



Influence of Component Fibre Properties on the Tensile Properties of Ramie Blended Yarn

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Abstract

Usage of unexplored lesser known natural fibres in the global arena is not only the important striking area, but simultaneously to search out a suitable avenue for which separate spinning system is not widely available or established. Blending of different fibres having similar or different properties is an important consideration to upgrade certain functional properties of textiles either in apparel or in technical textiles. The theory based on the mechanical properties of the component fibres of blended yarn is well explained by Hamburger in 1949. Blending of indigenous ramie with jute/acrylic will help development of textiles with better functional properties by combining positive features of both the fibres. The tensile properties of blended yarns and influence of component fibres on mechanical characteristics of indigenous ramie-jute and ramie-acrylic blends spun on existing jute spinning frame with an appropriate processing technology divulges that fibre properties like tenacity, fineness and breaking extension mainly dominates the tensile characteristics of the blended yarn.

Keywords: Degumming; Indigenous ramie; Jute and acrylic; Blending; Tensile properties; Compatibility

Introduction

Ramie, a member of the urticaceae or nettle family, grown mainly in temperate and tropical areas, and well known as “China Grass” in Western Europe and America which is derived from the bark of the stem of the plant *Boehmeria nivea*, (L). Gaud, by decortication and washing. It contains about 19-30% of an incrusting material known as gum, depending upon the variety, agro-climatic condition of cultivation and other factors. The α -cellulose content of ramie is high than that of other bast fibres like flax, hemp and jute which unveils as one of the most promising natural fibres. Ramie fibre is appraised as a valuable textile fibre for its high strength especially wet strength, lustre and microbial resistivity. The decorticated ramie in moist condition is very much prone to microbial attack. Proper degumming of the decorticated ramie fibre is, therefore, necessary to divulge its unique properties and make it suitable for textile purpose [1-6].

The philosophy of blending between two fibres depends on two basic principles which apparently appear to be a bit contradictory.

Ramie may be blended with cheaper fibres so that a cheaper product mix becomes feasible. In this category, blending of ramie with jute, pineapple, mesta, banana, roselle hemp appear to be worth pursuing.

Ramie is often blended with synthetic fibres to produce diversified blended fabrics which are expected to fetch higher prices per unit weight of ramie and consequently higher profitability.

Increasing ecological consciousness has gain momentum in ramie which is green, biodegradable and recyclable. If the apparent demerits of ramie can be masked, a diverse range of products can be developed by exploiting the intrinsic properties of ramie. One of the ways of masking is blending of ramie with natural/synthetic fibres. It is felt that such binary blending will help development of textiles with better functional properties by combining positive features of the constituent fibres. Therefore, binary blending will give a wider application of ramie for development of value added and diversified products, which are indispensable at this juncture [7-12].

Literatures on degumming and processing of ramie fibres alone or in blends with other fibres are available, but little work has been

reported on the blending behavior and analysis of ramie blends with jute and acrylic since the early work of Mazumder et al. [7]. Pal et al. [8] delineated on ramie-polyester blend. Cheng et al. [9] revealed on ramie-acrylic yarns by siro spinning technology owing to the remarkable and significant improvement in yarn properties, siro spinning technology to be employed in ramie yarn production will have a high potential particularly for the high count single yarn fabrics. Gupta et al. [11] investigated the physico-mechanical properties of ramie-tasar and ramie-polypropylene blended yarn in semi worsted spinning system. Dey et al. [10] delineated the mechanical properties of ramie-tasar waste in spun silk processing system. Gupta et al. [11] studied the yarn properties and processing performance of ramie-polypropylene blends on jute rove spinning system. However, very scanty literatures are available for apparel quality textile threads from blends of ramie with acrylic/jute, the reported work is an endeavor for conversion into luxury textiles using existing fibre processing system due to the non-availability of specialized spinning system available for ramie and their possible commercial utilization.

Materials and Methods

Materials

Acrylic fibres, from Indian Petrochemicals Corporation Limited (I.P.C.L.), Baroda having specifications non-shrinkable, 4 denier, 100 mm long, , Decorticated ramie fibre, Ramie Research Station, ICAR-Central Research Institute for Jute and Allied Fibres, Sorbhog, Assam and Corchorus Olorious, grade TD₂ from NIRJAFT, Kolkata procured for this study.

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Chemicals

All chemicals used in this research work for degumming were analytical grade. Decorticated ramie fibres were degummed chemically to a residual gum content of 5.47% following a simple degumming method by Dey.

Methods

Evaluation of fibre properties: The tensile properties of fibres were measured using Instron Tensile Tester (Model 5567, UK made) following standard parameters for fibres (ASTM D3822) maintaining 10 mm gauge length and 10 mm/min traverse.

Evaluation of gravimetric fineness: The gravimetric fineness expressed in mass per unit length was ascertained by cutting and weighing method. Small length of fibres/filaments were cut into 2 mm length and 500 pieces were counted and weighed in precision micro balance. The results are expressed in g/km i.e., tex.

Spinning of yarn: Degummed ramie was sprayed with 2% oil-in-water emulsion, passed through Fraser's jute softener machine (63 pair rollers) and then piled for 48 hours for softening and lubrication. It was then manually cut into 200 mm staple lengths. Slivers of ramie and acrylic were prepared in Flax finisher card. Degummed ramie and acrylic slivers were blended at first drawing stage in five different blend compositions-80:20, 60:40, 50:50, 40:60 and 20:80. Yarns of 84 tex were spun on a FLCB Rove spinning machine using modified conventional jute processing machinery with blend percentage of ramie ranging from 20 to 80%.

Similarly 2% oil-in-water emulsion was sprayed on Corchorus Olitorius, grade TD₂, passed through Fraser's jute softener machine (63 pair rollers) and piled for 48 hours for softening and lubrication. It was then processed through jute breaker (JF2) and finisher card (JF4). Slivers of ramie were prepared in Flax finisher card. Degummed ramie and finisher carded jute slivers were blended at first drawing stage in five different blend compositions - 90:10, 75:25, 50:50, 25:75, and 10:90. Yarns of 84 tex were spun on FLCB Rove spinning machine using modified conventional jute processing machinery with blend percentage of ramie ranging from 10 to 90% using suitable twist to the fibre fleece (Figure 1).

Evaluation of linear density of Yarn: The yarn linear density of the was measured following standard method IS 685(1962) and communicated in tex.

Evaluation of tensile properties of yarn: The tensile properties of the yarn e.g., tenacity and breaking extension (%) are measured on

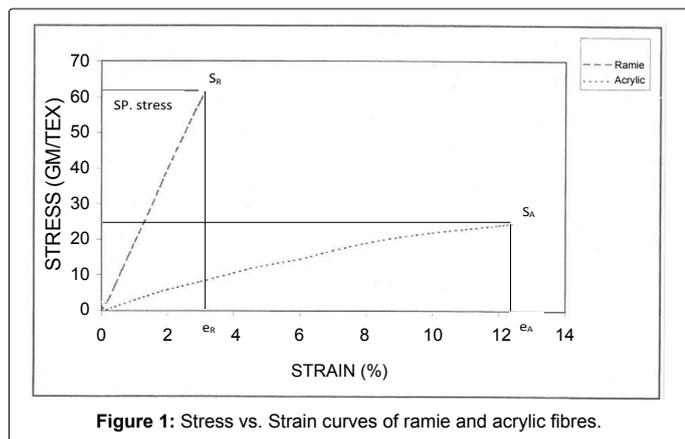


Figure 1: Stress vs. Strain curves of ramie and acrylic fibres.

Properties	Ramie	Jute	Acrylic
Tenacity (mN/tex)	600.67	291.75	215.82
Extension (%)	3.1	2.2	12.4
Fineness (tex)	0.83	1.98	0.44

Table 1: Tensile Properties of fibres.

Zwick tensile tester following standard parameters for yarn IS: 1670-1970.

Results and Discussion

Behavior of tensile properties of ramie-acrylic blended yarns

The results in Tables 1 and 2 reveals that the tensile behavior of two incompatible fibres ramie and acrylic can be shown by plotting a graph. Further, we can easily predict how much tenacity of ramie-acrylic blended yarn should change according to the blending ratio with the help of Hamburger theory (Figure 2).

Here, e_r is the first rupture point where all jute fibres are strained to breaking point as its extensibility is lower than acrylic and e_a is the second rupture point when all acrylic fibre breaks.

Consider, linear density of the yarn composed of ramie and acrylic is T tex.

The Figure 1 shows the stress-strain curves of ramie and acrylic. Figure 3 shows the change of yarn linear density with blend components.

If r is the percentage weight of ramie, and a be the percentage by weight of acrylic fibre then, $T_r = \frac{rT}{100}$ and $T_a = \frac{aT}{100}$ Where T_r = Linear density of ramie in tex and T_a = Linear density of acrylic in tex.

When strain reaches the point e_r all the fibres of ramie will be on the point of breaking and the total load P_1 supported by the composite yarn will be the sum of loads supported by the two components P_{1R} and P_{1A} .

$$\text{Where } P_{1R} = \frac{rTS_r}{100} \text{ and } P_{1A} = \frac{aTS_{R/A}}{100}$$

$$\text{If } S_1 \text{ is the Yarn tenacity at } e_r, S_1 = \frac{P_1}{T} = \frac{T}{100} (aS_r + bS_{R/A})$$

All fibres of ramie component will then break and for the second rupture at e_a when all fibres of acrylic break

$$P_2 = P_{2a} = \frac{aT}{100} Sa$$

If S_2 is the yarn tenacity at e_a

$$S_2 = \frac{P_2}{T} = \frac{bSa}{100}$$

It is clear from Table 2 vis a vis Figures 2 and 3 that the tenacity of acrylic yarn is low than that of ramie yarn due to high tenacity of ramie fibre than that of acrylic fibre. Strength utilization percent of fibre in ramie yarn is 29.88% whereas in acrylic yarn it is 62.72%.

Table 1 reveals fineness or linear density of ramie and acrylic which are different. The average fineness and tenacity of the degummed ramie fibres were 0.83 tex and 600.67 mN/tex, respectively whereas acrylic fibres fineness and tenacity were 0.44 tex and 215.82 mN/tex. The spinnability of blended yarn enhanced due to the higher fineness of acrylic fibre resulting more regular yarn and also by providing more numbers of fibres per yarn cross section although the nominal linear densities of the yarns are same i.e., 84 tex. The stress-strain curves of ramie and acrylic unveil that ramie fibre is almost linear but that of

Property	100%A	80%A/	60%A/	50%A/	40%A/	20%A/	100%R
		20R	40%R	50%R	60%R	80%R	
Tenacity (Gm/tex)	13.8	12.5	12.1	13.6	14.4	15.1	18.3
Breaking extension (%)	24.8	15	8.1	3.7	2.6	2.1	2.1
Weight C.V% on 2' cut length	14	19	21	24	22	23	26
Grist C.V%	4	5	4	3	4	5	6

Table 2: Tensile Properties of Ramie-Acrylic blended yarns.

Properties	100%J	90%J/	75%J/	50%J/	25%J/	10%J/	100%R
		10%R	25%R	50%R	75%R	90%R	
Tenacity (Gm/tex)	10.1	10.6	12.7	14.9	15.4	16.9	18.1
Breaking Extension (%)	1.86	1.95	2.04	2.08	2.1	2.17	2.18
Grist C.V%	33	32	27	27	26	26	25
Weight C.V% on 2' cut method	8	7	7	6	6	5	5

Table 3: Tensile properties of Ramie-jute blended yarns.

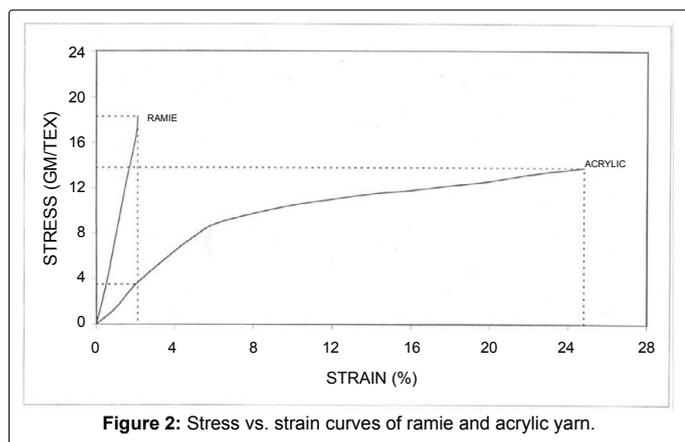


Figure 2: Stress vs. strain curves of ramie and acrylic yarn.

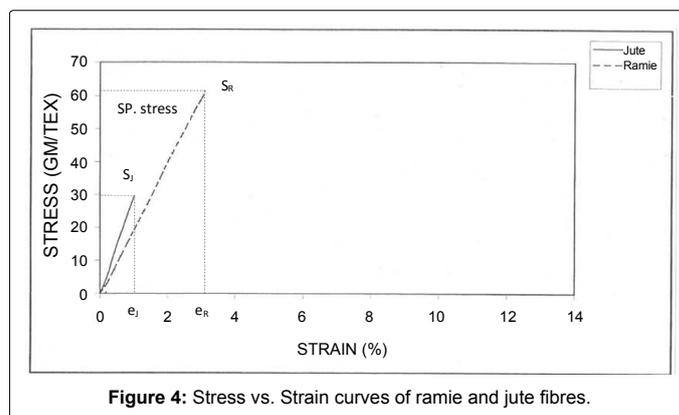


Figure 4: Stress vs. Strain curves of ramie and jute fibres.

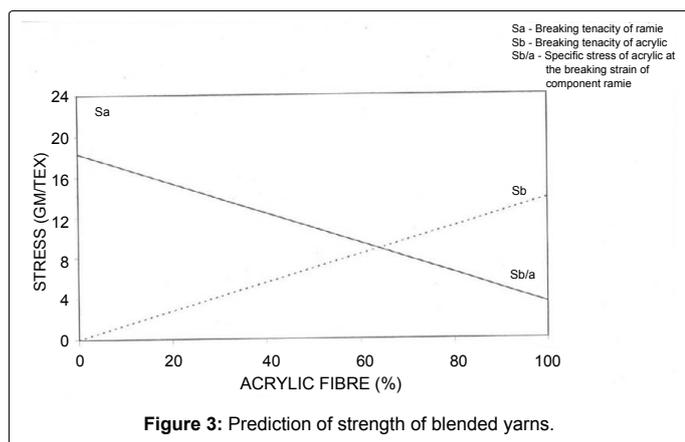


Figure 3: Prediction of strength of blended yarns.

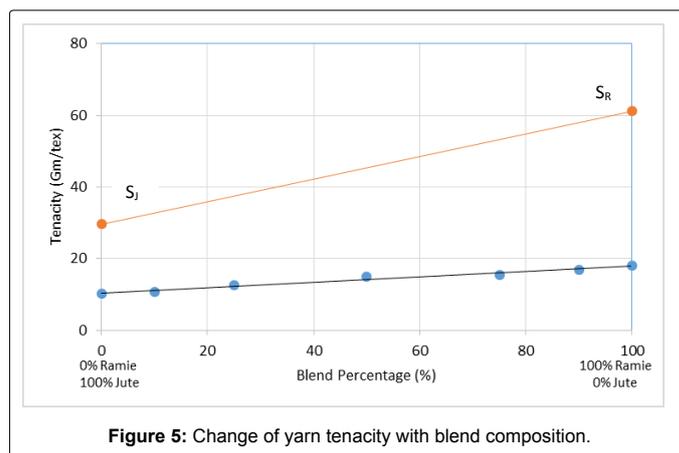


Figure 5: Change of yarn tenacity with blend composition.

acrylic is non-linear. From the stress-strain curves, it is apparent that strength and modulus of ramie fibre is much higher compared to acrylic fibre. But on the reverse the elongation percentage of acrylic is much higher than ramie. This imbalance of ramie and acrylic will have effect on the tensile properties of the blended yarn. The acrylic yarn is more regular than ramie yarn in terms of weight C.V% on 2' cut length as well as strength C.V% which can be visualized from Table 2.

Behavior of tensile properties of ramie-jute blended yarns

It reveals from Table 3 that the tenacity of yarn is progressively increasing as the percentage of ramie increases in the blend. The stress-strain behavior of ramie and jute is almost linear (Figure 4). The yarn tenacity varies with blend compositions as shown in Figure 5 applying Hamburger theory. In Figures 4 and 5 describing the theory are enumerated below.

E_J is the first rupture point and e_R is the second rupture point



Figure 6: Jawhar coat from ramie-jute.



My Passion, my creation, my wardrobe at ICAR-NIRJAFT, Kolkata.

Figure 7: Jawhar coat from ramie-acrylic.

in Figure 4. Since ramie and jute are both compatible fibres, their extensibility is within close to each other. Hence, when load is applied to the ramie-jute blended yarn, both the component fibres in the blended yarn are strained to the breaking point at the same time and hence there occurs only one rupture. It is evident from Figures 6 and 7 that ramie – jute blended yarn follows the Hamburger theory. Similar trend is observed in both case.

Conclusion

Development of apparel quality textile grade thread spun on existing jute spinning frame with an appropriate processing technology out of indigenous ramie-jute and ramie-acrylic blends without any difficulty. Ramie being a less extensible fibre with high specific stress when blended with acrylic, a more extensible fibre should follow the Hamburger theory but there is a huge difference in their fineness and strength utilization it is deviating from the theory. On the contrary, when ramie is blended with jute, a compatible fibre having an extensibility slightly lower than ramie and less specific stress, it follows Hamburger theory. The blended yarn has a good scope for development of luxury textiles.

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