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Development and Characterization of Banana Fiber Reinforced Composites

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Abstract

Banana fiber reinforced epoxy composites have gained significant attention in recent years due to their high strength, low weight, and biodegradability. The objective of this work was to prepare a natural fiber reinforced composite product by using nanoparticle technique method. A long banana fiber reinforced epoxy polymer composite plate was prepared by compression molding method. In this study, we aimed to enhance the mechanical properties of banana fiber reinforced epoxy composites by incorporating various fillers such as seashell, nano clay, and silica. The filler materials were added to the epoxy matrix at different weight fractions, and the mechanical properties of the resulting composites were evaluated. The results showed that the addition of fillers significantly improved the mechanical properties of the composites, including tensile strength, wear strength, water absorption property and impact strength. Then the optimum level from the three different nano particles is analysed.

Keywords: Banana Fiber, Epoxy, Filler Materials.

1. Introduction

Fiber-reinforced composites are increasingly used in various industries due to their high strength, low weight, and excellent mechanical properties. Natural fibers such as banana fibers have been gaining significant attention as an alternative to synthetic fibers due to their eco-friendliness, biodegradability, and low cost. Banana fibers have been used in various applications such as papermaking, textiles, and packaging. In recent years, researchers have also investigated the use of banana fibers as reinforcement in composites. Epoxy resins are widely used as matrix materials in fiber-reinforced composites due to their excellent mechanical properties, thermal stability, and chemical resistance. However, the mechanical properties of epoxy composites can be further enhanced by adding fillers such as nanoparticles, seashell, and silica. These fillers can improve the interfacial adhesion between the fiber and the matrix, increase the stiffness and strength of the composite, and reduce the weight of the composite.

2. Literature Survey

Effect of seashell powder on mechanical properties of banana fiber-reinforced epoxy composites by C.K. Santhosh Kumar, et al. (2016). This study investigated the effect of adding seashell powder on the mechanical properties of banana fiber-reinforced epoxy composites. The results showed that the addition of seashell powder improved the tensile and flexural strength of the composites. Preparation and mechanical properties of nano clay reinforced banana fiber/epoxy composites by R. Krishnan et al. (2016). This study investigated the effect of adding nano clay on the mechanical properties of banana fiber-reinforced epoxy composites. The results showed that the addition of nano clay improved the tensile and flexural strength of the composites.

Effect of silica nanoparticles on the mechanical properties of banana fiber-reinforced epoxy composites by J. Varghese et al. (2015). This study investigated the effect of adding silica nanoparticles on the mechanical properties of banana fiber-reinforced epoxy composites. The results showed that the addition of silica nanoparticles improved the tensile and flexural strength of the composites.

Mechanical and thermal properties of banana fiber reinforced epoxy composites filled with seashell powder by S. Ramesan et al. (2018). This study investigated the effect of adding seashell powder on the mechanical and thermal properties of banana fiber-reinforced epoxy composites. The results showed that the addition of seashell powder improved the tensile, flexural, and compressive strength of the composites, as well as their thermal stability.

Mechanical and water absorption properties of nano clay-reinforced banana fiber/epoxy composites by A. Fattahi et al. (2019). This study investigated the effect of adding nano clay on the mechanical and water absorption properties of banana fiber-reinforced epoxy composites. The results showed that the addition of nano clay improved the tensile and flexural strength of the composites, as well as their resistance to water absorption.

3. Materials

3.1. Banana fiber

It can be extracted by employing chemical, mechanical or biological methods. The chemical method causes environmental pollution, while mechanical method fails to remove the gummy material from the fiber bundle surface. Biological procedures yield more fiber bundles than the other two procedures without any harm to the environment. The extraction of banana fibers using biological natural retting has already been reported. After extracting the fibers, degumming is essential prior to the utilization of fibers. The removal of heavily coated, noncellulosic gummy material from the cellulosic part of plant fibers is called degumming.

Banana fiber is multiple celled structures. The lumens are large in relation to the wall thickness. Cross markings are rare and fiber tips pointed and flat, ribbons like individual fiber diameter range from 14 to 50 microns and the length from 0.25 cm to 1.3 cm, showing the large oval to round lumen. The extraction of banana fiber can be treated in alkaline(NAOH) for removing the lignin content. These fiber are immersed in the alkaline for three hours and temperature kept at 80 degree Celsius.

3.2. Epoxy resin

Epoxy resins are not used alone for coatings, normally being cross linked. Epoxy resins, based upon bisphenol A (or F) and epichlorhydrin, cured at room temperature by aliphatic polyfunctional amines and polyamides are used in heavy duty coatings for ships, oil rigs, and storage tanks, as well as water pipes. The epoxy resin-containing component of the paint is mixed with the polyamine-containing component prior to application. This is a two pack system. They also form the basis of the two pack adhesive (Araldite) available from most hardware stores. Epoxy resins also react at elevated temperatures with aromatic amines, cyclic anhydrides, aminoplasts, and phenolplasts. In these applications, epoxy resin is present with the cross-linking agent in the coating and no mixing prior to application is required. This is a one pack coating. Epoxy resins have been used with acrylic coating resins, as powder coatings, and as high solids coatings. Epoxy resins are used as intermediates in UV coatings. Electro deposition automobile primers are based upon epoxy resins crosslinked with polyisocyanate. Epoxy resins are used as additive resins in some coatings to improve properties such as adhesion and resistance.

3.3. Filler material

Nano clay: Nano clay, also known as nano-sized clay mineral, is a type of clay mineral that has been modified at the nanoscale level. Nano clay particles have a high aspect ratio and a large surface area that makes them useful as a filler material in composites, coatings, and other applications.

Nano Silica: Nano silica, also called silica nanoparticles, is a form of silicon dioxide with particle sizes in the nanometer range. Nano silica particles are commonly used as a filler material in composites, coatings, and adhesives due to their high surface area and unique properties, such as high strength, high transparency, and chemical inertness.

Seashell: A seashell is the hard outer protective layer that is found on the exterior of marine mollusks, such as clams, oysters, and snails. Seashells are made primarily of calcium carbonate and have a variety of uses, including as decorative items, jewelry, and construction materials. In the context of composite materials, seashells can be used as a natural filler material to enhance the mechanical properties of the composite.

4. Methodology

A composite plate of 30*30 cm were produced by using compression molding method. Molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured; this process is known as compression molding method The process employs thermosetting resins in a partially cured stage, either in the form of granules, putty-like masses, or preforms.

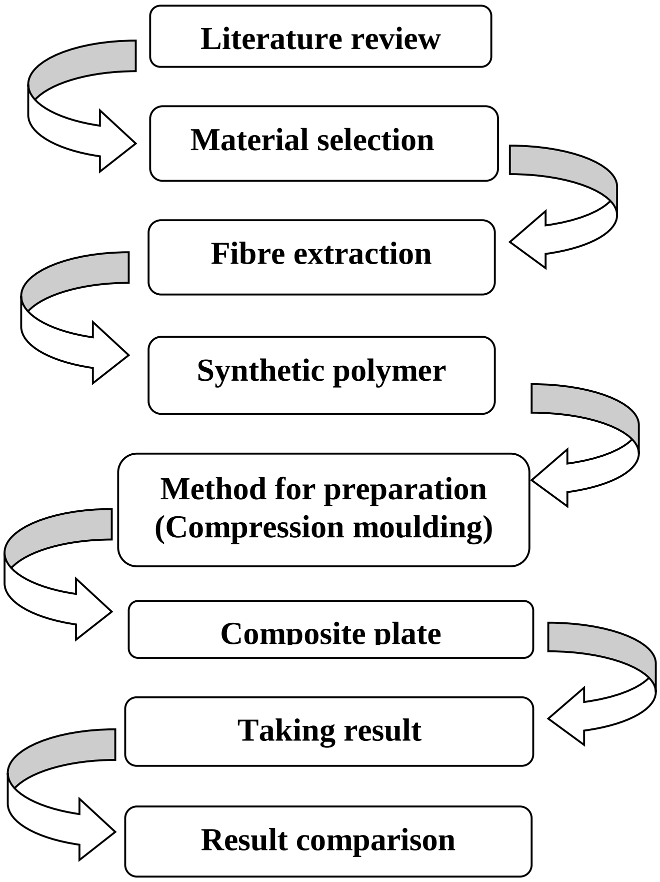

Figure 1: Methodology

5. Applications

5.1. Automotive Industry

The use of lightweight and strong materials in the automotive industry is crucial for improving fuel efficiency and reducing emissions. The banana fiber reinforced epoxy composites with fillers can be used in the production of car parts such as body panels, engine components, and suspension parts.

5.2. Aerospace Industry

The aerospace industry also requires lightweight and strong materials for the production of aircraft parts. The banana fiber reinforced epoxy composites with fillers can be used in the production of aircraft components such as wings, fuselage, and landing gear.

5.3. Construction Industry

The construction industry can benefit from the use of eco-friendly materials that have high strength and durability. The banana fiber reinforced epoxy composites with fillers can be used in the production of building materials such as roofing tiles, wall panels, and flooring.

5.4. Sports Equipment

The sports industry can benefit from the use of lightweight and strong materials for the production of sports equipment such as tennis rackets, hockey sticks, and golf clubs.

5.5. Packaging Industry

The banana fiber reinforced epoxy composites with fillers can be used in the production of biodegradable and environmentally friendly packaging materials.

6. Fabricated Plate

Figure 2: Fabricated Plate

7. Test Result

Table1: Impact Test

Sample Number	Impact Energy(J)	Impact Strength (J/m^2)	Angle
S1	1.421	273.2	138
S2	1.028	197.6	141
S3	1.028	180.3	141

Table 2: Hardness Test

Sample Number	Trial 1	Trial 2	Trial 3
S1	80	76	82
S2	82	83	84
S3	83	82	86

Table 3: Wear Test

Sample Number	Load (N)	Speed (RPM)	Time (Min:Secs)	Height Loss Wear (µ)	Frictional Force (N)
S1	10	573	5:30	45	5.3
	20	573	5:30	70	7.9
	30	573	5:30	105	18.1
S2	10	573	5:30	40	4.2
	20	573	5:30	66	9.9
	30	573	5:30	100	16.6
S3	10	573	5:30	25	1.8
	20	573	5:30	45	6.9
	30	573	5:30	180	15.4

*Track Radius 50 mm Constant

8. Conclusion

In conclusion, the use of natural fillers such as seashell and nano clay, as well as synthetic filler like silica, in banana fiber reinforced epoxy composites has been investigated in this study. The mechanical and physical properties of the composites were analyzed through various tests, including impact strength tests, wear property and hardness test as well as water absorption and thermal stability tests.

The results showed that the addition of nano clay and silica as fillers significantly improved the mechanical properties of the composites, such as wear and impact. Seashell filler also showed some improvement in the mechanical properties, although not as much as the synthetic fillers. The water absorption and thermal stability properties of the composites were also improved with the addition of fillers.

Overall, the study demonstrated that the incorporation of fillers into banana fiber reinforced epoxy composites can significantly improve their mechanical and physical properties, making them suitable for a range of applications in various industries. The use of natural fillers, such as seashell, can also offer a more sustainable and environmentally friendly option for composite materials. Further research is needed to optimize the filler content and processing conditions for these composites to achieve the best possible properties.

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