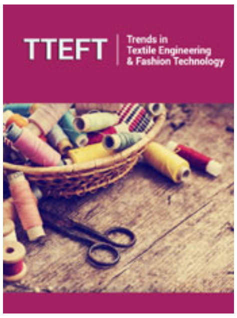
Enzymes in Textile Industry: Towards to Sustainable Textile Processes

Derya Aydin*
Ak-Kim Kimya San. ve Tic. A.S., Çiftlikköy, Turkey

ISSN: 2578-0271



***Corresponding author:** Derya Aydin, Ak-Kim Kimya San. Ve Tic. A.S., 77600 Çiftlikköy, Yalova, Turkey

Submission: June 01, 2023
Published: July 05, 2023

Volume 8 - Issue 5

How to cite this article: Derya Aydin*. Enzymes in Textile Industry: Towards to Sustainable Textile Processes. Fashion Technol. 8(5). TTEFT. 000697. 2023.
DOI: 10.31031/TTEFT.2023.08.000697

Abstract

In the latest two decades, interest for industrial enzymes has increased considerably. Different type of enzymes are used in the textile sector for treatment of natural sourced fibres such as cotton and wool. Beside increased consumption of these biomacromolecules, the textile industry still requires highly stable enzymes, and good performance at extreme values of pH and temperature.

For large extent commercialization of these bio-catalysts, their reusability factor becomes mandatory. Maintenance of their activity during industrial processes is highly significant. Necessity of new methodologies are continously increasing for the immobilization of enzymes with superior activity and usage.

Keywords: Bio-catalysts; Textile; Enzymes; Bleaching; Washing; Dyeing

Introduction

Enzymes have a long tradition in textile processing and fibre modification. Usage of highly specific enzymes for various textile applications is becoming increasingly accepted because of their ability to replace harsh chemicals currently used in the industry which provides reduction of water, chemicals and energy usage. The most important property for specific industrial-scale application is resistance to high temperatures, pH changes, and the presence of chemicals used in bleaching, washing, or dyeing. These situations have negative effect on 3-dimensional structure of the ezymes and the function [1].

Enzymes can be used in all steps of textile processing, from fibre and fabric processing, to laundry detergents [2]. Application of enzymes in cotton fibres is a non-toxic, sustainable process can be used for a large range of cotton processing conditions.

Textile enzymes are non-toxic and environmentally sustainable and help reduce pollution which happens due to textile production. The mostly used textile enzymes **are amylases for removing the starch, catalases for degrading excess hydrogen peroxide, pectinases, laccases and lipases for textile bleaching and cellulases as anti-pilling agents in finishing process.**

Enzyme treatments in textile industry

Textile de-sizing: Modern production processes for textiles introduce a considerable strain on the warp during weaving to prevent yarn from breaking. For this purpose a removable protective layer is applied to the threads. Starch and other sticky materials are used as sizing for weaving cotton fabrics. Starch is a very attractive sizing agent due to its cost advantage and availability in most regions of the world. This starch is easily removed from textiles using enzymes **like amylases. Before enzymes, de-sizing process is carried out at high temperatures using corrosive substances like salt which results in fading and weakening of the cotton fabric**. Effective sizing of starch can be done with amylase enzymes which selectively remove the size without attacking the fibres [3]. Amylases are used at mild temperatures and prepare textile for dyeing and wrapping up.

Amylases are enzymes that cleave starch molecules and related compounds, by hydrolysing α-1,4- and/or α-1,6-glucosidic linkages, in either endo or exo-locations [4].

According to many studies on immobilized amylases, the general enzymatic actitivity is usually reduced, so practical applications of immobilized amylases in textile desizing are rare [3,4]. In one of these studies, the immobilization of α-amylase on magnetic composite microspheres is reported via easy separation under a magnetic field for repeated use which cane be a potential for textile applications. In another study, an amylase type was immobilized via glutaraldehyde based coupling onto zirconia-coated alkylamine glass beads. The immobilized enzyme was used in removal of starch stain from cotton fabrics with detergents. Results demonstrates better washing in presence of immobilized amylase than that with detergent alone [5].

Bio-finishing and polishing: Bio-finishing and polishing is the washing of different textiles like cotton and linen before packaging. Bio-polishing treatments prevent the pilling on the textiles which causes undesirable appearance of cloths. Cellulase enzymes hydrolyze the microfibers and remove them from the outer surface of the fabrics providing a polished and smoother surface. Cellulases constitute a group of enzymes that are able to catalyze cellulose hydrolysis via degrading β-(1-4) linkages of the biopolymer. Cellulolytic systems belong to three major classes such as endoglucanases, exoglucanases and β-glucosidases [6]. The multicomponent cellulase system is mostly used in biopolishing step of textile processes which is the removing process of tiny fibres from cotton fabrics resulting in smooth fabric surface. It is used in denim garment treatment to achieve the stonewashed final look, as well.

1.1. Enzymatic bleaching of textiles

Bleaching agents are used to remove the color on cotton and other textiles and make them white. Hydrogen peroxide is usually used as a bleaching agent which causes fabric damage and high use of water during the bleaching process.

Textile fibers are bleached with less fiber damage and less water usage using textile enzymes **such as pectinases, laccasses, and glucose oxidases for bleaching leads to less fiber damage and less water usage. These enzymes are suitable for the bleaching process due to their operating temperature range and active pH.** Pectinases are enzymes able to breakdown complex pectins into simpler molecules, galacturonic acids. Pectin are macromolecules that ocur as structural polysaccharides in plant tissues. Pectinases include polygalacturonases, pectin esterases, pectin lyases and pectate lyases [7].

Many non-cellulosic impurities are found in the cellulose matrix of the primary wall which limits the dyeing and finishing processes of a cotton fibre. Therefore scouring is essential in order to remove the cuticle and the primary wall compounds from the cotton fibre to obtain good wettability. Bioscouring has become a feasible alternative to classic chemical scouring since it provides far more eco-friendly process. Several other types of enzyme can be used for bioscouring such as laccases, lipases, proteases, cellulases, xylanases and cutinases [8].

Anti-peroxide enzymes: Catalases are ubiquitous enzymes in aerobic organisms, where they catalyze breakdown of H_2O_2 into water and oxygen. As a strong oxidizing agent, H_2O_2 oxidizes reactive dyes which constitute a major reason for dye loss and non-uniformity in dyeing. Consequently, residual H_2O_2 in bleaching baths must be removed from the fabric prior to dyeing [9].

Immobilization of enzymes: Application of enzymes provides mild reaction conditions, biodegradability and catalytic efficiency. The harsh conditions of industrial processes, however, increase neccessity of enzyme stabilization in order to improve their industrial lifespan [10].

Enzyme immobilization can be defined as the attachment of soluble enzymes to different types of support materials resulting in reduction enzyme mobility. The industrial application of enzymes requires its recovery and reuse to make an economically feasible process in many cases. Additionally, the use of an immobilized enzyme allows simplification of the reactor design and easy control of the reaction. Thus, most of the enzyme sourced process limitations may be overcomed by enzyme immobilization to facilitate large scale and economic formulations [11].

Many methods of immobilization, coupled to a wide spectrum of supports have been tested, and are well documented in the literature. Variety of natural and synthetic support materials are used for the immobilization of enzymes. Many methods like entrapment, support binding and cross linking of enzyme crystals were developed to meet all the challenges to enzyme activity. This ideal microenvironment could be optimal pH, polarity, or amphilicity. This can be done with a variety of materials including: polymers, sol-gels, polymer/sol-gel composites, and other inorganic materials. Finally, enzymes may also be immobilized through the cross-linking of proteins to an insoluble support to prevent the loss of enzyme into the substrate solution [12-15]. Support materials are critical in the usefulness of an immobilized enzyme since it need to have low-cost and least limitation in mass transport between substrate and product. This is important for the efficiency of enzyme and the process.

In industry, immobilized enzymes are preferred to the free ones for their prolonged activity. Enzymes specifically to textile processing conditions should focus on interactions between the enzyme protein, textile chemicals and additives-which often destabilize the enzyme, and hence reduce its activity.

Conclusion

Destabilization of enzymes is one of the main disadvantage which prevents general application of these interesting biomolecules for industrial scale. Nevertheless, enzymes have already a long history in textile processing. As the enzyme immobilization technology improves, the availability and comercialization of immobilized enzymes in industry has more opportunity to increase. This increase in the availability of immobilized enzymes would allow for a growth in the application of immobilized enzymes throughout the chemical and medical fields. Regulatory enforcement of pollution reduction directives upon textile manufacturers has led them to expand the use of enzymes in actual processing of fibres and textiles; this trend has rapidly gained wide recognition, because of their nontoxic and eco-friendly characteristics.

References

1. Tzanov T, Andreaus J, Guebitz G, Cavaco Paulo A (2003) Protein interactions in enzymatic processes in textiles. Electron J Biotechnol 6(3): 17-23.
2. Queiroga AC, Pintado MM, Malcata FX (2007) Novel microbialmediated modifications of wool. Enzyme Microb Technol 40(6): 1491-1495.
3. Gupta R, Gigras P, Mohapatra H, Goswami VK, Chauhan B (2003) Microbial α-amylases: a biotechnological perspective. Process Biochem 38: 1599-1616.
4. Hamilton LM, Kelly CT, Fogarty WM (2000) Review: Cyclodextrins and their interaction with amylolytic enzymes. Enzyme Microb Technol 26(8): 561-567.
5. Nilhan Kayaman-Apohan, Ayşe Ogan, Atilla Güngör (2006) Soybean oil based resin: A new tool for improved immobilization of α-amylase. J Appl Polym Sci 100(6): 4757-4761.
6. Qiu GM, Zhu BK, Xu YY (2005) α-Amylase immobilized by Fe_3O_4/ poly(styrene-co-maleic anhydride) magnetic composite microspheres: Preparation and characterization. J Appl Polym Sci 95(2): 328-335.
7. Dhingra A, Khanna M, Pundir CS (2006) Immobilization of α-amylase onto alkylamine glass beads affixed inside a plastic beaker: Kinetic properties and application. Indian J Chem Technol 13: 119-121.
8. Azevedo AM, Martins VC, Prazeres DM, Vojinovic V, Cabral JM, et al. (2003) Horseradish peroxidase: A valuable tool in biotechnology. Biotechnol Ann Rev 9: 199-247.
9. Chelikani P, Ramana T, Radhakrishnan TM (2005) Catalase: A repertoire of unusual features. Ind J Clin Biochem 20(2): 131-135.
10. Hoondal GS, Tiwari RP, Tewari R, Dahiya N, Beg QK (2003) Microbial alkaline pectinases and their industrial applications: A review. Appl Microbiol Biotechnol 59(4-5): 409-418.
11. Wang Y, Caruso F (2005) Mesoporous silica spheres as supports for enzyme immobilization and encapsulation. Chem Mater 17(5): 953-961.
12. Kawaguti HY, Manrich E, Sato HH (2005) Production of isomaltulose using *Erwinia* sp. D12 cells: Culture medium optimization and cell immobilization in alginate. Biochem Eng J 29(3): 270-277.
13. Sheldon RA, Schoevaart R, Van Langen LM (2005) Cross-linked enzyme aggregates (CLEAs): A novel and versatile method for enzyme immobilization: A review. Biocatal Biotransform 23(3-4): 141-147.
14. Keeling T, Brennan JD (2001) Fluorescent probes as reporters on the local structure and dynamics in sol-gel derived nanocomposite materials. Chem Mater 13(10): 3331-3350.
15. Tsai HC, Doong R (2007) Preparation and characterization of urease encapsulated biosensors in poly(vinyl alcohol)-modified silica solgel materials. Biosens Bioelectron 23(1): 66-73.