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THE FABRICATION AND MECHANICAL TESTING OF RAMIE AND FLAX FIBER EPOXY REINFORCEDCOMPOSITE WITH NANO TiO_2 FILLER.

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Abstract :
This study investigates the fabrication and mechanical properties of ramie flax fiber epoxy composites reinforced with nano TiO2 filler. Ramie flax fibers were incorporated into an epoxy matrix along with varying concentrations of nano TiO2 filler. The composites were fabricated using a hand lay-up technique followed by compression molding. Mechanical testing, including tensile, flexural, and impact tests, bio-degradable was conducted to evaluate the performance of the composites. Results indicate that the addition of nano TiO2 filler enhances the mechanical properties of the composites compared to those without filler. Furthermore, scanning electron microscopy (SEM) analysis was employed to examine the morphology and interfacial bonding of the composites. Overall, this research demonstrates the potential of utilizing ramie flax fiber epoxy composites with nano TiO2 filler for various structural applications, offering improved mechanical performance and sustainability.

Keywords;Ramie flax Fiber, epoxy composites, nano TiO2 filler, fabrication, mechanical testing, tensile strength, flexural properties, impact resistance, SEM analysis, interfacial bonding.

1.INTRODUCTION:

Natural fiber-reinforced polymer composites have emerged as promising alternatives to traditional materials in various engineering applications due to their lightweight nature, renewability, and eco-friendly characteristics. Among these natural fibers, ramie flax fibers have attracted considerable attention owing to their high tensile strength, stiffness, and low density, making them suitable candidates for reinforcing polymer matrices. In particular, epoxy resins are widely utilized as matrix materials in composite fabrication due to their excellent mechanical properties, chemical resistance, and adhesion to fibers. However, despite their inherent advantages, natural fiber-reinforced epoxy composites often exhibit limitations such as inferior interfacial bonding and inadequate mechanical properties, which can restrict their widespread adoption in demanding applications.To address these challenges and further enhance the performance of natural fiber-reinforced epoxy composites, researchers have explored the incorporation of nanofillers to improve mechanical properties, enhance interfacial adhesion, and impart additional functionalities to the composite materials. Among various nanofillers, titanium dioxide (TiO2) nanoparticles have garnered significant attention due to their unique properties, including high aspect ratio, large surface area, and excellent mechanical strength. By dispersing TiO2 nanoparticles within the epoxy matrix, it is possible to reinforce the composite structure at the nanoscale, thereby enhancing its overall mechanical performance and durability.This study aims to investigate the fabrication process and evaluate the mechanical properties of ramie flax fiber epoxy composites reinforced with nano TiO2 filler. The research will focus on assessing the effects of varying TiO2 filler concentrations on the mechanical performance of the composites, including tensile strength, flexural properties, and impact resistance. Additionally, scanning electron microscopy (SEM) analysis will be employed to examine the morphology of the composites and evaluate the interfacial bonding between the fibers, *epoxy* matrix, and TiO2 nanoparticles. The insights gained from this study are expected to contribute to the development of sustainable and high-performance composite materials for diverse engineering applications, including automotive components, aerospace structures, and construction materials. Overall, the integration of ramie flax fibers, epoxy resin, and nano TiO2 filler holds significant potential for advancing the field of composite materials by offering enhanced mechanical properties, improved sustainability, and broader application possibilities. Through systematic experimentation and analysis, this research seeks to elucidate the underlying mechanisms governing the behavior of these composite materials and provide valuable insights for their optimization and practical implementation in real-world engineering scenarios.

2.EXPERIMENTAL:

2.1.MATERIALS

- Ramie Fiber (30x20cm)
- Flax Fiber (30x20cm)
- Epoxy Resin
- Epoxy Hardner
- Titanium Dioxide Tio_2
- Mild Steel Plate (400cmx300cmx20cm)
- P.V.C Sheets

2.2 Ramie Fiber:

Ramie fiber, derived from the Boehmeria nivea plant, is an ancient textile material known for its remarkable strength and durability. Originating in East Asia, particularly China, it has been cultivated for millennia. Its exceptional resistance to mildew and sunlight makes it ideal for enduring fabrics. Ramie's smooth surface gives fabrics a luxurious appearance while also boasting excellent moisture absorption properties, ideal for hot climates. The fiber's breathability ensures comfort in wear, making it suitable for various apparel and textile applications. Ramie undergoes a meticulous processing journey, from harvesting to spinning, resulting in high-quality yarns and threads. Beyond textiles, ramie finds utility in industrial sectors, including rope and net production, owing to its robust nature. Its sustainability is noteworthy, requiring minimal chemical inputs and being biodegradable. Despite its benefits, ramie's stiffness and brittleness pose challenges in certain applications. Nonetheless, its rich history and versatile properties continue to make ramie a sought-after material in modern industries.

Fig1.Ramie Fiber mat

2.3 Flax Fiber: Flax fiber, derived from the flax plant, is valued for its strength, flexibility, and eco-friendly nature. It undergoes processing steps like retting and drying to obtain clean fibers. These fibers are lightweight yet possess good tensile strength, making them ideal for reinforcement in composite materials. Flax fiber composites are used in automotive parts, construction materials, and sporting goods. Despite their moisture absorption tendency, proper treatment enhances their performance. The biodegradable nature of flax fibers aligns with sustainable manufacturing practices. Their renewable source and lower environmental impact contribute to their growing popularity in materials engineering.

Fig2.Flax Fiber mat

Fig3.Epoxy Resin

Fig4.Epoxy Hardener

2.4 Epoxy Resin:

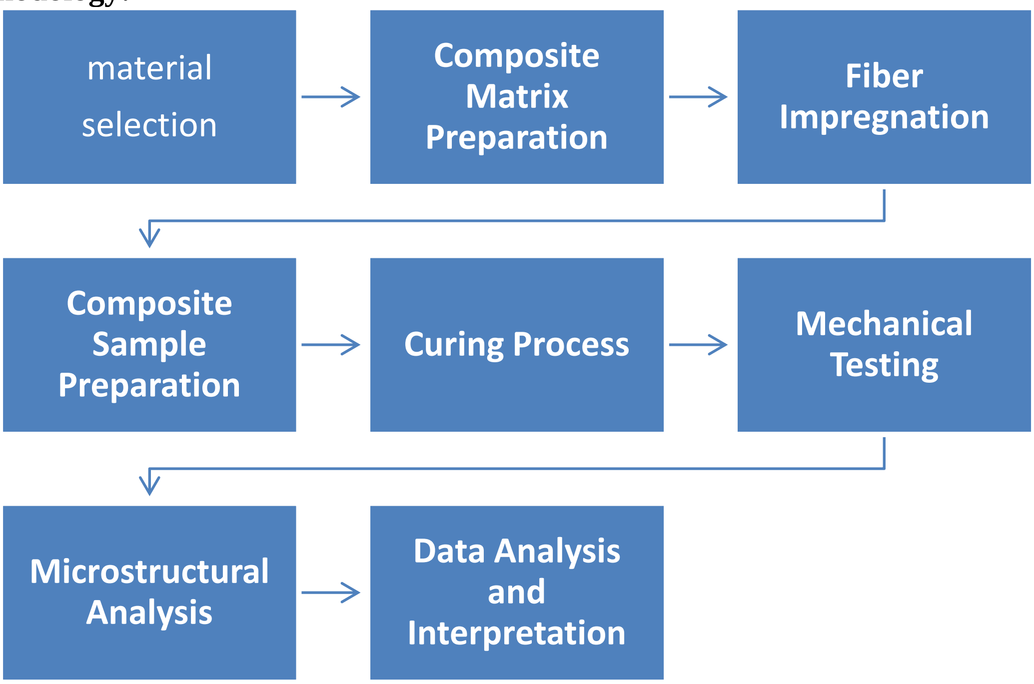
Epoxy resin and hardener are essential components in composite fabrication projects. Epoxy resin, a thermosetting polymer, acts as the matrix that binds reinforcement materials like fibers together. It offers excellent adhesion, chemical resistance, and mechanical properties when cured. The hardener, typically a curing agent like amine or anhydride, initiates the cross-linking reaction with the epoxy resin, leading to the formation of a rigid and durable composite structure. The ratio and curing conditions of epoxy resin and hardener significantly impact the final material properties, including strength, stiffness, and thermal resistance. Proper mixing and curing procedures are crucial for achieving the desired mechanical and thermal characteristics in epoxy-based composites. Adherence to manufacturer guidelines and safety protocols is essential during handling, mixing, and curing processes for optimal results.

2.5 Titanium dioxide(Tio$_2$ nano):

The function of TiO2 (titanium dioxide) nanoparticles in the fabrication of ramie flax fiber epoxy composites is multifaceted. Firstly, TiO2 serves as a reinforcing agent within the epoxy matrix, contributing to improved mechanical properties such as tensile strength and flexural modulus. Additionally, TiO2 nanoparticles facilitate the formation of a nanostructured network within the composite, enhancing the distribution and homogeneity of filler particles for uniform properties. The presence of TiO2 also promotes stronger interfacial bonding between the ramie flax fibers and the epoxy matrix, reducing the risk of delamination and enhancing overall composite integrity. Furthermore, TiO2 can contribute to enhancing the barrier properties of the composite, making it more resistant to environmental factors such as moisture and chemicals. Depending on its surface treatment, TiO2 nanoparticles can impart additional functionalities to the composite, such as UV resistance or antimicrobial properties, expanding its potential applications. In essence, TiO2 plays a pivotal role in improving the performance, durability, and functionality of ramie flax fiber epoxy composites, making them viable for various engineering and structural applications.

Fig5.Titanium dioxide

3.Methodology:



This methodology involves selecting and preparing ramie flax fibers, epoxy resin, and TiO2 nanoparticles. The epoxy matrix is then mixed with TiO2 nanoparticles and impregnated into the ramie flax fibers. Composite samples are prepared, cured, and subjected to mechanical testing to assess properties like tensile strength and flexural modulus. Microstructural analysis using scanning electron microscopy (SEM) is conducted to examine the distribution of TiO2 nanoparticles and interfacial bonding. Finally, data analysis is performed to understand the effects of TiO2 concentration on composite performance.

4.Testing:

Testing plays a crucial role in evaluating the performance and properties of materials, components, and systems across various industries. Here are key aspects and types of testing commonly employed.

4.1Purpose:

Testing is conducted to validate design specifications, assess quality and reliability, ensure regulatory compliance, and identify potential defects or weaknesses

4.1.1. Impact Test:

This test assesses the ability of the composite material to withstand sudden loading or impact forces.It provides insights into the material's toughness, resistance to fracture, and energy absorption capacity under dynamic conditions.

4.1.2. Flexural Test:

The flexural test, also known as bending test, evaluates the material's stiffness and strength when subjected to bending forces.It helps determine the modulus of elasticity (flexural modulus) and maximum bending stress the material can withstand before failure.

4.1.3. Tensile Test:

Tensile testing measures the material's tensile strength, elongation, and modulus of elasticity under tensile (pulling) forces.It provides crucial data on the material's ability to resist stretching or breaking when pulled in opposite directions.

The tests conducted in this study encompass a comprehensive assessment of the ramie flax fiber epoxy composites reinforced with nano TiO2 filler:

4.1.4. SEM Analysis (Scanning Electron Microscopy):

SEM analysis is used to examine the microstructure of the composites at a high resolution. It provides visual information about the distribution of TiO2 nanoparticles, the quality of interfacial bonding between fibers and matrix, and any defects or failure mechanisms within the material.

5. Biodegradability Test:

The biodegradability test assesses the environmental sustainability of the composite material by determining its ability to degrade naturally over time. This test is crucial for evaluating the eco-friendliness and long-term environmental impact of the composite in real-world applications.

By conducting these tests, the study aims to gain a comprehensive understanding of the mechanical properties, microstructural characteristics, and environmental impact of the ramie flax fiber epoxy composites reinforced with nano TiO2 filler. These insights can inform material design, optimization strategies, and potential applications in sustainable engineering and manufacturing.

Fig6.Tensile, Impact and Flexural Tests

5.Results and Discussion:

SPECIMEN.1: Ramie:flax = 5:4 ratio

Ramie and flax mix with 5:4 ratio to prepare matrix

SPECIMEN.2: Ramie:flax = 4:5 ratio

Ramie and flax mix with 4:5ratio to prepare matrix

SPECIMEN.3: Ramie:flax = 5:5 ratio

Ramie and flax mix with 5:5 ratio to prepare matrix

5.1 Tensile Test :

Fig7.Tensile Test on Specimens

SPECIMEN NUMBER	ULTIMATE LOAD	ULTIMATE TENSILE STRENGTH
SPECIMEN 1	3638.56	51.16
SPECIMEN 2	3169.52	41.02
SPECIMEN 3	3711.41	47.24

5.2 IMPACT TEST:

Fig8.impact Test on Specimens

SPECIMEN NUMBER	IMPACT 1 (Joules)
SPECIMEN 1	14
SPECIMEN 2	8
SPECIMEN 3	16

5.3FLEXURAL TEST:

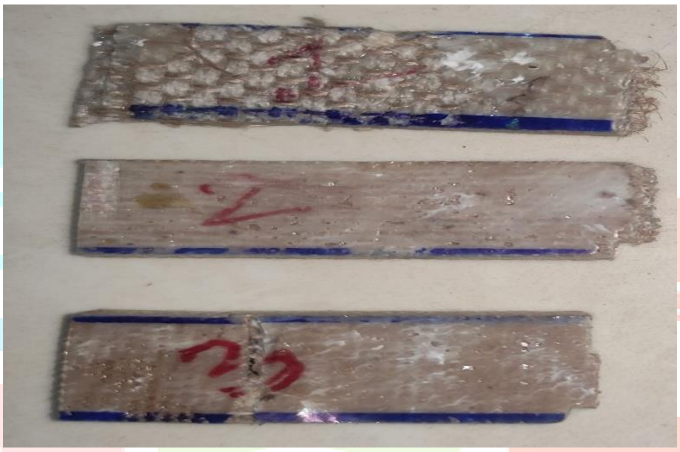
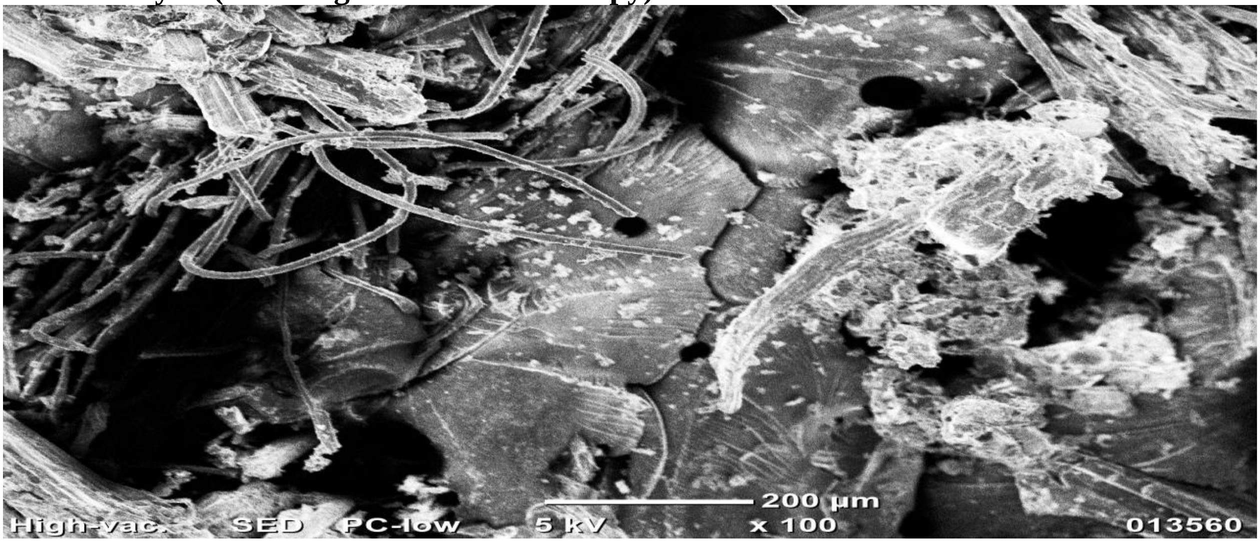
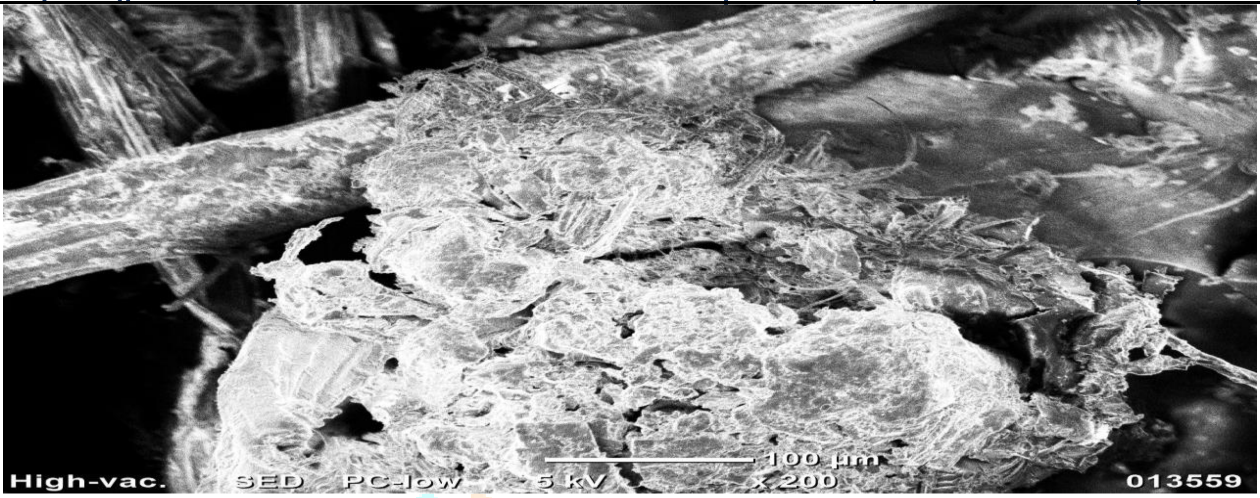


Fig9.Flexural Test on Specimens

SPECIMEN NUMBER	ULTIMATE LOAD	FLEXURAL TENSILE STRENGTH
SPECIMEN 1	573.82	95.3
SPECIMEN 2	437.11	68.39
SPECIMEN 3	546.88	80.57

5.4 SEM Analysis (Scanning Electron Microscopy):





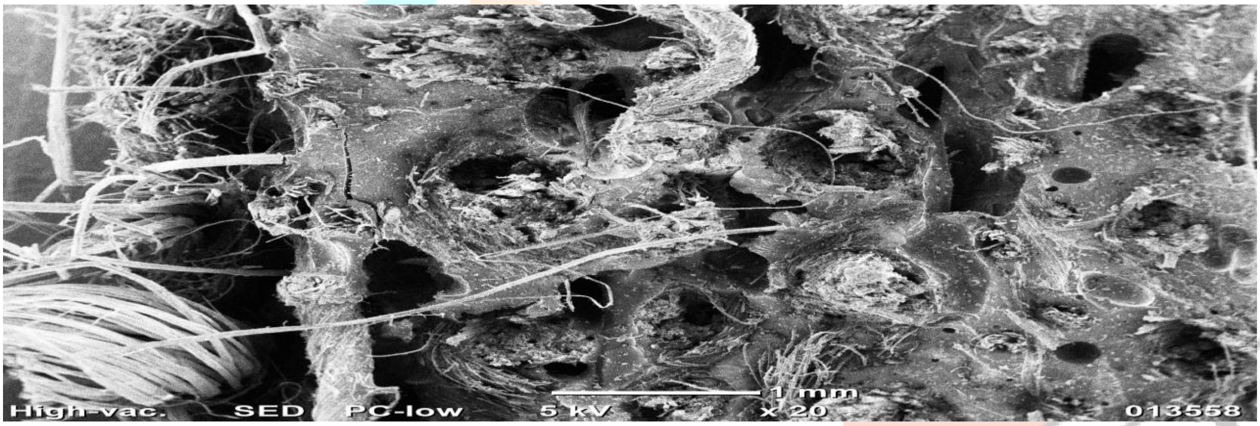


Fig10 S.E.M Analysis

5.5 BIO DEGRADABLE TESTING:

SPECIMEN NUMBER	Weight in 1st week	Weight in 2nd week	Weight in 3rd week	Weight in 4th week
SPECIMEN 1	40grms	38.7grms	36.28grms	35.42grms
SPECIMEN 2	40grms	38.54grms	37.86grms	36.85grms
SPECIMEN 3	40grms	39.02grms	38.16grms	37.89grms

6.CONCLUSION:

The fabrication of ramie and flax fiber epoxy reinforced composites with nano TiO2 filler involves a systematic process to ensure the desired mechanical properties. Initially, the raw ramie and flax fibers are cleaned, dried, and optionally cut to the desired length. The epoxy resin is then prepared by mixing it with a suitable hardener, followed by the dispersion of nano TiO2 filler in a solvent. Proper dispersion techniques such as sonication or stirring are employed to achieve uniform distribution of the filler within the epoxy matrix. The prepared fibers are then combined with the epoxy resin mixture, along with the nano TiO2 filler, if included. This composite mixture is then molded into the desired shape using a mold or shaping apparatus and cured according to the recommended schedule for the epoxy resin system. Post-curing may be performed if necessary to enhance mechanical properties further. Mechanical testing, including tensile, flexural, impact, and compression tests, is conducted to evaluate the composite's performance. Analysis of test results and characterization techniques such as SEM or FTIR may be employed to assess the microstructure and chemical interactions within the composite. Overall, this process aims to develop robust composites with improved mechanical properties for various engineering applications.

7.PROBLEM STATEMENTS:

The project of fabricating ramie and flax fiber epoxy reinforced composites with nano TiO2 filler addresses key challenges in composite materials. By enhancing mechanical properties like strength, stiffness, and impact resistance, the composites become suitable for demanding applications. Incorporating nano TiO2 filler also improves durability against moisture, UV radiation, and chemical exposure, extending the lifespan of these materials. This approach contributes to lightweight solutions without compromising on strength, crucial for industries like automotive and aerospace. Furthermore, using renewable natural fibers promotes sustainability and reduces environmental impact compared to synthetic alternatives. The exploration of nanocomposite technology expands knowledge in advanced material science and offers opportunities for cost-effective manufacturing. Academic contributions include insights into fabrication techniques, filler dispersion methods, and mechanical testing protocols, benefiting future research in this field. Overall, this project bridges the gap between industry needs for high-performance materials and the quest for sustainable and innovative solutions in material science.

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