Differential Response of Cotton Fibres to Easy-Care Finishing

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The improvements in crease recovery angles and the concomitant tensile losses as a result of formaldehyde crosslinking aimed at imparting easy-care properties to cotton fibres widely differing in fineness, length and breaking strength and extension have been compared. The fineness, length and breaking strength in the decreasing order of importance appear to influence the response of cotton fibres to easy-care finishing. The fine, long staple cotton fibres exhibit a better balance of properties with regard to crease recovery and tensile loss than the coarse, short staple cottons. Limited observations on cottons treated with DMDHEU also lead to similar conclusions.

Several attempts have been made to characterize cotton fibres in the untreated state, as well as after various chemical modifications effected to impart desirable characteristics to the fibres. These studies have shown that different cottons respond to mercerization and crosslinking treatments differently. The changes in the physical characteristics of cottons widely differing in fibre properties after crosslinking have so far been considered under different headings. In this concluding paper, an attempt is made to identify fibre parameters which make significant contributions to easy-care properties.

Experimental Procedure

Materials and crosslinking — Cottons differing widely in their fibre properties, such as length, fineness, initial strength and extension were chosen for this study. The methods of purifying as well as crosslinking with formaldehyde have been detailed in the previous publications. The duration of formaldehyde crosslinking was varied to obtain a range in bound formaldehyde content.

Test methods — The bundle crease recovery angles of the untreated as well as crosslinked fibres were measured by the method developed by Venkatesh and Dweltz. The breaking strength at 0 and 1/8 in nominal test lengths, gravimetric fineness and effective length were determined according to ASTM methods.

Results and Discussion

The crease recovery angle and tensile properties of American Upland cottons differing widely in maturity have been studied after formaldehyde crosslinking. The results show that fibre maturity does not have much influence on the response of cottons to crosslinking, except that the amount of bound formaldehyde is higher for low maturity cottons than for high maturity cottons in a given time interval. It has also been shown that fibre orientation does not significantly alter easy-care properties, unless the fibres are very highly oriented (for example, in ramie). In the case of long staple cottons, it has been found that Giza-45, the strongest as well as the finest cotton, exhibits the highest improvement in crease recovery angle at any bound formaldehyde level and that the Egyptian cottons show a better balance of crease recovery and tensile loss properties at durable press levels than Indian cottons. The study of short staple cottons has shown that fine cottons exhibit a marginally better balance of (improvement in) crease recovery angle and tensile (loss) properties than coarse cottons more or less of the same staple length.

The crease recovery and other physical characteristics of representative cottons differing widely in fineness, length and breaking extension after formaldehyde crosslinking are compared in Table 1.

The improvements in crease recovery as well as the percentage tensile losses for various cottons at 0.5% bound formaldehyde level are shown with decreasing effective length in Fig. 1. It is seen from Fig. 1 and Table 1 that there is no definite trend for either of the properties. It is also seen from Table 1 that the initial strength does not have any influence on the improvement in crease recovery or the loss in tensile strength as a result of crosslinking. Of course, the initial tenacity comes into the picture indirectly, as the strength retained after crosslinking depends on the initial strength. It is clear from Fig. 2, where the bundle tenacities at 0.0, 0.5 and 0.8% bound formaldehyde levels are shown for cottons of different initial tenacities, that there is also no definite trend.

The most important factor seems to be the fineness. The crease recovery angles at 0.5 and 0.8% bound formaldehyde levels are plotted as a function of fineness in Fig. 3. The improvement in crease recovery at any level of bound formaldehyde is seen to decrease with decreasing fineness. The tensile losses, on the other hand, appear to be higher for finer than for coarser cottons (Table 1). Not only does the tensile loss depend on the fineness, but the...
TABLE 1 — PHYSICAL PROPERTIES OF CROSSTEX LINKED COTTON FIBRES

<table>
<thead>
<tr>
<th>Cotton</th>
<th>Effective length (mm)</th>
<th>Fine-ness (µg/in)</th>
<th>Tenacity (1/8 in g/tex)</th>
<th>Crease recovery angle (°)</th>
<th>Improvement in crease recovery, Tensile loss, deg</th>
<th>Efficiency factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giza-45</td>
<td>36.5</td>
<td>3.0</td>
<td>36.0</td>
<td>85</td>
<td>27</td>
<td>45</td>
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<tr>
<td>Karnak</td>
<td>34.2</td>
<td>3.0</td>
<td>27.0</td>
<td>80</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Sudan</td>
<td>38.0</td>
<td>3.3</td>
<td>31.0</td>
<td>85</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>ISC-67</td>
<td>30.5</td>
<td>3.3</td>
<td>22.4</td>
<td>82</td>
<td>14</td>
<td>33</td>
</tr>
<tr>
<td>Hopi Acala</td>
<td>31.8</td>
<td>3.5</td>
<td>20.9</td>
<td>88</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>Laxmi</td>
<td>25.8</td>
<td>3.5</td>
<td>19.2</td>
<td>81</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>B-1007</td>
<td>26.2</td>
<td>3.6</td>
<td>20.1</td>
<td>80</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Sujata</td>
<td>33.5</td>
<td>3.6</td>
<td>30.4</td>
<td>86</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>Sankar-4</td>
<td>32.5</td>
<td>3.7</td>
<td>23.3</td>
<td>85</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Digvijay</td>
<td>24.1</td>
<td>4.6</td>
<td>22.2</td>
<td>79</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Kalyan</td>
<td>24.0</td>
<td>6.4</td>
<td>16.6</td>
<td>74</td>
<td>9</td>
<td>22</td>
</tr>
</tbody>
</table>

Fig. 1 — Plots of Δ CR as well as percentage tensile losses for cottons of different effective lengths at 0.5% HCHO (length axis arbitrary)

Fig. 2 — Bundle tenacity of cotton fibres at three levels of bound formaldehyde (fineness of individual cottons are indicated inside the figure)

Fig. 3 — Crease recovery angles of cottons of different finenesses (fineness axis arbitrary)

strength retained as a result of crosslinking also depends on it (Fig. 2). At a given tenacity, the coarser cotton retains more strength than the finer cotton.

At a given fineness, the long staple cottons (for example, Sudan) exhibit higher crease recovery angles and higher retained strength at comparable bound formaldehyde levels than short staple Laxmi. The efficiency factor, which is defined as the ratio of the improvement in crease recovery angle to the tensile loss at any bound formaldehyde level, is maximum for fine, long staple cottons. These observations suggest that the fibre parameters, fineness, length and strength and extension in decreasing order of importance influence the response of cottons to crisslinking. However, it is seen from Table 1 that beyond the fineness value of 3.5, there is no significant change in the efficiency factor. Further, if the comparison is restricted to Indian cottons only, there does not seem to be any definite trend, though the cottons differ widely in length as well as fineness.
elusions. In fact some limited data available support these conclusions.

When chemically modified in the fabric form, apart from the type of cotton used, other factors, such as yarn and fabric geometry, will have a significant influence on the distribution and fixation of crosslinking agents, the improvements in crease recovery angles and the concomitant tensile, tear and abrasion losses. In the fabric, the fibre movement is very much restricted on account of yarn construction and fabric geometry. The fibres are also subjected to strain resulting from the tension, bending and torsion. These factors and also the presence of yarns at right angles to the direction of loading significantly influence crease recovery and other mechanical properties of fabrics. Nevertheless, some useful correlations have been established between the crease recovery as well as the tensile properties of fibres, yarns and fabrics chemically modified to impart durable press properties. From a limited study, Grant et al. have shown that resin finished fabrics woven with cottons of different fibre properties exhibit different crease recovery angles. Nevertheless, it appears important and interesting to study formaldehyde crosslinked as well as resin finished fabrics woven with cotton fibres differing widely in length, fineness and breaking strength. The results thus obtained will prove to be of immense value to the textile technologist in selecting the right cottons.

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References