

Pre-treatment of Textiles Prior to Dyeing

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1. Introduction

Cotton is the leading fibre in Textile Industry. Cotton is still the "King" of fibers because most of the world's apparel is made of Cotton. Apart from its fairly good strength, it is considered to provide comfort due to good moisture absorption and wicking properties¹. It is estimated that approx. 20 million tons of Cotton is processed worldwide yearly. Unlike man made cellulosic fibers such as Rayon and Lyocell, Cotton must be properly prepared for Dyeing, printing and finishing.

1.1 Typical pre-treatment of cotton involves²

- Singeing
- Desizing (Conventional and Enzyme Processes)
- Scouring (Conventional and Enzyme Processes)
- Bleaching
- Neutralization
- Peroxide removal
- Bio-polishing
- Mercerizing
- Optical Brightening

1.2 Objectives of pre-treatment²

- Good desizing effect
- Removal of seed husks
- Removal of foreign substances from the fibers
- Lowest possible fiber damage
- High degree of Whiteness
- Good Physical/Technological ratings
- High color yield
- Levelness of the effects
- High and even Hydrophilicity / Rewettability

2. Water consumption in textile industry

Amount of water consumed depends to a large extent (refer Table A³), on machine design and complexity of process (refer Table B, C³). Different machines have their own

characteristic features that set lower limits to the amount of water required e.g. machines such as winch or hank dyeing machine work at material to liquor ratio of at least 1:10-15 while jigger works at 1:3.

Many detailed surveys reveal remarkably wide variations in quantities of water used, i.e. from 5 - 5000 lit/kg of fabric processed. Average consumption in the scouring and bleaching of cotton fabrics was found to be in the range of 10 - 80 lit/kg and 10-130 lit/kg respectively depending on the machine and process employed. In case of dyeing carried out in jigger, the consumption of water is 10 - 60 lit/kg, while that carried out in a winch, it is around 100 - 450 lit/kg.

In another survey carried out at wool processing mills the average consumption of water for various unit processes showed marked variation and the average consumption appeared to be higher than necessary for efficient scouring, milling and dyeing. In case of consumption of water by various types of washing machine, some information has been published. The cost determining factors in this case are water hardness, level control, spray devices, water pressure and washing temperature.

Purpose	Percent water Use	
	Cotton textile	Synthetic textile
Steam generation	5.3	8.2
Cooling water	6.4	-
Demineralized or RO water for specific purpose	7.8	30.2
Process water	72.3	28.3
Sanitary use	7.6	4.9
Miscellaneous and fire fighting	0.6	28.0

Table A. Water usage in Textile Mills (%)

Process	Percent water consumed
Bleaching	38%
Dyeing	16%
Printing	8%
Boiler	14%
Other uses	24%

Table B. Total Water Consumed during Wet Processing

Process	Requirements in litres/ kg of product
Sizing	0.5-8.2
De-sizing	2.5-21
Scouring	20-45
Bleaching	2.5-25
Mercerizing	17-32
Dyeing	10-300
Printing	8-16

Table C. Water requirements for Cotton Textile Wet Finishing Operations

3. Future implications⁴

The Textile Industry is aware of the decrease in water sources and is developing new technology and new chemical alternatives, but the challenge will lay in converting the technology in current textile facilities into the new technology that uses less water. Another challenge will lie in changing the mindset of the current generations in the textile industry to use new chemical alternatives instead of the chemicals they have used in the past decades. This will be a slow process, but one that will need to happen in order for the textile industry to maintain current production and grow in the future.

3.1 Global trends

The textile companies are forced to reduce their consumption of water and energy. Due to

- The rising global consumption of resources like water and energy and the drastically increasing costs,
- Impact of the processes on the world climate,
- More stringent environmental obligations for water and air,
- More stringent regulations and limits

3.2 Present measures by the textile industry

- Reduction of heat energy consumption
- Reduction of fresh water consumption

3.3 New processes-breakthrough techniques

- Reduction of chemicals
- Replacement of chemicals by less harmful chemicals
- More advanced measurement and control techniques- Need for novel economical, environmentally friendly and gentle processes
- Designing machines that use solvents / media other than water for processing

4. Desizing

Conventional desizing of textile: Cold solutions of dilute sulphuric or hydrochloric acids are used to hydrolyze the starch; however, this has the disadvantage of affecting the cellulose fiber in Cotton fabrics. Alternative eco-friendly desizing agents are available in the market in the form of enzymes. Complete removal of starch-containing size without fiber damage is best obtained by using enzymatic desizing agents. Rossari offers wide range of desizing enzymes.

PAD BATCH

Rexsize LHT New Liquid	2.0-5.0 g/L
Common salt	1.0-5.0 g/L
Kleenox PSF Liquid	2.0-5.0 g/L
Proton WDE Liquid	1.0-3.0 g/L

pH: 6.5-8.0

Pad at 80-85°C, Batch at RT for 6-12 hours, Pick up: 80-100 %

CONTINUOUS - PAD STEAM

Rexsize LHT New Liquid	3.0-5.0 g/L
Common salt	1.0-5.0 g/L
Kleenox PSF Liquid	2.0-5.0 g/L
Proton WDE Liquid	1.0-3.0 g/L

pH: 6.5-8.0, Pad at 80-85°C Steam at 90-110°C for 1-2 mins, Pick up: 80-100 %

5. Scouring⁵

Scouring of cotton textiles is an essential treatment in textile wet processing in order to obtain a sufficiently hydrophilic fabric. During scouring, waxes and other hydrophobic materials are removed from the cotton fibers. In nature these non-cellulosic materials create a physical hydrophobic barrier to protect the fiber from the environment throughout its development. In aqueous textile processing the waxes and pectins impede wetting and wicking, subsequently obstructing aqueous treatments. Conventionally, scouring is done in a hot aqueous solution of NaOH to remove hydrophobic components from the primary wall (e.g. pectin, protein and organic acids) and the cuticle (waxes and fats). However, alkaline scouring is a nonspecific process. The use of high concentrations of NaOH also requires neutralization of wastewater. Even though alkaline scouring is effective and the costs of NaOH are low, the scouring process is rather inefficient because it consumes large quantities of water and energy. It is clear that this process needs to be improved considerably to meet today's energy and environmental demands. In the last couple of years, a lot of research has been directed to replace this process with an enzymatic one.

As far as scouring and bleaching is concerned, in earlier times this was supposed to be a two bath process, but currently majority of process houses do a one bath scouring and bleaching process.

In the present time the above mentioned one stage scouring and bleaching process seems to be very ideal with respect to the age old processes that were used earlier. Although robust, this process has some drawbacks that give us scope of further developments:

- **Temperature of Pre-treatment:** As can be seen above, the main backbone of the process is the one step scouring and bleaching that imparts the desired properties to the cotton

substrate. The temperature of treatment for this chemical is close to boil. If this temperature can be reduced, there will be considerable amount of time and energy saving

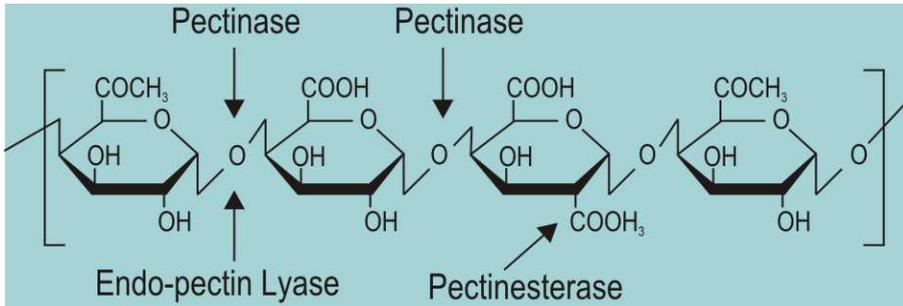
- **No. of Baths before dyeing:** There are total 5 baths that are used before the actual dyeing operation starts. Among 5, the last 3 baths are used basically because of the high pH value of the scouring treatment that requires intensive rinsing and neutralizing. This means that large amounts of water are also consumed. If somehow the scouring treatment can be carried towards neutral pH than we can save directly 3 baths of water. This will contribute significantly to water savings as well as reducing the load on ETP plant. For process houses that buy water in tanker, saving of three baths will be a boon.
- **Damage caused to the cotton substrate:** The aggressive scouring treatment conditions frequently damage the fibre. Due to complete removal of the outer pectin coating of the cotton fibre, the surface profile becomes rough. This affects considerably friction properties of yarn. This also leads to increase in the amount of fly generation. Also there is a considerable strength loss due to oxy-cellulose formation while carrying out peroxide bleaching in alkaline condition.
- **Time of Pre - treatment:** The total time currently required is 2 hrs and 50 min. If some alternative is available that will help to reduce this time than there will be an direct increase in the production and thus allow the organization to reap the benefits from increase in productivity without any increase in the cost of assets.
- **Increase in cost of auxiliaries:** Deployment of caustic and peroxide in the scouring treatment makes the use of peroxide remover and acetic acid mandatory. This further increases the cost of the process.

5.1 'Bio-scouring', the new way

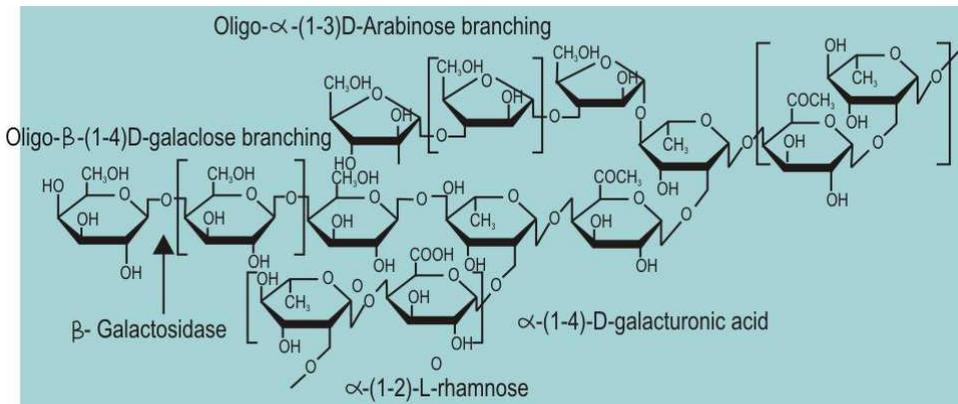
The aforementioned disadvantages of scouring with sodium hydroxide has motivated the textile industry to introduce more enhanced biological agents, which would be as effective in removing non-cellulose substances but would not have any damaging effects on cotton and would be less energy and water consuming. As we all know the outer protective coating of the cotton fibre is made up of pectin. The primary aim of any scouring process is to break this outer pectin layer. Once this is broken the cellulose polymers present inside the cotton fibrils are exposed. These have high affinity for water due to abundance of hydroxyl group, thus making the cotton fibre hydrophilic. If there is a way to break this pectin through some other route then the desired scouring effect can be achieved easily.

Pectins, chemically are high molecular weight, negatively charged, acidic, complex branched heteropolysaccharides primarily containing an alpha- (1,4) polygalacturonic acid backbone which can be randomly acetylated and methylated. Contrary to the proteins, lipids and nucleic acids, pectic substances do not have a defined molecular weight. Three different kinds of pectins have been isolated from cotton:

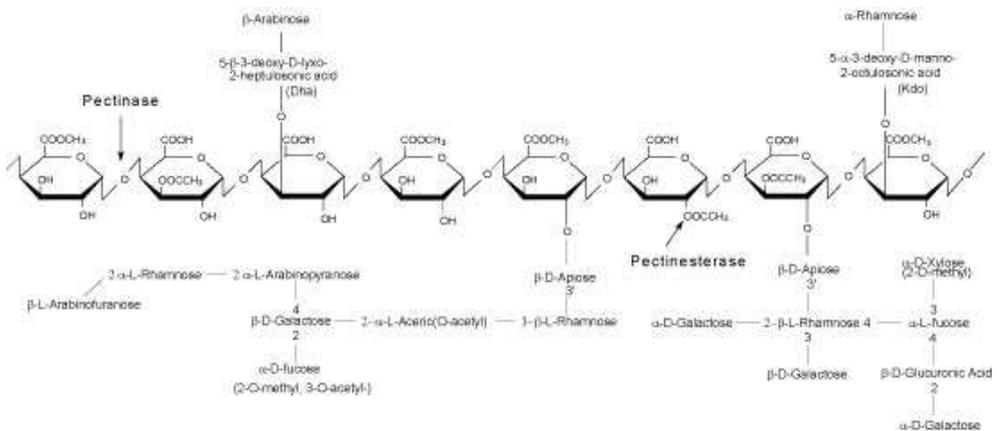
1. Homogalacturonans: These are composed of simple alpha-(1,4) polygalacturonic acid backbone. Some modifications of Homogalacturonans backbone with beta-D- Xylose branching at C3, or apiofuranose substitutions in the backbone with beta-D-Apiosyl-(1,3')-beta-D-Apiose branching are also found. A typical structure of homogalacturonans can be represented as follows:



- Rhamnogalacturonans I. - This contains alternating alpha-(1-4) galacturonosyl and alpha-(1-2) rhamnosyl residues, with primarily oligo alpha-(1-3) arabinose and oligo beta-(1-4) galactose branching. Atypical structure of it can be represented as follows:

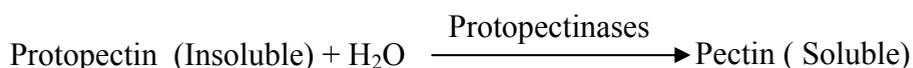


- Rhamnogalacturonans II. - It is composed of simple alpha-(1,4) polygalacturonic acid backbone with complex branching with composed of up to 11 different monosaccharide types. A typical structure of it can be represented as follows.



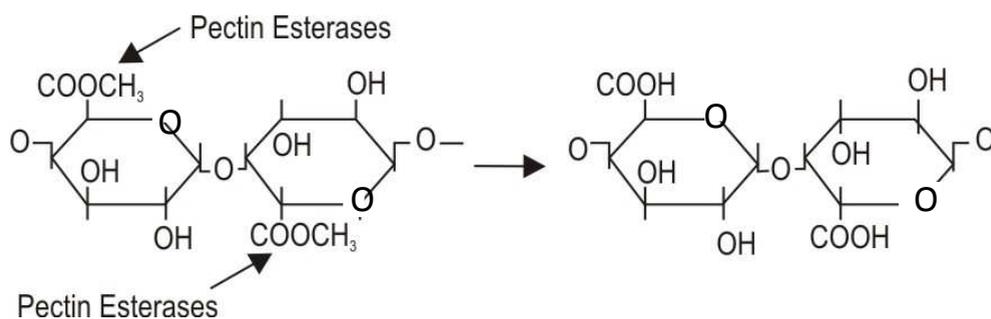
To break this outer pectin layer of cotton fibre, Pectinase enzymes can be used. In general it can be said that the pectinases or pectinolytic enzymes catalyze the random hydrolysis 1, 4-alpha-D-galactosiduronic linkages in pectin substances. These enzymes are further classified based on the specificity of their reaction sites. Four main types of enzymes are used to break down pectin substances namely protopectinases, pectin esterases, polygalacturonases and pectin lyases. All these three different types have different roles to play in pectin degradation.

Protopectinases: These catalyze the solubilisation of insoluble protopectin and give rise to highly polymerized soluble pectin.



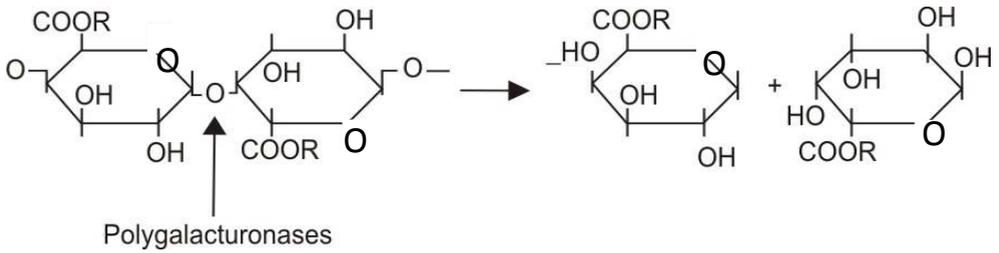
They are classified in to two types based on their reaction mechanism. A-type protopectinases and B- type protopectinases. A-type reacts with the inner site i.e. polygalacturonic acid of protopectin whereas B- type react on the outer side i.e. on the polysaccharides chain that may connect the polygalacturonic acid chain and cell wall constituents. A-types have molecular weight of about 30 KDa. B- types have molecular weight of about 45 KDa.

Pectin Esterases: These liberate pectin and methanol by de-esterifying the methyl ester linkages of pectin backbone.



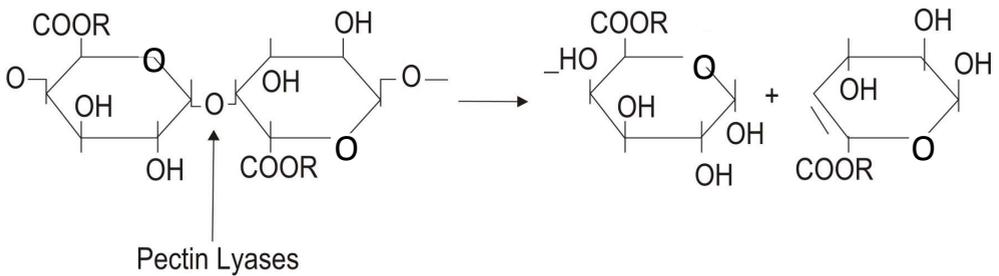
Their activity is highest on 65- 75% methylated pectin, since the enzyme is thought to act on methoxy group adjacent to free carboxyl group. Its action has very little effect on the molecular weight of the pectin. These are highly specific enzymes. Some of them attack only the reducing end while the others attack the non- reducing end. Molecular weights vary in the range of 35- 50 KDa. They are active in the pH range of 4-8. Optimal temperature range for maximum activity is 40- 50°C.

Polygalacturonases: These enzymes directly reduce the molecular weight of the pectins. They catalyze the hydrolytic cleavage with the introduction of water across the oxygen bridge.

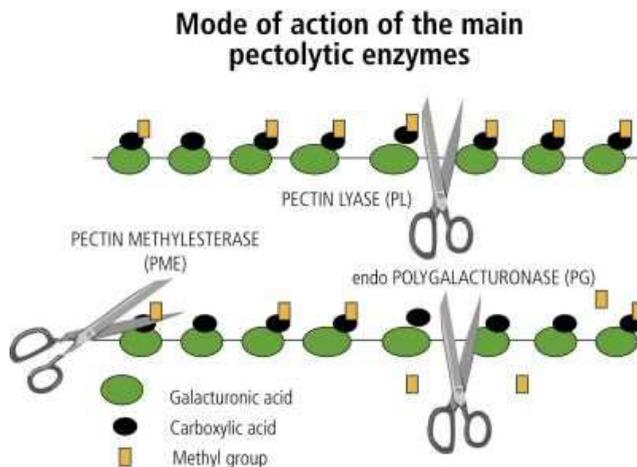


These are the most commonly used enzymes in the market. They are classified further as endo- galacturonases and exo- galacturonases. Endo types are found extensively in nature whereas exo-types occur less frequently. Polygalacturonases obtained from different sources vary widely with respect to their physiochemical and biological properties as well as their mode of action.

Pectin Lyases: They also contribute to the depolymerisation of pectin. These catalyse the trans- eliminative cleavage of the galacturonic acid polymer. The lyases break down the glycosidic linkages at C-4 and simultaneously eliminate H from C-5 position, producing an unsaturated product.



In a much simplified way, the action of the above mentioned Pectinase enzymes can be summarized pictorially in the figure given below:

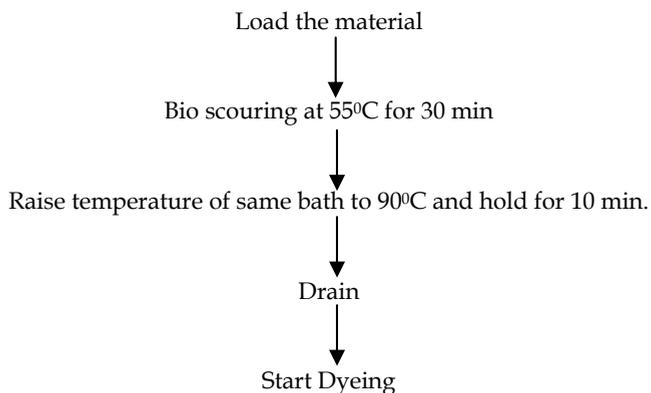


5.2 Rossari's Bio- scouring enzyme – 'Scourenz ABE Liquid '

From the above literature survey, it is very clear that the cotton can be bio- scoured using Pectinases enzyme. As we have seen there is a large pool of sources from which Pectinases enzyme can be obtained and also a huge number of combinations possible depending on the type of pectin degradation required. At Rossari Biotech Ltd, R & D department have developed a bio scouring enzyme named 'Scourenz ABE Liquid', that is successful in producing the desired scouring effects on cotton and its blends. It's a complex mixture of Protopectinases and Polygalacturonases that completes the bio scouring process in 30-45mins and gives a fabric with absorbency within 4-5 seconds. Lower treatment temperature of 55- 60°C and milder acidic conditions with a pH requirement of 5- 5.5 are the advantages that have proven to be a boon to our customers that are currently using this enzymes.



The process route that has to be used for carrying out bio scouring operation is:



The actual bio-scouring process takes place at 55°C. In this step the pectins are decomposed and emulsified. After bio-scouring, raising the temperature of the same bath to 90°C helps in melting of waxes and oils. These released waxes are emulsified at high temperature and the bath is drained. This removes the entire impurities from the bath and the cotton substrate is ready for dyeing.

The enzymatic process of bio- scouring on bulk scale involves following stages:

- Transfer of enzyme molecules from aqueous phase to fibre surface
- Adsorption of enzyme molecule on to the substrate surface

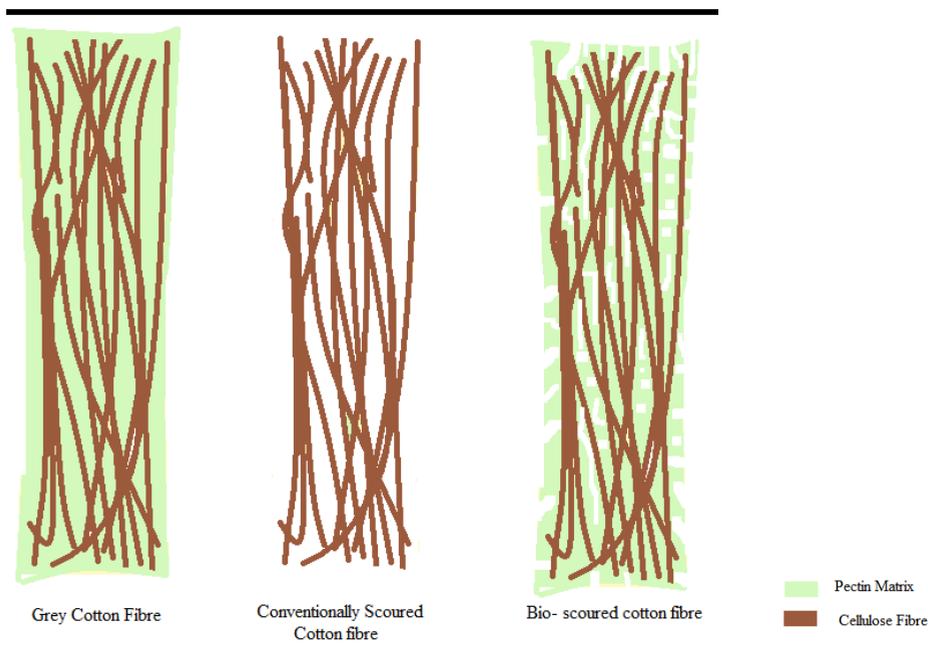
- Catalysis of surface hydrolytic reaction by the enzyme
- Transfer of hydrolytic reaction product to the aqueous phase. After breaking down and removing pectin, which binds, as a natural binder, non-cellulose substances within the fibre cellulose core, other non-cellulose substances can be removed from the cotton by using surfactants and by mechanical action.

Since at least two stages of the enzymatic reaction i.e. transport of enzyme molecules on the cotton substrate and transport of enzymatic reaction products from the cotton substrate in to the solution are controlled by diffusion, the overall rate of hydrolysis depends on the respective diffusion rates. This is the reason why, while carrying out bio-scouring high level of liquor exchange, agitation and turbulence is required. Mechanical agitation of the enzyme processing solution not only improves transport of bulky enzyme molecules toward the surface of the cellulose fabric and in to the interior of the cotton yarn but also helps in release of degraded pectin from the surface of the cotton in to the solution.

5.3 Structure of the bio-scoured fibre against conventionally scoured fibre

In conventional scouring the entire amount of pectin is removed from the cotton fibre. This pectin serves as a binding material for the cellulose fibrils. After its removal the coherence between the fibrils decreases due to which the strength of the structure goes down. Also it leads to harshness of yarn and increased hairiness on the surface.

While designing our bio-scouring enzyme we had the aim of removing the pectins to a level just enough that it facilitates the even absorbency of the yarn, but should not eliminate them completely from the surface. Presence of pectin leads to strength retention, lesser hairiness and smoother surface profile.



Advantages:

- **Water Saving:** In bio- scouring process only one bath is used before the actual dyeing starts, whereas in conventional process a minimum of 5 baths are used. This leads to a total 4 bath saving. Considering an MLR of 1:7, the total amount of water that will be saved is about 28 litres for every Kg. processed. For a unit doing a 30 Mt. of bleaching every day, the amount of water that will be saved is 840,000 Litres per day. On annual basis the amounts comes to be 306600,000 litres of water.
- **Temperature Saving:** The entire process takes place at a temperature of 55°C as against 98°C. The temperature difference is about 43°C. The specific heat of water is 4.186 Joule/ gram K. It requires 4.186 joules of energy to heat 1 gm. of water by 1 Kelvin. Assuming an MLR of 1:7, for every Kg. of cotton, 7 litres of water is used during the bleaching process. In order to heat water from 55 degrees to 98 degrees the amount of heat energy required will be:

Amount of heat energy required per kg. of cotton

$$= (98 - 55) \times 1000 \times 4.186 \times 7 = 1259998 \text{ Joules} = 1260 \text{ KJ}$$

1260 KJ is the amount of energy that will be saved for every Kg. of material processed. If calculated the impact of same on yearly basis for a production plant doing a bleaching of 30 Mt. On daily basis, the amount comes out to be

Amount of heat liberated per year for 30 Mt./ Day Plant

$$= 1260 \times 30 \times 1000 \times 365 = 13797000000 \text{ KJ} = 13797000 \text{ MJ}$$

Thus on yearly basis a unit of daily production of 30 Mt. can save energy of the magnitude 1.38×10^7 MJ. If 1.38×10^8 MJ is extrapolated to various natural fuels available than we can save following quantity of fuel:

Fuel Source	Calorific Value (MJ/Kg.)	Fuel saved per year (6.41×10^6 / Calorific value)	Fuel saved per day
Coal (Anthracite)	27	510.63 Metric tonnes.	1400 kg
Coal (Lignite)	15	919.55 Metric tonnes	2519.8 kg.
Wood	15	919.55 Metric Tonnes	2519.8 kg.
Diesel	44.80	307.45 Metric Tonnes	842 Kg.
Kerosene	46.20	298.20 Metric Tonnes	817 Kg.

All the above mentioned figures are taken considering 100% performance of the concerned parameters involved. If taken in to account boiler efficiency, Combustion efficiency, Heat transfer losses, Steam Transportation losses than the figure will increase by 10 - 25%.

According to the United states Department of forestry, an average weight of a fully grown tree is about 680 Kg. Thus, by using Scourenz ABE Liquid, we would be indirectly contributing to plantation of 3.7 fully grown trees per day. Also, it will lead to reduction in contribution of global warming by any organization since we are inhibiting 1260 KJ of energy to enter in to our bio systems for every Kg. of cotton material bleached. Any organization will have its huge benefits in terms of carbon foot prints and help them to earn through carbon credits.

- **Time Saving:** The process of conventional scouring takes place about 2hrs 50 min. for completion. Whereas the bio-scouring process will not take more than 50 min. for completion. Thus for every batch dyed we are saving 2hrs per batch. A conventional dyeing process takes place in about 7 hours. Whereas using bio- scouring the same

dyeing can be completed in 5 hours. In terms of percentage the time saving will be 29%. Thus any process house can raise its production by 29% approximately by using the bio-scouring process.

- **Smother surface profile:** Presence of pectin in yarn helps to give a smoother profile. This binding agent prevents the hairiness of the cotton that gets generated due to abrasion with processing equipment's. Also pectin itself acts as a softener for the cotton. So the application of final softener can be reduced from 25- 40%. Smoother profile will also help in improving the loom running efficiency by 4% at least.
- **Lesser Weight loss:** Weight loss in bio- scouring process is not more than 1.5%. In conventional process the weight loss is close to 4%. The total saving in the weight loss can be close to 2.5%. In this era, where the cotton prices have shown a steady inflation, this will be a considerable advantage to the process owner.
- **Environmental benefits:** Reduced effluent treatment cost, as avoiding caustic soda, which in turn reduces TDS. During conventional scouring if we consider TDS to be 100% the Scourenz ABE Liquid process has only 20-40% TDS.
- **Lesser cost of Auxiliaries:** In a conventional scouring recipe the chemicals used and their respective cost are:

Summary of benefits:

Gain Type	Saving Parameter	Amount
Tangible and direct measurable gain	Energy Cost	1.51 Rs./ kg.
	Weight Loss	Less by 2.5% (4.0 Rs./Kg.)
	Softener cost	-15% (20 paise/ Kg.)
	Chemical Cost	75 paise/ Kg.
	Water saving	28 litres/ Kg.
Intangible gain leading to benefits	Loom performance	Improved by 4% (Direct increase in profit by 3%)
	Time saving	2 hours. (If utilised will give 29% higher profits)

6. Bleaching⁶

Traditional bleaches for cleaning clothes are hypochlorite and persalts. The proportions used differ widely, depending on the local environmental legislations. Over the last few years major changes have occurred in the bleach compounds used in the detergent formulations all over the world, as the chlorine - containing bleach compounds, which were popular for their low temperature application have been withdrawn for the market and their usage has become limited. This is due to the formation of highly toxic chlorinated organic by products (AOX) during the bleaching process as well as effluents discharged there from. Moreover, the legal regulations have stipulated very low limiting values for AOX in the textile effluent. Nowadays textile industries are obliged to bleach without using chlorine-containing compounds.

Maximum Levels for the indirect discharge of effluent	
Pollutant	Limits
AOX	0.5 ppm

Bleaching using Sodium hypochlorite in batch method, the fabric is treated using 1-3 g/L available chlorine at alkaline pH of 11-11.5 at room temperature for nearly two hrs. Disadvantages of Hypochlorite bleaching are a) all protein impurities must be completely removed before bleaching otherwise the fabric may turn yellowish. b) Residual chlorine must be removed otherwise fabric may be damaged.

As compared to other bleaching agents, bleaching the material with peroxide has following advantages:

1. It is a universal bleaching agent and can be used for bleaching cotton, wool, silk, jute.
2. Weight loss is less as compared to hypochlorite bleaching
3. Superior fastness can be achieved
4. Better absorbency
5. Lesser chemical degradation of cotton
6. Lesser tendency of after yellowing

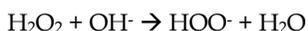
6.1 Bleaching chemistry

Since hydrogen peroxide contains an atom of loosely combined oxygen, it has powerful oxidising properties. Due to this it has a bleaching action on textile substrate. In a neutral aqueous solution, hydrogen peroxide is ionised into perhydroxyl and hydrogen ions.



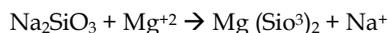
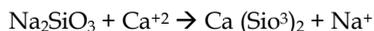
This perhydroxyl ion is supposed to be the active bleaching agent. But the bleaching effect is dependent greatly on the pH of the solution. In acidic or neutral pH, perhydroxyl and hydrogen ions are found in solution. These hydrogen ions have a tendering effect on cellulose due to its acidic nature. It is found that in acidic or neutral pH tendering effect of H^+ ions is more than the bleaching effect of the $\text{HOO}\cdot$ ions. This tendering will in turn impart yellowness to the cotton substrate. So it is not recommended to carry out bleaching in acidic conditions.

On the other hand, in alkaline condition following equilibrium exists:



Here we can see that along with perhydroxyl ion and water molecules are in equilibrium. Due to this in alkaline pH we get more bleaching effect and less tendering of cotton. This is the reason why bleaching is carried out in alkaline pH. But it is observed that in alkaline medium although the damage to cotton fibre is less, the stability of peroxide itself is also very less. In absence of stabiliser, in alkaline medium at temperatures as high as 100-110°C, the entire peroxide will get decomposed in less than 10 min. The presence of water hardness and the iron contamination in commercial processes further enhances the action of peroxide decomposition. If the bleaching is continued in such a way, that not only the bleaching efficiency will be hampered but also the uniformity of bleaching will not be good. Such material when taken for further dyeing will lead to problems like lesser depth, patchy dyeing etc. So it becomes mandatory to use a stabilising agent in bleaching baths to get good bleaching performance.

Conventionally Sodium Silicate was used as a stabiliser for peroxide bleaching. It stabilizes the peroxide solutions considerably even at pH of 10. It takes about 54 min. for peroxide to decompose to extent of 50% in presence of silicate. The stabilising effect can be explained as follows:



This way the water hardness is removed from the solution. But this advantage is accompanied by a disadvantage that the calcium and magnesium silicate formed are sparingly soluble in water and get deposited on the surface of bleaching equipment leading to abrasion of fabrics, difficulty in washing off. Due to this silicates have been replaced by new generation stabilizing agent. One of these category includes magnesium based compounds like magnesium hydroxide, Magnesium – EDTA (Ethylene Diamine tetra acetic acid), copolymer of styrol- maleic acid with magnesium haloids, magnesium silicates etc. Other group of stabilising agents include polyorganosiloxanes such as poly-methyl and poly-ethyl siloxanes which along with stabilising effect have an added benefit of reducing the abrasion resistance when used for bleaching of yarn or sewing threads.

The world is facing a crisis of energy consumption, and the situation is worsening day by day. Correct practices for energy, consumption has become essential in everywhere of life, from industrial as consumer practices. The textile industry as a whole has taken some measures in this direction by combination of several step processes into one step process, the less use of water in processing to reduce the expense of energy in drying and chemical processing at lower temperatures.

The entire bleaching process takes place near about 3 hours for a full white process and about 2 hours for a RFD process.

6.2 Drawback of the conventional bleaching process

A very interesting phenomenon comes in to picture when we analyse the conventional bleaching process. Till now, it is very clearly understood that with increase in temperature the stability of peroxide decreases rapidly in alkaline medium. The bleaching temperature that is used conventionally is around 100°C. At this temperature the peroxide is highly unstable. So in order to stabilise the peroxide we are adding an external stabiliser. These two facts are contradictory to each other:

1. Destabilization of peroxide by selection of a higher bleaching temperature
2. Addition of external stabiliser in order to stabilise the peroxide.
3. This makes us think as to why not lower the temperature of bleaching to a level that without decreasing the scouring efficiency we can achieve same bleaching efficiency at that obtained in conventional high temperature process.
4. On this idea, Rossari, which has always believed in innovating ways to make the process more eco- friendly and cost effective, has brought a new molecule to revolutionize the bleaching process used in textile industry. We are launching this molecule in the name of 'Koolwhite 2020' in the commercial market.

6.3 Need for research

Bleaching at low temperatures (ambient temperature to 30°C to 80°C)

Catalytic bleaching

- Use of catalysts in order to
 - lower the bleaching temperature (65- 80 °C; no steamer)
 - shorten the bleaching time (5-10 min)
 - decrease the damage of the fabric (DP value > 2000)
 - reduce the chemical consumption with lower pH range (3 g H₂O₂/l, pH 10)

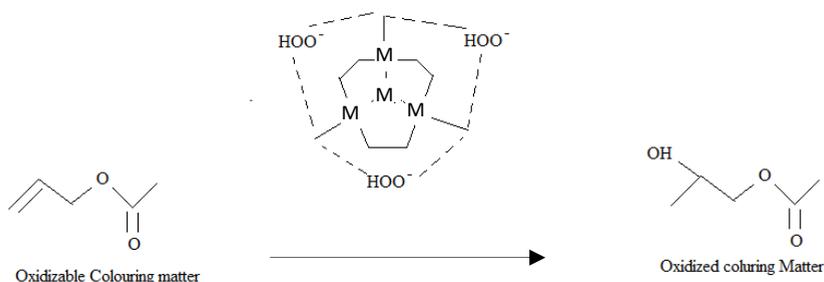
6.4 KOOLWHITE 2020 Liquid - Instant whiteness guaranteed at low temperature

In the coming times chemical processes in everyday's life has to be environmentally safe, cost effective and sparing energy. While designing this molecule we had the target of lowering the bleaching temperature without reducing the bleaching performance. As the bleaching temperature decreases, the activity of traditional bleaching agent like hydrogen peroxide is reduced. To maintain the bleaching efficiency, effective catalysts are required.

Several transition metal complexes with different ligands are reported to be promising low temperature peroxide bleach catalysts. In an intensive research carried out at our R&D centre, it has been found that transition metal derived complexes and related ligand systems are effective catalyst for oxidation of colouring matter by hydrogen peroxide at lower temperatures.

Similar kind of complexes in combination with peroxide have been reported to exhibit remarkable catalytic activity, in presence of suitable buffers, for stereo- selective epoxidation of olefins, oxidation of alkanes and alcohols at ambient temperature. For the first time these have been deployed commercially on a bulk scale in textile as a bleaching catalyst. Using this catalyst the bleaching can be carried out at temperatures as low as 80°C.

At this low temperature, in alkaline medium the release of perhydroxyl ions is slower as compared to 100°C. The metal- ligand system complexes these released perhydroxyl ions and prevent its decomposition in to water and oxygen. This further increases the stability of the perhydroxyl ions in the alkaline solution. When this 'Metal- Ligand- Perhydroxyl ion' complex comes in contact with an oxidizable colouring matter impurity on the textile substrate, the perhydroxyl ion is released. This released ion oxidizes the colouring matter and thus produces a bleaching effect. This can be pictorially represented as follows:



The major advantage of the molecule is that due to its stable intermediate structure it is relatively inert to cotton material and leads to lesser oxy-cellulose formation.

For carrying out bleaching on various cotton substrates a typical bleaching recipe using Koolwhite 2020 liquid can be stated as follows:

100% Cotton Woven:

Chemicals	RFD	Full white
Kleenox Knitz Liquid	1.5 g/L	1.5 g/L
Koolcat Liquid	0.1 %	0.1%
Koolwhite 2020 liquid	0.8%	1%
Caustic	1.2 g/L	2 g/L
Peroxide	2.5 g/L	7 g/L

100 % Cotton Yarn

Kleenox Knitz Liq 0.2%

Kleerix PER Liq 0.3%

MLR 1:10, Rotate at 60°C for 10 min.

In the same bath

add↓

Kleenox Knitz Liq 1.0%

Hydrogen Peroxide (50%) 7.0%

Caustic flakes - To Adjust pH of 12

Koolwhite 2020 Liq 1%

Rosba NBS 200 Liq 0.5%

MLR- 1:10, Treat at 80°C for 30 min.

100 % Cotton Hosiery

Kleenox Knitz Liq 1.2%

Koolcat Liq 0.1%

Hydrogen Peroxide (50%) 7.0%

Caustic flakes - To Adjust pH of 12

Koolwhite 2020 Liq 1%

Rosba NBS 200 Liq 0.5%

MLR- 1:10, Treat at 80°C for 30 min.

Terry towel

Kleenox LF Conc Liq 1.0% o.w.f.

Kool CAT Liq. 0.1% o.w.f

Hydrogen peroxide (50%) 7.0% o.w.f.

Caustic soda flakes 2.0 % (To adjust pH at 12.0)

Kool white 2020 Liq 0.5% o.w.f.

Rosba NBS 200 Liq 0.4% o.w.f.

Bath Mat

Zywet Cab 125 Liq 0.6%

Kleerix PE 500 Liq 0.8%

Greendye Eco New Liq 1.0%

Hydrogen peroxide (50%) 3.0%

Caustic soda flakes 0.8 % (To adjust pH at 12.0)

Kool white 2020 liq. 0.7-1.0%

At 70°C for 30 mins

Continous Bleaching range recipe

Kleenox Knits Liquid 10 g/L

Hydrogen peroxide (50%) 10 g/L

Caustic soda flakes 10 g/L (To adjust pH at 12.0)

Koolwhite 2020 liquid 10 g/L

6.5 Bulk trial results

Today Kool'white 2020 is not merely a concept or a theoretical hypothesis but a well-established commercial bleaching catalyst that is giving benefits to our customer in terms of cost, time, and money saving and helping them to evolve as a green technologies user in international market. It has increased their market credibility and buyers prefer ability considering the fact that the ultimate consumer has become more conscious about the type of product it's using and its consecutive environmental impact.

Advantages of the process

Environmentally friendly

The specific heat of water is 4.186 Joule/ gram K. It requires 4.186 joules of energy to heat 1 gm. of water by 1 Kelvin. Assuming an MLR of 1:7, for every Kg. of cotton, 7 litres of water is used during the bleaching process. In order to heat water from 80 degrees to 100 degrees the amount of heat energy required will be:

Amount of heat energy required per kg. of cotton

$$= (100 - 80) \times 1000 \times 4.186 \times 7 = 586040 \text{ Joules} = 586 \text{ KJ}$$

586 KJ is the amount of energy that will be saved for every Kg. of material processed. If calculated the impact of same on yearly basis for a production plant doing a bleaching of 30 Mt. On daily basis, the amount comes out to be

Amount of heat liberated per year for 30 Mt./ Day Plant

$$= 586 \times 30 \times 1000 \times 365 = 6416700000 \text{ KJ} = 6416700 \text{ MJ}$$

Thus on yearly basis a unit of daily production of 30 Mt. can save energy of the magnitude 6.41×10^6 MJ. If 6.41×10^6 MJ is extrapolated to various natural fuels available than we can save following quantity of fuel:

Fuel Source	Calorific Value (MJ/Kg.)	Fuel saved per year (6.41×10^6 / Calorific value)	Fuel saved per day
Coal (Anthracite)	27	237.5 Metric tonnes.	651 kg
Coal (Lignite)	15	427.7 Metric tonnes	1172 kg.
Wood	15	427.7 Metric Tonnes	1172 kg.
Diesel	44.80	143 Metric Tonnes	392Kg.
Kerosene	46.20	138.7 Metric Tonnes	380 Kg.

All the above mentioned figures are taken considering 100% performance of the concerned parameters involved. If taken in to account boiler efficiency, Combustion efficiency, Heat transfer losses, Steam Transportation losses than the figure will increase by 10 – 25%.

According to the United states Department of forestry, an average weight of a fully grown tree is about 680 Kg. Thus, by using Koolwhite 2020 Liquid as the bleaching catalyst we would be indirectly contributing to plantation of 1.5 trees per day. Also, it will lead to reduction in contribution of global warming by any organization since we are inhibiting 586 KJ of energy to enter in to our bio systems for every Kg. of cotton material bleached. Any organization will have its huge benefits in terms of carbon foot prints and help them to earn through carbon credits.

Strength retention

The intermediate manganese- perhydroxyl ion complex formed is a more stable complex as compared to perhydroxyl ions itself. Due to this the oxidation reaction becomes more site specific and there is a higher degree of decolourization and lesser degree of fibre damage. Fabric or yarn bleached using Koolwhite 2020 shows a lesser oxy-cellulose formations compared to conventional bleaching process.

Bleaching Process	CSP readings			RKM readings		
	Grieg	RFD	Full white	Grieg	RFD	Full white
Current Std.	2466	2453	2374	22.4	22.2	21.3
Koolwhite 2020	2466	2621	2412	22.4	22.6	22.1

The yarn bleached using Koolwhite 2020 process shows a lesser cuprammonium fluidity and higher degree of polymerization. This clearly demonstrates that Koolwhite 2020 process causes lesser damage to the fibre as compared to conventional bleaching at 100°C. To confirm this CSP and RKM readings were taken for the same yarn and the results clearly justified the analogy.

The yarn bleached using Koolwhite 2020 is found to give better loom efficiency. In general the weaving performance is found to increase by 3-5 %.

Weight loss

The cuprammonium fluidity and the degree of polymerization data suggests that there has been lesser fibre degradation. Fibre degradation generally leads to formation of oligomers of lesser molecular weight. Due to their smaller size and partial hydrophilic nature, they tend to get easily suspended in water. Presence of emulsifying and wetting agents further enhance this action. This contributes to the weight loss of the fibre. Since in Koolwhite 2020 process there is a lesser extent of oligomer formation, the overall weight loss in the yarn or fabric is observed to be less. In general it has been seen that the weight loss is less by 2-5% on the weight of material.

Smoother surface profile

Koolwhite 2020 process leads to lesser oxy-cellulose formation. In bleaching process, it is observed that oxy-cellulose formation is higher on the surface as compared to the core of fibre. This is because of higher degree of abrasion and continuous contact with fresh bleaching solution. On the other hand Koolwhite 2020's reaction mechanism inhibits any damage to the yarn even after the ever changing fresh bleaching liquor on the surface of the yarn. Due to this the yarn profile is much smoother. This has an direct impact on the amount of finish to be used on the yarn. The customer using Koolwhite 2020 process can reduce the finish in the final bath from 15- 40%.

Time saving

Between the conventional bleaching temperature and Koolwhite 2020 bleaching temperature there is a difference of at least 25°C. Also with tighter government regulations, hot drain has been banned. So even if the bleaching is taking place at higher temperature, it needs to be cooled down to 80°C and then drained. With Koolwhite 2020 the bleaching temperature is itself at 80°C. So, as compared to conventional process, we get an overall temperature difference of 50°C including heating and cooling cycle. If we consider average rate of heating and cooling around 1.75°C/ minute, the total time saving comes out to be 29 minutes. Just by adopting the catalyst and without changing any other parameter we can get a time saving of 30 min. minimum. A contribution of 30 min. for a 3.5 hr of cycle is 14%. This directly means that there is a scope of increasing the production by 14% if Koolwhite 2020 process is adopted.

Summary of benefits

Gain Type	Saving Parameter	Amount
Tangible and direct measurable gain	Energy Cost	70 paisa/ kg.
	Weight Loss	Less by 2% (3.2 Rs/Kg)
	Softener cost	-15% (20 paisa/ Kg.)
Intangible gain leading to benefits	Loom performance	Improved by 4% (Direct increase in profit by 3%)
	Time saving	30 min. (If utilised will give 10% higher profits)

Thus the use of Koolwhite 2020 can lead to overall cost reduction by at least 4.10 Rs/Kg. In present competitive market where every penny counts, this is a significant amount of saving.

Eco friendly textiles consume less energy and resources. Using eco-friendly fabrics and sustainable printing processes, alleviates the need for cost prohibitive energy and water consumption.

7. Advantages to the subsequent dyeing and finishing process

- In most cases a better colour yield
- Noticeably brighter shades
- Savings in dyeing costs possible
- Similar or even better wash, water- and rubbing-fastness properties
- Good hand feel
- Lower lint

Rossari Biotech Ltd has introduced environment friendly products:

- Greenacid New Liquid when used in processing sequence instead of acetic acid will contribute to reduction in BOD, COD.
- Greenacid ANV Liquid: an environment friendly solution for effluent treatment plants.

Features:

- Based on Organic acid, does not contain mineral acid
- Ultra low BOD and COD
- Toxicologically and environment friendly
- pH of neutralised fabric remains steady
- Also possess property of core alkali neutralization
- Good decalcifying property
- Possess good antimicrobial properties

Parameters	Greenacid ANV liquid
COD mg/l (mgO ₂ /mg)	0.90
BOD mg/l At 27°C 5 days (mgO ₂ /mg)	0.45

8. Bipolishing

Cotton and other natural fibres based on cellulose can be improved by an enzymatic treatment known as Bio Polishing.

Before Bio- polishing



After Bio- polishing



Lyocell fibres display a higher tendency to fibrillation compared with other cellulosic fibres because they have a higher degree of crystallinity on the fibre length (90% for Lyocell, in contrast with 60-70% for viscose fibres). In order to remove the primary fibrillation, in washing, whitening or dyeing, it is necessary to apply enzymatic treatment with the use of special cellulosic enzymes. Enzymatic treatment, doubled by a controlled mechanical action, lead to a complete and of long duration defibrillation. Bio polishing after dyeing results in colour loss, so it is preferred before dyeing.

9. Concluding remarks in general

- In textile focus should be on
 - Processes, environment and products
 - Products with enhanced functionality are important to survive the competition
- New Processing concepts have to be adapted in order to be able to produce short batches
- New processes offer the opportunity to fulfil the needs of the customers
- Reducing environmental impact will help textiles processors save resources
- Reduces water and energy use versus conventional high-temperature processes.

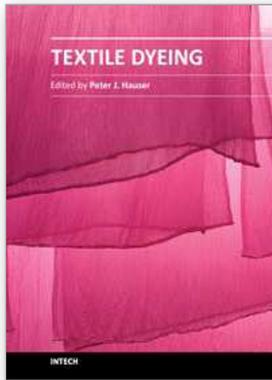
10. Conclusion

Adequate steps must be taken by the textile industries for the optimum utilization of energy and water resources. The textile industry is expected to play an ever-more-progressive role in developing environmentally friendly technologies and processes. Training the employees and creating awareness among them regarding the importance of water and energy conservation is also essential. There is a lot of potential for savings. By saving on the energy and water resources, textile industries can not only save on the costs, but can also help to slow down the climate change.

The textile industry is aware of the decrease in water sources and they are developing new technology and new chemical alternatives, but the challenge will lay in converting the technology in current textile facilities into the new technology that uses less water. Another challenge lays in changing the mindset of the current generations in the textile industry to use the new chemical alternatives instead of the chemicals they have used in the past decades. This will be a slow process, but one that will need to happen in order for the textile industry to maintain current production and grow in the future.

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The coloration of fibers and fabrics through dyeing is an integral part of textile manufacturing. This book discusses in detail several emerging topics on textile dyeing. "Textile Dyeing" will serve as an excellent addition to the libraries of both the novice and expert.

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