Short Communication

Study on crosslinked dyed jute carpet pile yarns

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Jute carpet pile yarns have been treated with Indosol E-50 powder, dyes and magnesium chloride hexahydrate (MgCl2.6H2O) catalyst, and both treated (crosslinked dyed) and untreated yarns are used to prepare jute carpets in a mill. Several carpet parameters, such as thickness recovery, compression recovery, work of recovery, tuft withdrawal force and moisture content, of the treated carpet samples have been studied and compared with those of the untreated carpet of the same pile height. The results show improvement in the performance characteristics of the crosslinked dyed jute carpet.

Keywords: Carpet pile yarns, Crosslinking agent, Jute carpet

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Jute fibres are largely used for the industrial production of cheap and aesthetically attractive jute carpets. But these carpets are found to possess defects, such as poor resilience, poor colour fastness, high fibre shedding propensity and excessive hygroscopic behaviour, in comparison to synthetic and wool carpets. As a result, jute carpets are losing markets in competition with those carpets. Hence, it is essential to address these defects of jute carpets to make them competitive products. Earlier, blending of jute fibre with other quality allied/synthetic fibres and chemical modification of jute fibres were presumed to be some of the probable means to improve the serviceability of jute carpets and furnishing products.1-4 For improving crease resistance properties of bleached jute fabrics, jute was crosslinked with urea-formaldehyde (UF) and melamine formaldehyde (MF) precondensate.4-6 Based on this, the resilience of jute carpets was increased by about 4% with UF crosslinking on jute carpet pile yarn having 4.5% resin add-on. The present work was, therefore, undertaken to improve the properties of jute carpet by crosslinking jute carpet pile yarn with Indosol E-50 powder using magnesium chloride hexahydrate (MgCl2.6H2O) catalyst.

Jute (Corchorus capsularis) carpet pile yarn (white jute, 7.5 × 2 = 15 lbs/spy) was used for the study. Indosol E-50 powder was used for the study. It is a white powder, cationic in character, and polyfunctional organic nitrogen derivative having pH 6.5-7 (50g/L).

Preparation of Treating Liquor

The requisite amount of Indosol E-50 powder (Sandoz) (40 g/L) was dissolved in water and the pH of solution was adjusted at 6. Magnesium chloride hexahydrate (BDH analytical grade, 10% on the weight of precondensate) was then added followed by the addition of a few drops of wetting agent (Nikanil of Ciba Geigy). Procion M type of reactive dye (ICI) was dissolved by pasting 20 g/L with cold water followed by pouring warm water. The solution, thus prepared, was used to treat jute carpet pile yarn.

Pretreatment of Jute Carpet Pile Yarn

The jute carpet pile yarn (50 kg) was bleached with hydrogen peroxide to remove natural waxes and pectic substances, treated with acetic acid for neutralization, washed with water, dried in the air, dyed and finally crosslinked.

Impregnation

The bleached jute yarns were treated with predissolved dyes and common salt (30 g/L) for exhaustion in a solution maintaining 1:10 M:L ratio for 20 min, hydroextracted and then immersed in another bath having solution (yarn-to-liquor ratio 1:10) of crosslinking agent along with catalyst for 30 min. The yarns were then hydroextracted to 100% wet pick-up, dried, cured, washed and air dried.
Drying and Curing

The impregnated yarns were dried at 110°C for 4 min to residual moisture of 4% and cured at 150°C for 4 min in the chamber of an Industrial Cloth Stenter (Toda Tsutto Kasha Ltd.). The cured yarns were cooled to ambient temperature (24 h) and then washed successively in sodium carbonate solution (1%) to remove unfixed dyes and water. The yarns were hydroextracted and air dried. The resin add-on was determined by the standard method.7

Determination of Physical Properties of Yarns

The treated and untreated (control) yarns were conditioned for 48 h in a standard atmosphere (65±2% RH at 20±2°C) according to B.S.1051. The fibre strength (kg/mg) was determined by Pressley bundle strength tester. The tensile strength (N) was determined by Good Brand single yarn tester. The count (lb/spy), moisture content (%) and moisture regain (%) were determined by standard methods. The results are shown Table 1.

Preparation of Sample Carpet

Two pieces of jute carpets (12 inch × 36 inch) were prepared in the Bengal Carpet Mills Ltd., Savar, Dhaka, Bangladesh, by using separately the untreated (control) and the treated jute carpet pile yarns.

Determination of Carpet Parameters

Sizeable test specimens (3 inch × 3 inch) were cut out of the sample carpets according to the requirement of digital thickness gauge.8 The specimens were exposed to a standard atmosphere (48 h) according to BS 1051. The thickness was then measured by using the above thickness gauge which was initially at the foot pressure of 1.72 kN/m² or 16 gf/cm². The thickness was measured at different loads, such as 5.17, 20.67, 41.34, 62.01 and 82.68 kN/m² for a compression period of 30 s in each case. The thickness was also measured in the same manner after decreasing the load gradually from 82.68 kN/m² to 1.72 kN/m². The results are given in Table 2.

The thickness recovery was calculated using the following equation:

\[
\text{Thickness recovery} \% = \left(\frac{b}{a}\right) \times 100
\]

where \(a\) is the initial thickness (mm) of the test specimen; and \(b\), the final thickness (mm) of the test specimen after withdrawal of all the applied loads.

<table>
<thead>
<tr>
<th>Load kN/m²</th>
<th>Mean thickness (mm) Unreated</th>
<th>Mean thickness (mm) Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.72</td>
<td>12.3673(1.177)</td>
<td>12.8829(0.603)</td>
</tr>
<tr>
<td>5.17</td>
<td>12.1133(1.644)</td>
<td>12.7609(0.481)</td>
</tr>
<tr>
<td>20.67</td>
<td>10.9626(3.421)</td>
<td>12.4790(0.581)</td>
</tr>
<tr>
<td>41.34</td>
<td>9.7409(4.132)</td>
<td>12.2301(0.789)</td>
</tr>
<tr>
<td>62.01</td>
<td>8.9839(4.160)</td>
<td>11.6053(4.324)</td>
</tr>
<tr>
<td>82.68</td>
<td>8.4988(3.992)</td>
<td>10.4419(2.647)</td>
</tr>
<tr>
<td>62.01</td>
<td>8.5065(3.967)</td>
<td>10.4521(2.365)</td>
</tr>
<tr>
<td>41.34</td>
<td>8.5826(3.861)</td>
<td>10.5258(2.300)</td>
</tr>
<tr>
<td>20.67</td>
<td>8.8087(3.714)</td>
<td>10.7899(2.209)</td>
</tr>
<tr>
<td>5.17</td>
<td>9.4183(3.263)</td>
<td>11.3741(1.647)</td>
</tr>
<tr>
<td>1.72</td>
<td>9.7815(2.935)</td>
<td>11.6637(1.311)</td>
</tr>
</tbody>
</table>

Values in parentheses indicate CV %.

The work of recovery of the respective test carpets was calculated using the following equation:

\[
\text{Work of recovery} \% = \left(\frac{Y}{X}\right) \times 100
\]

where \(X\) is the work of compression during loading sequence; and \(Y\), the work of recovery during unloading sequence. The \(X\) and \(Y\) parameters were calculated as follows:

\[
X = \frac{0.5A + 2.75B + 5.25C + 6D + 6E - 20F}{2000}
\]

and

\[
Y = \frac{0.5A' + 2.75B' + 5.25C' + 6D' + 6E' - 20F'}{2000}
\]
where $A$ is the initial thickness (mm) of the test specimen at zero foot pressure, i.e. 1.72 kN/m$^2$ pressure (dead load); $B-E$, the thickness at 5.17, 20.67, 41.34 and 62.01 kN/m$^2$ respectively during loading; $A'-E'$, the thickness at 1.72, 5.17, 20.67, 41.34, 62.01 kN/m$^2$ respectively during unloading; $F & F'$, the thickness values at 82.68 kN/m$^2$ and on withdrawal of load. The results of thickness recovery, compression recovery, work of recovery and the moisture content of the untreated (control) and the treated carpet samples are shown in Table 3.

The tuft withdrawal force (twf) was measured by WIRA (Wool Industry Research Association, Australia) tuft withdrawal tensometer. The force was measured in Newton. The open end of the tuft yarn was locked with a pair of scissors. The scissors were pulled upward and attached to a pointer moving round a graduated dial giving the exact Newton force required for withdrawal of the tuft yarn under investigation. The mean value of 25 readings was calculated. The loss in thickness (%) of both the carpets was determined by using WIRA dynamic loading machine after thousand dynamic impacts or beatings on each sample. The results are shown in the Table 4.

Table 3—Parameters of untreated and treated jute carpets to indicate variation in performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Untreated carpet (control)</th>
<th>Treated carpet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness recovery, %</td>
<td>79.09</td>
<td>90.54</td>
</tr>
<tr>
<td>Compression recovery, %</td>
<td>33.16</td>
<td>50.05</td>
</tr>
<tr>
<td>Work of recovery, %</td>
<td>23.00</td>
<td>26.17</td>
</tr>
<tr>
<td>Moisture content, %</td>
<td>12.40</td>
<td>11.50</td>
</tr>
</tbody>
</table>

Table 4—Thickness, tuft withdrawal force and thickness loss due to loading on untreated and treated jute carpets

<table>
<thead>
<tr>
<th>Property</th>
<th>Untreated carpet</th>
<th>Treated carpet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of the carpet measured under a load of 1.72 kN/m$^2$, mm</td>
<td>12.3673</td>
<td>12.8829</td>
</tr>
<tr>
<td>Tuft withdrawal force, N</td>
<td>7.60</td>
<td>6.22</td>
</tr>
<tr>
<td>Thickness loss due to 1000 impacts, %</td>
<td>60.58</td>
<td>64.80</td>
</tr>
<tr>
<td>Thickness after 1000 impacts, mm</td>
<td>7.4930</td>
<td>8.3490</td>
</tr>
</tbody>
</table>

It appears from Table 1 that the treated pile yarn shows improvement in most of its physical properties, except the fibre strength and tensile strength. The yarn shows greater count owing to resin add-on. The treated yarn is found to have less affinity for moisture absorption than the untreated yarns. The moisture content and moisture regain of the modified yarns are found to be 13.80% and 12.13% corresponding to 14.28% and 12.50% for control yarns. In addition to this, the treated carpet possesses lesser moisture content than the control carpet. Hence, it is inferred that the treated carpet will be more durable than the untreated carpet because of lesser susceptibility to fungal growth on account of lesser moisture content. The thickness of untreated and treated carpets during loading and unloading sequence is given in Table 2 with CV percentage in parentheses. It is observed that the thickness of both untreated and treated carpet decreases with increasing loading sequence; finally the thickness increases during unloading sequence for both the carpets. Again the thickness recovery (%), compression recovery (%), and work of recovery (%) for untreated and treated carpet is given in Table 3. It appears that the thickness recovery, compression recovery, work of recovery are higher for treated carpet than those for untreated carpet. For more in depth assessment of the carpet properties of the control jute (untreated) and the treated jute carpet of the same pile heights, three more carpet parameters were studied which are (i) thickness of the respective carpet measured under a load of 1.72 kN/m$^2$, (ii) tuft withdrawal force (N) and (iii) per cent thickness loss due to dynamic 1000 impacts. The results are given in Table 4. It is observed that the treated carpet retains more thickness under the pressure than the control carpet. This indicates that the treatment has made the carpet more slippy and polished and has increased the load withstanding capacity as compared to the control carpet, which is really an outstanding improvement. Table 4 also shows the higher thickness value for the treated carpet as compared to control carpet. It has been found that the coarse, hairy, specky, knotty surfaces generally show greater twf values than the polished surfaces. Hence, this idea may ample support our claim that the Indosol E-50 powder treatment has indeed increased the comfort characteristics of the jute carpets. Table 4 also shows that the treated carpet loses less thickness due to dynamic impact in comparison to control carpet. 9, 10

It is inferred that the treatment of jute with Indosol E-50, dyes and MgCl$_2$ (6H$_2$O) improves the performance characteristics of jute carpet by showing higher thickness recovery, compression recovery and work of recovery, lower tuft withdrawal force and lesser moisture content in the modified jute carpet.
Acknowledgement

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References