Experimental Analysis on Tensile and Compressive Properties of Ramie Cellulose Fibre Reinforced Polymer Composite

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**Abstract:** Ramie cellulose fiber, gotten from the stem of the ramie plant (Boehmeria nivea), has earned impressive intrigued in later times owing to its particular properties. These incorporate momentous ductile quality, amazing dampness assimilation capabilities, and commendable biocompatibility. These highlights render ramie cellulose fiber well-suited for differing applications, traversing materials, paper generation, and composite materials. Tests of ramie cellulose fiber within the shape of yarns or texture were gotten from Go Green Items in Chennai. The ramie textures had an zone thickness of 135.1 g/m 2 and a thickness of 0.291 mm. The ductile quality of the twist and weft yarns measured 44.81 MPa and 55.45 MPa, separately. The morphology of ramie strands, recognizing between chemically treated and untreated tests. The nearness of pollutions, especially those wealthy in hydroxyl substance like hemicelluloses, pectin, and lignin, is discernible on the surface of the untreated filaments. Mechanical properties of ductile quality of the fiber treated by the antacid arrangement gotten the esteem of 29.87 which is expanded when compared to the untreated filaments. The adaptable quality of the fiber soluble base treated gotten the most elevated esteem of 34.76 is expanded when compared with untreated filaments. Affect vitality gotten the esteem of 19 when compared to the untreated filaments. The fiber illustrated essential ductile quality, flexural quality, and affect vitality retention capabilities, highlighting its potential for assorted applications in dental biomaterial.

**Keywords:** Ramie cellulose fiber, composite materials, tensile strength, compressive strength.

# Introduction

In later a long time, there has been a noteworthy worldwide move towards increased environmental mindfulness, driving to expanded intrigued within the advancement of low-cost, biodegradable materials with improved properties. This move is driven by a developing acknowledgment of natural issues and a collective commitment to economical hones. The use of cellulosic and lignocellulosic materials, such as cellulose strands, wood strands, sisal, jute filaments, and nut flour, as fillers or fortifications for polymeric networks has picked up energy, giving an eco-friendly elective to conventional materials [(Woodings, 2001)](https://paperpile.com/c/PToojE/HJ4C). Ramie, once a dominant common fiber within the material industry, has confronted limitations in its far reaching utilize due to challenges within the degumming handle and a need of comprehensive information in mechanical handling. In any case, with the expanding worldwide center on environmental mindfulness and the request for secure, biodegradable and recyclable materials, ramie is recapturing consideration. Eminent for its shine, quality, surprising microbial resistance, and sterile properties, ramie has particular preferences. However, challenges such as the nearness of encrusting gummy materials and cohesiveness have prevented its broader application. In case these challenges can be successfully tended to, ramie's natural properties might be tackled to engineer a different extent of items. This move has the potential to position ramie as a profitable and feasible asset within the material industry, adjusting with the current biological consciousness.2 Ramie strands, extricated from Boehmeria nivea among lignocellulosic materials, recognize themselves through surprising mechanical quality, showing a ductile quality extending from 400 to 1600 MPa. Moreover, they highlight the next concentration of Î±-cellulose, extending from 80% to 85%, outperforming cotton and silk filaments in this viewpoint. Morphologically, these strands ordinarily degree 120 to 150 mm in length, with the potential to reach an amazing 620 mm. Their breadth shifts between 40â60 Î¼m to 126 Î¼m. In 2016, the worldwide generation of ramie totaled 102,466 thousand tons, predominantly driven by China, which accounted for an overpowering 97.38% of the generation share . Fiber may be a fabric that takes after bits of string and is used within the generation of components with craved properties[(Chauhan, 2021)](https://paperpile.com/c/PToojE/mASm) [(Harsha & Subramanian, 2022)](https://paperpile.com/c/PToojE/qwZE). Composite materials, on the other hand, are compositions made from different substances, where these substances are held together by a lattice gum. The lattice gum plays a pivotal part in giving different properties, counting malleable quality, firmness, and limiting weight. Composites are broadly categorised based on the lattice constituent, driving to classifications such as natural lattice composites (OMC), where an natural substance serves as the framework[(Chauhan, 2021; Wallenberger & Weston, 2003)](https://paperpile.com/c/PToojE/mASm+Lh8F) . Inside OMC, there are two essential sorts: polymer lattice composites (PMC), where polymers act as the network, and carbon-carbon composites (CCC), where carbon substances serve as the framework. Polymer framework composites (PMC) are assisted categorised into fiber-reinforced composites (FRC), particulate-reinforced composites (PRC), and basic composites (SC). Fiber-reinforced plastics (FRP), a subset of PMC, are composite materials made by fortifying filaments with a polymer lattice. Common strands incorporate glass, aramid, carbon, and wood [(Agarwal & Broutman, 1980)](https://paperpile.com/c/PToojE/IHGj) [(Dharman 2021)](https://paperpile.com/c/PToojE/mzswr). In particulate-reinforced composites, particulates like silica, ruddy mud, and SiC are utilized as support with a polymer framework[(Balaz, 2008)](https://paperpile.com/c/PToojE/x9bO) . It's worth noticing that particulate support is by and large less successful than fiber support in terms of reinforcing the composite fabric[(Agarwal & Broutman, 1980)](https://paperpile.com/c/PToojE/IHGj)[(Sabarathinam & Madhulaxmi, 2021)](https://paperpile.com/c/PToojE/F4gWM)[(Sushanthi et al., 2021)](https://paperpile.com/c/PToojE/oXDKu)[(Harsha et al., 2022)](https://paperpile.com/c/PToojE/V6qNs) . Basic composites are materials composed of two or more diverse constituent materials with unmistakable physical and chemical properties. Surface medicines, such as antacid and silane, have been connected to ramie fiber, affecting the mechanical properties of ramie fiber-reinforced poly(lactic corrosive) (PLA) composites. These medications lead to moved forward grip between the fiber and PLA lattice, coming about in upgraded mechanical and thermo-mechanical properties within the composite. This underscores the noteworthiness of surface treatments in advancing the execution of ramie fiber-reinforced composites through reinforced holding with the polymer matrix (8). Composite fabric characteristics expand past common fiber properties, enveloping components like interfacial holding, surface range, measurements and fortification volume division. The fiber-matrix interface is essential for stack exchange, impacted by attachment quality subordinate on forms such as fiber official and lattice intelligent. Urgently, fiber surface treatment decides properties and grip levels. Additionally, hydrophilic properties, driven by hemicellulose and cellulose, impact the interaction between common filaments and hydrophobic frameworks, affecting grip bonds. A comprehensive understanding of these components is fundamental for enhancing composite fabric properties [(Lomov, 2011)](https://paperpile.com/c/PToojE/ohAI) . Using brief and long ramie filaments in conjunction with soy protein polymer composites, we effectively created completely biodegradable and eco-friendly materials. The characteristic polar bunches in both the strands and the protein-based tar cultivated vigorous interaction, driving to a tall interfacial shear quality. Particularly, the brief fiber composites discover application in bundling, though the long fiber composites illustrate guarantee for utilize in basic lodging or transportation [(Tasnim et al., 2025)](https://paperpile.com/c/PToojE/GbQQ)[(Ajay, Suma, et al., 2022; Katyal et al., 2021; Maiti, 2021)](https://paperpile.com/c/PToojE/Zyco+7AMO+XANA). Alkaline-treated ramie filaments experience characterization through the Cheson strategy to find out their chemical composition. Moreover, FT-IR testing is utilized to distinguish the utilitarian bunches display in ramie filaments. Morphological tests are conducted to look at the surface structure and breadth of ramie filaments. Besides, pliable testing is employed to assess the ductile quality and pliable modulus of PLA/ramie composite materials [(Low & Dong, 2021)](https://paperpile.com/c/PToojE/BCrX). Investigate examinations demonstrate certain downsides in composites created with natural strands and thermosetting tar. These strands show expanded affectability to dampness, and there's a less cohesive combination at the interface between the hydrophilic fiber and hydrophobic framework [(Tiwari & Jain, 2023)](https://paperpile.com/c/PToojE/KqII7)[(Graf et al., 2023)](https://paperpile.com/c/PToojE/kXnNR) . The importance of the interface is broadly recognized for its urgent part in impacting the mechanical execution [(Laplante, 1997)](https://paperpile.com/c/PToojE/qT4O)[(Deepika et al., 2022; Harsha & Subramanian, 2022; Solanki et al., 2022)](https://paperpile.com/c/PToojE/qwZE+ZB0G+1p0C) . point of the test investigation is to explore the ductile and compressive properties of a composite fabric comprising ramie cellulose fibers.Through careful testing, the consider points to offer a comprehensive knowledge into the material's mechanical reaction beneath pressure and compression, in this manner giving profitable data almost the execution and potential applications of the ramie cellulose fiber composite.[(Ajay, Rakshagan, et al., 2022; Ajay, Sasikala, et al., 2022; Chidambaram et al., 2022)](https://paperpile.com/c/PToojE/kI83+TV5y+j0Qe)

# Materials and Method

Ramie cellulose fiber tests within the shape of yarns or texture. Ramie textures with the zone thickness of 135.1 g/m? and thickness of 0.291 mm, were given by Go green items, Chennai. The pliable quality of the twist and weft yarns was 44.81 MPa and 55.45 MPa, individually. Figure 1 and 2 gives a visual comparison of the morphology of ramie filaments, showing both chemically treated and untreated examples.



## Alkali Treatment

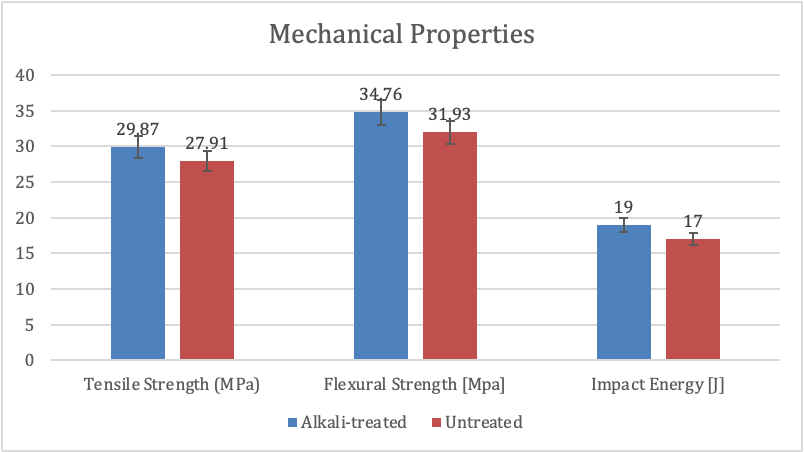
Soluble base Treatment The antacid arrangement concentration was 1 wt% (weight rate compared to refined water), the ramie texture and soluble base shower proportion was 1:20. After submerging the textures within the soluble base fluid for 60 min, at a temperature of 60 Â°C, the textures were evacuated and washed to neutral, in warm water, and after that cured in an electro-thermal blowing broiler (Show DHG-9070A, Shanghai Logical Instrument Co. Ltd., Shanghai, China) for 12 h. The temperature within the stove was kept at 80 Â°C amid the drying handle. As per the ASTM standard the exploratory was conducted for this cross breed composite. For pliable test(ASTM D638), flexural test-3 point twisting test(ASTM D790), Izod Affect test(D256) was taken after.

## Fabrication of the Composite

Ramie fabric-reinforced PLA composites were made employing a pressure driven press.The composition of ramie fabric/PLA (v/v) was 60/40, crosslink agent/PLA (w/w) was 33/67, and curing agent/PLA (w/w) was 1/99. The method included at first squeezing the ramie fabric/PLA prepreg for 10 minutes at room temperature with weights up to 10 MPa. Hence, it experienced warm squeezing for an extra 60 minutes at a temperature of 90 Â°C, applying weights up to 20 MPa to guarantee uniform PLA permeation. The squeezing proceeded at weights up to 20 MPa, at a temperature of 115 Â°C, for 2 minutes. Taking after this, the method continued with weights up to 20 MPa at a temperature of 130 Â°C for 30 minutes, taken after by cooling to room temperature. The composites were at that point evacuated from the press and subjected to post-curing at a temperature of 140 Â°C for 120 minutes. The recorded time prohibited the warming prepare term, beginning from when the pressure driven press come to the set temperature.

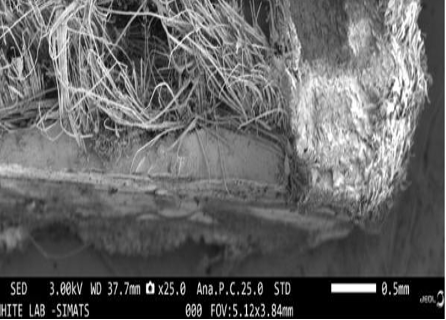
# Results and Discussion

The untreated filaments show discernible debasements on their surface, especially substances wealthy in hydroxyls, such as hemicelluloses, pectin, and lignin. These debasements can influence the generally quality and properties of the filaments. Upon subjecting the ramie filaments to soluble base treatment, a noteworthy enhancement within the cleanliness of the fiber surface is watched. The soluble base treatment successfully expels a few of the debasements that were display on the untreated strands. This cleaning prepare improves the generally immaculateness of the ramie strands, making them more reasonable for different applications, particularly in composite materials where a clean and uniform surface is vital for ideal execution. In outline, the morphological comparison, as portrayed in Figure 1, highlights the positive affect of antacid treatment on the cleanliness and immaculateness of ramie filaments. This enhancement has suggestions for the execution of these strands in applications extending from materials to composite materials, where a cleaner surface is regularly related with improved mechanical and basic properties. After experiencing soluble base treatment, ramie filaments shown eminent advancements in their mechanical properties. The ductile quality expanded to 29.87, displaying upgraded resistance to extending. The alkali-treated filaments illustrated a surprising flexural quality of 34.76, showing expanded solidness and resistance to twisting. Besides, the affect vitality retention capability moved forward, with a recorded esteem of 19 compared to untreated filaments. These positive results highlight the potential of alkali-treated ramie strands for assorted applications, accentuating their prevalent mechanical execution and expanded flexibility. Figure 3. Appears the mechanical Properties of ramie fiber composite.



**Figure 3.** Mechanical Properties of ramie fiber composite

The morphology of untreated ramie filaments appears recognizable debasements wealthy in hydroxyls, affecting fiber quality. Soluble base treatment essentially progresses fiber surface cleanliness by evacuating debasements, upgrading generally virtue. This advancement is significant for applications, especially in composites, where a clean surface is fundamental for ideal execution [(Balaji Ganesh S & Sugumar, 2021; Jabin et al., 2021)](https://paperpile.com/c/PToojE/gwGJ8+VODSA). The positive affect of soluble base treatment on ramie strands recommends potential headways in mechanical and auxiliary properties.Alkali-treated ramie strands display upgraded mechanical properties, making them perfect for composite materials. The expanded malleable quality strengthens the composite structure, especially vital in businesses like aviation or car. The increased flexural quality contributes to the material's capacity to resist twisting and distortion, upgrading generally solidness. Made strides affect vitality assimilation is useful in applications like development materials or sports gear, avoiding breaks amid sudden impacts. Alkali-treated ramie filaments play a profitable part in composite materials, raising their quality, strength, and affect resistance for different high-performance applications. Figure 4. Appears the SEM picture of ramie fiber composite.



**Figure 4**. SEM image of ramie fiber composite

Ramie fiber, inferred from the plant Boehmeria nivea (L.) Gaudich, stands out as a noteworthy and environmentally-friendly elective to cotton. Extricated from the plant base, ramie fiber serves as a pivotal crude fabric within the material industry and brags a outstandingly lower carbon impression compared to cotton. Its development requires less water, and it holds guarantee as a potential source for wholesome creature feedstock. When differentiated with glass strands, characteristic strands like ramie offer unmistakable points of interest, counting biodegradability, strong mechanical properties, lower thickness, and higher particular solidness [(Graf et al., 2023; Ramamurthy & Jaiganesh, 2021; Tiwari & Jain, 2023)](https://paperpile.com/c/PToojE/QqPPw+KqII7+kXnNR). The manufacture of cross breed composites utilizing ramie and jute common filaments as support, an epoxy polymer as a network, and SiC and cellulose as fillers through a hand layup handle[(Govindaraj & Dinesh, 2021; Rajeshkumar et al., 2021; Sushanthi 2021)](https://paperpile.com/c/PToojE/faeg+Ww7m+WLmD). Mechanical tests illustrated an upgrade in ductile and flexural quality as the substance of bidirectional woven ramie fiber expanded, whereas these properties diminished with higher substance of chopped jute fiber. The Izod affect test comes about shown that the chopped jute fiber form exhibited more prominent resistance to affect loads compared to woven ramie tangle filaments. Thus, the affect vitality expanded with the hoisted substance of chopped jute fiber within the half breed composites. Surface morphological examination using SEM uncovered highlights like fiber pullout, splits, and other disappointment modes within the cross breed composites (14). Strands illustrate critical potential as strengthening components in tar network composite materials. Composites containing 45% ramie strands displayed a surprising upgrade in malleable quality, coming to up to a 338% increment compared to uncovered polyester gum. Interests, not one or the other the texture sort nor the string breadth applied a considerable impact on the pliable properties of the examined composites. Instep, the prevailing calculate forming the ductile conduct was the volume division of adjusted ramie filaments inside the composite structure . The discoveries recommend that utilizing low-concentration soluble base medications demonstrates exceedingly advantageous in upgrading the surface properties and by and large execution of abaca filaments for progressed composite applications. Furthermore, inquire about on Glass-sisal polyester cross breed composites uncovered pliable and flexural qualities of roughly 12.35 MPa and 53.46 MPa, separately. Analyzing the affect of a basalt external layer on flax-reinforced composites demonstrated made strides soundness in both inactive and energetic loads. An exploratory examination into a new hybrid composite fabric utilizing ramie-flax illustrated a progressive 15% increment in ductile and flexural quality, beside an 8% diminishment in quality properties compared to immaculate ramie strands (16) (Chehelgerdi et al., 2023). Cellulose strands are regularly utilized to fortify thermosetting lattices, showing a challenge due to their hydrophilic nature. Thermoplastic networks like polyethylene and polypropylene, with hydrophobic characteristics, require methodologies to decrease interfacial vitality for viable utilize of lignocellulosic strands as support. Overcoming this challenge includes bringing down the fiber's surface vitality, and uniting a matrix-compatible polymer onto the fiber surface has demonstrated successful in improving fiber-matrix grip and scattering within the framework . Essentially, ramie cellulose fiber composites confront the assignment of joining hydrophilic strands with hydrophobic thermoplastic frameworks[(Neha et al., 2021)](https://paperpile.com/c/PToojE/F3g9L)[(Maliael et al., 2021)](https://paperpile.com/c/PToojE/Ck0vs)[(Lakshmi, 2021)](https://paperpile.com/c/PToojE/PRW6F). Utilizing methodologies like surface vitality decrease through joining can make strides fiber-matrix grip and scattering (Saadh et al., 2024). The special characteristics of ramie cellulose strands, such as tall ductile qualityand biocompatibility, may direct the optimization of these techniques to improve composite properties . Various analysts are progressively recognizing the worldwide request for common strands, provoking examinations into half breed composites consolidating cellulosic strands. The exploration of half breed composite classes has uncovered noteworthy properties when common filaments are combined with their partners or other fortifications. In a related ponder, analysts inspected the mechanical conduct of natural-glass fiber-reinforced polymers and their half breed composites. Their discoveries recommended that joining common filaments like hemp, bamboo, banana, coir, cotton, pineapple, abaca, jute, and sisal into glass fiber-reinforced polymers upgrades item effectiveness in both designing and innovation segments . the mechanical conduct of epoxy composites strengthened with brief Agave filaments. The comes about uncovered that epoxy composites with both untreated and alkali-treated Agave strands, particularly the briefest filaments (3 mm), illustrated great grip with the epoxy tar. Moreover, the composite joining alkali-treated filaments shown marginally higher malleable, compression, flexural, and affect quality compared to the one with untreated filaments. The application of soluble base treatment for fiber surface alteration contributed to upgraded composite quality characteristics, displaying the potential benefits of surface medications in optimising the mechanical execution of normal fiber-reinforced composites.

# Conclusion

The exploratory investigation of ramie cellulose fiber composites uncovered promising mechanical properties, with made strides pliable quality and basic steadiness. The application of soluble base treatment assist upgraded the composite's execution, as prove by cleaner surface morphology and expanded grip between strands and the lattice. This ponder underscores the potential of ramie cellulose fiber composites for different applications, underscoring their part as low-cost, biodegradable materials with upgraded properties. Assist inquire about and prepare optimization can contribute to the progression of these feasible and high-performance materials.

# SCOPE OF FUTURE RESEARCH

Future inquire about can investigate optimization of preparing parameters and surface alterations for upgraded ramie fabric-reinforced PLA composites. Examination into the affect of fiber introduction, appraisal of biodegradability, and joining of multifunctional properties offer roads for encourage investigation. Progressed characterization methods and application-specific thinks about, together with life cycle appraisals and advertise possibility examinations, can contribute to a comprehensive understanding and more extensive appropriation of these composites. Collaborative endeavors with differing disciplines can bring inventive points of view to the improvement and application of ramie fabric-reinforced PLA composites.

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