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Bio-Scouring- An Advancement In Preliminary Processing Of Textile

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Abstract

The environmental issues related to the textile industry have gained global attention as it is producing large quantities of pollution and waste with various toxic substances and chemicals. Due to the growing awareness among people about the pollution caused by the textile industry, the chemical processes of the textile industry are being replaced with the bio-processing process. Textile bio-processing has become the preferred option to overcome the consequences of chemical treatment, as it is less harmful to the environment and also to the textiles. The use of enzymes in the textile industry can be considered the best possible use of the bio-processing technique. The use of enzyme treatments in the textile industry is very promising, as they are environmentally friendly, produce high-quality products, and reduce the use of water, energy, and time.

Keywords- Textile industry, Bio-processing, Bio-scouring, Enzymes, Environment

Introduction

The textile manufacturing and processing industries are among the most polluting industries in the world. They have to face huge challenges in order to survive. They need to maintain eco-standards to protect the environment. The textile manufacturing and processing industry continuously causes unimaginable damage to the environment. The chemicals used in processing the textile are harmful to the environment and aquatic life. They are responsible for 20% of all freshwater pollution and 25% of world industrial water pollution. The use of enzymes will prove to be a valid solution for the survival of textile processing industries (**Mojsov, 2014; Parameswari, G. A. & Priya, M. R. 2018**).

It's no secret that there's a pressing need to reduce the harmful environmental impact of the textile industry in order to sustainably use the world's natural resources. As a result, the textile industries are searching for new technologies that can scale up product production, consume fewer resources, and have little or no environmental impact (**Kirk et al. 2002; Bornscheuer and Buchholz, 2005**). Thus, bio-based materials, such as enzymes, can either replace or complement traditional technologies to move towards cleaner textile manufacturing and processing **(Hofer, 2009; Wohlgemuth, 2009; Soetaert and Vandamme, 2010)**.

Enzymes have now become an essential part of the textile industry. In the textile industry, enzymes are used at two different stages. The first stage is the preparatory stage and the second stage is the finishing stage. The enzymatic treatments like bio-retting, bio-scouring, bio-desizing, degumming of silk, bio-bleaching, etc. are used at the preparatory stage and enzymatic treatments like bio-polishing, wool finishing, bio-stoning of denim, shrink-proof wool, etc. are used at the finishing stage in the textile industry. The birth of such an enzymatic processing of textiles offers many advantages when compared to traditional chemical methods. Enzymes consume less water, less energy, fewer chemicals which significantly reduce or even eliminate waste. In addition, enzymes are used for effluent treatment. The residue left from enzymatic treatments is readily biodegradable and does not pose an environmental threat **(Kumar, D., 2021; Gomes, 2007; Rehman, M. M. A. & Imran, M. A. 2014)**.

Bio-scouring

Scouring is an important pre-treatment operation in the dispensation of cotton and cotton-blend materials. The main objective of scouring is to remove the non-cellulosic ingredients of cotton fiber, which make the fiber non-absorbent. Conventionally, scouring is done in a hot aqueous solution of NaOH to remove hydrophobic impurities from the primary wall (e.g., pectin, protein, and organic acids) and the cuticle (waxes and fats). Enzymes in textile wet processing have added a new line of research and likely eco-friendly substances to give a good solution to the problem of highly toxic chemicals causing environmental pollution. Removal of hydrophobic and non-cellulosic substances such as waxes, pectins, and proteins from the textiles is known as scouring **(Mojsov, 2012, 2019; Bristi, U., et al. 2019)**. When enzymes are used in the scouring, the process is known as Bio-scouring.

Many conditions are important to the performance of the enzymes, such as the concentration of the enzymes in the bath, the time and temperature of treatment, the pH of the bath, and additives. The pH of the environment is crucial for the activity and stability of the enzyme, which ranges between 5 and 9. An alkaline or acidic environment depends on the type of enzyme. Acidic enzymes work in a slightly acidic medium (pH between 4 and 6) and alkaline enzymes work in a slightly alkaline medium (pH between 7 and 9). Care must be taken to monitor the pH, as extreme values lead to collapsing the three-dimensional form of the enzymes and losing their catalytic behaviour. A non-ionic surfactant helps in the smooth functioning of the scouring process.

During bio-scouring, a complex reaction takes place between the pectinase and the pectin that causes the hydrolysis of the pectin substances. Removal of pectin and other non-cellulose substances enhances the absorbency and whiteness and helps in the penetration of the dye and other substances into the fiber of the fabric. Enzymatic scouring produces higher-quality fibers that are softer to touch and have better strength than conventional scouring. This procedure is compatible with other procedures, equipment, and materials. Bio-scouring is a simple, repeatable, and safe procedure that can be easily used in the textile industry. Bio-scouring can also be used for blends of cotton, silk, wool, and cashmere, as the damage caused to the fibers is less. The effluents are less harmful as the load is comparatively lower than the conventional sodium hydroxide scouring, which results in a highly toxic effluent **(Hamlyn, 1995; Losonczi, 2004)**.

Procedure of Bio-scouring

According to **Pan N. C. et al. (2013)** enzymes and non-ionic surface active agents were used for bio-scouring process. The temperature of the bath was maintained at 50°C for 2 hours, keeping the material to liquor ratio at 1:10. The pH of the bath was maintained by using acetic acid and sodium acetate buffer. After the treatment, the temperature of the bath was raised to 90°C and maintained at that temperature for 15 minutes after which the samples were washed and dried.

Enzyme Inactivation

After finishing treatment, it is essential to complete the reaction at the end by inactivating the enzyme to avoid damage to the fabric. Failure to inactivate the enzyme at the end results in damage to the fibers and, in extreme cases, the destruction of the whole fabric material. Therefore, from a technical perspective, inactivation of the enzyme is very important **(Laga, S.K. & Kumar, S. 2012, Ullah S. 2018, Laga et al. 2014)**.

There are two processes of inactivation of enzyme:

1. Hot treatment at 80° C for 20 minutes.
2. By raising the pH to 11-12.

Enzymes used in Bio-scouring

Enzymes are highly substrate-specific; they react with their specific substrates in a region within the protein molecule called the active site. The International Commission on Enzymes (EC) classification system has divided enzymes into six categories based on their basic function: oxidoreductases, transferases, hydrolases, lyases, isomerases, and ligases **(Choudhury, R. A. K. 2014)**. Most of the enzymes used for bio-scouring in the textile industry belong to the class hydrolases. Hydrolase enzymes, which are popularly used for bio-scouring in the textile industry, are given below:

1. Proteases
2. Pectinase
3. Cellulase
4. Lipases
5. Cutinase

Bio-scouring by Proteases

Proteases are one of the most important groups of enzymes used in the textile industry for bio-scouring because proteases are used to break down non-collagenous skin constituents and remove non-fibril proteins **(Solanki et al. 2021; Saha et al. 2011)**.

Bio-scouring by Pectinases

Pectinases are one of the fastest-growing enzymes in the textile industry. Pectinase enzymes were among the first enzymes used in homes. Commercial use of pectinases began in the textile industry in 1930. Pectinases mainly work by breaking down long and complex molecules known as pectin. The alkaline pectinase enzymes are mainly used in fiber crop degumming and retting **(Kashyap et al. 2001)**. These enzymes are also used for bio-scouring in the textile wet processing industries.

Bio-scouring by Cellulases

The third-largest industrial enzyme is cellulase, which is responsible for the degradation of cellulose, a common natural polymer. Cellulases also play a role in the transformation of lignin cellulose into glucose units, which are further utilized in the bio-stoning of denim, in the bio-scouring and bio-polishing processes, and in the softening and lustre enhancement of textile fibers **(Kakkar, P., & Wadhwa, N. 2021)**.

Bio-scouring by Lipases

Lipase enzymes hydrolyze unsaturated oil droplets and convert them into soluble products during the scouring process. Lipases are derived from the pancreas of animals. Today, lipases are produced by a variety of bacterial, yeast, and mold, species. In the textile industry, lipases are used to remove sizing materials (biodegradable), natural triglycerides, bio-scouring, and lubricants to provide a higher absorbency fabric for better levelness in the dyeing process. Lipase enzymes also reduce the number of blemishes and cracks in the abrasion systems of denim **(Hasan et al. 2006**).

Bio-scouring by Cutinases

Cutinases are a group of enzymes that are multifunctional. They belong to the group of enzymes known as hydrolases. Cutinases are able to catalyze hydrolytic reactions. Due to their multifunctional nature, cutinases have great potential to be extensively used in the textile industry. The cellulosic fiber's cuticle layer is complex. It contains cutin (a protein), wax (a wax protein), pectin, and protein. Wax and cutin are both hydrolyzed by cutinases in the bio-scouring process **(Agrawal et al. 2008; Degani et al. 2002; Yan et al. 2011; Zhang et al. 2010, 2011)**.

Advantages of bio-scouring are as follows:

- Hairiness, fluff and pills are also removed.
- Achievement of surface smoothness and a clear structural appearance.
- Increased flexibility and therefore a soft handle even with end-products and mercerized fabric.
- Improved luster and knoppy surface material are converted into elegant and high-quality surface appearance.
- Increased in moisture absorbency and wettability.

Disadvantages of the bio- scouring:

However, there are some drawbacks to bio-polishing **(Reja, M. 2021; Rahman, H. et al. 2014)**, including: -

- Reduce fabric strength
- Reduce slight weight of the fabric
- Highly controlled condition is required

Bio-scouring should be done at the correct batching time, at the correct temperature, and with the correct enzyme concentration to avoid issues with the fabric like low GSM, loss of weight, and loss of strength **(Rasel, M. et al. 2018)**.

Conclusion

One of the most worrying situations in the textile industry is its environmental impact. Pollution-free processes are becoming more and more popular worldwide. In this context, enzymes are emerging as the new and best alternative to conventional methods of textile processing. Currently, enzymes are being adopted for all types of textile processing that are used in the textile industry, such as bio-scouring. Bio-scouring is biodegradable, environmentally friendly, and the most commonly used wet processing method in the textile industry. Bio-scouring has gained a lot of attention in the textile industry in recent times. The process involves washing the fabric with an enzyme to remove the impurities and waxy material from the fiber. The enzyme hydrolyzes the glucose bond β1-4 and produces a permanent effect. This process removes impurities from the fabric, smoothes the surface of the fabric, gives it a cleaner and shiny appearance, makes the fabric softer and cooler, and improves its overall surface appearance. Bio-scouring serves textile processing industries and creates awareness for adopting eco-friendly textile processing methods. It helps the textiles industry grow and thrive in a sustainable manner for future prosperity and happiness.

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