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A Review on Composite Materials Reinforcing with Organic/Natural Materials

Dr. S. Arunkumar[1], P. Bharathvaaj[2], R.K. Mathubalan[3], S. Logesh[4]
[1]Assistant Professor, Mechanical Engineering, Thiagarajar College of Engineering, Madurai, Tamil Nadu, India.
[2,3,4]Mechanical Engineering, Thiagarajar college of engineering, Madurai, Tamil Nadu, India.
Email Id: *sakmech@tce.edu[1], bharathp561@gmail.com[2], mathubalan1204@gmail.com[3], logeshss2002@gmail.com[4]*

Abstract
The utilization of natural and fiber-reinforced polymer matrix composites as a sustainable solution in the industries. The composite consists of sugarcane bagasse and mesquite fibers. which offers a low-cost, environmentally friendly alternative with potential applications in various industries. epoxy resin known for its cost-effectiveness and resilience, serves as the matrix material. Types of fabrication methods are Vacuum Bag Molding, Hand Lay-Up, Filament Winding, and Hydraulic compression molding from the literature we collected Hydraulic compression molding technique with varying fiber orientations (uniaxial, biaxial, and triaxial) is selected for its versatility and reduced material waste. The study involved alkaline, potassium permanganate, and potassium dichromate treatments. The overall study concludes the promising potential of using bagasse and mesquite fibers as sustainable alternatives for reinforcement in epoxy resin composites, offering a viable solution for valorizing agricultural waste and promoting environmentally conscious manufacturing practices. Chemical treatments and fiber processing play a crucial role in enhancing the properties of the fibers, making them suitable for composite applications.
Keywords: *Compression moulding, Bagasse fibers, Mesquite fibers*

1. Introduction
The natural and fiber-reinforced polymer matrix composite has many benefits, such as low production costs, low energy consumption, environmental friendliness, and general contribution to achieving sustainable development. This kind of composite has also been a popular research topic in many countries [1,46]. A fiber-reinforced polymer (FRP) is a composite material consisting of a polymer matrix embedded with high-strength fibers, such as glass, aramid and carbon, natural fiber, etc. Reinforced polymer composites (RPC) will have high corrosion resistance, wear resistance, appearance, temperature-dependent behavior, environmental stability, thermal insulation, and conductivity Many types of natural fibers have been investigated for use in plastics including jute, straw, Flax, hemp, wood, sugarcane, bamboo, grass, kenaf, sisal, coir, rice husks, wheat, barley, oats, kapok, mulberry, banana fiber, raphia, pineapple leaf fiber, and papyrus, etc [2,39,48]. In many areas, lots of landscapes are occupied by Prosopis juliflora(PJ) plants, which makes it difficult to cultivate crops also it absorbs the water and nutrients from the land and makes it unable to cultivate [3,4,47]. A lot of research work is undergoing to use these plants effectively for various applications. Saravanakumar et al analyzed the parameters of the fibers, they found that they had an average microfibril angle of 10.64 and utmost elongation strength of 558 MPa. It was found that the aspect ratio of the PJ fibers had a significant impact on the mechanical qualities of the finished product [5]. The tensile and thermal properties of treated PJ fibers were shown to be superior to those of untreated fibers in a study by Madhu et al [6]. Filler-reinforced epoxy composites can improve mechanical properties by as much as 45

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percent, according to research by Santhosh et al., who studied the morphology and properties of PJ and reinforced composites [7]. Natural fibers have gained popularity and are beginning to supplant synthetic fibers, owing to their contribution to sustainable practices. As a result of environmental, social, and economic development, numerous industries have altered their manufacturing processes, materials, and procedures to ensure a sustainable future. While natural fibers have significant disadvantages, they can be overcome with appropriate chemical treatments and fiber processing [8]. Sugarcane bagasse (SCB) is an organic waste generated in the production of sugar and ethanol. It is estimated that for each tonne of sugarcane produced, approximately 300 kg of SCB is generated [9,37]. SCB is classified as a low-cost, low-density, biodegradable, and renewable residue.
In the present study, we describe a new approach to reuse SCB and mesquite and form a useful natural composite material.

2. Materials And Methods

2.1 Mesquite Fiber

Prosopis juliflora fiber (Table 1) (PJF), has the potential characteristics to be effectively used as reinforcement materials in the manufacturing of composite applications. Alkaline treatment of PJF will improve cellulose degradation temperature and also density will be increased due to alkaline treatment.[6]. The various physical and chemical treatments help in reducing moisture content in the fibers as well as modifying the mechanical properties, thermal stability, and surface morphology of these fibers [11,36]. Fibers are removed from the bark by utilizing a conventional combing process. [5].

2.2 Sugarcane Bagasse as Reinforcement

The residue after extracting juice from sugarcane is regarded as bagasse. It is estimated more than 200 million tons of sugarcane bagasse are obtained annually in India alone [12,43]. Sugarcane bagasse is approximately composed of 50% cellulose, 25% hemicellulose, and 25% lignin [13,35]. Studies have shown bagasse has a density of 1.28 g/cc and a crystallinity index of about 35%[14]. the tensile strength is in the range of 20–50 MPa, and the tensile modulus is 2.7 GPa[15]. Sugarcane bagasse like all other natural cellulosic fibers has a natural disadvantage of hydrophilicity which tends to draw moisture from the surroundings resulting in swelling and loss of mechanical properties (Table 2). To some extent, this deficiency of natural fibers could be minimized by modifying them by subjecting them to various chemical treatments [16,38].

Table 1 Properties of Prosopis Juliflora Fiber [10,49]

S. No.	Properties	Prosopis Juliflora Fibre
1	Density (g/cm3)	0.589
2	Moisture content (wt.%)	8.48
3	Lignin (wt.%)	15.11
4	Cellulose (wt.%)	60.42
5	Hemicelluloses (wt.%)	15.21
6	Wax (wt.%)	0.58
7	Elongation at break (%)	1.55 ± 0.12
8	Tensile strength (MPa)	570 ± 8.4
9	Young's modulus (GPa)	5.87 ± 1.7
10	Diameter (μm)	20

Table 2 Tensile Properties of Bagasse Fiber [17]

Bagasse fibers	Tensile strength (MPa)	Tensile modulus (GPa)
Untreated fibers (Ramleea et al., 2019, Vilay et al., 2008)	20-50, 96	2.7, 6.42
Alkali-treated fibers (Vilay et al., 2008)	156	7.13
Acrylic acid-treated fibers (Vilay et al., 2008)	229	8

2.3 Epoxy

Epoxies have superior mechanical qualities, including increased thermal stability, wear and chemical resistance, and resistance to aging caused by environmental factors [23]. The natural fiber reinforcement in the epoxy matrices results in lower density, weight, and cost, accompanied by better

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renewability and biodegradability. physical, mechanical, and thermal properties of natural fiber-reinforced epoxy composite display better performance for manufacturing high-performance automotive and aerospace products and their components [22]. Composition of Baggse is shown in Table 3.

Table 3 Composition of Baggse

S. No	COMPOSITION OF BAGASSE	REFERENCE
1	Cellulose 43%, Hemicellulose 10.1%, Lignin 33.23%, ash 1%, Moisture 6.45%	Ibrahim et al[14]
2	Cellulose 40%, Hemicellulose 24.5%, lignin 20%, wax 3.5%, ash 2.4%, silica 2%	Mulinari et al[19]
3	Cellulose 49.44%, hemicellulose 23.19%, Lignin 12.56%, Ash and extractives 14.8%	Ramleea et al[20]
4	Cellulose 36.32%, Hemicellulose 24.7%, lignin 18.14%	Vilay et al[21]
5	Cellulose 35.46%, Hemicellulose 31.25%, lignin 23.7%, ash 9.5%	Kordkheili et al[15]
6	Cellulose 50.4%, Hemicellulose 28.5 %, lignin 14.9%, ash 2%	Xiong et al[18]

3. Extraction of Mesquite

3.1 Water Retting

The water retting process for the extraction of mesquite fibers. Retting is a process of separating fibers in the stem from the woody portion by the action of microorganisms present in the water [24,45]. it is a process in which A glass tank (30 L) filled with 20 L of well water and heated to 28 C was used to ret nettle stems. The tank should be covered with a transparent glass lid to maintain the water temperature constant. the bark was easily removed from the core by rubbing the stalk with one's fingers. After drying, fibers are mechanically separated [25]

3.2 Alkaline Treatment

Alkaline treatment is a process in which PJFs are treated under concentrations of 6% (w/v) using NaOH solution maintained at room temperature for about 45 min [6].

4. Extraction of Bagasse

4.1 Alkaline Treatment for Bagasse

Alkali treatment reduces the degree of polymerization and minimizes lignin content and hemicellulose from the fiber. Some reports indicate alkaline treatment influences the number of possible reaction sites on the fiber surface and an increase in the surface roughness, both contributing to the enhanced mechanical properties [26]. In this process, extracted sugarcane bagasse fibers are subjected to alkali pretreatment by soaking in aqueous 10% NaOH solution for 3 hours. The soaked bagasse is separated and rinsed with distilled water until a neutral pH is achieved. After rinsing, the fibers should dry for 24 hours [27-30 &42].

4.2 Potassium Permanganate Treatment (Kmno4)

In this treatment, 1 gm of 10% NaOH pretreated bagasse is taken along with the 10% of 5 mL KMnO4 in a round bottom flask fitted with a condenser and heated in a water bath for 8 hours. Then wash it with water to attain the neutral pH and further wash it with oxalic acid to remove the MnO2 impurities. it should dry at last to remove moisture content [31,40].

4.3 Potassium Dichromate Treatment (K2Cr2O7)

This treatment involves taking 1 gm of pretreated bagasse along with 10% of 5 mL K2Cr2O7 solution in a round bottom flask fitted with a condenser and then it should heat in a water bath for 8 hours. Then wash it with water to attain a neutral PH. It is dried to remove moisture content completely [31,41].

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Page No: 538-544

4.4 Method

Compression Moulding Process for fabricating naturally Fiber-reinforced Polymer Matrix Composites (PMCs) due to its ability to produce high-quality, uniform parts with excellent mechanical properties [32, 33]. The process offers excellent control over Fiber orientation and alignment, ensuring that the composite material conforms to the desired shape and maintains structural integrity [34-37]. Sugarcane bagasse and mesquite are chopped before combining with epoxy resin in different compositions. Compression test is carried out by a universal testing machine on composite specimens following the ASTM D790 standard [38]. Compression molding enables the consolidation of multiple layers of fiber reinforcement, resulting in a strong and durable composite structure for complex shapes also high pressure applied during compression molding helps to eliminate voids and achieve uniform resin distribution, ensuring consistent mechanical properties throughout the complex shape [39, 43].

Conclusion

The review highlights the promising potential of utilizing bagasse and mesquite fibers as sustainable alternatives for reinforcement in epoxy resin composites [44-46]. This not only addresses the imperative need for valorizing agricultural waste but also fosters a shift towards more environmentally friendly practices in manufacturing. As industries continue to seek sustainable solutions, the examined composite materials and fabrication techniques stand out as viable options, opening avenues for further exploration and adoption in real-world applications [47-49].

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