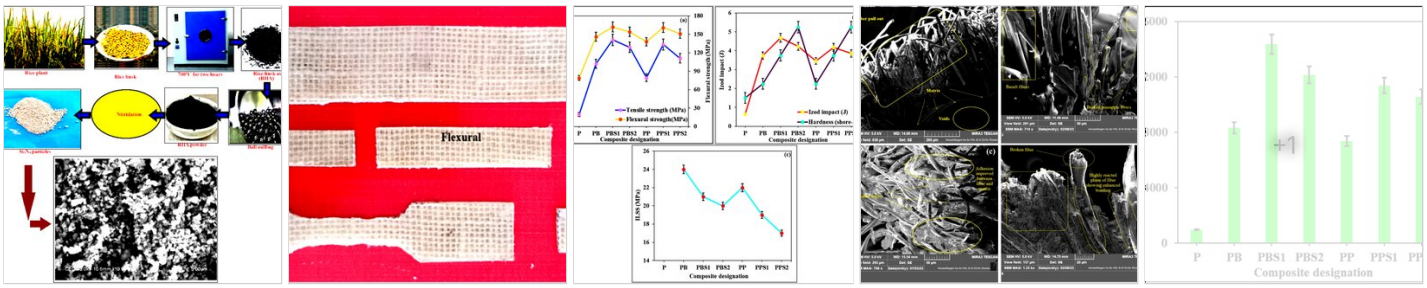
Mechanical, wear, and low cycle fatigue behaviour of rice husk ash Si3N4 and pineapple/basalt Fiber–reinforced polyester composite

September 2023
DOI: 10.1007/s13399-023-04931-1

J. Jesumanen · M. Chandrasekaran · P. Babu Aurtherson

Abstract and figures

The objective of this investigation was to develop lightweight polyester composites for possible application of human prosthetics. Since present materials in human prosthetics are either metals or synthetic harmful fibre and fillers, the present study proposes to introduce a new alternative biocomposite material for manufacturing human prosthetics. Thus, in this study, pineapple-basalt fibre sandwich with rice husk Si3N4 particle polyester composites was developed with two different staking sequences. The composites are prepared using the hand layup technique, and testing was carried out in accordance with American Society of Testing and Materials (ASTM) standards. The highest measured mechanical values for composite designation PBS1 up to 124 MPa, 162 MPa, 4.68 J, 21 MPa, and 79 shore-D for tensile strength, flexural strength, Izod impact, and hardness, respectively, when compared to all other composite designations. Corresponding to this, maximum fatigue life counts of 14,370 were seen for composite designation PBS1 with 1.0 vol. % Si3N4 particles included. However, the higher wear resistances value up to 0.007 for wear loss and 0.028 for co-efficient of friction (COF) for composite designation PBS2 resulted from the enhanced Si3N4 particle volume percentage up to 3.0 vol. %. The scanning electron microscope (SEM) fractography of the broken samples shows that the silane surface treatment has increased the interaction between the fibre and matrix phase. Thus, based on the present research, it is clear that the novel material structure (B/P/P/B) with pineapple/basalt fibre and Si3N4 is capable of replacing the existing man-made synthetic materials used in human prosthetic production with more advantageous attributes such as light weight, high strength, durable, abrasion resistance, and fatigue damage free.



Page 1

Biomass Conversion and Biorefinery
https://doi.org/10.1007/s13399-023-04931-1

ORIGINAL ARTICLE

Mechanical, wear, and low cycle fatigue behaviour of rice husk ash Si_3N_4 and pineapple/basalt Fiber–reinforced polyester composite

J. Jesumanen[1] · M. Chandrasekaran[1] · P. Babu Aurtherson[2]

Received: 6 May 2023 / Revised: 9 September 2023 / Accepted: 13 September 2023

Abstract
The objective of this investigation was to develop lightweight polyester composites for possible application of human prosthetics. Since present materials in human prosthetics are either metals or synthetic harmful fibre and fillers, the present study proposes to introduce a new alternative biocomposite material for manufacturing human prosthetics. Thus, in this study, pineapple-basalt fibre sandwich with rice husk Si_3N_4 particle polyester composites was developed with two different staking sequences. The composites are prepared using the hand layup technique, and testing was carried out in accordance with American Society of Testing and Materials (ASTM) standards. The highest measured mechanical values for composite designation PBS1 up to 124 MPa, 162 MPa, 4.68 J, 21 MPa, and 79 shore-D for tensile strength, flexural strength, Izod impact, and hardness, respectively, when compared to all other composite designations. Corresponding to this, maximum fatigue life counts of 14,370 were seen for composite designation PBS1 with 1.0 vol. % Si_3N_4 particles included. However, the higher wear resistances value up to 0.007 for wear loss and 0.028 for co-efficient of friction (COF) for composite designation PBS2 resulted from the enhanced Si_3N_4 particle volume percentage up to 3.0 vol. %. The scanning electron microscope (SEM) fractography of the broken samples shows that the silane surface treatment has increased the interaction between the fibre and matrix phase. Thus, based on the present research, it is clear that the novel material structure (B/P/P/B) with pineapple/basalt fibre and Si_3N_4 is capable of replacing the existing man-made synthetic materials used in human prosthetic production with more advantageous attributes such as light weight, high strength, durable, abrasion resistance, and fatigue damage free.

Keywords PMC · Fibre · Filler · Mechanical properties · Wear · Fatigue

1 Introduction

Polymer matrix composites are advanced structural materials made of strengthening fibres and fillers to reduce the cost and improve the load bearing properties. They are popularly used in many engineering applications, out of which an important application is human prosthetic application [1]. Because of superior mechanical, physical, and thermal resisting qualities, polymeric materials play a significant role in prosthetic gadget making applications. As of now, the prosthetic gadgets are made of synthetic fibre and fillers [2]. However, extensive use of these synthetic composites is polluting the environment heavily as they are non-degradable. Thus, natural polymer composite is generally preferable over synthetic polymers because of their widespread acceptability, availability, and cost-effectiveness [3]. Recently, biofibres and fillers have been added to the development of those prosthetic composite materials they receiving a lot of attention among researchers since they are capable in handling of applied loads and any harm environment [4]. Significant number of researchers in the area of prosthetic production is nowadays using natural fiber composite materials because they differentiate from typical materials in terms of their thermal, mechanical, and other characteristics. Prosthetic parts that help people with disabilities continue moving with greater freedom [5]. Synthetic prosthetic parts made of conventional materials are reportedly

✉ J. Jesumanen
jesumanen2023@gmail.com

M. Chandrasekaran
chandrasekar2007@gmail.com

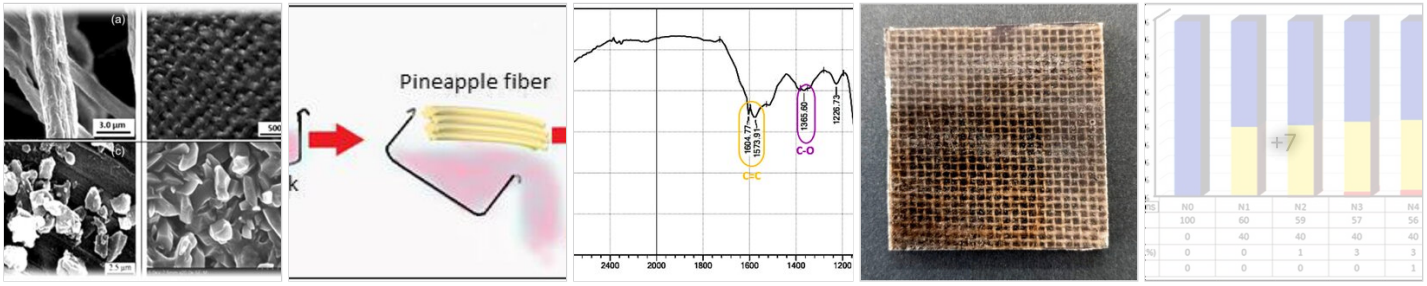
P. Babu Aurtherson
pbaurtherson@gmail.com

[1] Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, Tamil Nadu, India

[2] Department of Mechanical Engineering, DMI Engineering College, Aralvaimozhi, Kanniyakumari, India

Published online: 28 September 2023

Similar research



Fatigue, fracture toughness and dynamic mechanical behaviour of CTBN rubber toughened silane surface-modified pineapple fiber and micro B4C-reinforced epoxy hybrid composites

Article Full-text available

December 2022 · 106 Reads · 3 Citations

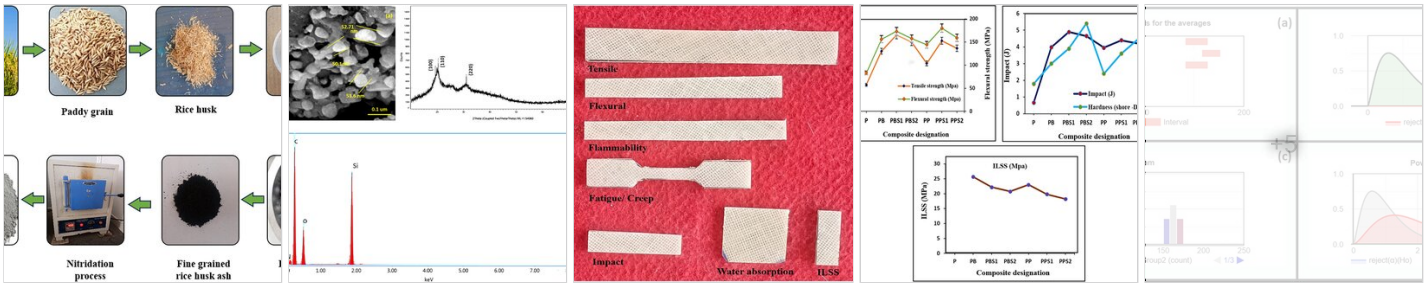
Biomass Conversion and Biorefinery

Venu Jaiganesh · M. Vinothkumar · Gurusamy P.

The present work investigates the fatigue, fracture toughness, and dynamic mechanical analysis of carboxyl-terminated acrylonitrile butadiene (CTBN) rubber-toughened epoxy composites reinforced with surface-modified pineapple fiber and micro boron carbide (B4C). This research aims to determine the effects of the inclusion of CTBN and surface modification on pineapple fiber and B4Cto form a composite with the epo...

Read more

View



Influence of rice husk ash Si3N4 ceramic on mechanical, wear and low cycle fatigue behavior of hybrid pineapple/basalt fiber reinforced polyester composite

Article Publisher preview available

June 2024 · 31 Reads

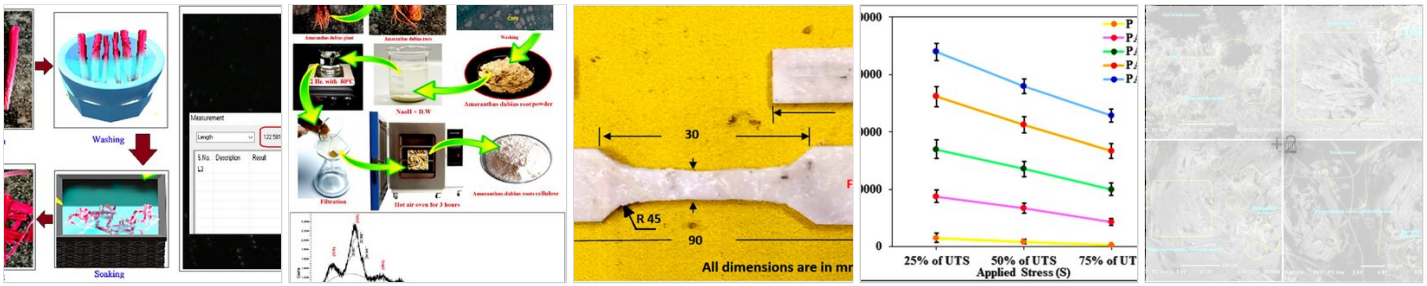
Biomass Conversion and Biorefinery

J Jesumanen · M Chandrasekaran · P. Babu Aurtherson

This paper presents a comprehensive characterization of hybrid fiber and bioceramic reinforced polyester composites, focusing on their mechanical, fatigue, and flammability, creep, and water absorption properties. The investigation explores the influence of fiber stacking sequence and the integration of Si3N4 particles on the performance of the composites. Mechanical tests reveal significant enhancements in...

Read more

View



Dynamic mechanical, tensile fatigue and water absorption behaviour of polyester composites comprises of Amaranthus dubius stem natural fiber and its root waste crystalline cellulose

Article Publisher preview available

September 2023 · 109 Reads · 5 Citations

Biomass Conversion and Biorefinery

J. Joshua Gnana Sekaran · P. Thirumurugan · Sumanth Ratna Kandavalli · K. Swarnalatha

This study aims to address the research gap of manufacturing a biodegradable composite material using economically sound and abundant waste reinforcements for eco-friendly applications. The primary aim of this research study was to examine how the addition of novel root cellulose and stem fiber of Amaranthus dubius influence fatigue and dynamic mechanical and hydrophobic behavior of an industrial grade...

Read more

View

Development of Pineapple Fibre and Biosilica Toughened Polyester Sustainable Biocomposite of Few Mechanical Properties for Automobile Application

Article Publisher preview available

January 2023 · 36 Reads · 6 Citations

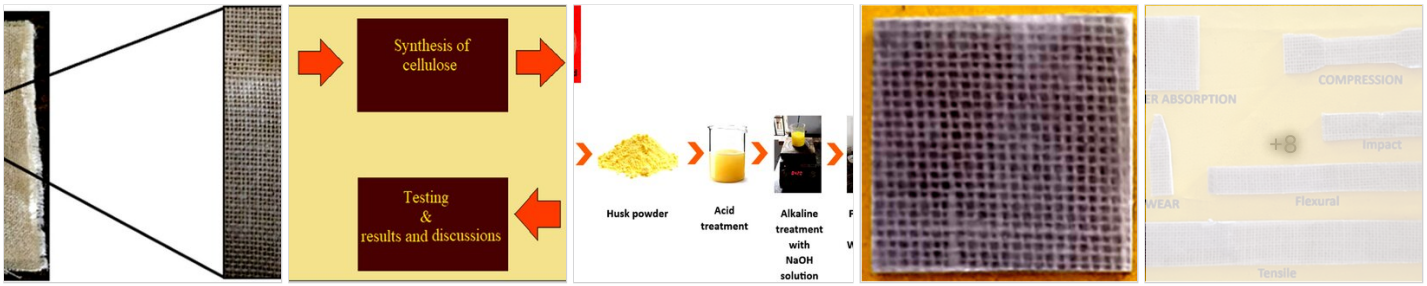
Silicon

A. Sivakumar · Karthi Vinith K S · L. Savadamuthu · P. Sathiamurthi

This investigation focused to make use of pineapple fabric and peanut husk ash (PHA) biosilica particles to develop lightweight polyester bio-composites for automobile and inexpensive technological applications. In order to create biosilica particles from peanut husk, a thermo-mechanical procedure and an aqueous solution method are used and silane-surface treatment is performed on it. The uniqueness of the...

Read more

View



Mechanical, wear, and water absorption behavior of polyester biocomposite using jackfruit seed husk cellulose and pineapple fiber

Article Publisher preview available

January 2024 · 93 Reads · 5 Citations

Biomass Conversion and Biorefinery

Kirubakaran Gokulamani · Senthamaraikannan Chinnasamy

To develop an eco-friendly and high toughness polyester composite for automotive applications, this present research utilized bio-based reinforcements such as jackfruit seed husk cellulose and pineapple fiber. The primary objective of this study was to investigate how the novel cellulose addition influenced the mechanical, water absorption, and wear resistance. The methodology employed encompasses the extractio...

Read more

View