Pseudo single-bath process for alkali treatment and bleaching of jute at ambient temperature

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Grey jute fibre has been alkali-treated and bleached at ambient temperature using sodium hydroxide by different process sequences namely true single-bath process of alkali treatment and bleaching, and pseudo single-bath process of alkali treatment and bleaching and then cold dyed with Procion Red M8B and Remazol Yellow FG. The effect of process sequences on physico-chemical properties of jute fibres has been evaluated. It is observed that the alkali treatment for 1 h using 60 gpl sodium hydroxide and 1:3 material-to-liquor ratio following the pseudo single-bath alkali treatment and ambient temperature bleaching process gives the optimum dyeing results. The treated fibre samples show sufficiently high whiteness index and dye uptake. The increase in dye uptake is about 18% in case of Procion Red M8B and about 42% in case of Remazol Yellow FG. As all the treatments have been carried out at ambient temperature, this process is highly suitable for cottage and small-scale industries in rural areas.

Keywords: Alkali treatment, Bleaching, Jute fibre, Pseudo single-bath process, Reactive dyeing

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1 Introduction

Jute has now found its use in several diversified applications, like furnishing fabric, automobile seat cover, carpet, blanket and selective apparel textiles. Hence, the colouration of jute has now become essential to make these value-added products attractive and make jute compatible with other natural and synthetic fibres with respect to their colour in case of blending. Moreover, the harsh feel of this fibre needs improvement for its application in value-added sector. Alkali treatment of jute fabric improves its softness but the removal of residual alkali is very tedious. Consequently, the wet processing of jute fabric although has occupied an important place in modern jute industry but still there is a scope for further improvement in it. Jute wet processing requires a lot of water, energy input for drying and more dye for a particular shade development. Therefore, a lot of research work is being carried out and more work in this regard is needed. Single-bath processing technology to reduce the requirement of water and energy, ambient temperature processing1,3 of jute textiles to make the process ecofriendly as well as cost effective and alkali treatment4-5 of jute fabric to improve its softness as well as dye affinity are some of the processes developed in the recent past to meet some of the requirements of wet processing in a jute industry. In the present work, an attempt has been made to carry out alkali treatment and ambient temperature bleaching of jute in sequences by true single-bath and pseudo single-bath processing techniques to get optimum bleaching effect and improved dye uptake. In this process, caustic bath can be reused, intermediate washing step can be avoided and material handling can be minimised by carrying out two processes (alkali treatment and bleaching) in the same bath. All the processes, like alkali treatment, bleaching and dyeing5, have been done at ambient condition and hence no electrical energy input is required. This process is, therefore, ideal for rural small-scale sector. Conventional hot bleaching, ambient temperature bleaching and dyeing experiments have also been done to make a comparative study.

2 Materials and Methods

2.1 Materials

Grey jute fibre of TD-3 variety having fineness of 2.4 tex was used for the experiment.

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The following chemicals of analytical grade were used for the study: hydrogen peroxide, trisodium phosphate, sodium hydroxide, sodium carbonate, sodium persulphate, sodium silicate, magnesium sulphate heptahydrate, non-ionic detergent (Ultravon JU) and acetic acid.

Reactive dyes, viz. Procion Red M8B (C.I. Reactive Red 11) and Remazol Yellow FG (C.I. Reactive Yellow 42), were used for dyeing of jute fibre.

2.2 Methods

Both conventional hot bleaching and ambient temperature bleaching processes were carried out as per the methods reported earlier\(^7\).

2.2.1 Single-Bath Alkali Treatment and Bleaching

For single-bath alkali treatment and bleaching at ambient temperature, the following different combinations were used to optimise the process:

- Ambient temperature bleaching of grey jute fibre (Sample Code - a) was carried out as per the method reported earlier\(^7\).
- Grey jute fibre (Sample Code - b) was dipped in water for 1 h, taken out, squeezed and immediately dipped in bleach bath for bleaching at ambient temperature.
- True single-bath process of alkali treatment and bleaching was carried out using the following three sequences:
  - Fibres (Sample Code - c) were dipped in sodium hydroxide solution (25 gpl) at 1:3 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. Rest of the chemicals apart from sodium hydroxide were added to the bath for ambient temperature bleaching. The alkali-treated and bleached fibres were then taken out, squeezed, kept in the plastic bag for 2 h, washed, soured and finally dried.
  - Grey jute fibres (Sample Code - d) were dipped in sodium hydroxide solution (50 gpl) at 1:3 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. Rest of the chemicals apart from sodium hydroxide were added to the bath for ambient temperature bleaching. The alkali-treated and bleached fibres were then taken out, squeezed, kept in the plastic bag for 2 h, washed, soured and finally dried.
  - Grey jute fibres (Sample Code - e) were dipped in sodium hydroxide solution (50 gpl) at 1:5 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. Rest of the chemicals apart from sodium hydroxide were added to the bath for ambient temperature bleaching. The alkali-treated and bleached fibres were then taken out, squeezed, kept in the plastic bag for 2 h, washed, soured and finally dried.
- Pseudo single-bath process of alkali treatment and bleaching was carried out using the following four sequences:
  - Grey jute fibres (Sample Code - f) were dipped in sodium hydroxide solution (25 gpl) at 1:3 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. The alkali-treated fibres were then dipped in a water bath (M:L ratio, 1:3) for 15 min. Then all other ingredients, except sodium hydroxide, were added to the bath and ambient temperature bleaching was carried out in the usual way.
  - Grey jute fibres (Sample Code - g) were dipped in sodium hydroxide solution (50 gpl) at 1:3 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. The alkali-treated fibres were then dipped in a water bath (M:L ratio, 1:3) for 15 min. Then all other ingredients, except sodium hydroxide, were added to the bath and ambient temperature bleaching was carried out in the usual way.
  - Grey jute fibres (Sample Code - h) were dipped in sodium hydroxide solution (50 gpl) at 1:5 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. The alkali-treated fibres were then dipped in a water bath (M:L ratio, 1:3) for 15 min. The alkali coming out to the water was then titrated and the concentration of sodium hydroxide was found to be 21.6 gpl. Hence, 3.4 gpl sodium hydroxide was added to the bath along with other bleaching ingredients for ambient temperature bleaching. The fibres were then squeezed to give 100% wet pick up and kept in a plastic bag for 2 h. Finally, they were washed, soured and dried.
  - Grey jute fibres (Sample Code - i) were dipped in sodium hydroxide solution (60 gpl) at 1:3 material-to-liquor ratio, kept as such for 1 h, squeezed and taken out. The alkali-treated fibres were dipped in a water bath (M:L ratio, 1:3) for 15 min. The alkali coming out to the water was then titrated and the concentration of sodium hydroxide was found to be 25 gpl. Hence, other bleaching ingredients except sodium hydroxide were added to the bath for ambient temperature bleaching. The fibres were then squeezed
to give 100% wet pick up and kept in a plastic bag for 2 h. Finally, they were washed, soured and dried.

2.2.2 Dyeing of Bleached Jute Fibres

Conventionally bleached, ambient temperature bleached, alkali-treated and ambient temperature bleached, single-bath (true and pseudo) alkali-treated and ambient temperature bleached jute fibres were dyed with two different reactive dyes using the following procedures:

Procion Red M8B – Dye bath was made with dye (4%) and Glaubers’ salt (60 g/L), keeping the material-to-liquor ratio at 1:20. The bleached fibre samples were dipped into the dye bath and kept as such for 1 h with stirring at a temperature of 30°C. After this treatment, the sodium carbonate (20 g/L) was added in the same bath and kept for 45 min under the same condition. Thereafter, the samples were washed with cold water, soaped with Ultravon JU (2 g/L) for 15 min followed by usual washing and drying in air.

Remazol Yellow FG – Dye bath was made with dye (4%) and Glaubers’ salt (80 g/L), keeping the material-to-liquor ratio at 1:20. The bleached fibre samples were dipped into the dye bath and kept for 20 min with stirring at a temperature of 30°C. After this treatment, the sodium hydroxide (4 g/L) was added in the same bath and kept for 2 h under the same condition. Thereafter, the samples were washed with cold water, soaped with Ultravon JU (2 g/L) for 15 min followed by usual washing and drying in air.

2.2.3 Determination of Physico – chemical Properties

2.2.3.1 Bundle Strength and Fineness

Bundle strength of grey and processed jute fibre samples was determined as per the IS : 7032 (Part VII) – 1975 method. The fineness of grey and processed jute fibre samples was determined as per the IS : 7032 (Part VIII) – 1976 method.

2.2.3.2 Whiteness, Yellowness and Brightness Indices

Whiteness index in the HUNTER scale, yellowness index in the ASTM D 1925 scale and brightness index in the TAPPI 45 scale of grey and processed jute fibre samples were measured by the Spectrascan – 5100® computer colour matching system using relevant softwares.

2.2.3.3 K/S Value, Reflectance and Colour Strength

Spectrascan-5100® computer colour matching system was used to measure K/S value, reflectance and colour strength of different types of reactive dyed jute fibre samples.

2.2.3.4 Wash Fastness

All the reactive dyed jute fibre samples were subjected to wash fastness test in a launder-O-meter as per the IS : 3361-1979 method. Wash fastness rating of all the dyed fibre samples was evaluated with the help of computer colour matching system.

3 Results and Discussion

Table 1 reveals that the ambient temperature bleached samples produce higher whiteness and brightness indices compared to the alkali-treated and
bleached samples. Here, alkali treatment and bleaching have been done by true single-bath method and pseudo single-bath method. In order to make the comparison with alkali treatment and then bleaching, a blank test was performed where the fibre was dipped in water bath for 1h, squeezed and then dipped in a bleach bath intended for ambient temperature bleaching in the usual way. In this case, the whiteness and brightness indices are found to be less than that produced in the case of only ambient temperature bleaching but higher than that produced in case of single-bath process. In true single-bath process (samples c, d and e) the whiteness index is slightly lower than that in ambient temperature bleaching process. In case of sample e, the alkali treatment before bleaching consumes a portion of alkali from the bath, resulting in lower concentration of alkali during ambient temperature bleaching whereas in samples d and e, the higher alkali concentration during ambient temperature bleaching produces lower whiteness index. In order to exploit higher benefit and reuse of costly chemicals, pseudo single-bath process was followed in single-bath alkali treatment and bleaching. Here, whiteness index produced is slightly lower but sufficient enough to get quality dyeing after bleaching. In sample f, the alkali treatment before bleaching and lower alkali concentration during bleaching result in lower whiteness index but in samples g and h, though the bleaching has been done in a separate bath after alkali treatment, sodium hydroxide concentration is nearly optimum in case of sample g and equal to optimum in case of sample h. Hence, the whiteness index values of these samples are higher than that of sample f. In sample i, the alkali concentration during alkali treatment has been chosen in such a way that while using the bath intended for ambient temperature bleaching, sodium hydroxide is released which is equal to the optimum concentration for ambient temperature bleaching. It is observed that the whiteness index produced in case of sample i is sufficient for subsequent dyeing in any particular shade. Bundle strength decreases from 28.2 g/tex to 23.0 g/tex after ambient temperature bleaching but there is marginal drop in tenacity in case of single-bath alkali treated and bleached samples compared to only ambient temperature bleached samples. There is swelling in fibres after ambient temperature bleaching and single-bath alkali treatment–ambient temperature bleaching. Swelling is found to be maximum in case of sample i, which is indicated by its highest air flow fineness reading.

Table 2 shows the effect of single-bath alkali treatment–ambient temperature bleaching on dyeing behaviour. It is observed that both the dyes behave equally in all the samples. Single-bath processed samples show higher colour yield in all the cases compared to that produced in case of only ambient temperature bleached samples. It is clear from Table 2 that the colour yield is maximum in case of sample i. This may be due to the maximum swelling during pseudo single-bath alkali treatment and ambient temperature bleaching, which helps the reactive dyes to enter the fibres through pores and fix there.

Considering all the properties like whiteness index, brightness index and colour yield for both types of reactive dyes, it is observed that sample i has produced best results. So, pseudo single-bath alkali treatment and ambient temperature bleaching using 60

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>8.27</td>
<td>3.41</td>
</tr>
<tr>
<td>b</td>
<td>7.99</td>
<td>3.18</td>
</tr>
<tr>
<td>c</td>
<td>9.15</td>
<td>4.39</td>
</tr>
<tr>
<td>d</td>
<td>9.42</td>
<td>4.64</td>
</tr>
<tr>
<td>e</td>
<td>9.54</td>
<td>2.55</td>
</tr>
<tr>
<td>f</td>
<td>9.23</td>
<td>4.26</td>
</tr>
<tr>
<td>g</td>
<td>9.39</td>
<td>4.37</td>
</tr>
<tr>
<td>h</td>
<td>9.31</td>
<td>4.41</td>
</tr>
<tr>
<td>i</td>
<td>9.77</td>
<td>4.68</td>
</tr>
</tbody>
</table>

Table 2 – Effect of different process sequences on dyeing behaviour
Table 3 – Physical properties and bleaching behaviour of different ambient temperature processed fibres

<table>
<thead>
<tr>
<th>Jute fibre</th>
<th>Bundle strength g/tex</th>
<th>Air flow fineness tex</th>
<th>Whiteness index (HUNTER)</th>
<th>Yellowness index (ASTM D 1925)</th>
<th>Brightness index (TAPPI 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey</td>
<td>28.21</td>
<td>2.41</td>
<td>53.99</td>
<td>46.21</td>
<td>23.96</td>
</tr>
<tr>
<td>Hot H₂O₂ bleached</td>
<td>25.48</td>
<td>2.14</td>
<td>83.17</td>
<td>18.82</td>
<td>64.59</td>
</tr>
<tr>
<td>Amb. temp. bleached</td>
<td>23.02</td>
<td>3.40</td>
<td>79.79</td>
<td>19.48</td>
<td>59.02</td>
</tr>
<tr>
<td>Amb. temp. alkali-treated and bleached</td>
<td>21.61</td>
<td>4.05</td>
<td>72.95</td>
<td>33.17</td>
<td>45.69</td>
</tr>
</tbody>
</table>

Table 4 – Dyeing behaviour of differently dyed jute fibres

<table>
<thead>
<tr>
<th>Jute fibre</th>
<th>Procion Red M8B (K/S value)</th>
<th>Reflectance</th>
<th>Wash fastness</th>
<th>Remazol Yellow FG (K/S value)</th>
<th>Reflectance</th>
<th>Wash fastness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot hydrogen peroxide bleached and dyed</td>
<td>8.11</td>
<td>5.51</td>
<td>3-4</td>
<td>2.61</td>
<td>14.14</td>
<td>3-4</td>
</tr>
<tr>
<td>Amb. hydrogen peroxide bleached and dyed</td>
<td>8.27</td>
<td>5.41</td>
<td>4</td>
<td>3.41</td>
<td>11.47</td>
<td>3-4</td>
</tr>
<tr>
<td>Amb. temp. alkali-treated, bleached and dyed</td>
<td>9.77</td>
<td>4.23</td>
<td>4</td>
<td>4.68</td>
<td>10.67</td>
<td>4</td>
</tr>
</tbody>
</table>

Gpl sodium hydroxide and 1:3 material-to-liquor ratio is the optimum process.

Table 3 shows the fibre bundle strength decreases slightly after ambient temperature bleaching as compared to conventional hot bleaching. The drop in fibre bundle strength is more in case of alkali-treated and bleached fibre. Due to swelling effect after alkali treatment, fibre becomes coarse. Whiteness and brightness indices are found to be maximum in hot conventional bleached fibre. Ambient temperature bleached jute fibres show sufficiently high whiteness and brightness indices whereas single-bath alkali-treated and bleached fibre shows whiteness which is sufficient enough for subsequent dyeing operation.

Dye uptake of ambient temperature bleached fibre is more than that of conventional bleached jute fibre (Table 4). It is maximum in case of alkali-treated and ambient temperature bleached jute fibre. These findings are true both in case of Procion Red M8B and Remazol Yellow FG dyes. Single-bath alkali-treated and ambient temperature bleached fibre swells maximum which helps dye to enter the fibre through the pores and fix inside, thereby producing deep shade.

4 Conclusions
4.1 Pseudo single-bath process of alkali treatment and ambient temperature bleaching produces bleached samples with sufficiently high whiteness and brightness indices.

4.2 The bleached fibres thus produced show very high affinity towards reactive dye, producing 18% more colour yield in case of Procion Red M8B and 42% more in case of Remazol Yellow FG dye.

4.3 Pseudo single-bath alkali treatment and ambient temperature bleaching using 60 gpl sodium hydroxide in the alkali bath and 1:3 material-to-liquor ratio in the bleach bath is the optimum process sequence.

4.4 This process is simple and cost effective as intermediate washing step after alkali treatment is eliminated. Moreover, the same alkali bath can be reused after correcting the concentration of alkali in the bath.

4.5 The total process of single-bath alkali treatment–bleaching and reactive dyeing is carried out at ambient temperature and hence is highly suitable for cottage and small-scale industries in rural areas.

References