A new bio-chemical scouring technique for cotton hand processing units

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Received 26 March 2007; accepted 24 September 2007

The cotton woven fabric has been subjected to anaerobic treatment using a mixed microflora at room temperature followed by mild alkali boiling. The required enzymes are produced in situ by a mixture of microflora and hence does not need external supply of costly enzymes. The treated fabric is then peroxide bleached, dyed with hot brand reactive dye and evaluated for various parameters. The results show that the properties of treated fabric are at par with the conventionally processed ones. The colour values of the treated and dyed samples are in fact higher than the conventionally processed ones. The above process can be easily coupled to the existing hand processing units. The new process may result in considerable reduction in pollution load along with appreciable saving in energy.

Keywords: Absorbency, Anaerobic treatment, Biochemical scouring, Colour strength, Cotton fabric, Viscosity, Whiteness index

IPC Code: Int Cl.8 D06C

Scouring is an important pre-treatment operation in the processing of cotton and cotton blended materials. The main objective of this operation is to remove the non-cellulosic constituents of cotton fibre, which make the fibre non-absorbent, posing serious technical problems in the subsequent wet processing operations. In fact, the scouring operation determines the ultimate quality of the finished product.

The scouring operation consists of treating the cotton goods with 1-2% of NaOH solution at high pressure and temperature for 4-5 h. This operation is not only energy intensive but also leads to environmental pollution. It is estimated that scouring operation consumes about 1% of the total water used, contributes 54% of the total BOD and is responsible for 10-25% of the total pollution load of the entire textile processing operations. It is pertinent to observe here that in view of the ever widening gap between the demand and the supply position of energy, serious efforts are being made in almost every field of activity either to cut down the un-necessary expenditure of energy or to adopt a low energy process.

In the light of the above observations it is not surprising that a number of studies have been initiated over the years to make scouring operation less energy intensive and more effective one. A survey of the literature shows that but for the development of a number of chemical additives and use of certain pure enzymes, the basic operation of scouring remains essentially energy intensive and polluting in nature. The present study is therefore, aimed at scouring the cotton fabric with less pollution and less energy consumption through biochemical approach. The anaerobic technique developed at CIRCOT for the degradation of the cellulosic waste is employed to carry out scouring operations on 100% cotton fabric. This technique is cost effective as the desired enzymes are produced in situ by a mixture of microorganisms.

100% cotton woven fabrics of low weight (78g/m²) was used. The fabric was in grey state. The required quantity of fabric was subjected to anaerobic digestion for 10h and 20 h respectively. The anaerobic digestion was carried out in a sealed glass jar employing a 100% mixed flora developed and maintained at CIRCOT.

Microbial consortium was used to treat the fabric. The consortium comprised both aerobic and anaerobic types. Species belonging to Bacillus and Micrococcus sp. from Gram positive group and Beijerinckia, Pseudomonas, Xanthomonas and Flavobacterium were from Gram negative group. Aspergillus, Penicillium and Mucor were from fungi and Streptomyces was the alone actinomycete. All these were from the aerobic ones surviving under anaerobic conditions. As and when the system was disturbed, these were acting as scavengers of oxygen and setting anaerobiosis. Among anaerobic groups, species of Methanomicrobium, Desulfoto-maculum, Clostridium, Chlorobiurn, Ectothiorhodo-spire, Thiodictyon and Rhodospirillum were predominant. The presence of Chlorella as green alga and Anacystis as blue green alga was found to grow profusely under anaerobic conditions. One species of protozoan belonging to the genus Monocerononas was also present in the consortium.

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The digestion was carried out at room temperature (~32°C). At the end of the digestion period, the samples were boiled with 0.5% and 1% NaOH solutions (owf) for 1h, washed and air dried. The above treated samples were bleached with peroxide employing a M:L ratio of 1:20 with 3g/L peroxide, 1.5 g/L Na-silicate and 1g/L NaOH (owf) at boil, maintaining the pH at 10-11 for 1h. The bleached samples were dyed with hot brand reactive dye. One set of the grey sample was subjected to conventional kiering process consisting of boiling with 1% NaOH under 15lb/inch² pressure for 4 h followed by bleaching and dyeing as described above. The fabric samples at different stages were evaluated for weight loss, wax content, whiteness index, uniformity of whiteness index, water absorbancy¹⁰, viscosity¹¹, colour strength, fabric strength and elongation-at-break.¹¹ All the treatments were compared with the conventionally kiered and bleached sample as control. The reflectance measurements of all the samples were carried out using Jaypak - 4802 computerised colour matching system. From the reflectance values, the colour strength (expressed as K/S value) was calculated at the wavelength of maximum absorption (λ_max) using the Kubelka - Munk equation.

Tables 1 and 2 show the comparative behaviour of the fabric samples subjected to conventional and anaerobic digestions for 10h and 20h in respect of weight loss, whiteness index, fabric strength and elongation, fluidity and colour strength.

The samples subjected to anaerobic digestion for 10 h under different experimental conditions, in general, show lower weight loss as compared to the conventionally kiered samples. Similar trend is observed in respect of the bleached samples too. Table 2 shows that the trend of weight loss for 20 h anaerobic digestion is similar to that for 10 h digestion. However, the weight loss of 20 h treated samples is higher than those of the samples subjected to 10 h digestion. It is interesting to observe an increasing trend in the whiteness index of the anaerobically kiered sample followed by boiling with 0.5% and 1% NaOH respectively. The treatment of anaerobic digestion followed by boiling with 1% NaOH confers the same whiteness index as that of the conventionally kiered ones. The samples anaerobically treated followed by alkali boiling and bleaching clearly show the increase in whiteness index with the increase in concentration of NaOH used for boiling. The whiteness index of the

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<table>
<thead>
<tr>
<th>Code</th>
<th>Treatment</th>
<th>Weight loss (g)</th>
<th>Whiteness index</th>
<th>Elongation retention (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nil</td>
<td>&gt;10 min</td>
<td>70.81</td>
<td>71.4</td>
</tr>
<tr>
<td>E1</td>
<td>Conv. kiered</td>
<td>Instant</td>
<td>85.99</td>
<td>73.8</td>
</tr>
<tr>
<td>E2</td>
<td>Conv. kiered+ bleached</td>
<td>Instant</td>
<td>85.99</td>
<td>73.8</td>
</tr>
<tr>
<td>A2</td>
<td>Ana. kiered+ bleached+dyed</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
<tr>
<td>A3</td>
<td>Ana. kiered+0.5% NaOH+bleached+dyed</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
<tr>
<td>A4</td>
<td>Ana. kiered+0.5% NaOH</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
<tr>
<td>A5</td>
<td>Ana. kiered+0.5% NaOH+bleached+dyed</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
<tr>
<td>A7</td>
<td>Ana. kiered+0.5% NaOH+bleached+dyed</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
<tr>
<td>A8</td>
<td>Ana. kiered+0.5% NaOH+bleached+dyed</td>
<td>Instant</td>
<td>55.72</td>
<td>74.6</td>
</tr>
</tbody>
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anaerobically treated, boiled with 1% NaOH and bleached samples is almost comparable with those of the conventionally kiered and bleached samples. Similar trend is witnessed in the case of samples subjected to 20h anaerobic digestion (Table 2). The study also shows that the extent of removal of wax through anaerobic digestion followed by 0.5% and 1% open alkali boiling is as efficient as that achieved through conventional kier boil. It can be seen from Table 3 that the wax contents of the fabric subjected to 10h anaerobic treatment and 1% alkali boil followed by bleaching are lesser than that of the conventionally kiered and bleached fabric.

The water absorbency of the fabric is an important functional parameter. It can be seen from Table 1 that the fabric subjected to only anaerobic treatment for 10h is not absorbent but the anaerobic treatment followed by alkali boiling makes the fabric absorbent. It is further noted that an increase in NaOH concentration employed for boiling after anaerobic treatment does not appear to have any influence on water absorbency property. The overall results of absorbency (Table 2) indicate that the samples become more absorbent with the increase in duration of digestion.

In general, it is observed that both the conventional and the anaerobic kiering treatments lower the fabric strength. It is evident from Tables 1 and 2 that the samples subjected to anaerobic treatment followed by alkali boiling possess an improved strength retention as compared to the conventionally kiered samples. Similar trend is observed in the case of samples subjected to 20h anaerobic treatment. It can also be inferred that the longer duration of anaerobic treatment leads to a lower strength retention. It is further noted that the strength reduction trend of the bleached samples differs from the treated and the control samples. It is seen that the extent of strength reduction of anaerobically treated bleached samples is much lower than conventionally kiered and bleached samples. This could possibly be attributed to the lower degradation of anaerobically treated samples as compared to the conventionally kiered samples as reflected by the fluidity values shown in the tables. This may be due to the fibrillar agglomeration in the case of cotton fibre samples subjected to anaerobic treatment as observed by Bhatawdekar et. al\textsuperscript{12}. The ends and picks values of the treated sample indicate possible fabric structural differences similar to that noticed during fabric shrinkage, and hence to some
extent the observed higher strength retention could possibly be due to the changes in the ends and picks values. The results also show that the anaerobic digestion process appears to be less degradative as reflected by the lower fluidity values. It could therefore be observed that the anaerobic digestion process confers a higher strength retention as compared to the conventional kiering process.

It is further noted that in all the samples whether conventionally kiered or subjected to anaerobic digestion, a general strength reduction is observed subsequent to dyeing. In respect of the elongation retention, the anaerobically treated samples (Table 1) show an entirely different trend to that of the conventionally kiered samples. In comparison to the conventionally kiered samples where a general reduction in elongation is observed, the anaerobically treated samples that are subjected to alkali boiling on the contrary show an increase in the elongation retention. Once again, the observed increase in the elongation may possibly be attributed to a relatively higher shrinkage factor of the treated fabrics as compared to the conventionally kiered ones. Such anomalous behaviour is not noticed in the case of samples subjected to 20h anaerobic treatment.

Tables 1 and 2 also depict the whiteness index of the control and the anaerobically kiered samples. Though the whiteness index of the samples subjected to only anaerobic kiering is much lower to that of the conventionally kiered sample, the whiteness improves when the anaerobically treated samples are given an alkali boiling. It can be seen that the whiteness index of anaerobically treated samples followed by 1% alkali boiling is almost at par with the conventionally kiered samples. However, it is interesting to note that in all the cases, the anaerobically treated and bleached samples show superior whiteness index values as compared to the conventionally kiered and bleached samples. It is also noted that the whiteness index of bleached samples increases when anaerobic treatment is followed by alkali boiling. In order to study the uniformity of whiteness achieved through anaerobic treatment, eight reflectance measurements were carried out on each of the samples and the coefficient of variation of the whiteness index was considered as a measure of the uniformity of whiteness. It can be observed that the variation in whiteness index decreases from 2.57 for conventionally kiered to 1.27 and 0.99 for the anaerobically treated alone and alkali boiled samples respectively. Though the variation in whiteness index of the sample boiled with 1% NaOH is higher still it is much lower than the conventionally kiered sample. Thus, on the whole the anaerobic treatment followed by alkali boiling appears to impart more uniform whiteness as compared to the conventionally kiered samples. A similar trend is observed with the bleached samples also.

To study the response of such anaerobically treated and bleached samples to dyeing, all the samples were dyed to 2% shade employing a hot brand reactive dye. The anaerobically kiered samples, in general, show higher K/S values as compared to the conventionally kiered samples. However in the case of samples A2, B2, A5, B5, A8, B8 and E2, the K/S values of treated
samples are almost at par with the control. The colour characteristics of the anaerobically treated sample match with that of the conventionally kiered control sample. The $L^* a^* b^*$ values indicate that the anaerobically treated dyed samples have a relatively higher colour strength with marginally higher yellowish tinge.

The study reveals that the anaerobic treatment followed by mild alkali boiling could offer a simple, low energy, ecofriendly kiering technique for 100% cotton fabric. The quality of the kiered samples in terms of fabric strength, elongation, whiteness index and the uniformity of the whiteness is at par with that obtained through conventional kiering process. The colour strength of treated and dyed samples is slightly higher than that of the control. In brief, the properties of the fabric subjected to 10h biochemical technique is comparable to that obtained in conventional treatment.

References