Effect of pretreatments on ambient temperature bleaching and reactive dyeing of jute

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Bleaching of grey jute yarn by conventional hot hydrogen peroxide bleaching, ambient temperature bleaching and ambient temperature bleaching using spent liquor has been studied. Before bleaching, the jute yarns were either scoured or treated with alkali at ambient temperature. One set of alkali-treated jute yarns was washed, dried and then used for bleaching and the other set of alkali-treated yarns was dried without washing and used for bleaching. All the bleached samples were dyed at room temperature using cold brand reactive dye. It is found that the whiteness and brightness indices of the jute yarn samples bleached by conventional process follow the order: grey bleached > scoured and bleached > alkali-treated (without wash) and bleached > alkali-treated (with wash) and bleached. For ambient temperature bleached samples, the order is: grey bleached > scoured and bleached > alkali-treated (with wash) and bleached. The dye uptake value increases with the following order of pretreatments: alkali-treated (without wash) > alkali-treated (with wash) > scoured > grey.

Keywords: Bleaching, Brightness index, Dyeing, Dye uptake, Scouring, Wash fastness, Whiteness index

1 Introduction

The eco-friendly and biodegradable nature of jute fibre along with its tenacity and long staple length has made this fibre attractive in the field of textiles and other decorative end uses worldwide. The natural golden fibre needs proper chemical processing, viz., pretreatment, bleaching, dyeing and aftertreatment, to make it attractive to the customer. Processing of jute is difficult due to its complex chemical structure i.e., cellulose, hemicellulose and lignin composition. A particular chemical treatment may be beneficial to one component but detrimental to other. Therefore, a balance is to be maintained during its chemical processing to get the optimum effect. Bleaching of jute is done in such a way that it produces creamy white fibre rather than milky white fibre to avoid the damage of the fibre. Similarly, the dyeing process is also selected in such a way that it does not damage the fibre and at the same time results in optimum fastness and dye uptake. Moreover, the jute product being heavy in nature, requires a lot of water to maintain a desirable material-to-liquor ratio as well as the drying of the material requires lot of energy.

To solve the above problems, the present work was aimed at chemical processing of jute yarn at ambient temperature. The process 1,2,3 requires less water, less energy and the damage to the fibre is minimum while using the conventional textile machineries without additional capital investment. The process is also suitable for small and cottage industry. Water and environment pollution problem is less in this process which makes reuse of chemical solution. As the whole process is carried out at ambient condition, it is easy to control the processing condition and the health hazard problem to the labour is also minimized. Conventional processing has also been carried out to compare the new process with the conventional process. An attempt has also been made to make the process economic, eco-friendly and energy efficient.

2 Materials and Methods

2.1 Materials

2.1.1 Substrate

The spinning of grey jute fibre was done in a jute spinning system. The average count of jute yarn produced was 235 tex.

2.1.2 Chemicals

Hydrogen peroxide, sodium hydroxide, sodium silicate, trisodium phosphate, magnesium sulphate
heptahydrate, sodium persulphate, sodium sulphate, Ultravon JU (non-ionic detergent) and acetic acid, all of analytical grade, were used.

2.1.3 Dye
Cold brand reactive dye Procion Red MSB (supplied by M/s Hindusthan Ciba-Geigy Limited, Mumbai) was used for dyeing of jute yarn.

2.2 Methods
A diagrammatic flow chart of the total experiment is shown in Fig.1.

2.2.1 Scouring
Grey jute yarn was scoured with sodium hydroxide (2 g/L) and non-ionic detergent (5 g/L) at 100°C for 1 h, keeping the material-to-liquor ratio at 1:20. After scouring, the yarn was washed thoroughly in hot water and cold water in succession and neutralized with acetic acid (2 ml/L) followed by usual washing.

2.2.2 Alkali Treatment
Grey jute yarn was treated with sodium hydroxide (10 g/L) and non-ionic detergent (2 g/L) at ambient temperature (30°C) for 4 h, keeping the material-to-liquor ratio at 1:10. After the treatment, one set of yarn sample was taken out from the solution, squeezed and dried in air. The other set of yarn sample was washed thoroughly in cold water, neutralized with acetic acid (2 ml/L), again washed and finally dried in air.

2.2.3 Conventional Bleaching
Bleaching of grey, scoured and alkali-treated jute yarn samples was done in a closed vessel for 2 h at 90°C, keeping the material-to-liquor ratio at 1:20, with hydrogen peroxide (1 vol.), trisodium phosphate (5 g/L), sodium hydroxide (1 g/L), sodium silicate (10 g/L) and non-ionic detergent (2 g/L). After bleaching, the yarn samples were washed thoroughly in cold water, neutralized with acetic acid (2 ml/L), again washed and finally dried in air.

2.2.4 Ambient Temperature Bleaching
Grey, scoured and alkali-treated jute yarn samples intended for ambient temperature bleaching were separately dipped in the solution containing hydrogen peroxide (10 vol.), sodium silicate (20 g/L), sodium hydroxide (20 g/L), trisodium phosphate (5 g/L), sodium persulphate (10 g/L), magnesium sulphate heptahydrate (0.5 g/L), Ultravon JU (10 g/L) and squeezed to give 80% wet pick-up. The samples were then put in a plastic bag and kept overnight, washed in cold water, neutralized in acetic acid (2 ml/L), again washed and dried at room temperature.

2.2.5 Ambient Temperature Bleaching using Spent Liquor
The liquor left out after ambient temperature

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**Fig.1** — Diagrammatic flow chart of the total experiment represented by the alphabets to indicate process alternatives
bleaching as in 2.2.4 was reused for the preparation of second batch of sample so that the effluent disposal problem is minimum. Grey, scoured and alkali-treated jute yarn samples intended for ambient temperature bleaching (using spent liquor) were dipped in the spent liquor and squeezed to give 80% wet pick-up. The samples were then put in a plastic bag and kept overnight, washed in cold water, neutralized in acetic acid (2mL/L), again washed with cold water and dried at room temperature.

### 2.2.6 Dyeing

Grey conventional bleached, scoured and conventional bleached, alkali-treated and conventional bleached, grey ambient temperature bleached, scoured and ambient temperature bleached, alkali-treated and ambient temperature bleached jute yarn samples were dyed with cold brand reactive dye Procion Red MBB under the following conditions:

Dye bath was prepared with dye (4% owm) and Glauber's salt (60 g/L), keeping the material-to-liquor ratio at 1:20. The yarn samples were dipped into the dye bath and kept for 1 h with stirring at a temperature of 30°C. After this, sodium carbonate (20 g/L) was added in the same bath and kept for 45 min in 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.

### 2.2.7 Determination of the Physico-chemical Properties

#### 2.2.7.1 Whiteness Index, yellowness index and brightness index

Whiteness index in the 'HUNTER' scale, yellowness index in the 'ASTM D 1925' scale and brightness index in the 'TAPPI 45' scale of the grey, scoured, alkali-treated, grey bleached, scoured and bleached, alkali-treated and bleached jute yarn samples were measured by the Spectrascan-5100® computer colour matching system using relevant softwares.

#### 2.2.7.2 $\lambda_{max}$ and K/S Values

Spectrascan-5100® computer colour matching system was used to measure $\lambda_{max}$ and K/S values.

#### 2.2.7.3 Wash Fastness

All the reactive dyed jute yarn samples were subjected to wash fastness test in a launder-O-meter as per IS : 3361-1979 (ref.4). Wash fastness ratings of all the dyed jute yarn samples were evaluated with the help of computer colour matching system.

### 3 Results and Discussion

It is clear from Table 1 that the conventional bleaching produces better white yarn as compared to ambient temperature bleaching whether it is done by using original liquor or spent liquor. It may be due to the removal of impurities at alkaline boiling which gives opportunity to the bleaching agent to react immediately on the fibre. Ambient temperature bleaching from original bath produces better whiteness compared to that from spent liquor due to the obvious reason. The difference in whiteness and brightness indices of the yarn produced by grey-bleach or scour-bleach process is minimum in case of ambient temperature bleaching compared to the conventional bleaching (Table 1).

Alkali treatment at ambient condition swells the yarn and takes out impurities and non-cellulosic matters like hemicellulose, lignin, etc. on the surface. Therefore, the yarn becomes darker after alkali treatment, but if the yarn is washed, it becomes brighter compared to grey yarn which is evident from Table 2. Alkali-treated yarn with wash behaves like

#### Table 1--Effect of scouring on conventional and ambient temperature bleaching

<table>
<thead>
<tr>
<th>Sample</th>
<th>Whiteness index (HUNTER)</th>
<th>Whiteness index (ASTM D1925)</th>
<th>Brightness index (TAPPI 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>45.28</td>
<td>47.72</td>
<td>16.57</td>
</tr>
<tr>
<td>B</td>
<td>46.53</td>
<td>47.07</td>
<td>17.86</td>
</tr>
<tr>
<td>C</td>
<td>77.92</td>
<td>24.95</td>
<td>55.19</td>
</tr>
<tr>
<td>D</td>
<td>73.91</td>
<td>30.49</td>
<td>47.78</td>
</tr>
<tr>
<td>E</td>
<td>71.71</td>
<td>22.84</td>
<td>47.35</td>
</tr>
<tr>
<td>F</td>
<td>70.21</td>
<td>34.17</td>
<td>42.31</td>
</tr>
<tr>
<td>G</td>
<td>67.79</td>
<td>28.42</td>
<td>40.88</td>
</tr>
<tr>
<td>H</td>
<td>66.64</td>
<td>39.91</td>
<td>36.76</td>
</tr>
</tbody>
</table>

#### Table 2—Effect of bleaching on alkali-treated jute yarns with wash or without wash

<table>
<thead>
<tr>
<th>Sample</th>
<th>Whiteness index (HUNTER)</th>
<th>Yellowness index (ASTM D1925)</th>
<th>Brightness index (TAPPI 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>48.06</td>
<td>47.48</td>
<td>19.92</td>
</tr>
<tr>
<td>J</td>
<td>41.31</td>
<td>60.81</td>
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</tr>
<tr>
<td>K</td>
<td>74.11</td>
<td>24.77</td>
<td>49.61</td>
</tr>
<tr>
<td>L</td>
<td>69.78</td>
<td>32.47</td>
<td>42.23</td>
</tr>
<tr>
<td>M</td>
<td>74.96</td>
<td>20.28</td>
<td>51.86</td>
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<tr>
<td>N</td>
<td>66.77</td>
<td>38.51</td>
<td>37.81</td>
</tr>
<tr>
<td>O</td>
<td>68.53</td>
<td>39.51</td>
<td>39.87</td>
</tr>
<tr>
<td>P</td>
<td>67.37</td>
<td>39.65</td>
<td>37.78</td>
</tr>
<tr>
<td>Q</td>
<td>64.42</td>
<td>39.42</td>
<td>34.81</td>
</tr>
<tr>
<td>R</td>
<td>66.26</td>
<td>38.86</td>
<td>36.03</td>
</tr>
</tbody>
</table>
scoured yarn and after hot conventional bleaching it gives whiteness as that of scoured and bleached yarn. If the alkali-treated yarns are dried without wash, they produce high alkaline condition during bleaching. Therefore, in hot conventional bleaching, the whiteness and brightness indices drop significantly. Experiments have shown that the alkali-treated without wash yarns release about 1.6 g/L sodium hydroxide in 1:20 material-to-liquor ratio condition. If these yarns are subjected to hot bleach without adding any alkali during bleaching, they produce whiteness as that of scoured and bleached yarns. Alkali-treated yarns dried without wash have impurities present on the surface of the swelled yarn structure and when subjected to ambient temperature bleaching structure they produce better whiteness compared to that of alkali-treated (with wash) ambient temperature bleached yarn. This may be due to high alkalinity, swelled structure and the impurities being present on the surface easily attacked by bleaching agent. This finding is true for both original liquor ambient temperature bleaching and spent liquor ambient temperature bleaching.

Table 3 shows the dyeing behaviour of scoured and bleached jute yarn. The scoured and hot conventional bleached jute yarn shows marginal higher dye uptake compared to control yarn. This may be due to the thorough removal of impurities present on the surface of jute yarn during scouring. Ambient temperature bleaching was done at higher alkaline condition which results in swelling of the yarn to some extent. Therefore, the ambient temperature bleached jute yarn shows better dye uptake compared to the control jute yarn. Scoured and ambient temperature bleached jute yarn shows even better dye uptake. Table 3 shows that the yarns subjected to ambient temperature bleaching using spent liquor have a tendency of better dye uptake compared to the only ambient temperature bleached yarn if the yarn is bleached after scouring. Wash fastness property of dyed yarns is equally good for all the samples.

Two - step swelling of jute yarn, one during alkali treatment and another during ambient temperature bleaching, exposed more number of reactive hydroxyl groups to reactive dye and as a result the higher dye uptake is seen in case of alkali-treated ambient temperature bleached jute yarn (Table 4). If alkali-treated samples are not washed before ambient temperature bleaching, they yield even better dye uptake. This finding is true for both original liquor ambient temperature bleaching and spent liquor ambient temperature bleaching. Experiments have shown that about 9 g/L sodium hydroxide is released in 1:3 material-to-liquor ratio condition if alkali-treated samples are not washed. If ambient temperature bleaching is carried out without further addition of alkali during bleaching, no extra swelling takes place during bleaching, resulting in lower dye uptake. Therefore, alkali treatment without wash followed by ambient temperature bleaching and then dyeing with Procion Red M8B results in higher dye uptake.

4 Conclusions
4.1 Ambient temperature bleaching and reactive dyeing is simple, economical, energy saving, eco-friendly and can be done by using conventional textile machinery. The process is suitable for small-scale and cottage industries.
4.2 Ambient temperature bleaching produces sufficient whiteness suitable for subsequent use in dyeing.
4.3 Ambient temperature bleaching using spent liquor is economical, minimizes the effluent and produces sufficient whiteness for subsequent use in dyeing.
4.4 Ambient temperature bleaching of alkali-treated yarn without wash produces superior whiteness as compared to that of the ambient temperature bleached yarn pre-treated with alkali (with wash). If alkali-treated yarn without wash is used for conventional hot bleaching, addition of further alkali is not required during bleaching and the whiteness obtained is same as that of scoured and hot bleached yarn.

4.5 Ambient temperature bleached yarn always shows higher reactive dye uptake compared to that of conventional bleached yarn. Scoured and ambient temperature bleached yarn is even better in this respect.

4.6 Alkali-treated yarn without wash on ambient temperature bleaching and then dyeing with cold brand reactive dye produces maximum dye uptake. Therefore, for the production of same depth of shade, this yarn requires around 20% less dye than that required by the grey conventional bleached yarn.

4.7 For ambient temperature processing, alkali treatment without wash followed by ambient temperature bleaching produces better whiteness, and the dye uptake is also maximum.

References