Chemical Texturization of Ramie-Polypropylene Blended Yarns

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Ramie-polypropylene blended yarns have been texturized by treatment with 18% (wt/wt) sodium hydroxide solution at 25°C. It is observed that texturization results in the formation of crimp in the ramie fibre and the polypropylene fibre migrates to the surface of the yarn forming loop, which improves the yarn bulk and extensibility at the cost of some loss in yarn strength.

Ramie, like any other natural cellulosic fibre, cannot be texturized by the conventional thermo-mechanical process. It has been observed that like jute fibre, ramie fibre also develops crimp, i.e. gets texturized when treated with strong caustic solution. Recently, it has been established that the jute-polypropylene blended yarn can be texturized by such a chemical process. Texturization of cotton, viscose and polyester-viscose blended yarns by mechano-chemical methods has also been reported. Some patents are also available on the texturization of cellulosic fibre blended yarns. But no work has been reported so far on the texturization of ramie-polypropylene blended yarns. On treatment with strong caustic solution, ramie fibre develops crimp, but the polypropylene fibre remains almost unaffected. It can, therefore, be expected that when ramie-polypropylene blended yarns are caustic treated, the ramie and polypropylene fibre will behave as shrink and non-shrink components in the blended yarn. It will then have the desired texturization effect. Some of the results obtained from experiments on such texturization are reported in this paper.

Materials and Methods

Yarns of nominal linear density (64 tex) were spun in the semi-worsted spinning system. Stapled degummed ramie of 0.6 tex fineness and 125 mm length and crimped stapled polypropylene fibre of 1.7 tex fineness and 120 mm length were used. Two ramie-polypropylene blended yarns with blend proportions 80/20 and 60/40 and one all-ramie yarn were spun keeping the nominal twist factor as 35 tex1 TPC.

Texturization of yarns—Texturization of the blended yarns was carried out in the hank form for each type of yarn. Three hanks, each of 100 m, were prepared in wrap reel of 2 m circumference. Three different places of hank were tied very loosely with cotton thread so that lacing or tying does not affect swelling and bulking during texturization. Yarns in such form were treated with 18% NaOH solution. The yarn to liquor ratio, temperature of the liquor and residence period were kept as 1:20, 25°C and 60 min respectively. The treated yarn was then washed thoroughly in running water, neutralized with 1.5% acetic acid solution and air dried.

Determination of fibre properties—The fibre tex, diameter, crimp frequency and the dry and wet tensile properties were determined for both untreated and alkali treated ramie fibres. Fibre linear density or tex was measured on VIBROSCOPE. About 20 fibres were taken for linear density measurement. Diameter of the fibre was measured using a projection microscope (magnification, ×250). Crimp frequency was determined by counting the number of total crimps in a fibre using a projection microscope and measuring the length of the fibre. Tensile properties of the fibre were determined on Instron keeping the gauge length and cross-head speed as 5 cm and 0.5 cm/min respectively. Prior to wet test, the fibre samples were kept dipped in water for 24 hr. They were then tested inside water in a container on Instron. About 30 fibres were taken for studying their tensile properties. The stress-strain curves for the untreated and alkali treated ramie fibres were computed from the dry test loadelongation curve as per the method suggested by Meredith. The results are given in Table I and the stress-strain curves are shown in Fig. 1.

Yarn Properties

Length shrinkage—The length of the yarn hank prior to texturization and after texturization with 18% NaOH solution was noted. The percentage shrinkage in length was expressed as:

\[ \text{Length shrinkage (L), } \% = \frac{L_p - L_t}{L_p} \times 100 \]
where \( L_p \) and \( L_t \) are the lengths of untreated (parent) and textured yarns respectively. The values of the length shrinkage are given in Table 2.

**Weight loss**—The weight of the hank of both untreated and textured yarns was determined after conditioning them. From the weight difference, the weight loss was calculated as:

\[
\text{Weight loss (W), \%} = \frac{W_p - W_t}{W_p} \times 100
\]

where \( W_p \) and \( W_t \) are the weights of untreated and textured yarns respectively.

**Diameter**—The diameter of the untreated and textured yarns was measured using a projection microscope under 0.18 mN/tex pre-tension. Any particular portion of the yarn hank was selected randomly and 200 measurements were made for each yarn type. In the case of texturized yarn, both the core and overall diameters were noted, as the same yarn showed two distinct cylindrical shapes under the projection microscope due to the formation of loop on the surface of the yarn on texturization.

**Linear density**—The weight of the conditioned yarn hank was taken and the linear density was determined from the total length and weight of the hank. About 0.18 mN/tex pre-tension was applied prior to measuring the length of the textured yarn for removing the avoidable kinks.

**Bulkiness of the yarn**—The bulkiness of the yarn was calculated using the formula

\[
\text{Bulkiness (I)} = \frac{V_t}{V_p}
\]

where \( V_t \) is the specific volume of textured yarn; and \( V_p \), the specific volume of parent yarn. The specific volume of the yarn was calculated as

\[
\text{Specific volume of yarn (V)} = \frac{\pi D^2 L}{4M}
\]

where \( D \) is the diameter of yarn; \( M \), the mass of the yarn, and \( L \), the length of yarn. In the case of textured yarn, the overall diameter was taken for calculating the specific volume.

**Tensile properties**—Instron was used for testing the dry and wet tensile properties of the yarns. The gauge length, strain rate and pre-tension level were kept as 30 cm, 25 cm/min and 0.18 mN/tex respectively. The dry test was carried out with samples conditioned at 65% RH and 27±2°C, while the wet test was carried out after wetting the yarn for 2 hr in water having 0.1% wetting agent (Acenol). About 100 tests were carried out for each sample. The results are given in Table 2.

**Results and Discussion**

Data presented in Table 1 show that caustic treatment increases fibre diameter and linear density, reduces tenacity, but increases breaking extension considerably. Moreover, caustic treatment results in the formation of crimp in ramie fibre. Both the untreated and caustic treated ramie fibres show increase in tenacity and breaking extension on wetting. The stress-strain curves (Fig. 1) show that the modulus of the fibre has reduced considerably on texturization. A similar observation was made while studying the properties of caustic treated jute fibre.

Data presented in Table 2 show that on texturization, ramie-polypropylene blended yarn shows shrinkage along the length and loss in weight. However, the length shrinkage is much more prominent than the weight loss. This results in increase in the linear density of the yarn. The length shrinkage and the weight loss diminish with increase in polypropylene content in the blend. The higher weight loss in the yarn containing more ramie could be attributed to the loss of some residual gum in ramie and loss of oil applied to the ramie fibre while processing it for spinning. The increase in length shrinkage with increase in ramie content in the blend could be attributed to swelling and crimping of ramie in the caustic solution. The polypropylene fibre due to

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**Table 1**—Properties of Untreated and Alkali Treated Ramie Fibres

<table>
<thead>
<tr>
<th>Property</th>
<th>Untreated</th>
<th>Alkali Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear density, tex</td>
<td>0.56</td>
<td>0.67</td>
</tr>
<tr>
<td>Diameter, ( \mu )</td>
<td>20.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Crimp/cm</td>
<td>—</td>
<td>2.5</td>
</tr>
<tr>
<td>Tenacity, N/tex</td>
<td>0.50</td>
<td>0.31</td>
</tr>
<tr>
<td>Breaking extension, %</td>
<td>3.0</td>
<td>9.4</td>
</tr>
</tbody>
</table>

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**Fig. 1**—Stress-strain curves for untreated and alkali-treated ramie fibres
Table 2—Properties of Untreated and Texturized Ramie-Polypropylene Blended Yarns

<table>
<thead>
<tr>
<th>Property</th>
<th>Untreated</th>
<th>Texturized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R:PtR:PP</td>
<td>R:PtR:PP</td>
</tr>
<tr>
<td></td>
<td>100% 80/20 60/40</td>
<td>100% 80/20 60/40</td>
</tr>
<tr>
<td>Linear density, tex</td>
<td>64 64 64</td>
<td>98 88 80</td>
</tr>
<tr>
<td>Weight loss, %</td>
<td>— — —</td>
<td>5.2 4.0 3.6</td>
</tr>
<tr>
<td>Length shrinkage, %</td>
<td>225 290 310</td>
<td>336 440 510</td>
</tr>
<tr>
<td>Core diameter, μ</td>
<td>225 290 310</td>
<td>408 645 760</td>
</tr>
<tr>
<td>Overall diameter, μ</td>
<td>225 290 310</td>
<td>2.15 3.60 4.81</td>
</tr>
<tr>
<td>Bulkiness</td>
<td>— — —</td>
<td>*R. Ramie, and †P, Polypropylene.</td>
</tr>
<tr>
<td>Breaking stress, mN/tex</td>
<td>126.1 119.0 99.6</td>
<td>57.4 82.3 85.6</td>
</tr>
<tr>
<td></td>
<td>160.3 140.3 128.4</td>
<td>62.6 96.8 119.0</td>
</tr>
<tr>
<td>Breaking strain, %</td>
<td>1.7 3.0 3.2</td>
<td>12.4 20.8 18.4</td>
</tr>
<tr>
<td></td>
<td>3.2 6.3 6.8</td>
<td>13.2 22.9 20.5</td>
</tr>
<tr>
<td>Loss in dry breaking stress, %</td>
<td>— — —</td>
<td>45.5 30.8 14.1</td>
</tr>
<tr>
<td>Increase in breaking strain, %</td>
<td>— — —</td>
<td>629.0 593.3 475.0</td>
</tr>
</tbody>
</table>

Fig. 2—Stress-strain curves for untreated and texturized ramie and ramie-polypropylene blended yarns

The tensile properties of the texturized yarn show that on texturization, the yarn lost 14-54% of its original strength. The loss in strength was maximum for the all-ramie texturized yarn. The loss in strength can be attributed to the structural changes in the yarn, which are mainly due to the partial destruction of the helical structure of the yarn. The fall in strength became less with increase in polypropylene content in the blend (Fig. 2). The lower loss in the strength of ramie-polypropylene yarn can be attributed to the inertness of polypropylene fibre in alkali treatments. As the polypropylene fibre remains almost unaffected and the breaking extension of the ramie fibre increases on alkali treatment, the elongation balance in between
the texturized ramie and the polypropylene fibre improves considerably. This might be the reason for the lower loss of strength in blended yarn as compared to that in the all-ramie yarn.

Chemical texturization causes a marked increase in the breaking extension of yarn (Table 2), the magnitude of the increase decreasing with increase in polypropylene content in the blends. In the case of the all-ramie yarn, the increase in breaking extension is about 6.3 times, whereas for 60/40 and 80/20 ramie-polypropylene blended yarns, it is 480 and 590% respectively.

Like the untreated yarn, texturized yarn shows increase in strength on wetting (Table 2). The increase in wet strength could be attributed to increase in interfibre friction. It might also be partially due to increase in the strength of ramie fibre when wetted. There is very little change in the breaking extension of texturized yarn on wetting, whereas the breaking extension of the untreated or parent yarn increases markedly.

Conclusion

Texturization of ramie or ramie-polypropylene blended yarns is possible by treating the yarn with strong caustic solution. It improves the bulk and breaking extension of the yarn several times over that of untreated yarn. However, texturization causes slight loss in yarn strength. Thus, for texturization, ramie-polypropylene blended yarns are preferable to all-ramie yarn.

Acknowledgement

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References