Crease Recovery of Silk Fabrics

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Received 4 March 1976; accepted 2 June 1976

To improve the crease recovery of silk fabrics, dimethylol ethylene urea (DMEU) was applied to control, photo-graded and esterified silk fabrics. The effect of crosslinking was evaluated qualitatively by creasing the fabric and recovering the resin for periods ranging from 1 to $10^4$ min. The results indicate that although there is some improvement in the immediate recovery, none of the samples is crosslinked with DMEU. The esterified resin treated fabric shows the best recovery over the whole range of loading and recovery times.

Silk fabrics have good crease recovery. Crease recovery angles in the range 250–270°, similar to those for many synthetic fibre fabrics, have been reported. This can be attributed to the good elastic recovery of silk fibre. Further improvement in crease recovery is necessary to make silk easy-care or wash and wear. Since silk fibre is viscoelastic, it is necessary to know the time dependence of the deformation and recovery of the material. To understand clearly the above mentioned behaviour of silk, it was considered desirable to study the effect of resin treatment on silk and modified silk fabrics.

Experimental Procedure

The characteristics of the fabric used were:

- Threads/cm: 36/32 (warp/weft); yarn, 2/5.5 2/6 tex (warp/weft); yarn twist, 6.3 turns/cm; fabric weight, 72 g/cm² and fabric thickness, $16.7 \times 10^{-3}$ cm.

The fabric was treated with Lissapol N (10% on the weight of material), washed thoroughly and dried to remove surface finish, if any. The fabric was divided into three parts; one part served as the control, the second one was exposed to UV light and the third one was esterified with methanol. A part of each of the samples was treated with a resin, so that in all six different samples were obtained.

Preparation of photodegraded sample — The fabric was exposed to UV and visible light in a carbon-arc Atlas Fade-o-meter. The sample was wrapped around the revolving cage inside the Fade-o-meter. It was exposed for 10 hr at 65°C and 65% RH.

Preparation of esterified sample — Methanol (500 ml) containing 2.3 ml of concentrated HCl was used. The material to liquor ratio was 1:50. The material was treated with this solution for 3 hr at 65°C and then washed with water thoroughly to remove the last traces of methanol.

Fig. 1 — Long time crease recovery tester
Resin treatment — The samples were impregnated with a solution containing 8% dimethylol ethylene urea (DMEU) and 12% MgCl₂, squeezed in a padding mangle, keeping an expression of 100% and then dried in air for 10 min. The resin impregnated sample was then passed on a pin frame through a drying-cum-curing machine. The samples were first dried at 10℃ for 3 min in the first heating chamber and then cured for 3 min at 160℃ in the second chamber. The cured samples were washed thoroughly with water, squeeze dried and conditioned.

Load-elongation characteristics — Since only one fabric structure was used in the present study, the tensile behaviour of the fabric rather than that of yarn was investigated to assess the effect of different treatments. The fabrics (8 x 2 in) were tested on Intron tensile tester at cross-head speed of 10 cm/min. The load-elongation curves representing the average of ten samples each of warp and weft directions are given in Fig. 1.

Creasing and crease recovery measurement — Creasing was done by bending the fabric between two perspex plates (2 x 2 in) and keeping on them a 2 kg weight. This enabled long time loading to be carried out for several samples at one time. After the prescribed loading time, the weight and the top perspex plate were removed and the creased sample was transferred with the help of forceps to the crease recovery tester. The crease recovery angle was noted at regular intervals up to 10 min on this tester. For long time crease recovery measurements, the sample was kept as shown in Fig. 2, and measurements were made with a pointer working on a protector without touching or disturbing the sample. This arrangement prevented the effect of gravity or air draughts on recovery.

Results and Discussion

Effect of recovery time on crease recovery angle — Plots of crease recovery angle against recovery time for different loading periods are given in Figs. 3-5. It is evident that in all cases, initially the recovery angle increases rapidly with increase in loading period. Later, the increase becomes slower and finally it tends towards an equilibrium value. None of the fabrics was recovered completely even after 10^4 min. This is in accordance with the results reported by Vollrath for cotton and Hari for cotton and modified cotton fabrics. No similar data are available for silk fabrics. For the purpose of comparison, recovery at 10^4 min has been taken as equilibrium recovery.

The time dependence of the crease recovery can be explained on the basis of the viscoelastic behaviour of the fabrics. The instantaneous recovery may be attributed to the elastic part and the delayed recovery
to the time dependent (viscous) part. The non-
recovered fraction may be due to friction and perma-
nent deformation.

**Effect of loading period on crease recovery angle** —
Increase in loading period from 1 min to 1000 min
causes reduction in the immediate recovery \( \theta(1) \)
and maximum crease recovery \( \theta(10^4) \), but a part
of the reduction in immediate recovery is recovered
as delayed recovery (Table I). The delayed recovery
increases with increase in loading period. Poorer
recovery with increased loading period has been
reported in the case of cotton for both creasing and
tensile deformations. This has been attributed
to greater stress relaxation with time under strain, as
a result of which less energy is available in the sample
to aid recovery.

**Effect of modification on the crease recovery and
strength of the fabric** — It is evident from the data
presented in Table I that, in general, the results for
modified samples are almost similar to those for
control samples. However, critical examination of
the results indicates that although the immediate
recovery \( \theta(1) \) for photodegraded material is lower
than that for the original fabric, the equilibrium
recovery \( \theta(10^4) \) angles are the same. This indicates
that reduction in immediate recovery is recovered as
delayed recovery.

The reduction in immediate recovery is obviously
due to photochemical modification of the material.
Increased delayed recovery suggests increase in the
number of intermolecular bonds in the so-called
‘amorphous’ region of the fibre.

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**Fig. 4** — Crease recovery angle vs recovery time for light treated fabric (L) and light and resin treated fabric (LR) \([T_l, \text{time of loading}]\)

**Fig. 5** — Crease recovery angle vs recovery time for esterified fabric (E) and esterified and resin treated fabric (ER) \([T_l, \text{time of loading}]\)
TABLE 1 — Crease Recovery Behaviour and Strength of Treated Fabrics

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Loading period min</th>
<th>Recovery angle, deg</th>
<th>Recovery angle, deg $\theta(10^4)$</th>
<th>Delayed recovery angle, deg $\theta(t)^*$</th>
</tr>
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<tbody>
<tr>
<td>Original</td>
<td>1</td>
<td>308.4</td>
<td>268.6</td>
<td>39.8</td>
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<tr>
<td></td>
<td>10</td>
<td>280.0</td>
<td>212.0</td>
<td>68.0</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>251.6</td>
<td>150.0</td>
<td>101.6</td>
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<tr>
<td></td>
<td>1000</td>
<td>218.0</td>
<td>90.0</td>
<td>128.0</td>
</tr>
<tr>
<td>Original, resin</td>
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<td>282.0</td>
<td>38.1</td>
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<tr>
<td>treated</td>
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<td>288.0</td>
<td>220.0</td>
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<td></td>
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<td>162.0</td>
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<td></td>
<td>1000</td>
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<td>126.0</td>
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<td></td>
<td>1000</td>
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<td>215.0</td>
<td>69.0</td>
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<td></td>
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<td></td>
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<td></td>
<td>1000</td>
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</table>

*Delayed recovery angle = $\theta(t) = \theta(10^4) - \theta(10^4)$

The esterified fabric shows slight improvement in immediate and equilibrium recoveries compared to the original fabric. Esterification reduces the strength also, but increases elongation of the fabric. Although the presence of bulky methyl (hydrophobic) groups is likely to reduce the deformation, it can break some intermolecular bonds, thereby causing reduction in strength and increase in elongation. This effect, combined with the lower moisture content (hydrophobicity) in the fabric, may be responsible for better recovery.

Effect of resin treatment on crease recovery and strength of fabrics — Resin treatment improves the crease recovery in all the samples, but the major improvement is in immediate crease recovery (Table 1). An interesting feature is that the delayed recovery of the original fabric remains unchanged after resin treatment, but it is reduced in the case of photodegraded and esterified fabrics, except for 1000 min loading in the case of the photodegraded material.

When the loading period is increased from 2 min to 1000 min, the drop in the crease recovery angle is almost the same in the original and resin treated samples, suggesting that resin treatment does not reduce the ‘flow’ caused by increased time under load. Changes in delayed recovery and flow properties indicate whether the material is crosslinked or not. Since in the present case there is no perceptible change in these properties with resin treatment, it may be concluded that DMEU does not react with silk material to form crosslinks, but is simply deposited on it. Further, since methylated resin treated fabric shows the best recovery properties, this may be attributed to deep-seated deposition of the resin material in this fabric, which is quite obvious.

References