ScienceDirect

Materials Today: Proceedings

Available online 12 June 2024

In Press, Corrected Proof What's this?

Comparison of mechanical stability and morphology study between tree fibres and shrub fibres reinforced epoxy bio-composites

K. Subithalini, R. Pugazhenthi (pugal), R. Sridhar, C. Gnanavel

Show more

Share Cite

https://doi.org/10.1016/j.matpr.2024.06.010
Get rights and content

Highlights

- In this work, successfully prepared the lightweight, economical, and with good mechanical characteristics polymer matrix biocomposites reinforced with tree fibers of Morinda citrifolia and Tamarindus indica and also shrubs fibers of Tinospora cordifolia and Ipomoea staphylina were prepared.
- The epoxy composite reinforced with Tamarindus indica (TI) fibers exhibited the best overall mechanical performance, including the highest tensile strength (8.13 MPa), flexural load (0.32 KN), compression load resistance (5.98 KN), and relatively high Shore D hardness (51°).

- The epoxy composite reinforced with Tinospora cordifolia (TC) fibers showed the highest Shore D hardness (59°) among all composites, indicating superior hardness strength, but relatively low tensile strength (1.23 MPa) and flexural load (0.13 KN).
- SEM images confirmed the good dispersion of epoxy and natural fibers in the matrix, contributing to the observed mechanical properties, while the mixture of natural fibers and epoxy resin composite fibers exhibited inferior properties due to non-homogeneous dispersion within the polymer matrix.

Abstract

The material properties of bio-composites reinforced with natural fibers from shrubs (Tinospora cordifolia and Ipomoea staphylina) and trees (Morinda citrifolia and Tamarindus indica) are investigated in this study. Evaluation of these bio-composites' mechanical characteristics and microscopic structure was the main goal, with a comparison of the efficacy of shrub and tree fibers for use in future automobile structural parts, airplane interiors, and consumer goods in mind. Because of their unequal distribution within the polymer matrix, the characteristics of natural fibers and composite fibers made of epoxy resin were found to be insufficient. Utilizing an unprocessed natural fiber ratio of 50% fiber-to-resin, the composites were fabricated by hand layup technique. The findings showed that the epoxy composite enhanced with Tamarindus indica fibers (TIF) demonstrated outstanding mechanical properties, achieving a tensile strength of 8.15 MPa and compression strength of up to 5.89 kN. The compositions of the composites were analyzed using scanning electron microscopy (SEM) methods.

Introduction

Natural fiber-reinforced composites have gained significant attention in various industries due to their potential for enhancing mechanical properties and sustainability [1], [2]. This study focuses on investigating the material characteristics of epoxy bio-composites reinforced with a combination of synthetic and natural fibers, specifically derived from Morinda citrifolia, Tamarindus indica, Tinospora cordifolia, and Ipomoea staphylina [3]. The research aims to evaluate the mechanical integrity and microscopic structure of tree fibers in comparison to shrub fibers for potential applications in automotive structural components, aircraft interiors, and civilian products [4]. By employing a hand-layup technique and adhering to ASTM standards for specimen preparation, the study analyzes the composite structure using FTIR and SEM methods [5].

The sample of laminated composites was prepared using the hand layup technique. Initially, a 2 by 1 foot plywood board was used to create the desired design. Placed on a plywood board is plastic tape. Plywood boards, as opposed to metal or other types of molds, served as open molds in this project. Because plywood is inexpensive, extremely lightweight, and manageable. Plywood with a flat pattern was selected because we were creating flat type samples, and it worked well for our needs. The releasing agent was plastic tape. The findings highlight the exceptional tensile and compression strength of the Tamarindus indica-reinforced composite (TI) and the enhanced hardness exhibited by the Tinospora cordifolia-reinforced composite (TC) [6]. These results offer valuable insights into the mechanical and morphological characteristics of natural fiber-reinforced epoxy bio-composites, emphasizing their potential for diverse industrial applications.

Natural fiber-reinforced composites have gained significant attention in various industries due to their potential for enhancing mechanical properties and sustainability [7]. This study focuses on investigating the material characteristics of epoxy bio-composites reinforced with a combination of synthetic and natural fibers, specifically derived from Morinda citrifolia, Tamarindus indica, Tinospora cordifolia, and Ipomoea staphylina. The research aims to evaluate the mechanical integrity and microscopic structure of tree fibers in comparison to shrub fibers for potential applications in automotive structural components, aircraft interiors, and civilian products [8]. By employing a hand-layup technique and adhering to ASTM standards for specimen preparation, the study analyzes the composite structure using SEM methods [9]. The findings highlight the exceptional tensile and compression strength of the Tamarindus indica-reinforced fiber composite (TIF) and the enhanced hardness exhibited by the Tinospora cordifolia-reinforced fiber composite (TCF). These results offer valuable insights into the mechanical and morphological characteristics of natural fiber-reinforced epoxy bio-composites, emphasizing their potential for diverse industrial applications [10].

The usage of natural fibers and harnessing resources from nature is a splendid way to conserve the environment, while also focusing on enhancing material properties to elevate mechanical capabilities for various applications, meeting industrial sustainability needs [11], [12]. Boosting the mechanical strength of fibers at a larger scale can be achieved by incorporating a polymer matrix, leading to potential improvements in tribological behavior as well. Natural fibers serve as a viable alternative to synthetic fibers commonly used in modern industries, offering benefits such as lower density, cost-effectiveness, and biodegradability [13], [14]. Through innovative research, Manikandan et al unveiled a method involving surface-modified Morinda citrifolia fibers combined with 3μm silane-modified chitosan particles and epoxy resin, resulting in enhanced mechanical and thermal properties, as well as improved water uptake behavior in modified composite materials compared to their original form. In a similar vein, The integration of Tinospora cordifolia and Tectona grandis into epoxy and bisphenol resin, demonstrating superior performance in tensile strength, compression, and flexural tests for the composite material [15]. Further experimental evidence by Manikandan et al showcased the positive impact of introducing Tamarindus indica into epoxy and bisphenol resin, yielding enhanced mechanical strength and well-dispersed Tamarindus fibers within the matrix, as evidenced by SEM images [16].

Valadez-Gonzalez et al conducted tests confirming the efficacy of surface treatments on fiber-matrix interactions, focusing on morphological modifications to enhance interfacial shear strength between natural fibers and thermoplastic matrices through the use of silane-coupling agents and alkaline treatments, which increase surface roughness and expose more cellulose on the fiber surface [17]. Morinda citrifolia encompasses around 80 species globally, characterized by its medium height and green fruits that ripen with maturity. Tamarindus indica is a widely developed tree with a spreading and rounded shape, commonly found in West Africa and India [18], [19]. Tinospora cordifolia and Ipomoea staphylina are fibrous shrubs that are readily available in India, with both types of fibers being utilized in various traditional medicinal practices. Tinospora exhibits hepatoprotective, immunomodulatory, and anti-neoplastic properties [20], while Ipomoea is known for its anti-inflammatory, anti-diarrheal, and gastro protective effects [21]. The composites are crafted using hand layup techniques, which require low process parameters [22]. These composites, derived from trees and shrubs, can be applied in the manufacturing of automobile structural components, aircraft interior products, spacecraft, and other civilian applications that demand high damping, low weight, and energy absorption.This present study looks into two types of trees: Tamarindus indica and Moringa citrifolia, and two types of mushrooms: Tinospora cordifolia and Ipomoea staphylina. The major objective was to evaluate the mechanical properties and microscopic structure of these bio-composites, with an eye on comparing the effectiveness of shrub and tree fibers for usage in future consumer goods, airline interiors, and vehicle structural elements.

Access through your organization

Check access to the full text by signing in through your organization.

Access through **your organization**

Section snippets

Materials and methodology

The epoxy resin (VBR 8912) utilized in this study was the liquid diglycidyl ether of bisphenal-A type epoxy resin with a molecular weight of 195 g/mol and a kinematic viscosity of 12,000 cps. The curing agent (VBR 1209) employed for the solidification of the epoxy resin was TETA with a viscosity of 20 cps, sourced from Vasavibala Resins (P) Ltd, India. Various natural fibers including Morinda-citrifilia, Tamarindus–indica, Tinospora cordifolia, and Ipomoea staphylina were acquired from Go Green …

Mechanical properties

A tensile and flexural test was carried out on MCF, TIF, TCF, and ISF. The assessment of epoxy composites was performed following the guidelines of ASTM–D695 and ASTM–D 790. Utilizing a universal testing machine, the composites were subjected to testing with a transverse speed of 2.1 mm/sec and a load of 40 Ton. The compression test was conducted in accordance with ASTM–D 3039. Furthermore, the Micro-hardness (Shore-D) of the composites was determined using a durometer following ASTM–D 2240…

Conclusion

The natural fiber-reinforced composites of tree fibers (Morinda citrifolia and Tamarindus indica) and shrub fibers (Tinospora cordifolia and Ipomoea staphylina) are reinforced with epoxy have been successfully prepared and characterized. From this study it was inferred that the developed composites were lightweight, economical, and possessed good mechanical properties, among them Tamarindus indica fibers reinforced with the epoxy composite exhibiting the overall best performance.

The obtained…

CRediT authorship contribution statement

K. Subithalini: Methodology, Data curation. **R. Pugazhenthi:** Validation, Supervision. **R. Sridhar:** Visualization, Validation. **C. Gnanavel:** Writing – original draft, Visualization, Conceptualization.…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

Recommended articles

References (26)

K. Karthik *et al.*
Mater. Today:. Proc. (2022)

D.K. Patel *et al.*
Asian Pacific J. Trop. Disease (2012)

K. Karthik *et al.*
Mater. Today: Proc. (2022)

V. Ramesh *et al.*
Mater. Today: Proc. (2023)

Muthukumaran Ramasamy *et al.*
Mater. Today: Proc. (2021)

D.B. Dittenber *et al.*
Compos. A Appl. Sci. Manuf. (2012)

N.S.K. Gowthaman *et al.*
In Biopolymers and their industrial applications
(2021)

J.S. Binoj *et al.*
Process Saf. Environ. Prot. (2018)

M. Afroz *et al.*
Eur. J. Pharmacol. (2024)

D. Budelmann *et al.*
Compos. A Appl. Sci. Manuf. (2019)

View more references

Cited by (0)

View full text

© 2024 Elsevier Ltd. All rights reserved. Selection and peer-review under responsibility of the scientific committee of the 3rd International Conference on Materials Science and Engineering.

ELSEVIER

All content on this site: Copyright © 2024 Elsevier B.V., its licensors, and contributors. All rights are reserved, including those for text and data mining, AI training, and similar technologies. For all open access content, the Creative Commons licensing terms apply.

RELX™