

Probiotic Technology- A Novel Approach in scouring of Textiles

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Abstract

Today's scouring process is chemically based and highly alkaline. Due to the unspecific nature of chemical processes, not only the impurities but also the cellulose is attacked, leading to damage in strength properties. Furthermore, current processes cause environmental problems due to high COD, BOD and TDS content in the effluents. A wide range of studies have been carried out on bio-preparation of cotton in the preceding 10-12 years. This paper deals with application of probiotic scouring on cotton and analyzing the effectiveness of probiotic scouring over conventional scouring & testing the properties of pro-scoured cotton knitted substrates. It was found that that in probiotic scouring of cotton degradation of pectic substances is one of the most essential processes. Probiotic degradation of pectic accelerates the removal of waxy materials from the cotton primary wall, thus produces highly water absorptive cotton. Using probiotics, decreases the TS, TDS, COD, BOD thereby reducing both effluent load and preparation costs. 100% bio-degradable Scouring agent, sets new standards in pre-treatment for cotton significantly.

Keywords: Pretreatment • Cotton • Probiotic • Scouring • Effluent • COD • BOD • TDS • TS

Introduction

In the conventional textile wet processing, the grey fabric has to undergo a series of chemical treatments before it turns into a finished fabric. This includes desizing, scouring, mercerization, bleaching and washing. The chemicals used for all these steps are quite toxic. In the various pre and post operations during fabric manufacture, the non-cellulosic and foreign constituents are removed partially or completely.

The use of probiotic chemicals in the textile industry is an example of white industrial biotechnology, which allows the development of environmentally friendly technologies in fibre processing and strategies to improve the final product quality. The consumption of energy and raw-materials, as well as increased awareness of environmental concerns related to the use and disposal of chemicals into landfills, water or release into the air during chemical processing of textiles are the principal reasons for the application of probiotic in finishing of textile materials [1,2].

The cotton fibre is a single biological cell with a multilayer structure. These layers are structurally and chemically different and contain approximately 10% by weight of non-cellulosic substances such as lipids, waxes, pectic substances, organic acids, proteins/nitrogenous substances, non-cellulosic polysaccharides, and other unidentified compounds included within the outer layer of the fibre. These non-cellulosic materials create a physical hydrophobic barrier which protects the fibre from the environment throughout development; they provide lubrication during textile processing and affect the enhancement of the fabrics wettability and absorbency.

The common industrial removal of these impurities is conventionally carried out by treating the fabric with sodium hydroxide. Although alkaline scouring is effective and the cost of sodium hydroxide is low, the process is costly because it consumes large quantities of energy, water, and auxiliary agents. The strict pH and temperature requirements for alkaline scouring are

damaging too many fibres. The treatment is generally at a high temperature 80-100°C, employing strongly alkaline solutions of the scouring agent, e.g. pH 13-14. Due to the non-specific nature of chemical processes not only are the impurities but the cellulose itself is attacked, leading to damages in strength or other desirable fabric properties. Furthermore, the conventional scouring process can cause environmental problems due to the highly alkaline effluent from these processes [3,4].

The scouring stage prepares the fabric for the optimal response in bleaching. An inadequately scoured fabric will need a higher level of bleach chemical in the subsequent bleaching stages.

Comparison between conventional scouring and bio-scouring

Raw fibres, yarns or fabrics have various kinds of impurities like motes, seed coat fragments, pesticides, dirt, chemical residues, metallic salts of various kinds, and immature fibres. External impurities are removed in the blow room processing while internal impurities of cotton fibres removed by scouring processes. Cotton fibre is constituted with different layers in its body. Different constituent of cotton fibres are cellulose (90%- 94%), waxes (0.6%-1.3%), pectic substances (0.9%-1.2%), protein (0.6%-1.3%), ash (upto 1.2%), organic acids (upto 0.8%) and others (1.2%). The main target of scouring is to remove waxes, pectins, hemi-celluloses and minerals from the raw cotton fibres during the early stage of textile wet processing to make the fibres highly absorbent, which is necessary for the subsequent processes such as mercerizing, bleaching, dyeing, printing and finishing. For this purpose, Caustic soda (NaOH) treatment is used in conventional scouring, whereas, Enzymes (Cutinases, Pectinases etc.) treatment is applied in bioscouring process. Though Different scouring materials are used in the textile industry like NaCO₃, Ca(OH)₂ etc., alkaline (NaOH sodium hydroxide) is used mostly for the scouring. Conventional chemical scouring is done in hot (90°C-100°C) NaOH solution for 45-60 minutes. The conditions depend on the quality of scoured fabric required. Moreover, different agents are used such as reducing agents, detergent, sequestering agent (also called chelating agents or sequestering) and wetting agent. Sequestering agent reduces the water hardness, reducing agent prevent oxidation of cellulose by air oxygen at high pH, detergent acts as emulsifier to assist in removing waxy substances and wetting agent reduces the surface tension of water helps fibres to swell. However, use of enzymes in textile wet processing has added a new line research and likely eco-friendly substance to give a good solution to the problem of highly toxic chemicals causing environmental pollution. Enzymes, generally, act in low temperature with excellent efficacy

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[5,6]. It saves high cost of energy consumption compared to conventional process. Moreover, it reduces Biological/Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), and other waste water effluent load thus reduces ETP operational cost. The fabrics treated with harsh chemicals are also unsafe for human health but bio-scoured fabrics are completely safe.

Probiotic technology

Probiotic bio-chemicals are metabolites derived from a fermentation process of natural selected raw materials and a consortium of probiotic microorganisms. The organic molecules from the ingredients used during the fermentation break down, maintaining their functional groups. These groups are responsible for conferring specific properties that are useful during processing operations like textile scouring [7,8]. Such properties, namely hydrating, solubilizing, dispersing, and degreasing, can replace chemical or biological auxiliaries like surfactants and enzymes. Alternatively, such properties can synergistically improve the performance of traditional auxiliaries. This application has a positive impact on effluent pollution [9,10].

Probiotic scouring makes it possible to effectively scour fabric without negatively affecting the fabric or the environment. Hydrolysis by probiotic such as pectinases promotes efficient interruption of the matrix to achieve good water absorbance without the negative side effect of cellulose destruction. This process is called probiotic scouring [11-13]. It breaks down the pectin in cotton and thus assists in the removal of waxes, oils and other impurities. The optimum temperature is 90-95 °C and pH between 9-11. The fabric gives better wetting and penetration properties.

Plan of work

List of materials and chemicals:

- Substrate: 100% cotton woven fabric with gsm 110 and 100% cotton hank of 40^s count.
- Chemicals used: Sodium hydroxide (NaOH) LR grade.
- Auxiliaries: Commercially available Sequestering agent, Wetting agent and Detergent, ProScour obtained from Proklean Technologies Pvt. Ltd
- Equipment: Rota dyer machine, Laboratory Oven, Electric balance

Methodology

Conventional scouring

Conventional scouring was carried out using below mentioned recipe based on weight of the cotton material and maintaining MLR 1:30 at 95°C for 45 min in Rota dyer machine.

1. Wetting agent- 0.5%,
2. Sequestering agent- 0.3%,
3. Detergent- 0.1%,
4. NaOH- 2.5%

After the completion of the scouring process the samples were rinsed twice with hot water and cold water respectively and squeezed properly fol-

lowed by drying in oven.

Probiotic Scouring

Probiotic scouring was carried out by using the following recipe on the basis of weight of cotton material and maintaining MLR 1:30 at 95°C in Rota dyer machine.

1. Wetting agent - 0.1%
2. ProScour- 1%
3. NaOH- 1%/1.5%/2%

After the completion of the Probiotic scouring process the samples were washed with hot water and cold water then squeezed properly followed by drying in oven.

Testing

The effectiveness of process was assessed by checking the tensile strength, tearing strength, absorbency, weight loss of the cotton material. Also the effluent was tested for Total solids (TS), Total dissolved solids (TDS), Total suspended solids (TSS), Chemical oxygen demand (COD) and Biological oxygen demand (BOD).

Results and Discussion

Scouring of fabric

The woven fabric samples were scoured by conventional method and probiotic scouring process at varied concentrations of caustic. The pH of drain bath was noted and it was from 9.5 to 11. The results for fabric scouring are indicated in Table 1

Scouring of hank

The grey cotton hank samples were scoured by conventional method and probiotic scouring process at varied concentrations of caustic. The pH of drain bath was noted and it was from 9.5 to 11. The results for hank scouring are indicated in Table 2.

From the above results, it is observed that that the average weight loss % for fabric which is conventionally scoured is 6.44% and for yarn it is 5.94%. In the case of fabric scoured using probiotic technology weight loss is 0.9 %, 2.14% and 3.07% respectively for varied concentrations of sodium hydroxide. Also in the case of yarn, weight loss increases with the increasing concentration of caustic which can be attributed to the fact that both caustic and pro-scour remove the hydrophobic impurities efficiently. The weight loss in probiotic technology is less as compared to conventional scouring process.

The tearing strength in case of grey fabric is 1520 gmf and 656 gmf for warp way and weft way respectively. There was no significant difference obtained in warp way tearing strength for conventionally scoured fabric and probiotic scouring. In the case of weft way tearing strength of conventionally scoured fabric is less as compared to probiotic scoured fabric. Thus it can be stated that probiotic technology does not affect the strength of fabric and yarn too.

The water drop absorbency of conventionally scoured material is 0.6

Table 1. Effect of scouring methods on physical properties of fabric and effluent parameters.

Particulars	Conc. ⁿ of Caustic %	% Weight loss	Tearing strength (gmf)		Absorbency (sec)	COD	BOD	TDS (mg/lit)	TS (mg/lit)
			Warp way	Weft way					
Grey	–	–	1520	656	>3 sec	–	–	–	–
Conventional Scouring	2.5	6.44	1264	544	0.6 sec	2128	702	3800	4000
Probiotic scouring	1	0.9	1152	672	Instant	624	215	1600	2000
	1.5	2.14	1040	720	Instant	768	264	1800	2600
	2	3.07	1168	640	Instant	928	307	2200	2800

Table 2. Effect of scouring methods on physical properties of yarn and effluent parameters.

Particulars	Conc. ⁿ of Caustic %	% Weight loss	Single yarn Strength (gmf)	Absorbency (seconds)	COD	BOD	TDS (mg/lit)	TS (mg/lit)
Grey	--	--	179.1	>3 sec	--	--	--	--
Conventional Scouring	2.5	5.94	79.65	0.8	544	180	3000	3600
Probiotic Scouring	1	3.76	136.1	Instant	432	140	2000	2400
	1.5	5.33	174.55	Instant	448	150	2800	2800
	2	5.69	201.75	Instant	464	162	3000	3200

sec to 0.8 sec. and in the case of probiotic scoured material it is instant.

The chemical oxygen demand in case of conventional scouring for both fabric and hank is more and in the case of probiotic technology is less and lies in the range of 620 to 930 for fabric and 430 to 470 for hank for varied concentrations of caustic whereas in conventional scouring it shows as much as 2128 and 544 for fabric and hank respectively.

The biological oxygen demand in case of conventional scouring for both fabric and hank is more and in the case of probiotic technology is less and lies in the range of 210 to 310 for fabric and 140 to 165 for hank for varied concentrations of caustic whereas in conventional scouring it shows as much as 700 and 180 for fabric and hank respectively.

It is also observed that the TDS in case of conventional scouring for both fabric and hank is more and in the case of probiotic technology lies in the range of 1600 to 2200 for fabric and 2000 to 3000 for hank for varied concentrations of caustic whereas in conventional scouring it is 3800 and 3000 for fabric and hank respectively which is higher than probiotic scouring.

The TS in case of conventional scouring for both fabric and hank is more and in the case of probiotic technology is less and lies in the range of 2000 to 2800 for fabric and 2400 to 3200 for hank whereas in conventional scouring it shows as much as 4000 and 3600 for fabric and hank respectively.

Conclusion

In this study an attempt was done to find out the suitability and adaptability of probiotic scouring over conventional scouring process. The prospect of probiotic scouring over conventional scouring can be better judged from the following conclusive results.

- **Fabric strength:** It was found that, with Probiotic scouring, there is less strength loss in the fabric (both warp way and weft way) as well in yarn stage when compared with conventional scouring method.
- **Weight loss:** Since 30-50% less caustic is used in Probiotic technology, it has a strong impact on weight loss of the substrate. It was found that in the case of conventional scouring of fabric and hank, the weight loss is more than that of probiotic scouring.
- **Effluent parameters:** There has been stronger impact on the parameters of effluent when both the scouring methods were compared. The effluent parameters like total solids (TS), total dissolved solids (TDS), COD and BOD were comparatively less in Probiotic technology than conventional method which provides greater contribution in saving the load on ETP as well the cost of effluent treatment too.
- **Scope:** From the results of the study, eco-friendly probiotic scouring process shows wider scope to substitute the conventional scouring process of cotton substrates.

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