Pseudo single-bath process for ambient temperature bleaching and reactive dyeing of jute

S N Chattopadhyay, N C Pan & A Day

Chemical & Biochemical Processing Division, National Institute of Research on Jute & Allied Fibre Technology,
12 Regent Park, Kolkata 700 040, India

Received 19 June 2002; accepted 10 September 2002

Grey jute fibre has been bleached at ambient temperature using hydrogen peroxide and then cold dyed with Procion Red M8B and Remazol Yellow FG dyes by four different process sequences, namely conventional two-step process, true single-bath process, pseudo single-bath process and pseudo single-bath process using spent bleach bath. The effect of process sequences on colour yield of dyed jute fibre has been evaluated using computer colour matching system. It is observed that the colour yield by pseudo single-bath process is well comparable with that of the conventional two-step ambient temperature bleaching and cold reactive dyeing process. It is also observed that the colour yield is maximum in case of pseudo single-bath process and minimum in case of true single-bath process. The process of dyeing has no effect on \(\lambda_{max}\) value which confirms no alteration in the hue and tone of any sample dyed with reactive dye by different single-bath processes. The wash fastness is satisfactory in all the processes.

Keywords: Ambient temperature bleaching, Jute fibre, Pseudo single-bath process, Reactive dyeing

1 Introduction

Decreasing trend in the use of jute fibre in the traditional sector, like packaging, is being well compensated by the increasing use of jute in the diversified sectors. Jute is now finding its use in several diversified applications like curtains, upholstery, bags / luggage, handicrafts and even in apparel sector. So, the wet processing of jute has occupied very important position in jute industry as the diversified use needs attractive look where bleaching, dyeing and finishing are must. But the processing of jute requires a lot of energy, water, chemicals, etc. which not only increases the cost of processing but also leads to environment pollution through effluents. Several works have been done in the recent past, like ambient temperature bleaching \(^1\), foam application technology and single-bath bleaching-dyeing to combat the above problems. Considering the energy problem, environment pollution, ease of processing in the rural sector, etc., the present work has been devised in such a way that all the processings like bleaching and dyeing will be carried out at ambient temperature. Moreover, the attempts have also been made to carry out both the processes in the same bath. Also, the spent liquor after ambient temperature bleaching \(^5\) has been reused for another batch of ambient temperature bleaching. This is an integrated approach suitable specifically for rural small-scale sector where all the resources like thermal energy, electrical energy, skilled manpower, adequate finance, easy availability of chemicals, water, etc. are scare.

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.

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

Reactive dyes Procion Red M8B (nucleophilic substitution type) and Remazol Yellow FG (nucleophilic addition type) were used for dyeing of jute fibre.

2.2 Methods

2.2.1 Conventional Bleaching of Grey Jute Fibre

Bleaching of grey jute fibre was carried out in a closed vessel at 90°C for 2 h, keeping the material-to-liquor ratio at 1:20, using 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 fibre samples were washed thoroughly in cold water, neutralized with acetic acid (2 mL/L), again cold washed and finally dried in air.

2.2.2 Ambient Temperature Bleaching of Grey Jute Fibre

Jute fibre intended for ambient temperature bleaching was dipped in a 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) and Ultravon JU (10 g/L), keeping the material-to-liquor ratio at 1:3, and squeezed to give 100% wet pick-up. The samples were put in a plastic bag and kept as such for overnight. The samples were then washed, neutralized with acetic acid (2 mL/L) and washed again in cold water before drying at room temperature.

2.2.3 Dyeing of Ambient Temperature Bleached Jute Fibre

Ambient temperature bleached jute fibres were dyed with two different reactive dyes, namely Procion Red M8B and Remazol Yellow FG, using the following procedure:

Procion Red M8B — Dye bath was made with dye (4%) and Glauber’s 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 for 1 h with stirring at 30°C. After this treatment, 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 at boil followed by usual washing and drying in air.

Remazol Yellow FG — Dye bath was made with dye (4%) and Glauber’s 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 30°C. After this treatment, the sodium hydroxide (4 g/L) was added in the same bath and kept for 1 h under the same condition. Thereafter, the samples were washed with cold water, soaped with Ultravon JU (2 g/L) for 15 min at boil followed by usual washing and drying in air.

2.2.4 Single-Bath Bleaching - Dyeing of Jute Fibre

Ambient temperature bleaching and reactive dyeing of jute fibre was carried out by using three different process sequences, namely true single-bath process, pseudo single-bath process and pseudo single-bath process using spent bleach bath.

2.2.4.1 True Single-Bath Process

For ambient temperature bleaching, grey jute fibre was dipped in a 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) and Ultravon JU (10 g/L), keeping the material-to-liquor ratio at 1:3. After keeping the bath as such for 2 h, sodium hydrosulphite (10 g/L) was added to it and the solution was stirred for 15 min.

Procion Red M8B (4%) and Glauber’s salt (60 g/L) were added to the above bleach bath and kept for 1 h with stirring at 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 at boil followed by usual washing and drying in air.

Remazol Yellow FG (4%) and Glauber’s salt (80 g/L) were added to the above bleach bath and kept for 20 min with stirring at 30°C. After this treatment, the sodium carbonate (20 g/L) was added in the same bath and kept for 1 h under the same condition. Thereafter, the samples were washed with cold water, soaped with Ultravon JU (2 g/L) for 15 min at boil followed by usual washing and drying in air.

2.2.4.2 Pseudo Single-Bath Process

For ambient temperature bleaching, grey jute fibre was dipped in a 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) and Ultravon JU (10 g/L), keeping the material-to-liquor ratio at 1:3. The bleached fibre was then put in a separate bath containing 10 times its volume of water (M:L = 1:10). Sodium hydrosulphite (3 g/L) was added to the bath and kept for 15 min with continuous stirring.

Procion Red M8B dye (4%) and Glauber’s salt (60 g/L) were added to the above bath and kept for 1 h with stirring at 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 at boil followed by usual washing and drying in air.

Remazol Yellow FG dye (4%) and Glauber's salt (80 g/L) were added to the above bath and kept for 20 min with stirring at 30°C. After this treatment, the sodium hydroxide (4 g/L) was added in the same bath and kept for 1 h under the same condition. Thereafter, the samples were washed with cold water, soaked with Ultravon JU (2 g/L) for 15 min at boil followed by usual washing and drying in air.

2.2.4.3 Pseudo Single-Bath Process using Spent Bleach Bath

The liquor left out after ambient temperature bleaching, as described in section 2.2.2, was reused for the preparation of second batch of the sample. Grey jute fibre intended for ambient temperature bleaching using spent liquor was dipped in the above liquor and squeezed to give 100% wet pick-up. The samples were put in a plastic bag and kept for 2 h. The bleached fibre (without washing) was then put in a separate bath containing ten times its volume of water (M:L::1:10). Sodium hydrosulphite (2 g/L) was added to the bath and kept for 15 min with continuous stirring. The dyeing was carried out in the same way as mentioned in section 2.2.4.2.

2.3 Determination of Physico-Chemical Properties

2.3.1 Whiteness, Yellowness and Brightness Indices

Whiteness index (HUNTER scale), yellowness index (ASTM D 1925 scale) and brightness index (TAPPI 45 scale) of grey, conventional bleached and ambient temperature bleached jute fibre samples were measured by the Spectrascan-5100 (R) computer colour matching system using relevant softwares.

2.3.2 \( \lambda_{\text{max}} \) Reflectance and K/S Values

Spectrascan-5100 (R) computer colour matching system was also used to measure \( \lambda_{\text{max}} \) reflectance and K/S values of different types of reactive dyed jute fibre samples using relevant softwares and following formula:

\[
K / S = \left(1 - R \right)^2 / 2R = C
\]

where \( K \) is the coefficient of absorption; \( S \), the coefficient of scattering; \( R \), the reflectance of substrate at \( \lambda_{\text{max}} \); and \( C \), the concentration of dye. The \( K / S \) value is viewed as an index of dye uptake.

2.3.3 Wash Fastness

All the reactive dyed jute fibre samples were subjected to wash fastness tests in a launder-O-meter as per IS:3361-1979 (ref.6). Wash fastness ratings of all the dyed jute fibre samples were evaluated with the help of computer colour matching system.

3 Results and Discussion

Table 1 shows that both the whiteness and brightness indices are poor in case of grey jute fibre but after bleaching both the indices improve considerably. There is a substantial decrease in yellowness index after bleaching. Conventional bleaching process produces better bleaching effect compared to ambient temperature bleaching process. The whiteness and brightness achieved after ambient temperature bleaching are satisfactory enough for subsequent dyeing operation.

Table 2 shows that the ambient temperature bleached jute fibre produces higher K/S value as compared to conventional bleached jute fibre, indicating that the
colour yield is more in case of ambient temperature bleached jute fibre. This finding is true for both Procion Red M8B (substitution type of reactive dye) and Remazol Yellow FG (addition type of reactive dye). The higher dye uptake may be due to the high alkaline condition used during ambient temperature bleaching. Wash fastness property is found to be good in all the cases.

In true single-bath process (Table 3), the colour yield is very poor when sodium hydrosulphite is not added for counteracting the oxidising effect of hydrogen peroxide bleached bath and alkali is not added during the fixation stage of reactive dye. Some minor improvement in colour yield is observed when sodium hydrosulphite or alkali is added alone. But more improvement in colour yield is observed when both sodium hydrosulphite and alkali are added in the bath. This finding is true for both the reactive dyes studied. In all the cases, the colour yield is very poor when true single-bath process is followed. Wash fastness of all the samples is moderate. Low liquor ratio, high alkali concentration and very high oxidising agent concentration may be responsible for poor colour yield. Hence, it was decided that the true single-bath process will not serve the purpose and the idea of pseudo single-bath process was emerged.

In pseudo single-bath process, as the fibre was not washed after bleaching, it carried a portion of excess alkali to the dye bath. So, alkali was not added in the bath during fixation stage of reactive dyes. The colour yield of dyed samples was found to be poor in both types of pseudo single-bath processes. For the improvement in fixation of dyes, the alkali was added to the dye bath during fixation stage and the colour yield was found to be satisfactory in all the cases whether it is pseudo single-bath process or pseudo single-bath process using spent bleach bath (Table 4).

To optimize the concentration of reducing agent after bleaching both in case of pseudo single-bath process (Table 5) and pseudo single-bath process

---

### Table 3 - Effect of intermediate addition of reducing agent after bleaching and alkali during fixation stage of reactive dyeing on dyeing behaviour of jute fibre using true single-bath process at ambient temperature

<table>
<thead>
<tr>
<th>Addition of sodium hydrosulphite</th>
<th>Addition of alkali</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
<th>Wash fastness</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>550</td>
<td>37.34</td>
<td>0.53</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>550</td>
<td>33.76</td>
<td>0.65</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>550</td>
<td>32.88</td>
<td>0.69</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>550</td>
<td>26.46</td>
<td>1.02</td>
</tr>
</tbody>
</table>

RFL — Reflectance

### Table 4 - Effect of alkali during fixation stage of reactive dye in pseudo single-bath process and pseudo single-bath process using spent bleach bath at ambient temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With alkali</td>
<td>Without alkali</td>
<td>With alkali</td>
<td>Without alkali</td>
</tr>
<tr>
<td>( \lambda_{\text{max}} \text{ nm} )</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Reflectance</td>
<td>6.19</td>
<td>23.82</td>
<td>10.05</td>
<td>27.02</td>
</tr>
<tr>
<td>K/S</td>
<td>7.11</td>
<td>1.22</td>
<td>4.02</td>
<td>0.99</td>
</tr>
</tbody>
</table>

### Table 5 - Effect of reducing agent after bleaching on dyeing behaviour of reactive dyes using pseudo single-bath process at ambient temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda_{\text{max}} \text{ nm} )</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Reflectance</td>
<td>23.82</td>
<td>12.11</td>
</tr>
<tr>
<td>K/S</td>
<td>1.22</td>
<td>3.19</td>
</tr>
</tbody>
</table>

*a Sodium hydrosulphite concentration in g/L*
Table 6 - Effect of reducing agent after bleaching on dyeing behaviour of reactive dyes following pseudo single-bath process using spent bleach bath at ambient temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0°</td>
<td>1.5°</td>
</tr>
<tr>
<td>$\lambda_{\text{max}}$ nm</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Reflectance</td>
<td>30.82</td>
<td>9.61</td>
</tr>
<tr>
<td>$K/S$</td>
<td>0.79</td>
<td>4.25</td>
</tr>
</tbody>
</table>

*Sodium hydrosulphite concentration in g/L*

Table 7 - Effect of different single-bath bleaching-dyeing processes at ambient temperature on colour yield using two reactive dyes

<table>
<thead>
<tr>
<th>Process</th>
<th>Procion Red M8B</th>
<th>Remazol Yellow FG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\lambda_{\text{max}}$ nm</td>
<td>RFL</td>
</tr>
<tr>
<td>True single-bath process</td>
<td>550</td>
<td>25.46</td>
</tr>
<tr>
<td>Pseudo single-bath process</td>
<td>550</td>
<td>6.19</td>
</tr>
<tr>
<td>Pseudo single-bath process</td>
<td>550</td>
<td>8.44</td>
</tr>
</tbody>
</table>

using spent bleach bath (Table 6), different concentrations of sodium hydrosulphite (0, 1.5, 2.0, 3.0, and 5.0 g/L) were used. The colour yield increased with the increase in sodium hydrosulphite concentration up to 3 g/L in pseudo single-bath process and up to 2 g/L in pseudo single-bath process using spent bleach bath. Thereafter, a decreasing trend in colour yield was observed. Sodium hydrosulphite reacts with the active hydrogen peroxide remaining inside the fibre and in the bath up to the optimized concentration. The higher concentration, than the optimized one, acts on the dyestuff in addition to its action with oxidising agent, thereby reducing the colour yield.

Dyeing properties of jute fibre dyed with Procion Red M8B and Remazol Yellow FG at optimized condition using different processes are given in Table 7. It is evident that the colour yield is maximum in case of pseudo single-bath process and minimum in case of true single-bath process. By comparing the colour yields from Table 2 and Table 7, it is revealed that the pseudo single-bath process is well comparable with the conventional two-step process using ambient temperature bleaching and cold reactive dyeing. Pseudo single-bath process using spent bleach liquor produces higher colour yield than that produced by true single-bath process but lower than that produced by pseudo single-bath process.

4 Conclusions

4.1 Whiteness index produced by ambient temperature process is slightly lower than that produced by conventional hot bleaching process. The whiteness and brightness achieved after ambient temperature bleaching is satisfactory enough for subsequent dyeing operation.

4.2 Dyeing of ambient temperature bleached jute fibre produces higher colour yield as compared to conventional bleached jute fibre. This finding is true for both Procion Red M8B (substitution type) and Remazol Yellow FG (addition type) dyes. High alkaline condition during ambient temperature bleaching results in swelling of fibre which ultimately gives better colour yield.

4.3 In true single-bath process, the addition of reducing agent (sodium hydrosulphite) after bleaching and that of alkali during fixation stage is must. But the colour yield is very poor when true single-bath process is followed for ambient temperature bleaching and cold reactive dyeing. Low liquor ratio, high alkali concentration and very high oxidizing agent concentration may be responsible for poor colour yield. So, the true single-bath process was not found to serve the purpose and the idea of pseudo single-bath process was emerged.

4.4 In pseudo single-bath process, the addition of 3 g/L sodium hydrosulphite after bleaching and the
required amount of alkali for fixation of reactive dye is must. Colour yield produced by pseudo single-bath process is well comparable with that produced by conventional two-step process using ambient temperature bleaching and cold reactive dyeing.

4.5 Pseudo single-bath process using spent bleach bath produced higher colour yield than that produced by true single-bath process but it is lower than that produced by pseudo single-bath process. In this case, the optimized concentration of sodium hydrosulphite is 2 g/L to achieve maximum colour yield. As the spent bleach bath can be reused, this process becomes simple and economic with minimum effluent disposal problem as after spent liquor bleaching there is hardly any liquor left out in the bath for disposal.

4.6 Wash fastness ratings are satisfactory in all the processes.

References