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Dr Sivasubramanian Palanisamy

Department of Mechanical Engineering, P T R College of Engineering and Technology, Madurai, Tamil Nadu, India

Mechanical Behavior of Ramie and Flax Hybrid Natural Fiber Composites: An Evaluation Across Different Conditions

Abstract: The study investigated the use of a hybrid natural fiber reinforcement, combining ramie and flax, with epoxy resin as the matrix material, employing compression molding for fabrication. Among the various combinations tested, the hybrid composite with 40 wt.% fibers of 1 cm length demonstrated the highest tensile strength at 32.67 MPa. This optimal performance was attributed to improved compatibility between the fiber and matrix phases, enhanced stress transfer, and greater elastic deformation observed in composites with 30 to 40 wt.% fiber content. The inclusion of fibers, particularly at lengths up to 0.5 cm and 40 wt.%, led to a significant increase in flexural strength, from 43.75 MPa to 52.47 MPa. Additionally, the impact strength of these hybrid composites improved notably, ranging from 10.23 to 15.97 kJ/m^2. A 5% NaOH treatment significantly impacted the tensile strength, with values ranging from 28.42 MPa to 32.67 MPa, outperforming both untreated fibers and those treated with 8% NaOH. The alkali treatment also enhanced flexural strength, resulting in values between 49.83 MPa and 52.47 MPa, compared to 49.12 MPa and 49.99 MPa for the higher concentration treatment. The study found that the maximum tensile strength of 33.46 MPa was achieved under optimal conditions of 120°C temperature, 12 MPa pressure, and 7 minutes duration. Excessive pressure, high temperatures, and prolonged processing times were found to negatively affect the mechanical properties of the composites. SEM analysis confirmed that the hybrid composition with 40 wt.% natural fiber had superior fiber distribution, which contributed to the improved mechanical properties. This study is significant in the field due to the limited research on natural fiber incorporation, fabrication conditions, and surface treatments.

Keywords: Natural fiber, Flax, Ramie, Hybrid composite, fabrication condition, Mechanical Properties

Biography: Sivasubramanian Palanisamy currently serves as an Assistant Professor in the Department of Mechanical Engineering at P T R College of Engineering and Technology, located in Madurai, Tamil Nadu, India. He holds a Ph.D. in the field of Mechanical Engineering from Kalasalingam Academy of Research and Education (KARE) situated in Krishnankovil, Srivilliputhur, Tamil Nadu, India. Dr. Sivasubramanian Palanisamy's research expertise encompasses a wide range of areas, including biocomposite materials, the characterization of fibers, fiber-reinforced polymer composites, hybrid composites, fiber-reinforced elastomer composites, the study of tribological behavior in composite materials, and 3D printing. He has an impressive publication record, having authored over 60 research papers in renowned international journals and contributed to 15 book chapters. Additionally, he has delivered 23 keynote/invited/Expert talks in his specialized research domains. In recognition of his expertise, Dr. Sivasubramanian Palanisamy serves as a referee for numerous esteemed journals, including but not limited to Fibers, Biomass Conversion and Biorefinery, Engineering Science and Technology—an International Journal, Applied Science and Engineering Progress, Tribology in Industry, Buildings, Processes, Sustainability, and Energies.

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