavaco-Paulo, A., Gübitz, G.M.(2003).Textile Processing with Enzymes, *Woodhead Publishing Ltd*, England, ISBN 0-8493-1776-2

[7] Cavaco-Paulo, A., Almedia, L., Bishop, D. (1996).*Textile Res. J*., 1996,*66(5)*287-294.

[8] Cavaco-Paulo, A. (1998).*Carbohydrate Polymers*, 37, 273-277

[9] Chelikani, P., Fita, I., Loewen, P.C.(2004), Diversity of structures and properties among Catalases.*Cell. Mol. Life Sci*.,*61(2)*,192-208

[10] Cortez J, Bonner PLR, Griffin M.(2004). Application of transglutaminases in the modification of wool textiles.*Enzyme and Microbial Technology*.

[11] Dr. KiroMojsov (2014).Enzymatic Desizing of cotton.*International Journal of Management, IT and Engineering, Vol. 4, No. 1*.pp. 459-469.

[12] Dr. KiroMojsov (2012).Enzymatic scouring of cotton.*International Journal of Marketing, and Technology, Vol. 2, No. 9*.pp. 256-275.

[13] Fersht, A. 2007. Enzyme structure and mechanism, San Francisco: Brenda, W.H., *The comprehensive enzyme information system.50–2.* ISBN 0-7167-1615-1

[14] Hedin, P.A., Jenkis, J.N., Parrot, W.L.(1992). Evaluation of flavonoids in *Gossypium arboretum*(L.) cottons as potential source of resistance to tobacco budworm, *J. Chem. Ecol.18*, 105-114

[15] Fornelli, S. (1994).*MelliandTextilber*. 1994.*75*. 120-125

[16] Gulrajani, M.L.(1992). *Rev. Prog. Coloration.22*. 79-89

[17] KiroMojsov.(2011).*Technological-technical Faculty, Probistip,University “GoceDelcev”Stip, Makedonija.* APPLICATION OF ENZYMES IN THE TEXTILE INDUSTRY : A REVIEW. ***II International***

Congress "Engineering, Ecology and Materials in the Processing Industry". Jahorina, March 09th to 11th.

[18] Kundu, A.B., Ghosh, B.S., Chakrabarti, S.K., Ghosh, B.L.(1991).*Textile Res. J.61*. 720-723

[19] Meyer-Stork, L.S.(2002).*Maschen-Industrie.52*. 32-40

[20] Nalankilli, G.(1998).*Colourage.45(10)*. 17-19

[21] Pandey A, Nigam P, Soccol CR, Soccol VT, Singh D, Mohan R.(2000). Advances in microbial amylases.*BiotechnolApplBiochem, Vol.31*, pp.135-152.

[22] Pawar, S.B., Shah, H.D., Andhorika, G.R.(2002). *Man-Made Textiles in India.45(4).*pp.133

[23] Pazarloglu, N.K., Sariisik, M., Telefoncu, A.(2005).Laccase: production by Trametes. versicolorand application to denim washing process . Biochem.*40*.1673-1678

[24] Pedersen, A.H., Schneider, P.N.N.(1998). US Pat. 5795855 A. US-Patent.

[25] Quandt C, Kuhl B. (2001). Enzymatic processes: Operational possibilities and optimization (Enzymes Possibilite´set perspectives). *L'Industrie Textile Issue 1334_1335:116_119*.

[26] Rita Araujo, Margarida Casal and ArturCavaco- Paulo (2008).Applications of Enzymes for textile fibers processing.*Biocatalysis and Biotransformation.Vol. 26, No. 5*.pp. 332-349.

[27] Sharma, M.(1993).*Colourage.40(1).*13-17

[28] Shenai, V.A.(1990). Technology of Fibres: Technology of Textile Processing. *Sevak pub. Vol.I .Edition III.*

[29] Steward, M.A. (2005).Biopolishing Cellulosic Nonwovens, PhD Thesis, North Carolina State University.

[30] Uhlig, H.(1991).*Enzyme arbeitenfüruns*, Hanser, C., Verlag, Hamburg.