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COMPARATIVE EVALUATION OF TENSILE PROPERTIES AND MORPHOLOGICAL SYNERGY IN CALOTROPIS GIGANTEA AND VISCOSE HYBRID YARNS

Anu Priya. M[1], Shanvarthini. R[1], Ragul. M. D[1], Dr. Rajkumar. G[2]

[1]Bachelor Scholars, Department of Fashion Technology, Kumaraguru College of Technology, Coimbatore.
[2]Assistant Professor, Department of Fashion Technology, Kumaraguru College of Technology, Coimbatore.

Abstract – The textile industry is looking for sustainable, fully cellulosic fibres to cut back on synthetics. This study investigates the development of a hybrid yarn using Calotropis gigantea (Giant Milkweed) blended with Viscose at a 10s count. Using Single Yarn Strength Testing (ASTM D2256) and SEM analysis, three yarn types were compared: 100% Viscose, 70:30 Viscose/Milkweed, and 60:40 Viscose/Milkweed. Results indicate that while the hollow-core milkweed fibre alters tensile strength and tenacity, the 60:40 blend achieves the best balance in mechanical properties. This study establishes a starting point for utilizing Calotropis gigantea in sustainable yarn applications.

Key Words: *Calotropis gigantea, Viscose, Hybrid Yarn, Tensile Properties, SEM Analysis, Sustainable Textiles, Natural Fibres, Tenacity, Biodegradable Yarn, Technical Textiles*

1. INTRODUCTION

There is growing concern about synthetic fibres, and as a result, researchers are revisiting underused, natural alternatives. Calotropis gigantea is a prime example. It is easy to find, and with its high lumen-to-cell-wall ratio, it gives excellent insulation and floats well. However, the fibres are smooth and lack texture, which makes spinning them into yarn a technical challenge. Viscose, being strong and cohesive, helps bind the blend together. In this research, a 10s count hybrid yarn was developed and evaluated for tensile performance across blend ratios, particularly targeting coarse textile applications in industry.

2. OBJECTIVE

- Develop a 10s count hybrid yarn from Calotropis gigantea and Viscose fibres.
- Measure the breaking force and tenacity (RKM) for different blend ratios.
- Study how the hollow milkweed fibres interact with the viscose carrier fibre through morphological analysis.

3. MATERIALS AND METHODS

3.1 Raw Materials

Calotropis gigantea (Giant Milkweed) fibres and regenerated Viscose staple fibres were used as the primary raw materials.

Fig. 3.1 – Milkweed seed pods

Fig. 3.2 – Milkweed floss

Fig. 3.3– Collected Milkweed floss

3.2 Yarn Preparation

Hybrid yarns were spun to a 10s count at TIFAC'CORE of Kumaraguru College of Technology.

Fig. 3.4 – Fibre Feeding

Fig. 3.5 – Drawing

Fig. 3.6 – Blending

Fig. 3.7 – Roller Fed

Fig. 3.8 – Sliver Formation

Fig. 3.9 – Collection

Fig.3.10– Yarn

3.3 Tensile Testing

Single yarn strength was tested on a MAG Uni-strength Tester (ASTM D2256), at a 500 mm gauge length and 300 mm/min crosshead speed.

Fig. 3.11 – UniStretch 250

3.4 Morphological Analysis

SEM analysis was used to examine fibre interaction and confirm the hollow structure within the milkweed fibres.

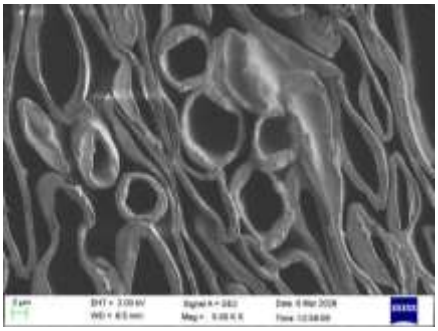

Fig. 3.12 – Milkweed Cross-sectional View

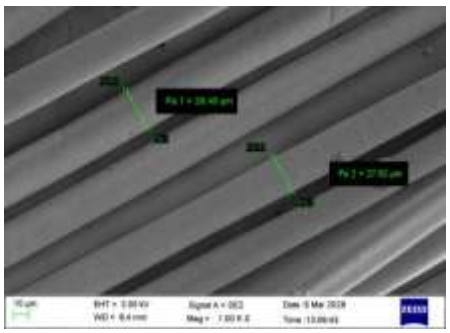

Fig. 3.13 – Milkweed Longitudinal View

4. RESULTS AND DISCUSSION

4.1 Tensile Performance and Tenacity

Table 1: Comparative Analysis of Tensile Properties

Sample ID	Fiber Blend Ratio (Viscose : Calotropis gigantea)	Avg Breaking Force (Kgf)	Avg Elongation (mm)	Avg Tenacity / RKM (g/tex)	Force CV%
Test 8	100% Viscose (Control)	0.381	27.90	0.034	5.97
Test 7	70% Viscose : 30% C. gigantea	0.241	11.90	0.021	3.14
Test 6	**60% Viscose : 40% C. gigantea**	**0.263**	**17.70**	**0.023**	**20.20**

Mechanical Strength: The 100% Viscose yarn (Test 8) serves as the benchmark with a breaking force of 0.381 Kgf. The addition of Calotropis gigantea results in a reduction of absolute tenacity due to its hollow-core morphology.

Optimal Hybrid Performance: Among the blends, the 60:40 ratio (Test 6) demonstrated superior stability over the 70:30 ratio, showing a higher breaking force (0.263 Kgf) and significantly better elongation (17.70 mm).

Structural Integrity: The CV% of 20.20% in the 60:40 blend highlights the technical challenge of blending smooth milkweed fibres; however, the 0.023 g/tex RKM confirms it is a viable substrate for technical and woven applications.

Morphological Advantage: The presence of the hollow lumen in Calotropis gigantea is the key functional driver, ensuring the 10s count yarn remains lightweight despite its high linear density.

To ensure statistical validity, ten observations were recorded for each blend ratio using a MAG Uni-strength tester operating on the CRE principle. Testing was performed under standard atmospheric conditions (21°C, 65% RH) following ASTM D2256 protocols. SEM morphological analysis was conducted at various magnifications to validate the interfacial bonding between the high-tenacity viscose carrier and the hollow-core Calotropis gigantea fibres.

5. DESIGN AND APPLICATION

5.1 Technical Textiles

With its mechanical properties and 10s count, this hybrid yarn shows considerable promise for technical textile applications.

Target Applications: Durable home textiles (curtains and table runners), eco-friendly upholstery, and industrial-strength cords.

Functional Benefit: The hollow milkweed core keeps products lightweight while enhancing insulation compared to solid cellulose yarns.

6. CONCLUSION

This study demonstrated the feasibility of engineering a 10s count hybrid yarn by blending Calotropis gigantea and Viscose. Inclusion of milkweed fibre lowers overall tensile strength compared to pure viscose; however, the 60:40 ratio achieves a favourable balance, yielding stable yarns suitable for woven and technical applications. SEM analysis confirmed complementary fibre interaction, establishing these blends as a viable, biodegradable option for sustainable textiles. Since both milkweed and regenerated cellulose (Viscose) are natural fibres, the resulting yarn is 100% biodegradable. There is significant scope for Calotropis gigantea in the future of greener, sustainable yarns.