STATIC INVESTIGATION OF ALMOND SHELL PARTICULATE REINFORCED SALTREERESIN EPOXY HYBRID MATRIX COMPOSITE

A PROJECT REPORT

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INTERNAL EXAMINER

EXTERNAL EXAMINER

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Abstract

Now a day, the awareness of the public along with exacting reasonable forces over the use of synthetic polymer, the construction and automotive industries started using the renewable materials. Since, natural filler hybrid matrix composites play major role in developing light load structural materials, this study focuses on utilizing Almond Shall Particulate as reinforcement in Sal tree resin Blended Epoxy Hybrid Matrix Composite along with different volume (5, 10, 15, 20, 25, 30, 35, and 40%) of natural fiber. The composite specimens were fabricated by using hand layup method. The mechanical properties were evaluated. The maximum mechanical properties were observed for the composite with 20 volume % Almond Shall Particulate Reinforced Sal tree resin Epoxy Hybrid Matrix Composite.

INTRODUCTION

Natural fiber reinforced polymer Composites are being investigated as a suitable alternative over conventional polymer composites by the researchers in the world.(1-15).Onuegbu et al. (2011) did investigations on the effect of snail-shell powder on the polypropylene composites. The results indicated an increase in the tensile, flexural, and impact properties with an increase in the filler content and filler size. Sarki et al. (2011) used coconut shell powder as filler material in an epoxy composite and the incorporation of coconut shell powder was found to increase the tensile strength and modulus with a slight decrease in the impact strength. Chun et al. (2013) used coconut shell powder as filler in recycled polypropylene and Sodium Dedecyl Sulfate as the coupling agent. The addition of the filler caused an increase in the tensile properties, thermal stability, and crystallinity and lowered the water absorption compared to the unmodified composite. Kuburi et al. (2017) examined the use of 15 wt% coconut shell powder filled composite prepared from recycled low density polyurethane polymer matrix. The effect of the coir fiber loading and the processing of the composite was investigated. The result showed improvement in both the mechanical properties and water absorption properties. Siro (2010) prepared a bio composite based on Poly Lactic Acid (PLA) and olive pit powder. The addition of the filler showed an increase in the tensile modulus and decrease in the flexural strength. Muthukumar et al. (2014) developed a polymer composite using coconut shell powder and groundnut shell powder in different volume fractions. The evaluation showed an increase in the tensile strength, impact strength, flexural property and hydrophilic behavior. Udhaya Sankar et al. (2015) did research on coconut shell powder reinforced polymer composites. The Results revealed an improvement in the mechanical properties like tensile strength and impact strength as a result of the filler addition. Chandramohan et al. (2017) studied the bio particle composite from coconut shell powder, walnut shell and rice husk in an epoxy matrix. The result revealed that 20 vol. % of the filler provided better mechanical property and modulus due to uniform dispersion of the filler in the matrix. Onuegbu et al. (2011) studied polypropylene based composites with groundnut husk powder in various particle sizes. Polypropylene composites were prepared in an extrusion-molding machine and the resulting composites were extruded as sheets. The Presence of pulverized groundnut husk caused an improvement in the tensile strength, modulus, flexural strength and impact strength of the composite. The increase in these properties with increase in the filler contents was seen along with a decrease in the filler particle size. Raju (2011) studied the use of groundnut powder as bio filler. Groundnut shell particles incorporated composites were fabricated with different grain sizes and volume fractions. The study indicates a volume ratio of 60:40 and 0.5 micron particle sizes providing a good reinforcement effect. Vasanta et al. (2015) made a study on the effect of coir fiber as the major reinforcement and rice husk as additional filler for improving the mechanical properties of a vinyl ester composite. The improvement in the mechanical properties (tensile

strength and flexural strength) of the hybrid composite material was observed. From the above literature, it is found that the addition of natural fillers increases the mechanical properties that were acceptable. When the filler is added to a thermoset, the curing reaction is affected by filler addition. The three-dimensional network of the thermoset has a higher molecular weight between crosslinking's (not entanglements, it is not a thermoplastic). This phenomenon reduces the tensile properties of the thermoset based composite. The mechanical properties of particulate-filled polymer micro and nano-composites are affected by particle size, particle content and particle/matrix interfacial adhesion. The decrease in mechanical strength is attributed to increasing in voids, poor adhesion at the filler, interface and shrinkage cavities as filler loading increased. It culminates in the quicker failure of the samples. Composite strength and toughness are strongly affected by all three factors, especially Particle/matrix adhesion. Various trends of the effect of particle loading on composite strength and toughness have been observed due to the interplay between these factors which cannot always be separated. Prediction of the strength of composites is difficult. The difficulty arises because the strength of composites is determined by the fracture behaviors which are associated with the extreme values of such parameters as interfacial adhesion. Thus, the load-bearing capacity of a particulate composite depends on the strength of the weakest path throughout the microstructure, rather than the statistically averaged values of the microstructure parameters. This may be as a result of unevenness in voids density and agglomeration of fillers arising from poor dispersion of fillers in the matrix. The variation of flexural strength with filler content. The decrease in flexural strengths was attributed to voids and weak interfacial bonding as the particles increased which resulted in weak bending load carrying capacity by the matrix.Very few researchers have reported the*Almond Shall* Particulate Reinforced *Sal tree resin*Hybrid Matrix Composite. The effect of the mechanical, behavior of the *Almond Shall* Particulate Reinforced *Sal tree resin*Hybrid Matrix Composite material with different vol % was analyzed.

1. INTRODUCTION

The use of the term “ fibers” to many structures and notions that would normally be described as a carbon nanotube, a fibril, a mono-filament, a staple yarn, a monofilament yarn, as well as the substance from which these objects are created, has muddied the meaning of the term. As will be seen, understanding how the solitary fibers contribute to the behavior, qualities, and uses of the collective fiber structure, particularly at the nanometer, requires distinguishing between them.

1.1.Fibers

The name “fiber” has emerged, somewhat arbitrarily, to identify fiber with the same composition and shape as CNTs but differing interior structures. The authors looked into two distinct sorts of fibers. The first was made out of a synthetic fiber blend that performed well in densely graded asphalt mixes. According to the standard technique UNE-EN 1097-6, the density of this mix was 0.947g/cm3. The alternative diameters of fibers, 4mm and 12mm, were examined for this type of fiber.For a long-lasting product, material selection is a crucial aspect of engineering design. Materials are important not only for mechanical properties but also for researching physical and metaphysical properties of items, as well as for consumer satisfaction. The ability to accomplish success at a minimal cost is critical for every design.Given the rising demand and awareness of environmental effects, the correct compatibility of the product's material with its performance and recyclability has recently been a higher emphasis in engineering product design. Several factors, constraints, and restrictions govern the use of a given type of material in a specific application. As a result, optimizing these constraints and selecting the appropriate material type is a difficult task that needs careful consideration. Modern approaches such as optimizations, informed judgments, and experts systems are used to arrive at Due to the inherent link between materials and their availability, machinability, product design, cost, legibility, and performance in the final product form, proper material selection is essential.

1.1.1. Types of Fibers:

a)Natural fiber

b)Man-made fiber

- Semi-synthetic fiber
- Synthetic fiber

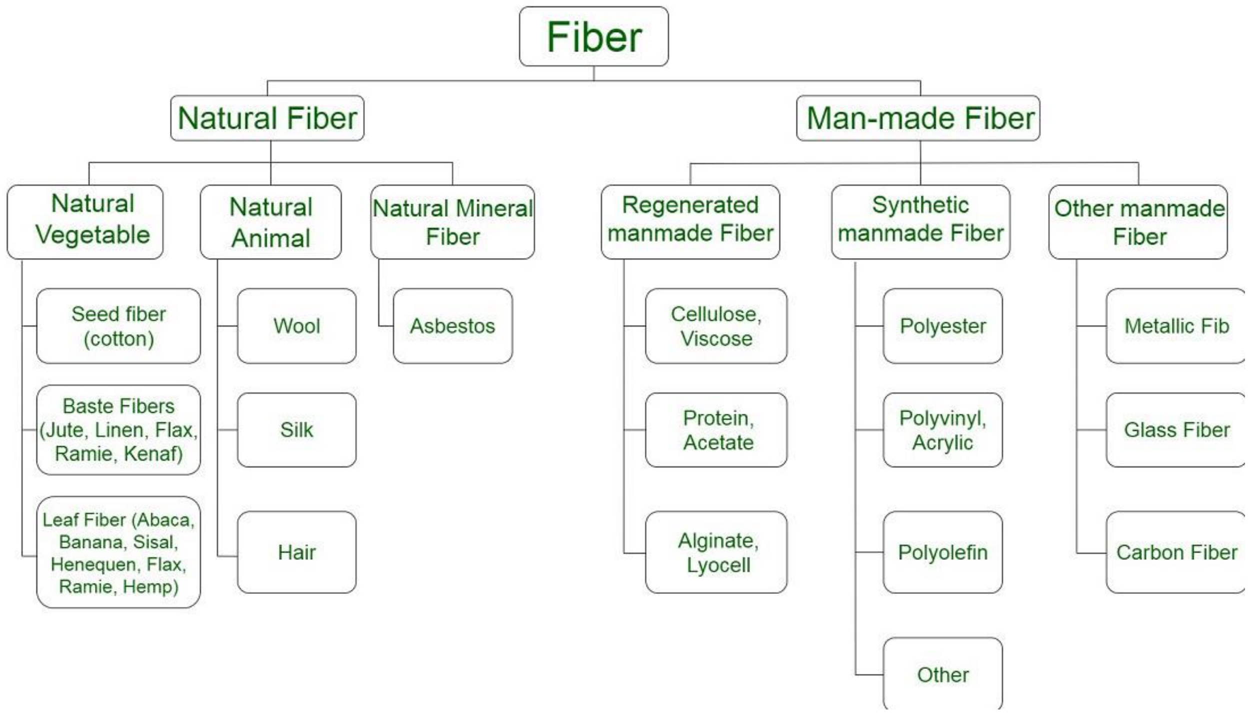


***Figure: 1: Fibers** types*

a) Natural Fiber:

NFPCs (natural fiber/plastic composites) are mostly made up of natural fibers (NFs).Natural fibers are becoming increasingly used as reinforcing agents in polymer-based composites.Natural fibers are less expensive, have a lower density and weight, and pollute less during the manufacturing process than synthetic fibers, posing fewer health hazards and being more environmentally friendly.They are extensively employed in many sorts of manufacturing sectors, such as aerospace industries, commercial mechanical engineering usage, and so on, due to their numerous benefits. The automotive industry,railways,machine components Manufacturing of sporting items,as well as coaches and aircraft construction military units, maritime constructions,biomedical equipment, and defenseorganization,to name a few. Therefore, Synthetic fibers provide a multitude of technological, economic, and environmental benefits over natural fibers.

The difference between natural and synthetic fibers.They are also discovered to be detrimental to one's health during processing. Recently, Natural fiber-reinforced composites have changed the focus of research and development away from monolithic materials. Natural fiber composites can be a cost-effective material for car body panels, interiors, storage devices, construction and industrial panels, partition boards, and false ceilings. Aircraft wings and wind turbine blades are constantly pushing the limits of size, necessitating the employment of cutting-edge materials, designs, and manufacturing techniques. Composites will be made with processed fibers and resin, as well as fillers and other components in the future. The research operations will be fine-tuned to incorporate better materials and manufacturing processes. The Fabrics, ropes, and papers made from natural and synthetic fibers have played an important part in human society.

Natural fibers like cotton, flax, and wool were the first materials used to clothe the world's population. Synthetic and regenerated fibers have recently overtaken cotton to dominate the global garment industry. Every day, we all wear coats, pants, and socks made of fibrous materials and are unaware of how they are disposed of fiber, particularly microfibers, which is found in abundance in the air, soil, river, lake, and ocean, and is considered anthropogenic litter that has become a global issue. As reinforcement, natural fiber is chosen. Bamboo and cotton fibers have been chosen as natural fibers since they have high strength and are readily available on the market. Because of its benefits, such as being adaptable, comfortable, soft, very smooth, breathable, reasonably light, strong, robust, and economical, one semi-synthetic fiber, viscose rayon fiber, is also utilized as reinforcement.Farmed gilthead sea bream and common carp consume plastic and non-plastic microfibers at various phases of their lives.

- **Advances in Natural Fibers:**

The use of natural fibers as reinforcement in composites has piqued the scientific community's interest for quite some time. Natural fiber materials continue to pique the curiosity of academics despite their maturity. On the one hand,society's environmental awarenesshas steadily risen in recent decades. As a result, the influence of consumerism on the environment is receiving more attention, resulting in the enactment of rules and restrictions by national governments and international organizations. These Lingo cellulose fibers can be made from wood,annualplants,agroforestry waste, or as a byproduct of industrial operations such as textile or paper production.

The possibility of using agroforestry waste as a reinforcement for polymer-based composites can give value to waste that is frequently burned in the field, increasing its value chain and resulting in more diversity. When hydrophilic natural fibers are combined with hydrophilic matrices, weak interphases result, compromising the composites' potential mechanical capabilities.This is a very active research area that has generated various solutions, but it must continue to be active to generate interphases that ensure a positive mix of tensile and impact capabilities of the materials.Another exciting area of research is the use of bio-based polymers as a matrix for natural fiber-reinforced composites.These matrices are comprised of renewable elements and do not include any oil. Its main disadvantage, according to research, is that it is more expensive than oil-based plastics, although bio-based polymers such as poly(lactic acid) have witnessed a significant increase in market share. Bio-based plastics must exhibit competitive properties when compared to oil-derived polymers to be of interest to the industry.This Special Issue contains research on the characteristics, applications, and implications of natural fiber-reinforced composites.

The following is a list of the scientific subjects covered in this issue:

- Plants that grow every year
- Strands that have been recycled
- Composites made of natural fibers
- Assessment of the life cycle
- Mechanical features
- Interphase
- Micromechanics
- Matrixes that degrade
- Biodegradable polymers

In a summary, the scientific papers in this special issue on natural fibers and polymers deal with the following subjects.**I**n their study "conductive Regenerated cellulose Fibers for Multi-Functional Composites," they looked at the mechanical properties of regenerated cellulose fibers coated with copper using an electroless plating process.

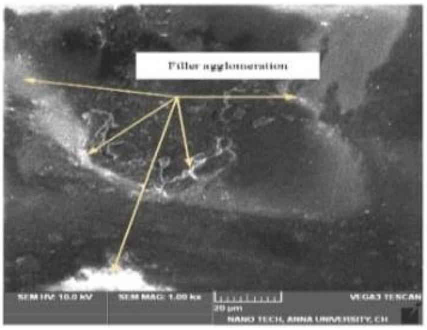
They also looked at the materials' molecular structure alterations and potential for use in sensing applications in "Mechanical and Structural Investigation."The findings demonstrated that when blended with ordinary glass or carbon fiber composites, regenerated cellulose fibers coated with copper offer potential as structural monitoring devices without severely impairing their mechanical performance. Natural Fibers generated from agricultural wastes, such as fibers, are utilized as an alternative reinforcement in concrete composites.

The goal of the study was to investigate the effects of coir fibers on the hydration reaction, microstructure, shrinkage, and mechanical properties of cement-based lightweight aggregate concrete (LWAC), and it found that treatment with coir fibers promotes the hydration reaction of cement due to the accelerating effects of the various treating agents. Every year, the amount of feature waste produced by the chicken meats industry grows. The researchers tested the mechanical capabilities of composite fiberboards made with various ratios of wood and feathers.The Surface activation of poly-lactic acid-based wood-plastic composites by atmospheric pressure plasma treatment." They created poly-lactic acid (PLA) composites and investigated the effects of a plasma treatment called dielectric barrier discharge (DBD) on the composites.

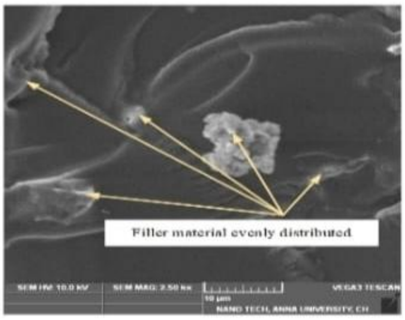
SEM ANALYSIS

- The addition of more than 35% v/v Almond Shell powder to Sal resin Epoxy Hybrid Matrix bio composite resulted in a decrease in tensile properties. This is due to natural filler agglomeration in the Sal resin epoxy hybrid matrix, as evidenced by the SEM images.
- Because of the clustering of the filling components, the composite material becomes more brittle, as demonstrated by the lower strain to failure.
- Furthermore, the filling might inhibit swilling as well as induce surrendering in clustered areas, as if the particulates had been treated with an anti-adhesive and their connection with the polymers were reduced.

SEM ANALYSIS



Tensile Specimen



Flexural Specimen

SEM Image of 35vol% Almond Shell powder with Sal tree resin Blended Epoxy Hybrid

❖ Natural Fibers and Their Properties:

Researchers from all across the globe are interested in developing materials that are both less expensive and more ecologically friendly, to reduce pollution and benefit society. Natural fibers have sparked a lot of interest in the research community.Due to their distinct and advantageous characteristics, such as low density, light weight, low cost, wide availability, recyclability, non-toxicity, high thermal stability, and biodegradability. Theroots, leaves, bark, and fruit are just a few of the plant parts that can be used to make natural fibers. Due to the limited natural wood supplies, significant programshave been launched to encourage.Alternative resources such as wood by-products, agricultural waste, and non-timber materials are being used.In 2011, Europe utilized 263.7 million wood-based goods across the world.Natural fibers have been used to meet mankind’s clothing needs for thousands of years.

Natural fibers are renewable resources, making them a preferable option for long-term supply since they have low-cost, low density, cheap processing costs, no health risks, and mechanical and physical qualities. Natural fiber's most essential properties are biodegradability and non-carcinogenicity, which have brought them back into popularity with the added benefit of being cost-effective.Fiber is the fundamental unit used in the production of textile yarn and fabric. It’s a hair-like structure that comes in either continuous filaments or a short length, similar to cotton. Until around a century ago, all of the fibers used to manufacture fabric came from natural sources, but as demand grew, new artificial fibers were developed, resulting in a wide range of textiles on the market. Suddenly, around the turn of the twentieth century, innovations and new advances in the field of synthetic fibers happened. However, the benefits of utilizing natural fibers are resurfacing, and demand for it is steadily expanding.

In terms of leather recycling, a novel bio-based product comprised of natural fiber latex, and waste leather has been proposed.The best findings were from the coco/leather/latex (50:40:10) sample, which matched mechanical test results for tension strength, break elongation, tear resistance, des-option, and flexibility.Natural fibers may be found in a variety of applications, such as the construction of sewage-system septic pipes, prompting their employment in a variety of recyclable items. The use of these natural fibers in the automobile industry is increasingly commonplace. Seatbacks, bumpers, dashboards, truck liners, main events, decking, railing, windows, and casing are all examples of places where it can be found in car interiors.

When these fibers come into direct touch with the ground, they absorb water from the air, causing voids to form inside the material.Another issue is the extremely polar surface of natural fibers, which generates an interfacial dissimilarity with non-polar polymers like polypropylene and polyethylene.Natural fibers have a porous structure and poor hydrophilic, as well as poor surface and mechanical qualities, limiting their usage in a commercial application. The great majority of natural fibers composites research data released in recent years provide minimum information on natural fibers categorization, chemical treatment effects, and applications. As a result, to build on previous achievements in this subject, more extensive effort is required. The goal of this work is to explain the value of natural fibers, their composites, and the key factors that determine the selection of these materials for various applications (automotive industry, for instance). Second, this study will examine various surface modifications and chemical treatments on natural fibers, as well as a summary of NFRPC, uses.

Table 1.1: *Difference between synthetic and Natural Filler Related*

Natural Filler	Synthetic Filler
It is derived from natural sources.	It is entirely man-made.
The structure of the fibers cannot be altered.	It is possible to alter the fiber structure.
It is easy to put on and take off.	Natural fibers are comfier.
Processing does not require any chemicals.	Processing necessitates a variety of chemical compounds.
It retains its natural radiance.	As needed, color is added.
It's good for the environment.	The environment is harmed by some fabrics.

- **Effects of machining parameters with natural fibers:**

Rice husk (RH), which has been discovered to have a greater silicon concentration than jute and kenaf, has been considered for the current research. It might be claimed that the machinability properties of RH composites are comparable to those of glass fiber composites with high silicon concentrations. However,because glass fiber is not cellulosic, rice husk, which is cellulosic by nature and has almost the same silicon concentration as glass fiber, was used for this study. RH is projected to have different qualities than jute and kenafbecause of its increased hardness and abrasiveness, although it comes from a plant-based natural source. Although the three natural fibers have different initial diameters, NFRCs (RH/PP, jute/PP, and kenaf/PP composites) suffer from fibers attrition throughout the production process.Natural fibers are materials made from biological stuff such as plants and animals. These materials may be stretched to vast lengths and spun into useful things like threads, ropes, and filaments.

• Because of its low specific weight, it possesses greater specific strength and stiffness than glass.

• It is a renewable resource that requires very little energy to produce.

• It can be made at a low cost.

• Its procedure is user-friendly since there is no tooling wear or skin discomfort.

• It has excellent thermal and insulating characteristics.

Natural fibers are also utilized to make composites, which havetheir own set of benefits.

Increased and productive use of natural fibers is reducing reliance on synthetic fibers and, as a result, lowering greenhouse gas emissions. The Natural fibers are biodegradable and can be used to replace non-biodegradable materials like High-Density Polyethylene (HDPE).Natural fibers had a 339 percent increase in stiffness values as compared to the HDPE matrix and a 33% increase in flexural strength. More studies on natural fibers, such as Kenaf fibers, have revealed that these fibers composites might be used to replace vehicle panels.Many studies on natural fibers have been conducted in the recent decade to identify a replacement for glass fibers. Natural fibers composites are fast gaining popularity and have the potential to replace metals and ceramics.These studies are motivated by weight savings, cheaper raw material costs, and environmental benefits due to natural fibers' biodegradability.

The Sunn hemp fiber is another type of natural fiber. Sunn hemp is one of the oldest fiber-producing crops in use in the textile industry. The fibers are taken from the plant stem's outer bark. These fibers are employed to manufacture pulp and paper, according to certain previous studies.Because of the high cellulose content and low micro fibril angle, these fibers have high strength. These fibers have an off-white color and excellent flexural qualities. These fibers can be used to strengthen polymers without compromising the biodegradability of the products.

For improved mechanical qualities, natural fibers composites are frequently reinforced with glass fibers, and vice versa. Glass fibers are classified further; nonetheless, E-glass fiber is the focus of our attention.

The following are some of the benefits of glass fibers:

• These fibers are exceptionally light and strong.

• Due to their thin structure, these fibers are less brittle and have high ductile qualities.

• The surface area to weight ratio of these fibers is high.

• Thermal insulators, these fibers are excellent.

• The structure of glass is amorphous;

As a result, characteristics are the same both along and across the fiber. The tensile qualities of natural fiber composites, such as sunn hemp composites, have been observed to be improved by glass fiber. The tensile strength of the composite improves as the glass fiber content increases.

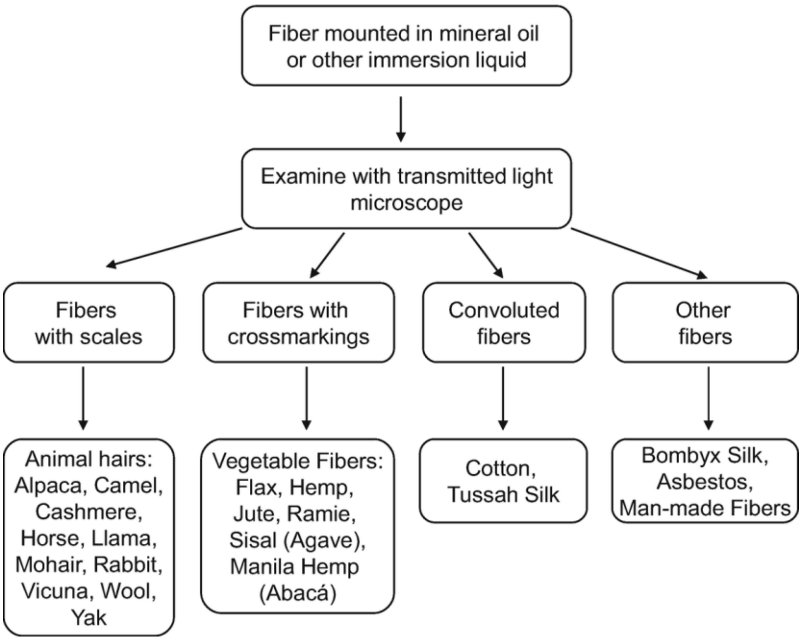


Figure2:*Identification of natural fibers*

- **Natural Fiber-Reinforced Epoxy Composites:**

The synergistic use of distinct natural fiber, along with lower product costs and higher versatility, makes them useful in a variety of industries, including automotive, construction, and aerospace. Several fiber combinations have been recorded in the literature for the development of hybrid polymer composites, including synthetic-synthetic fibers, synthetic-natural fibers, and natural-natural fibers. True, the performance of synthetic fiber-based hybrid composites remains superior; nevertheless, these composites have recently been called into doubt because of their energy and environmental issues.Natural fibers may be found in abundance in India,the Himalayan area. Grewoptive is a member of the Tiliacease family, Bhimal or Bihul is the local name. The casealpiniacease family includes Bauhinia values, also known as Kariyala, Malu, and Marjan. It's worth noting that there isn't much information available on employing G. Optiva and B. Vahliifibres as polymer composite reinforcement.

The thermosetting polymer matrices are highly cross-linked, break down at high temperatures without melting, and have a high stiffness to fragility ratio.Finish, color, texture durability, and other functional aspects are all provided by these matrices. Natural fiber reinforcement of thermosetting matrices increases the composite material's mechanical properties and resistivity, allowing it to be used in a variety of sectors such as automotive, aerospace, mariner,sportsgoods, and electronics. This chapter focuses on the various types and applications of thermosetting matrices. The addition oflong and short fibers to thermosetting composites, as well as their various production procedures, are covered in one section. Finally, both static and dynamic mechanical properties of thermosetting composites based on natural fibers are examined.In recent years, the development of innovative fiber-based materials has emphasized their immense potential to improve human life quality. Natural or synthetic elements may be present in these fibrous materials. Natural fibers, such as cellulosic, protein, and mineral fibers, come from the soil and are environmentally friendly.

Synthetic fibers, on the other hand, are man-made and, despite being the most commonly used fiber in the development of new materials, are not natural, they create some environmental concerns. The CO2 emissions and oil dependency, as well as issues with materials recycling, are all issues that need to be addressed. In affluent countries, the transportation industry is estimated to be responsible for 20% to 25% of total greenhouse gas emissions. As a result, the goal is to develop a lightweight, low-cost natural fiber composite for use in the automobile industry, allowing cars to be more fuel-efficient and environmentally benign. Many automotive components are already made from natural composites based on flax, hemp, and sisal fibers. Identify a few automotive companies that are already incorporating natural fibers into car components. Natural fibers have better strength, modulus of elasticity, moisture absorption, and low elongation and elasticity when compared to non-natural fibers. Animal, vegetable, and mineral fibers are separated into three categories based on their origin. Animal fibers, such as silk, hair, wool, and feathers, are non-proteinaceous in origin.

Natural fibers have some advantages, including their availability, nontoxicity, low density, low cost, biodegradability, outstanding toughness, and high specific strength. However, when used in composites, they have some drawbacks. Flammability, poor moisture absorption, and swelling properties are just a few instances of large variances in features. In a natural fiber-reinforced composite, low compatibility with many matrices, particularly polymers, is a major drawback due to the hydrophilic nature of the fibers and the hydrophobic polymer.As a result, numerous methods for altering natural fiber surfaces to reduce water absorption and promote adhesion to polymeric matrices have been tested. The features of natural fibers and the functionalization procedures that can be employed to change their surface for advanced green composites applications are discussed in this chapter. There will be several instances of natural fibers composites used in the automobile sector.

Every industry strives to reduce its reliance on resources derived from fossil fuels. The need for environmentally friendly, long-lasting materials is growing by the day. Alternative research including the use of natural fibers to replace glass and carbon fibers reinforcements must be expanded. The reducibility and properties of natural fiber-reinforced materials have previously transitioned from steel to aluminum, and are now shifting from aluminum to fiber-reinforced composites. Natural fibers composites and plastics advancement have led to forecasts of a 15% reduction in total automobile weight shortly. Natural fibers have a lower density than synthetic fibers, making them lighter than traditional composites.Renewable fibers have a lot of promise because of their low cost, large production volume, and other commercial advantages. Natural fibers utilize 60 percent less energy than glass fibers in themanufacturing process. Natural fibers are becoming increasingly popular due to their ecologically beneficial characteristics, which include improved energy recovery and carbon dioxide neutrality. A previous study on fiber-reinforced cementation composites discovered that employing fibers in cementation materials resulted in improved mechanical characteristics, durability, and fracture management.

Natural fibers are a feasible and cost-effective way to improve the mechanical characteristics of concrete, according to studies.Natural fibers are a viable and cost-effective way to improve the mechanical properties of concrete. The use of biologically produced fibers in structural components has received a lot of attention and is widely used. Natural fibers include cotton, jute, ramie, hemp, sisal, coir, and viscose, to name a few.These natural fibers are appropriate for use in cementation composites because of their great mechanical strength, low cost, and simplicity of handling. PVA, carbon fibers, bamboo fibers, and waste carpet fibers are just a few examples of synthetic and natural fibers that have been utilized in concrete to prevent cracking when subjected to high temperatures.

Typical synthetic and natural fiber TGA curves. Synthetic fiber (PVC) has a breakdown temperature of 320 degrees Celsius, yet at 800^0 Celsius only retains 1.28% of its weight. Other natural fibers with epoxy coatings were able to preserve higher weight

(17.85wt%, 18.62wt%, and 18.77wt%) after the TGA.Their decomposition temperature is significantly lower, at 260^0C, 250^0C, and270^0C respectively. As a result, organically produced mycelium fibers with Si sources had lower degradation rates and higher char yields than synthetic fibers and standard natural fibers with epoxy coatings. Synthetic methods and epoxy finishing, for example, have major environmental repercussions in commercial fiber production.

1.2.Study of almond shell

Due to the existence of greater cellulose content of 70-80 percent and a 10 microfibrillar angle, the natural fiber series of flax fiber has a higher tensile strength. 10 Almond shells, corn hub, sugarcane waste, and other renewable natural particle materials are used as fillers in polymer composites to improve mechanical qualities. Every year, a considerable amount of almond shell residue goes wasted and is just discarded.

1.2.1. Characteristics of almond shell

Some researchers investigated the impact of almond shells in improving mechanical characteristics in wood-based composites and found that the transverse strength increased. Beyond 30 wt percent almond shell, the water absorption capacity of almond shell reinforcement in wood-based composites approaches a maximum. In its application as a polymer composite reinforcement, the almond shell is through to have a limited water absorption capacity. Almond shells and flax fiber were added as natural reinforcements for the goal of compounding the mechanical qualities of the composite, which was referred to as hybridized composite. Almond shell is expected to have a restricted water absorption capacity when used as a polymer composite reinforcement. Natural reinforcements such as almond shells and flax were added to the composite, which was dubbed a hybridized composite, to improve its mechanical properties. In prior experiments of polymer composites filled with almond shells, ASP particles had a similar shape.

1.2.2. Data analysis of almond shell

In shows the look of injection-molded biocomposite parts as well as the color index. It can be observed that increasing the amount of almond shell in the starch-based polymer from 5% to 30% while keeping the same particle size (0.08-0.125mm) decreases the lightness and makes the material darker. The addition of 30% almond shell results in a darker brown color in the samples (Fig.3a).The L value of the starch-based polymer as received is 91, and it is decreased to 30.54 from 60.97. Furthermore,a coordinate that has identical values to the b coordinate is significantly larger.

In terms of particle size's influence (Fig.3b), it doesn't appear that this component has a significant aesthetic impact on the parts. The biocomposite with almond shell particle sizes less than 0.05mm, on the other hand, is the darkest, with L in the 30-39 range. This might be because smaller particle sizes have a bigger specific contact area with the matrix and can be spread more uniformly in the polymer matrix, preventing more light from passing through. All injection molded pieces had positive values for a and b color coordinates, indicating that the addition of almond shell resulted in color changes of varying intensities, depending on the amount of almond shell used. The principal thermal transitions of the as-received polymer and the produced biocomposites were determined using differential scanning calorimetry. Figures 4a and b show the DSC curves from the second heating scan of starch-based polymerMater-Bi-DI01A) and starch-based polymer/ASP bio-composites with varying ASP particle Size and content.The melting peaks of master-Bi DI01A as received are the first, smaller, at roughly 159-161 ℃, ascribed to the commencement of the crystalline phase fusion. Furthermore, the tiny melting peak at 110℃ and glass transition at 65 ℃ might be secondary transitions linked to starch chain restructuring.

2.1. Sustainable automotive **and** *Modelling of Damage Processes*

In 2019, Verama.D, et al [51] have utilized a natural fiber-reinforced polymer composites feasibility study for sustainable automotive industries. This chapter was talk about how it’s progressed in the construction of automotive interiors and exterior natural fiber-reinforced composites' mechanical properties, especially in the context of automobiles. Despite fact that chemical modification is required to overcome the constraints of NFRPCs, Which include moisture absorption, limited processing temperature, and variable quality, the benefits significantly exceed the drawbacks.

In 2019, Naveen.j, Jawaid.M, et al [52] a finite element analysis of natural fiber-reinforced polymer composites. The basics of the finite element model are covered in this chapter also include a description of a model-based methodology of natural fiber-reinforced polymer composites. The experimental assessment of the properties of natural fiber-reinforced composite is less realistic. Due to human error and the accuracy of the finding the testing machine. The use of finite elements was analyzed to natural fibers and natural fiber reinforced polymer composites have mechanical, thermal, and other properties that can help overcome these limits. The most common homogenization-based multi-scale constitutive approach used in finite element modeling to examine the influence of microstructures on the mechanical and thermal characteristics of NERPC is the representative volume element method. The design time and expense of testing will be greatly reduced if accuracy and an adequate finite element model for the material are developed. Natural fiber element modeling faces obstacles such as the fiber/matrix interface, 3D geometric modeling, and interfacial adhesion. Finite element models for structural materials should include thermal, mechanical, and dynamic performance. The most interesting future study topics may be progressive damage mechanisms and NFRPC analysis.

In 2019, Devnani, G.L and Sinha. S [53] have utilized the impact of nanofillers on the properties of natural fiber-reinforced polymer composites. In this study, a small quantity of material is added to a variety of polymers and other materials. This can dramatically increase the performance and quality of materials, including thermal, mechanical, water absorption, and flame retardation, among other things. Due to their economic effectiveness, biodegradability, lower weight, superior mechanical qualities, and sustainability, natural fibers are increasingly being employed as a substitute for synthetic fibers in polymer composites. However, there is still a compatibility issue between hydrophobic polymer matrix and hydrophilic fibers, which might lead to composite performance loss.

In 2019, Celik, Y.H., Kilickap, and Kilickap, A.I., [54] have analyzed Milling of natural fiber reinforced polymer composites an experimental investigation using cemented carbide (WC) end mills, researchers in end milling of jute fiber reinforced polymer composite plates with varying orientation angles (0/90, 30/60, and 45), the effects of cutting parameters such as cutting speed and feed rate on cutting force, delamination factor, and surface roughness were explored. Cutting force, deformation factor, and surface roughness were found to be affected by feed rate and cutting speeds. Cutting force, delamination factor, and surface roughness all decreased as the number of flutes on cutting tools increased.

In 2019, Mansor, M.R., Nurfaizey, A.H., et al [55]. have used natural fiber polymer composites in aerospace engineering. In this chapter, the current NFPC application is covered in aircraft engineering. The introduction to aerospace materials, particularly polymer composites, such as those used in airplane frames and engine building, as well as the benefit of the materials, are among the subjects discussed. The recent advancement of NFPC in aerospace applications such as aircraft radon and interior cabin components, comments on NFPC future trends and problems, are also discussed. Finally, the candidate material NFPC is one of the most promising for aerospace engineering applications. . Aerospace interior applications have the most potential market segment since they have reduced load-bearing requirements, more lightweight qualities, and cheap raw material coasts.

In 2019, Khan, A., Vijay, R., Singaravelu, et al [56] have utilized natural fiber from wiregrass that has been extracted and characterized for use as reinforcement in sustainable fiber-reinforced polymer composites. The purpose of this work is to extract and characterize Eleusineindica grass fibers taken from the stem using a manual retting procedure. Eleusineindica was greater cellulose content of 61.3 wt percent, a density of 1143 kg/m3 according to the findings.

In 2019 Siakeng, R., Jawaid, M., et al [57] have utilized a poly-lactic acid composite with natural fibers. In this chapter, the influence of treatment on natural fiber-reinforced polymer composites' water absorption characteristics is discussed. The basic characteristics of composites reinforced with various natural fibers and polymers are listed. Dimensional stability issues with these NFRPCs are highlighted. Based on previous literature, the effects of several forms of treatment on NFRPCs, such as alkali, silences, and acetylation, on water behavior are examined. All of the treatments had a thing in common. They were tried to lower the hydroxyl groups in the fibers and increase matrix-fiber adhesion. Aside from, fiber content and dimension had a substantial impact on the NFRPCs, water absorption.

In 2019, AbdHalip, J., Hua, L.S., Ashaari, Z., et al [58] have analyzed the water absorption impact of treated and natural fiber-reinforced polymer composites. All of the treatments had one thing in common. They all tried to lower the hydroxyl radical in fibers and increase matrix-fiber adherence. The polymer utilized to make NFRPC is also important, as several studies that PP-based composites have greater water abstraction capabilities than PE-based composites. The chemicals utilized in treatment have a big impact on how much the NFRPC improves in terms of water absorption. Acrylic acid, silences, and potassium permanganate treatments were more effective in improving the NFRPC's water absorption behavior. In compassion to other chemical treatment methods, peroxide treatment utilizing benzoyl peroxide and decimal peroxide is the most effective way for increasing interfacial adhesion and compatibility between the fiber and matrix.

In 2019, Adeniyi, A.G., Ighalo, J.O and Onifade, D.V., [59] have utilized the Fiber-reinforced polymer composites made from banana and plantain. Cultivators solely harvest banana and plantain fruits for consumption, as well as leaves for wrapping food. The plant's remaining parts are considered waste and a potential source of natural fibers for use as composite reinforcement. Banana and plantain fibers as fillers in plastic composites have been the subject of numerous studies throughout the years. Most researchers also choose to prepare the composite by hand layup and compression molding. The MEKP and cobalt accelerators, respectively, are the preferred composite additives. With consideration for other natural fibers. In decreasing the order of tensile strength in epoxy composites, these mechanical properties of banana fibres epoxy composites are intermediate.

In 2020, S.Wang, Z. Wu, S.Jiang, et al [60] have analyzed the WHMFC, was developed a Zylon-Kevlar Hybrid Fiber Reinforcement Technology for a Pulsed

Magnet of 100 T have The Wuhan National High Magnetic Field center has proposed using a reinforced method that combines zylon/epoxy composite and kevlar/epoxy composite to construct the 100 T Pulsed Magnet. Kevlar fabric offers superior wet implantation with exoxy than Zylon-fiber because of its rougher surface, thereby preventing shearing movements between the conductor surface and the reinforcing layer. The maximum von mise stress in the Zylon-Kevlar hybrid fibers is 3.68 Gpa, according to the simulation. The measured ultimate tensile strength from the explosion test is 4.97 Gpa.

In 2019, Y. Mo, L Yang, T. Zou, et al [61] have utilized Kevlar/Nano Cellulose Fibrils/Softwood Pulp Hybrid for the manufacturing of composite insulation paper with reduced permittivity, good thermal and mechanical properties. Nano Cellulose fibrils (NCFs) and Low-temperature treatment of Kevlar pulp, plasma were used as reinforcements in the creation of composite insulating paper with low-temperature plasma were used as reinforcements in the creation of composite insulating paper with low relative permittivity, die electric loss, superior mechanical properties, and thermal stability. The change was caused by the introduction of Kevlar pulp, which has a low dielectric constant loss, lowering the paper’s overall polarization. After adding 20% Kevlar pulp to the composite paper, the mechanical qualities of the paper deteriorated. In addition, the composite paper exhibited better insulating and thermal quantizes than regular paper. Due to the lack of compatibility of the fibers, the composite paper’s Yang’s modulus and tensile strength were significantly lower than those made from pure softwood pulp. The polarity of Kevlar fibers could be increased via a low-temperature plasma treatment, which could help with cellulosic fiber associativity. Fewer flaws and stronger fiber networks improved the insulating properties of the composite insulating paper. In high-voltage AC transformer insulation applications, it has the potential to replace pure softwood paper.

In 2020, A. Moss, M. K. Mohseni, et al [62] have analyzed, “Modeling and Characterization of a Fiber-reinforced Dielectric Elastomer Stress Actuator" In this study, a DEA can induce planar contraction when compressed through the thickness by reorienting the fiber reinforcement using a composite fiber-mesh dielectric. The performance of fiber-reinforcement stress in a dielectric elastomer actuator is investigated in this letter under a variety of loading circumstances. The results are then experimentally validated, and the best fiber angle for maximization mechanical work for a FRDETA under a dead load is determined. 880 kPa tensile stresses, 14.7 percent tensile strains, and a mass-specific power density of 10.7 J/kg were achieved by the FRDETA tested, all of which are within the values recorded for natural muscle.

In general, these tensile actuators offer a simple approach for creating stress in larger soft robotic devices.

In 2021, Venkataraman, S., And Athijayamani, A., et al [63] have utilized Polymer composites reinforced with natural cellulose fibers. Natural cellulose fibers have inspired a lot of interest in this topic as a potential replacement for manufacturing fibers like glass, aramid, or carbon for polymer matrix composites. Natural fibers, while not as strong as synthetic fibers, are readily available, low density, low cost, renewable, and biodegradable. These industrial sectors require improved material with such a max strength ratio for the fabrication of parts and components, as well as an increase in quality due to the high cost of composite materials with synthetic fibers and environmental concerns. Natural cellulose fillers, such as fibers and particles, are lightweight, environmentally benign, renewable, widely available, and biodegradable. The most widely utilized fibers to reinforce polymers are natural cellulose fibers such as sisal, banana, flax, jute, hemp, pineapple leaf, and coir. Environmental problems are alarming the entire world, thus research on these biocomposites is gaining traction among researchers all over the world.

In 2019, Rajak, D.K., Pagar, D.D., Menezes, P.L., et al [64] have researched Outstanding characteristics of fiber-reinforced polymer composites including great durability, stiffness, damping property, flexural strength, and corrosion resistance, wear, impact, and fire, as well as a high strength-to-weight ratio. Because the constituent elements and manufacturing techniques of composite materials determine their performance, the functional properties of various fibers available around the world, their classifications, and the fabrication techniques used to fabricate composite materials must be investigated to determine the material's optimal characteristics for the desired application. The amazing performance of hybrid fiber-reinforced composite materials, which combine the best of all worlds, has been discovered to be one of the most promising and efficient studies that have revealed the outstanding performance of fiber-reinforced composite materials. The efficacy of the manufacturing technique is dependent on the combination of type and amount of matrix or fiber material used type of composites, which dominate the majority of applications in the most sophisticated sectors. Composite materials are used in a variety of sectors depending on the qualities are required. Future studies will focus on developing novel composite structures that combine multiple types and use new production techniques.

In 2021, Ilyas, R.A., Sapunan, S.M., Nurazzi, et al [65] have analyzed natural fibers composites for automobile components on a macro to nano-scale, this chapter discusses modern bio-composites developments, particularly natural fiber polymer composites (NFPC). This low-density material has excellent mechanical and barrier properties. It's also low-cost, biodegradable, and regenerative. NFPC has advanced applications in automotive components, papermaking, flexible optoelectronics, scaffolds, optical devices, pharmaceutical products, substitutes/medical biomaterials, spaceflight, aviation, and tissue repair, to name a few. The automobile uses of natural fiber reinforced polymer composites are summarized.

In 2019, Habibi, M., Laperriere, L. MahiHassanabadi, H., et al [66] have analyzed fiber Mechanical characteristics of unidirectional flax fiber composites in place of stitching or weaving in natural fiber reinforcement manufacturing, The pressure short fibers in the composite resulted in a minor drop in longitudinal tensile modulus and strength of around 10%. The tensile strength in the transverse direction on other hand has nearly doubled. In compression loading, a similar pattern was seen with no influence on transverse compressive strength, the transverse modulus was somewhat raised. In tensile loading, the presence of short fibers has a considerable favorable effect on fracture behavior.

In 2019, Rezghimaleki, H., Hamedi, M., et al [67] have utilized drilling of jute fiber reinforced polymer composites have been studied in an experimental setting, short fibers can be used instead of weaving or stitching UD strands in the wetly paper making process. When short fibers are utilized as a binder, the cohesiveness between UD yarns is maintained. The presence of short fibers was found to harm longitudinal mechanical characteristics. Along with the Vud yarns, there is also a noticeable reduction in delamination and longitudinal splitting. However, It is widely acknowledged that increased twist has a significant detrimental influence on mechanical properties and impregnation ability. In the new reinforced manufacturing technique, untwisted flax strands are employed (Tex 5000).

In 2020, Chandramohan, D., Sathish, T., Kumar, S.D. et al [68] have utilized Jute/aloe vera hybrid natural fiber-reinforced composite's mechanical and thermal properties. The impact of cutting settings, drill bit varieties upon axial force, delamination size, or surface roughness while drilling jute fiber reinforced polymer composites was investigated in this work. They are three different types of drill bits and cutting parameters were used to evaluate the drilling behavior of the produced composites, feed is the cutting parameter that has the highest influence on the thrust force generated by an HSS twist drill when drilling jute fiber-reinforced composites, while CoroDrill 856 has the least impact. Drilling with an HSS twist drill produced less delamination than drilling with the Coro Drill 854 and Coro Drill 856. The size of the texture has a big impact on the size of the detachment. Drilling coarse-textured jute fibers resulted in JFRPs with the smallest delamination size.

In 2019 Naveen, J., Jawaid, M., Amuthakkannan, P. et al [69] have analyzed the mechanical and physical properties of sisal fiber-reinforced polymer composites, A study of the behavior of natural composites such as aloe vera and jute has been attempted. The following thermal and mechanical parameters jute and aloe vera are calculated: ultimate tensile strength, flexural strength, and impact strength, as well as thermal conductivity and heat deflection temperature. The effect of exposing natural composites to water is investigated using a water absorption test. Thermo gravity metric analysis is used to determine how much weight is lost as a result of temperature change jute and aloe vera plants were used to extract natural fibers and composites were bonded using epoxy as a resin. Various experiments, including tensile, flexural, and impact tests, were performed on those specimens to better understand the behavior of critical attributes for natural composites. Hybrid laminates were also created to investigate the effects of combining different natural fibers. The heat deflection temperature of the hybrid laminates is lower, and this needs to be increased. The material will deflect more at lower temperatures if the heat deflection temperature is lower.

In 2019 Alzebdeh, K.I., Nassar, M.M. et al [70] have analyzed Fabrication parameters have an impact on the strength of fiber polypropylene composites, This chapter examines the breakthrough in sisal fiber-based technologies, as well as the consequences of sisal fiber hybridization with other plant and synthetic fibers on mechanical and physical properties. In addition to its traditional usage, sisal fiber has the potential to be used in the aerospace and car sectors. Source, age, and location, as well as fiber diameter, experimental temperature, gauge length, and strain rate, all impact the physical and mechanical characteristics of sisal fibers. As are suit moisture absorption is reduced and mechanical qualities are improved. Use the sisal fiber effectively in various requests, a link between mechanical qualities and manufacturing technology must be established. Glass-silica fiber hybrid composites' mechanical characteristics were investigated. On high-performance and high-costkevlar, carbon sisal fiber hybrid composites, the impacts of processing parameters, treatments, gauge length, and matrices have still to be studied.

In 2019, Vinayagamoorthy. R, [71] have presented the induce of fiber surface modification of the mechanical characteristics and vetiveriazizanioides reinforced polymer compositions. In this investigation, the natural fiber is processed with a chemical such as an alkali, peroxide, and benzoyl chloride. Chemically treated fibers are used as reinforcements in composites, their mechanical properties are investigated. Three different compounds were used to create new composites, which were then examined for mechanical properties. Benzoyl composites outperform all other composites in terms of tensile, compressive, and impact strength. When comparing the untreated and benzoyl composites, benzoyl enhanced tensile strength by 113 percent, compressive strength by 56.78 percent, and impact strength by 95 percent, according to research. A composite treated with hydrogen peroxide has greater flexural strength than all other composites. The flexural strength was increased by 56.13 percent after being treated with hydrogen peroxide. Although the flexural strength of the hydrogen peroxide-treated composite was somewhat lower than the benzoyl composite, it had a higher elongation capacity in tension, flexure, and compression tests.

In 2020, Reddy, B.M., Mohana Reddy, Y.V., et al [72] have utilized Alkali-treated Cordia-Dichotoma natural fiber composites mechanical, morphological, and thermo-gravimetric analyses. Cordia-dichotoma fibers were treated with sodium hydroxide (NaOH) in the current work, and composites with varied weight ratios of these fibers bonded with epoxy were created. The composites' tensile and flexural strengths were tested. For a thorough material characterization, IR spectroscopy (FT-IR), scanning electron microscopy, and thermo-gravimetric analysis was used. The tensile and flexural strengths of the composites were assessed. In addition, IR spectroscopy (FT-IR), scanning electron microscopy, and thermo-gravimetric analysis were performed for complete material characterization. The effect of the aforementioned NaOH treatment on the thermal, morphological and mechanical, characterization of the composite material is investigated. Due to their specific application areas and advantages, Cordia-dichotoma natural fiber and epoxy resins were used to make the composite using the hand lay-up method. Five separate composite specimens were created. C5, C10, C15, C20, and C25. Using suitable equipment, several characteristics of the composite were examined, including tensile, flexural strengths, thermal stability, chemical functional group identification, and micro/nanostructures.

In 2019, Vijay, R., Singaravelu, D.L., et al [73] have analyzed a unique natural fiber derived from the grass Saccharumbengalense. In the current work, the fiber isolated from the stem of the Saccharum Bengalense grass was examined for physicochemical, thermal, tensile, and morphological qualities (SB). The result indicated that fiber has good chemical ingredients, such as cellulose (53.45%), hemicellulose (31.45%), and lignin (11.7%), as proven by chemical analysis and Infrared Spectroscopy using Fourier Transform (FTIR). The thermal stability of the SB fibers was determined using thermogravimetric analysis (TGA). which revealed that maximal degradation occurred at 336°C char residue was 16.4%. The morphological properties are studied using scanning electron microscopy (SEM). SB fibers might thus be employed in natural fiber-based polymer composites as reinforcement. SB fiber has a density of

1165 kg/cm3, making them a good substitute for synthetic fibers in lightweight applications. According to the chemical analysis, the proportion of lignin was somewhat greater, causing brittle fracture during a tensile test. The SB fibers were thermally stable up to 336°C. SB fibers have a rough exterior surface with small fissures, according to SEM investigations. SB fibers can be utilized as a natural fiber in an environmentally friendly composite.

In 2019, Liu, Y., Xie, J., Wu, N., Wang et al [74] have presented mechanical, tribology and morphological aspects of corn stalk fiber reinforced polymer composites after silence treatment. The influence of the concentration of the silent solution on the mechanical, tribological, and morphological properties of corn stalk fiber (CSF) reinforced polymer composites were investigated in this study. The silence-treated CSF reinforced polymer composite (CMS) revealed a potential low-density characteristic, according to the results. Water absorption and perceived and perceived porosity of polymer composite systems may be successfully reduced by silence solution treatments of the CSF. The friction performance of the silence-treated CSF was not significantly improved. SEM was used to examine the worn surface, and the results showed that silence-treated CSF promoted the formation of secondary plateaus on the polymer composite surface, which could improve tribology and morphological characteristics. From 100 to 150 degrees Celsius, the friction coefficient increased, rapidly reduced as the temperature rose to 350 degrees Celsius. During the fade and recovery tests, the silence-treated CSF did not increase its friction performance but also did not reduce it much. The wear rate of polymer composites might be improved greatly by CSF treatment with silence solution. The creation of contact plateaus during the friction process is not visible in raw CSF, resulting in a rather rough surface. The foregoing finding is that silence-treated CSF may be used in biopolymer composites successfully.

In 2019, Balaji, A, Sivaramakrishnan, K., Karthikeyan, B., et al [75] have utilized mechanical and morphological features of hybrid polymer composites reinforced with sisal, banana, and coir fibers. Compression molding was utilized to make hybrid polymer composites reinforced with fibers such as sisal (SF), banana (BF), coir (CF), and sisal/banana/coir (SBCF). E, E/SF, E/BF, E/CF, and E/SBCF laminates were made by stacking 30% SF, BF, and CF with 70% E and 10% of each fibre with 70% E in the following stacking order: E, E/SF, E/BF, E/CF, and E/SBCF laminates. A Fourier-transform infrared spectroscopy approach was used to examine the chemical production of the novel polymer composites and hybrid polymer composites. The mechanical findings revealed that E/SF polymer composites outperformed the other polymer composites in terms of strength. The physic-mechanical characteristics of epoxy polymer composites reinforced with SF, BF, CF, and SBCF were investigated. The following conclusion is drawn from the result discussion given. In this study the recommended that hybrid polymer can be employed in the manufacturing of vehicle and furniture applications based on the finding.

In 2020, Kumar, S.S., [76] have present for engineering purposes a data collection of the mechanical characteristics of natural fiber reinforced polyester composites. In this data set the mechanical characteristics of sisal, Sorghum bicolor, and coconut coir reinforced polyester composites are included. By altering the weight percentages of sorghum bicolor and coconut coir from 5 to 25 wt. Percent, The mechanical dataset shows the strength of natural fiber composites in terms of tensile, flexural, impact, and hardness. Hand layup was used to create the composite samples. In-plane tensile, flexural, impact and hardness of natural composites were used to determine mechanical characteristics. The information in this dataset will assist the reader in natural fiber reinforced polyester composites' main properties. The inclusion of sisal and coconut coir fiber, on the other hand, appears to improve the characteristics.

In 2019., Liu, Y., Lv, X., Bao, J., et al [77] have utilized the natural cellulosic fiber from corn stalk waste that has been silence treated and untreated as a possible reinforcement polymer composites. Silence's impacts on Corn Stalk Fiber (CSF) chemical, surface morphological, and mechanical characteristics, as well as the impact strength and impact fracture surface morphology of CSF, reinforced polymer composites, were studied. The chemical result revealed that silence treatments remove a specific percentage of hemicelluloses and lignin from the CSF surface while also increasing the CSF’s Crystalline Size (CRS). The tensile strength of CSF treated with a 5 wt. percent silence solution is 2.43 Gpa. Treatments that boost fiber-matrix interfacial bonding and polymer composite impact strength include silence 41.22 MPa and Young's modulus of 18.98 GPa 223.33 MPa. SEM scans demonstrated that the surface morphology of the treated CSF was minimally rung and relatively clean after silent treatments. The Si-O-Si stretching vibration was observed in the spectra of 9 wt percent and 13 wt percent silent treated CSF, confirming that some of the hemicellulose and pectin were removed from the CSF surface. Silence concentrations that were appropriate for the fiber-matrix interfacial bonding of the fiber and matrix enhanced the impact strength of the polymer composites.

In 2020., Kenned, J.J., Sankaranarayanasamy, K., et al [78] have utilized the goal of this research to use a unique process form fabricating natural fiber reinforced polymer composites that can compete for glass fiber composites in tars of thermo-mechanical characteristics without use an of any chemicals. The reinforcing fibers were taken from the endian banana plant’s pseudo-stem. Later, a non-woven fabric composite comprised of banana fibers reinforced with an unsaturated polyester (UPE) matrix was created using a needle punching process. To assess mechanical properties, composite specimens were subjected to tensile, flexural, hardness, quasi-static indentation (QSI), and dynamic mechanical analysis (DMA) tests. However, needle-punched banana fiber composites (NPBFC) had the best attributes at 40% fiber content, increases in tensile and flexural strength of 36% and 33%, respectively, when compared to random banana fiber composites (RBFC). Infrared spectroscopy is used to depict the distinctive bonds of cellulose, X-ray diffraction analysis is used to depict the distinctive bonds of cellulose, and X-ray diffraction analysis was used to reveal the crystalline index. A thermal study was also performed, and the improved NPBFC was shown to be stable up to $260°C$. In addition, a link between morphology and characteristics was discovered. Finally, theoretical models were used to validate the experimental results. This research finds that the unique NPBFC synthesized has the potential to be used as a possible reinforcement for industrial safety helmets, automobile door panels, and lightweight structural applications.

In 2020, Chen, C., Yang, Y., et al [79] have utilized the reinforcement of reinforced concrete beams, natural fiber reinforced polymer and carbon fiber reinforced polymer is used. This article compares the permanence of natural fiber reinforced polymer (NFRP) and carbon fiber-reinforced polymer (CFRP) in the flexural strengthening of RC beams using a multi-objective approach. Because the elastic modulus of NFRP laminates and concrete is comparable, the NFRP-strengthened once. Increasing the NFRP reinforcement ratio and NFRP width enhanced ultimate load and ductility substantially. Narrow NFRP has a greater strength-to-weight ratio than broad NFRP. The cost advantage of natural fiber was significantly negated by the huge volume of impregnated epoxy resin, and the overall cost efficiency of NFRP laminates ranged between 60% and 160 percent that of CFRP laminates. The environmental impact of NFRP laminates was likewise raised by epoxy resin, and the environmental impact of NFRP and CFRP strengthening was identical. Flax FRP has a lesser environmental effect than jute FRP in general. To enhance cost efficiency and reduce environmental impact, prefabrication of NFRP laminates utilizing the vacuum infusion process is advised.

In 2020, Sumesh, K.R., Kanthavel, K. et al [80] have utilized extraction and use of mechanical and thermal properties of cellulose fiber produced from peanut oil cake in pineapple/flax natural fiber composites. This fiber powder is utilized to improve the applications of natural fiber epoxy composites made from pineapple (P) and flax (F). CMF had a better Crystalline Index (Crl) of $70.25° and$ crystalline size of 5.5mm, according to X-Ray Diffraction (XRD) findings. The presence of cellulose in functional groups of filler was confirmed by FTIR findings, which showed peaks at 1058cm-1, 1162cm-1, 1370cm-1. Mechanical studies showed that incorporating CMF into PF hybrid fiber composites had a good influence. The addition of CMF to the thermal stability equation improved the degradation temperature, residual percent, endothermic peak, and enthalpy. The filler substitution increased the degradation temperatures T50, T70, T70 from 387.73–391.08°, 434.81–454.81°, and 468.91–553.36° in the 30% PF combinations. The usage of cellulose filler generated from peanut oil cake in mechanical and thermal applications of natural fiber composites was investigated in this study. The extraction of cellulose microfibers from peanut oil cake and the insertion of cellulose filler into natural fiber composites are still in the works. Cellulose micro filler was created by powdering these cellulose fibers in a high-energy ball mill (CMF). Pineapple and flax fiber epoxy hybrid composites are combined with this filler powder. This feature causes a greater stress point during loading, resulting in unequal fiber/filler mixing in the epoxy matrix material. With 3 percent CMF, the greatest enhancement in tensile, flexural, and impact characteristics was 45.56 percent, 34.11 percent, and 45.1 percent in 35 percent PF. These qualities are enhanced by CMF's high crystalline structure, wide surface area, and dimensional stability. With a filler addition of up 3%, the combination with 35 percent PF showed an increase in degradation temperature and residual percent. The substitution of CMF resulted in an increase in endothermic peak and enthalpy as measured by DSC. 30 percent PF/2CMF untreated fibers 28 and 35 percent PF/3 percent PF/3 percent the results revealed a significant improvement in the characteristics. This technology can be used to produce low-cost composites that are more thermally stable.

In 2019, Prabhu, L., Krishnaraj, V., et al [81] have analysis mechanics, chemistry, and acoustics of sisal–tea waste–glass Fiber reinforced epoxy based hybrid polymer composites were investigated. Natural fiber-reinforced composites are replacing metals in this study due to their low weight, high strength-to-weight ratio, non-corrosive nature, and stiffness. Natural fibers have limited in their application due to weak interfacial adhesion between fiber and matrix, a low melting point, and a lack of moisture resistance. Hybridization allows you to fine-tune the characteristics of composites to meet specific needs and get the best results. Customers are also searching for environmentally-friendly automobiles, thus many in the automobile industry are transitioning to a "Green view." Natural fiber-reinforced polymer (GFRP) is becoming more used in automobile parts. Because of their eco-friendliness and sound absorption qualities, sisal (S) and waste tea fiber (T) were chosen for this investigation. Hemicellulose, waxes, and lignin are all hydrophilic compounds found in both fibers. As a result, the fiber is chemically treated with 5% alkaline (NaOH) and then hybridized with GFRP using an epoxy matrix. The mechanical characteristics of the material were studied, including tensile strength, impact strength, and flexural strength. Scanning electron microscopy (SEM) examination was also used to look at interfacial features such as internal fractures, blowholes, and fiber pullouts. The mechanical characteristics of sisal-tea-glass fiber reinforced hybrid composites, such as tensile, flexural, and impact, are studied using varied weight ratios of sisal and tea fibers. The composites' tensile strength, tensile modulus, flexural strength, flexural modulus, and impact strength all increased when more sisal content was hybridized with glass fiber. These enhancements to the investigated material's properties might make it appropriate for usage in car components such as dashboards, seat bases, frontal and rear bumpers, aircraft interior paneling, brake pedal, speaker compartment, soundproofing materials, and furniture.

In 2019, Binoj, J.S. and Bibin, J.S., [82] have utilized a failure investigation of Agave tequilana fiber polymer composites that were discarded. In this the present study examines are thermo-mechanical characteristics of waste Blue Agave Fiber (BAF) and uses it as reinforcement in composites. Composite specimens were made with varying fiber and matrix composition to achieve a consistent fiber length. Meanwhile, when the examined composites had high fiber content, they had better mechanical characteristics. The high specific strength demonstrated their suitability for composite fabrication in locomotive and basic applications, and the fiber composition was determined to be ideal in terms of weight percent. The reason for fractured tensile and flexural test specimen failures was also investigated using scanning electron microscopy (SEM). The flexural strength and modulus of the BAFC are 56.25 MPa and 1.12 GPa, respectively. In addition, the failure examination is carried out of SEM, which revealed the reasons for the fiber and matrix's poor compatibility. Finally, when compared to existing natural fiber reinforced polyester composites, its newly designed BAFC material has reduced weight, superior mechanical, and thermal qualities. As a result, this unique material with 40 percent fiber content and 60 percent matrix content, manufactured BAFC, may be suggested for a wide range of industrial and home applications.

In 2020, Lokesh, P., Kumari, T.S., et al [83] have researched the mechanical characteristics of a bamboo fiber-reinforced polymer composite were investigated. In this study natural fiber reinforced polymer composites (NFPC) have a high affinity substituting synthetic fiber composites. Because of advantages such as lightweight, non-toxic, non-abrasive, simple accessibility, low-cost biodegradability, When compared to synthetic fiber-based composites such as lightweight, non-toxic, non-abrasive, easy availability, cheap cost, and biodegradability, natural fiber's intrinsic mechanical qualities, such as particular tensile modulus and other distinguishing features, provide a satisfactory result. In this case, natural fiber's inherent mechanical properties, such as specific tensile modulus and other distinctive traits, give a satisfying outcome when compared to synthetic fiber-based composites. Bamboo strands of various lengths are glued together with epoxy resin to make composite materials. To make composite materials, bamboo fibers of various lengths and contents are bonded with epoxy resin. The impact of fiber length and content on composite mechanical behavior is investigated. It has been successful to fabricate epoxy-based composite materials reinforced with bamboo fibers. The mechanical parameters of the composites, such as tensile strength, flexural strength, and impact strength, are significantly affected by the NaOH treated fibers used. Excessive fibers in composite materials reduce the mechanical properties of the composite due to a lack of appropriate bonding between the matrix and fiber at the interface. According to the current study, increasing the treated content of fiber in composite materials improves impact, tensile and flexural strength.

In 2020, Narayanasamy, P., Balasundar, P., et al [84] have analyzed a characterization of unique natural cellulosic fiber is derived from the fruit bunch for use in environmentally friendly polymer composites. The alkali treatment is found to minimize amorphous levels is remove non-cellulosic components that were detected by FTIR analysis. According to the X-ray diffraction pattern, the crystalline index of alkali-treated CGFB fibers was greater than raw fibers. Alkali-treated materials thermal degradability and stability the fiber content of the fruit bunch was higher than the untreated fiber. SEM and atomic force microscopy images revealed a somewhat roughened surface of the fiber due to the removal of non-cellulosic components and surface impurities after alkali treatment.

In 2019, Herrera, F.V., Pinheiro, I.F., et al [85] have utilized environmentally polymer composites based on PBAT in natural fibers from the Amazon forest were used. Natural fibers are removed by mechanical processing, and composites are made by melting them together. All composites had a greater modulus of elasticity than the pure polymer, with the improvement varying based on the kind of fiber used as reinforcement. The addition of Fiber C enhanced the polymer's modulus of elasticity by 48%, while the addition of Fibers M and T raised the PBAT'S modulus of elasticity by 48%, 70, and 72 percent, respectively. The research created biodegradable composites using PBAT was three distinct natural fibers from the Amazon rainforest. To our knowledge, these composites are the first to successfully incorporate fibers from C. Lanjouwensis, T. Micrantha as fillers in polymeric systems is give mechanical reinforcement. Using more crystalline fibers with a structural organization aligned in a given direction produces the highest reinforcing effect.

In 2019, Selvakumar, K. and Meenakshisundaram, O., [86] have analyzed jute and human hair-reinforced polymer composites mechanical and dynamic mechanical. Carbon emissions may be lowered in autos by replacing metallic components with lightweight natural fiber-reinforced composite-based components, according to this study. Heat and dynamic stresses applied simultaneously to polymer composite materials alter crystalline, resulting in material characteristics and weight deterioration. Many researchers are interested in using biocomposites for car parts that have superior mechanical and thermal qualities compared to traditional materials. The current study focuses on the fabrication of five distinct fiber compositions of jute and human hair-reinforced epoxy-based polymer composites. For assessing the viscoelastic behavior of composites, the influence of fiber composition frequency and dynamic behavior of novel combinations of natural composites is investigated. Mechanical characteristics of the composites improved as the human hair content increased. The glass transition temperature (Tg) for all composites is between 80 and 95°C, as determined by storage modulus, loss modulus, and damping curve. More stress transmission in the interface was seen as a result of the higher fiber concentration in the matrix, resulting in high dynamic mechanical properties. the amount of human hair in a composite rises, mechanical parameters such as tensile strength and impact strength improve. It increases the inter-locking of fiber with epoxy matrix, resulting in increased stress transmission at the interface, due to the hydrophobic nature of human hair. The storage modulus values are primarily influenced by the fiber mix in all composites. Chemical interaction between cellulose fiber and keratin fiber improves the viscoelastic behavior of human hair and jute fiber-reinforced polymer composites. When compared to Composites A, D, and E, the loss modulus quality in the transition area for Composites B and C is relatively high. In addition, the E00 value shows a sharp decline in the transition zone is smaller for all composite.

In 2020, Hao, X., Zhou, H., Mu, B., Chen, L., et al [87] have analyzed fiber form and orientation distribution impact the anisotropy of mechanical properties, creep behavior, and thermal expansion of natural fiber/HDPE composites. The effect of fiber shape and orientation distribution on NFPC mechanical properties creep behavior, and thermal expansion was investigated in this work. The natural fiber in the composites exhibited a preferential orientation along the extrusion direction, as evidenced by optical micrographs. The NFPCs' flexural characteristics are impact strength is maximum at zero angles and declined significantly as the orientation angle increased, as confirmed by finite element analysis. The PW/HDPE composites exhibited the best flexural and impact strength and the least creep strain and thermal expansion at zero angles, although there was a modest variation in mechanical parameters between the NFPCs at a 90-degree angle The high aspect ratio (L/D) of poplar wood fiber induced significant anisotropy of features in the PW/HDPE composites at various angles. According to these data, high fiber L/D and orientation distribution had a beneficial impact on the features of NPCs. In 2019, Kumar, S., Patel, V.K., Mer, K.K.S., et al [88] have utilized an effect of Grewiaoptiva/Bauhinia Vahlii fibers on physicomechanical and dry sliding wear behavior in Himalayan natural fiber-reinforced epoxy composites. The physical and mechanical characteristics of 6 wt percent hybrid G. optiva/B. vahlii fiber added composites were found to be the best. An L27 orthogonal array Taguchi approach was utilized to determine the best amount of control parameters. The optimal combination of control parameters for attaining the lowest wear rate was found to be 4 wt percent fiber content, 2.5 m/s sliding velocities, 15 N normal load, and 2000 m sliding distance.

In 2021, Soundhar, A. and Kandasamy, J., [89] have utilized Crab shell/sisal natural fiber hybrid composites that were studied mechanically, chemically, and morphologically. optiva/B. vahlii composites, G. optical fiber-based composites maintained their remarkable physical properties. For hybrid G. optiva/B. vahlii fiber reinforcement, tensile strength, flexural strength, hardness, and impact energy all rose and stayed higher as fiber content increased. To discover the ideal combination of control settings that will result in the lowest wear rate, the Taguchi technique is applied. The lowest wear rate was found in G. optical and hybrid G. optiva/B. vahlii fiber-based composites with a controlling factor of 4% fiber content, 2.5 m/s sliding velocities, 15 N normal load, and 2000 m sliding distance. Finally, the hybridization of B. vahlii with G. Captiva/epoxy composites resulted in enhanced mechanical properties and a decreased sliding wear rate, implying that the composites produced might be employed in lightweight engineering applications.

In 2020, Dawit, J.B., Regassa,Y. et al [90] have analyzed Acacia tortilis property characterization for natural fiber reinforced polymer composite. Mechanical properties, morphological features, X-ray diffraction analysis, and Fourier transform infrared spectroscopy were performed on the hybrid composites created in this chapter. In comparison to previous combinations, adding up to four weight percentages of crab shell particles considerably increased tensile (50%) and flexural (38%) strength. It is clearly shown that including crab shell particles into the polymer matrix boosts the flexural and tensile strength of hybrid composites. The morphological behavior of broken surfaces revealed that there was an enhanced link between the fiber and the matrix. Surface flexural fractures of various composites are employed in this investigation. A0 composite, A1 composite, A2 composite, A3 composite, and A4 composite. 13 XRD JOURNAL OF NATURAL FIBERS. Sisal fiber has a percentage of Crystalline of 63.76 percent and a crystalline index of 0.43. The XRD pattern indicated that the cellulose portion of the sisal fiber is more crystalline, whereas the lignin portion is more amorphous. The crystalline index and percentage of crystalline of crab shell particles are 0.44 and 63.95 percent, respectively, indicating that the crab shell particles are in a hydrated crystalline form FTIR investigations confirmed the presence of -C-O, -O-H, -C-H, and C = C groups in sisal fiber, crab shell particles, and CSP/SF hybrid composites. The hybrid CSP/SF composite sample A3 revealed considerable improvements in tensile strength of 46.70 MPa (50 percent) and flexural strength of 136.21 MPa when compared to earlier combinations (38 percent). In the composite formation, SEM micrographs revealed excellent fiber-matrix interfacial bonding. When moreover 4% of crab shell particles were incorporated in the polymer composites, the aggregation interaction between fiber and matrix resulted in diminished properties.

In 2020, Jirawattanasomkul, T., Likitlersuang, S., et al [91] have analysis natural fiber reinforced polymer composites that were used to reinforce pre-damaged reinforced concrete beams. structural behavior natural fibers are used in light-weight engineering goofs and have adequate mechanical qualities, but their widespread use as reinforcement in composite constructions poses a hurdle. Chemical composition, density, and tensile tests of mechanical properties were done after successful fiber extraction, as well as the influence of chemical treatment for bundles of fiber, and positive results were achieved. Validation with published data suggests that acacia tortillas fiber could be used as a natural fiber in green composites. Acacia tortillasfibers were manually removed and successfully treated using the weather retting method as part of this study. Alkali treatment increased the tensile characteristics of Acacia tortillas fibers, according to most investigations. This research also found that Acacia tortillas fibers can be used to reinforce composite materials for applications that require a lightweight design with better strength.

In 2019 Barua, A., Jeet, S., Bagal, D.K., et al [92] have analyze the hybrid Taguchi-CoCoSo approach was used to assess the mechanical properties of a micro sic particles composite reinforced with natural fibers. this study the following the hand layup procedure for producing the composite material, mechanical characterizations are carried out. Multi-response optimization was carried out using a recently developed approach for multi-criteria decision making (MCDM), specifically the combined compromise solution (CoCoSO) method. A pairwise comparison matrix was utilized to determine the relative relevance of measured norms. ANOVA demonstrated that density had the biggest effect on mechanical behavior based on experimental findings on the ultimate tensile strength (UTS), density, and flexural strength. This can help with the fabrication of various structures and parts in a range of sectors. According to ANOVA, factor A, palm fiber, is the most impacting parameter for composite fabrication when the maximum density, UTS, and flexural strength are all studied concurrently. The industry will be able to build more optimal composites that can be employed in a variety of applications with more accurate unit process forecasts.

In 2019, Wang, D., Onawumi, P.Y., et al [93] have utilized Natural-fiber reinforced polymer composites' machinability Taguchi's Method was used to plan the experiments.

The goal of this study is to see how conventional drilling (CD) and hybrid ultrasonic-assisted drilling (UAD) affect a hemp fibres vinyl ester composite laminate. When compared to CD, the results show that UAD is more efficient in a variety of drilling circumstances. The research shows that UAD is a promising machining procedure for improving the machinability of heterogeneous NFRP composite materials. This research used a hybrid dry machining process with ultrasonically assisted drilling to exhibit enhanced machining of the HF/VE NFRP composite material. The study found that UAD can increase the machinability of natural fiber-reinforced heterogeneous composite materials. The lathe was used for the drilling trials to maintain uniform rotational speed and feed rate. As evidenced by our past research, using a top-down drill should not affect the outcomes.

In 2020, Rajeshkumar, G., et al [94] have analyzed the effect of sodium hydroxide treatment is on phoenix fiber-reinforced polymer composites' dry sliding wear behavior In this study Compression molding was used to create the composites, which had the optimal fiber length (20 mm) and fiber volume fraction (40 percent). The untreated and treated fiber-reinforced composites' shore The degree of hardness was determined. A pin-on-disk wear testing machine was used to evaluate different weights (10, 20, and 30 N), sliding speeds (1, 2, and 3 m/s), and sliding lengths (1, 2, and 3 km). The composites reinforced with 15% treated fiber composites, in particular, showed improved wear resistance under all operating conditions and were suggested for use in car and machine tool friction composites. Due to increased interfacial bonding and stiffness, the hardness value of the treated fiber included composites was found to be greater. The SWR rose is applied load and sliding speed increased, and dropped as the sliding distance grew. The lvalue showed the opposite pattern, indicating that there was no association between the SWR and l in terms of operational conditions.

In 2019, Davis, A.M., Hanzly, L.E., et al [95] have analyzed the dimensional stability of flax fiber reinforced polypropylene composites was studied. Flax fiber reinforced polymer composites with high-performance and long-lasting properties. When molding polymers and polymer composites, the component almost invariably warps or loses its "dimensional stability" After molding, the shrinkage of flax fiber reinforced polypropylene (PP) composites is measured to determine their dimensional stability. Shrinkage and dimensional stability are inextricably linked. Dimensional stability was assessed as shrinkage in PP and flax fiber reinforced PP composites. the general, stiffer composite withstood shrinkage is better. It is true to regardless of where the stiffness increase came from tensile testing along the molding flow direction, where polymer molecules, crystals, flax fiber were aligned, resulted in higher stiffness in parallel samples. SEM investigation revealed that the fibers were orientated along the tensile deformation direction, resulting in a higher modulus and less shrinkage for these composites. Even when testing perpendicular to the molding flow direction, adding maleic anhydride-modified polypropylene (MAPP) coupling agent and MAPP flax fiber increased stiffness and reduced shrinkage. As assessed by increased peak stress during tensile testing and seen in SEM images, MAPP improved fiber-polymer interactions.

In 2020, Wongsa, A., Kunthawatwong, R., et al [96] have utilized Geopolymer mortar with natural fiber reinforcement and a high calcium fly ash content. This study investigated the characteristics of natural fiber geopolymer mortars with high calcium fly ash. In the geopolymer mortar, two types of natural fibers, sisal fiber, and coconut fiber were used in varying amounts of 0 percent, 0.5 percent, 0.75 percent, and 1.0 percent volume fraction. The qualities of geopolymer mortar reinforced with fibers were compared to those of glass fiber and control geopolymer mortars in terms of mechanical, thermal, and physical properties. The inclusion of natural fiber as a reinforcing material resulted in considerable improvements in tensile strength and flexural strength, similar to the usage of glass fiber, according to the findings. Workability, dry density, ultrasonic pulse velocity, and compressive strength values, on the other hand, were all decreasing. High calcium fly ash geo-polymer mortars reinforced with sisal, coconut, and glass fibers were investigated mechanically, thermally, and physically in this work. The flexural and splitting tensile strengths of geo-polymer mortars reinforced with fiber were discovered to increase when the fiber volume % was increased. Thermal conductivity and water absorption were not significantly affected by fiber volume fraction. Natural fibers were used as reinforcing materials in fly ash-based geopolymer mortars, and their tensile and flexural strength performance was comparable to synthetic fiber. Furthermore, geopolymer mortars reinforced with sisal fiber and coconut fiber had greater flexural strength to compressive and splitting tensile strength to compressive ratios than those reinforced with glass fiber. As a consequence of the tests, natural fibers such as sisal and coconut fibers might be employed as reinforcing materials in geopolymer composites instead of synthetic fiber or glass fiber.

In 2019, Siakeng, R., Jawaid, M., et al [97] have analyzed the mechanical, dynamic, and thermo-mechanical characteristics of coir/pineapple leaf fiber reinforced poly-lactic acid hybrid bio-composites. Natural fiber-based on polymer composites have been extensively researched as synthetic material substitutes. Pineapple leaf fibers and coir fibers (CF) were put into a PLA matrix to form composite materials with better mechanical and thermal characteristics, which might be utilized as biodegradable food packaging. Using an internal mixer plasticizer and a hot press machine, bio-composites with various fiber ratios were created. The findings of mechanical and thermal examinations of the produced composites were compared to those of pure PLA. Mechanical tests revealed that all of the composites outperformed neat PLA in terms of tensile and flexural modulus. In addition, the inclusion of [PALF raised strength values, while the addition of CF improved strengths, as well as their thermal stability, have increased thanks to the hybridization of CF and PALF and their integration into a PLA matrix. The inclusion of coir decreases the material's tensile and flexural strength. This indicates that the PLA matrix has higher tensile overall flexural strength than CF/PLA composite. The addition of PALF to PLA composite had the opposite impact, as tensile and flexural characteristics dramatically improved. Due to its toughness, CF, on the other hand, contributed to an increase in impact strength. The storage modulus of the tidy PLA specimen was the lowest of the complete set of specimens examined. The stress transmission is increased when CF and PALE are added. Furthermore, optimum fiber hybridization resulted in enhanced storage modulus the result. CF and PALF reinforced composites, as well as hybrid composites, have TMA curves. Hybrid composites have improved mechanical and thermal characteristics thanks to the natural fiber reinforcement of the plastic PLA matrix. Reinforcing the PLA matrix with CF and PALF enhanced the mechanical and thermal characteristics of the bio-composites. The hybrid composite C1P1 outperformed the other two hybrid composites in terms of tensile and flexural properties, as well as storage and loss modulus. Furthermore, its mechanical and thermal characteristics are equivalent to those of standard materials and polymers reinforced with plant/glass fibers. It can be concluded that fiber loading at a 1CF:

1PALF ratio, as in hybrid composite C1P1, has the best mechanical and thermal properties while also permitting adequate distribution within the PLA matrix, and is thus the best fiber hybridization ratio among the choices evaluated.

In 2019, Akasheh, F. and Aglan, H., et al [98] have utilized the fracture toughness of carbon fiber-reinforced polymer. The specimens were built using three different reinforcing techniques. To prevent fracture initiation, the focus is selectively reinforcing the crack tip. The mechanical properties, fracture toughness, and fracture using three behavior of printed composites were evaluated. In a multilayered structure, 3-D printed composites used unidirectional carbon fiber bundles and strengthen nylon/chopped fiber resin. The goal of this research was to see how 3-D printing could be used to make load-bearing structures with built-in reinforcement for simulated faults like side notch. As a result, the carbon fiber bundles reinforcement has no synergetic effect. By raising the packing density and adjusting the deposition temperature of the fiber bundles, the fusion and hence the efficacy of the reinforcement may be increased. It was also discovered that the matrix layers and neighboring carbon fiber bundles the reinforcement have no adherence. Because both the carbon fiber bundle size and the matrix material are thermoplastic, adjusting the deposition temperature during printing could improve adhesion and result in a denser composite. Damage to the fiber within the carbon bundle during deposition may occur, reducing the reinforcement’s efficiency. The displacement mismatch between the fiber bundle and the matrix during deposition is thought to be the cause. This can be handled by adjusting the tension and the carbon bundle that has been placed on the matrix.

In 2019, Atiqah, A., Jawaid, M., et al [99] have analyzed Sugar palm/glass fiber reinforced thermoplastic polyurethane hybrid composites exhibit dynamic mechanical properties. Hybrid composites based on thermoplastic polyurethane were produced with the addition of sugar palm fiber and glass fiber. The best ratio of 30 wt% sugar palm fiber to 10 wt% glass fiber was employed to reinforce the hybrid composites, which were then subjected to dynamic mechanical analysis (DMA) to analyze their dynamic capabilities. The untreated and treated hybrid composites were made via melt compounding and then hot pressed. The combined 6 percent alkaline-2 percent silences fiber treatment was shown to be the most efficient in improving the dynamic mechanical properties of SPF/GF reinforced TPU hybrid composites that can be used in applications requiring high-temperature tolerance, such as automotive components. The thermal-mechanical characteristics of hybrid composites made from sugar palm, glass fiber, and TPU matrix were investigated in this study. The addition of 30 wt% glass fiber to hybrid composites (10/30 SP/G) improved storage and loss modulus. As a result, these hybrid composites may be employed in a wide range of high-temperature applications.

In 2019, Yang, S., Liu, W., Fang, Y et al [100] have analyzed durability and interfacial performance of pultruded glass fiber-reinforced polymer composites are affected by hygrothermal aging. The fiber/matrix interface of pultruded glass fiber-reinforced polymer (GFRP) composites was examined after they were exposed to hygrothermal conditions for 180 days, including deionized water immersion and saltwater immersion at 20 5 C, 30 1 C, and 60 1 C. Moisture absorption and its impact on tensile characteristics were addressed. After 180 days of immersion in deionized water, specimens lost 25.7 percent of their tensile strength and 26 percent of their modulus, respectively, whereas corresponding losses for specimens submerged in saltwater were 2.1 percent and 18.2 percent, respectively. The single-fiber fragmentation test and the short-beam shear test were chosen to represent a loss of macro-and microinterfacial characteristics, respectively. After 180 days in deionized water and saltwater at 60 1 C, the inter-laminar shear strength of specimens decreased 28.8% and 18.5 percent, respectively, whereas the corresponding interfacial shear strength decreased 53.2 percent and 23.5 percent, indicating that the diffusion rate of micro-interface was higher than that of macro-interface in the fiber direction. In this study As the temperature climbed, the moisture absorption of pultruded GFRP composites increased nonlinearly. Raising the temperature of the pultruded GFRP composites enhanced their moisture absorption capacity and diffusion coefficient in both deionized water and saltwater. Because saltwater has a high concentration of dissolved particles, which inhibit moisture diffusion by osmosis, equilibrium moisture absorption of specimens submerged in saltwater was somewhat lower than that of specimens submerged in water at the same temperature. After 180 days of age, specimens submerged in deionized water at 20 5 C lost 25.7 percent and 26 percent of their tensile strength and modulus, respectively, whereas specimens immersed in saltwater at 20 5 C lost 2.1 percent and 18.2 percent of their respective tensile strength and modulus. The findings revealed that increased moisture absorption resulted in a more rapid deterioration of tensile characteristics. A computational approach based on the change in interfacial strength and the Weibull distribution was used to characterize the temperature effects on pultruded GFRP composites. Furthermore, in hygrothermal circumstances, the ultimate bearing capacity of pultruded GFRP composites was seen to deteriorate.

2.1 Introduction

In 2019, Verama.D, et al [51] have utilized a natural fiber-reinforced polymer composites feasibility study for sustainable automotive industries. This chapter was talk about how it's progressed in the construction of automotive interiors and exterior natural fiber-reinforced composites' mechanical properties, especially in the context of automobiles. Despite fact that chemical modification is required to overcome the constraints of NFRPCs, Which include moisture absorption, limited processing temperature, and variable quality, the benefits significantly exceed the drawbacks. In 2019, Naveen.j, Jawaid.M,et al [52] a finite element analysis of natural fiber-reinforced polymer composites. The basics of the finite element model are covered in this chapter also include a description of a model-based methodology of natural fiber-reinforced polymer composites. The experimental assessment of the properties of natural fiber-reinforced composite is less realistic. Due to human error and the accuracy of the finding the testing machine. The use of finite elements was analyzed to natural fibers and natural fiber reinforced polymer composites have mechanical, thermal, and other properties that can help overcome these limits. The most common homogenization-based multi-scale constitutive approach used in finite element modeling to examine the influence of microstructures on the mechanical and thermal characteristics of NERPC is the representative volume element method. The design time and expense of testing will be greatly reduced if accuracy and an adequate finite element model for the material are developed. Natural fiber element modeling faces obstacles such as the fiber/matrix interface, 3D geometric modeling, and interfacial adhesion. Finite element models for structural materials should include thermal, mechanical, and dynamic performance. The most interesting future study topics may be progressive damage mechanisms and NFRPC analysis.

In 2019, Devnani, G.L and Sinha. S[53] have utilized the impact of nanofillers on the properties of natural fiber-reinforced polymer composites. In this study, a small quantity of material is added to a variety of polymers and other materials. This can dramatically increase the performance and quality of materials, including thermal, mechanical, water absorption, and flame retardation, among other things. Due to their economic effectiveness, biodegradability, lower weight, superior mechanical qualities, and sustainability, natural fibers are increasingly being employed as a substitute for synthetic fibers in polymer composites. However, there is still a compatibility issue between hydrophobic polymer matrix and hydrophilic fibers, which might lead to composite performance loss. In 2019, Celik,Y.H., Kilickap, and Kilickap, A.I., [54] have analyzed Milling of natural fiber reinforced polymer composites an experimental investigation using cemented carbide (WC) end mills, researchers in end milling of jute fiber reinforced polymer composite plates with varying orientation angles (0/90, 30/60, and 45), the effects of cutting parameters such as cutting speed and feed rate on cutting force, delamination factor, and surface roughness were explored.Cutting force, deformation factor, and surface roughness were found to be affected by feed rate and cutting speeds. Cutting force, delamination factor, and surface roughness all decreased as the number of flutes on cutting tools increased.

2.2 Literature on synthetic filler composites

In 2019, Mansor, M.R., Nurfaizey, A.H., et al [55]. have used natural fiber polymer composites in aerospace engineering. In this chapter, the current NFPC application is covered in aircraft engineering. The introduction to aerospace materials, particularly polymer composites, such as those used in airplane frames and engine building, as well as the benefit of the materials, are among the subjects discussed. The recent advancement of NFPC in aerospace applications such as aircraft radon and interior cabin components, comments on NFPC future trends and problems, are also discussed. Finally, the candidate material NFPC is one of the most promising for aerospace engineering applications. . Aerospace interior applications have the most potential market segment since they have reduced load-bearing requirements, more lightweight qualities, and cheap raw material coasts. In 2019, Khan, A., Vijay, R., Singaravelu, et al [56] have utilized natural fiber from wiregrass that has been extracted and characterized for use as reinforcement in sustainable fiber-reinforced polymer composites. The purpose of this work is to extract and characterizeEleusineindica grass fibers taken from the stem using a manual retting procedure. Eleusineindica was greater cellulose content of 61.3 wt percent, a density of 1143 kg/m3 according to the findings.

In 2019 Siakeng, R., Jawaid, M., et al [57] have utilized a poly-lactic acid composite with natural fibers. In this chapter, the influence of treatment on natural fiber-reinforced polymer composites' water absorption characteristics is discussed. The basic characteristics of composites reinforced with various natural fibers and polymers are listed. Dimensional stability issues with these NFRPCs are highlighted. Based on previous literature, the effects of several forms of treatment on NFRPCs, such as alkali, silences, and acetylation, on water behavior are examined. All of the treatments had a thing in common. They were tried to lower the hydroxyl groups in the fibers and increase matrix-fiber adhesion. Aside from, fiber content and dimension had a substantial impact on the NFRPCs, water absorption.In 2019, AbdHalip, J., Hua, L.S., Ashaari, Z., et al [58] have analyzed the water absorption impact of treated and natural fiber-reinforced polymer composites. All of the treatments had one thing in common. They all tried to lower the hydroxyl radical in fibers and increase matrix-fiber adherence. The polymer utilized to make NFRPC is also important, as several studies that PP-based composites have greater water abstraction capabilities than PE-based composites. The chemicals utilized in treatment have a big impact on how much the NFRPC improves in terms of water absorption. Acrylic acid, silences, and potassium permanganate treatments were more effective in improving the NFRPC's water absorption behavior. In compassion to other chemical treatment methods, peroxide treatment utilizing benzoyl peroxide and decimal peroxide is the most effective way for increasing interfacial adhesion and compatibility between the fiber and matrix.

2.3 Literature on natural filler composite

In 2019, Adeniyi, A.G., Ighalo, J.O and Onifade,D.V., [59] have utilized the Fiber-reinforced polymer composites made from banana and plantain. Cultivators solely harvest banana and plantain fruits for consumption, as well as leaves for wrapping food. The plant's remaining parts are considered waste and a potential source of natural fibers for use as composite reinforcement. Banana and plantain fibers as fillers in plastic composites have been the subject of numerous studies throughout the years. Most researchers also choose to prepare the composite by hand layup and compression molding. The MEKP and cobalt accelerators, respectively, are the preferred composite additives. With consideration for other natural fibers. In decreasing the order of tensile strength in epoxy composites, these mechanical properties of banana fibres epoxy composites are intermediate. In 2020, S.Wang, Z. Wu, S.Jiang, et al [60] have analyzed the WHMFC, was developed a Zylon-Kevlar Hybrid Fiber Reinforcement Technology for a Pulsed Magnet of 100 T have The Wuhan National High Magnetic Field center has proposed using a reinforced method that combines zylon/epoxy composite and kevlar/epoxy composite to construct the 100 T Pulsed Magnet. Kevlar fabric offers superior wet implantation with exoxy than Zylon-fiber because of its rougher surface, thereby preventing shearing movements between the conductor surface and the reinforcing layer. The maximum von mise stress in the Zylon-Kevlar hybrid fibers is 3.68 Gpa, according to the simulation. The measured ultimate tensile strength from the explosion test is 4.97 Gpa.

In 2019, Y. Mo, L Yang, T. Zou, et al [61] have utilized Kevlar/Nano Cellulose Fibrils/Softwood Pulp Hybrid for the manufacturing of composite insulation paper with reduced permittivity, good thermal and mechanical properties. Nano Cellulose fibrils (NCFs) and Low-temperature treatment of Kevlar pulp, plasma were used as reinforcements in the creation of composite insulating paper with low-temperature plasma were used as reinforcements in the creation of composite insulating paper with low relative permittivity, die electric loss, superior mechanical properties, and thermal stability. The change was caused by the introduction of Kevlar pulp, which has a low dielectric constant loss, lowering the paper's overall polarization. After adding 20% Kevlar pulp to the composite paper, the mechanical qualities of the paper deteriorated. In addition, the composite paper exhibited better insulating and thermal quantizes than regular paper. Due to the lack of compatibility of the fibers, the composite paper's Yang's modulus and tensile strength were significantly lower than those made from pure softwood pulp. The polarity of Kevlar fibers could be increased via a low-temperature plasma treatment, which could help with cellulosic fiber associativity. Fewer flaws and stronger fiber networks improved the insulating properties of the composite insulating paper. In high-voltage AC transformer insulation applications, it has the potential to replace pure softwood paper. In 2020, A. Moss, M. K. Mohseni, et al [62] have analyzed, "Modeling and Characterization of a Fiber-reinforced Dielectric Elastomer Stress Actuator" In this study, a DEA can induce planar contraction when compressed through the thickness by reorienting the fiber reinforcement using a composite fiber-mesh dielectric. The performance of fiber-reinforcement stress in a dielectric elastomer actuator is investigated in this letter under a variety of loading circumstances. The results are then experimentally validated, and the best fiber angle for maximization mechanical work for a FRDETA under a dead load is determined. 880 kPa tensile stresses, 14.7 percent tensile strains, and a mass-specific power density of 10.7 J/kg were achieved by the FRDETA tested, all of which are within the values recorded for natural muscle. In general, these tensile actuators offer a simple approach for creating stress in larger soft robotic devices.

In 2021, Venkataraman, S., And Athijayamani, A., et al [63] have utilized Polymer composites reinforced with natural cellulose fibers. Natural cellulose fibers have inspired a lot of interest in this topic as a potential replacement for manufacturing fibers like glass, aramid, or carbon for polymer matrix composites. Natural fibers, while not as strong as synthetic fibers, are readily available, low density, low cost, renewable, and biodegradable. These industrial sectors require improved material with such a max strength ratio for the fabrication of parts and components, as well as an increase in quality due to the high cost of composite materials with synthetic fibers and environmental concerns. Natural cellulose fillers, such as fibers and particles, are lightweight, environmentally benign, renewable, widely available, and biodegradable. The most widely utilized fibers to reinforce polymers are natural cellulose fibers such as sisal, banana, flax, jute, hemp, pineapple leaf, and coir. Environmental problems are alarming the entire world, thus research on these biocomposites is gaining traction among researchers all over the world. In 2019, Rajak, D.K., Pagar, D.D., Menezes, P.L., et al [64] have researched Outstanding characteristics of fiber-reinforced polymer composites including great durability, stiffness, damping property, flexural strength, and corrosion resistance, wear, impact, and fire, as well as a high strength-to-weight ratio. Because the constituent elements and manufacturing techniques of composite materials determine their performance, the functional properties of various fibers available around the world, their classifications, and the fabrication techniques used to fabricate composite materials must be investigated to determine the material's optimal characteristics for the desired application. The amazing performance of hybrid fiber-reinforced composite materials, which combine the best of all worlds, has been discovered to be one of the most promising and efficient studiesthat have revealed the outstanding performance of fiber-reinforced composite materials. The efficacy of the manufacturing technique is dependent on the combination of type and amount of matrix or fiber material used type of composites, which dominate the majority of applications in the most sophisticated sectors. Composite materials are used in a variety of sectors depending on the qualities arerequired. Future studies will focus on developing novel composite structures that combine multiple types and use new production techniques.

2.4 Literature on fiber reinforeced polymer composites

In 2021, Ilyas, R.A., Sapunan, S.M., Nurazzi, et al [65] have analyzed natural fibers composites for automobile components on a macro to nano-scale, this chapter discusses modern bio-composites developments, particularly natural fiber polymer composites (NFPC). This low-density material has excellent mechanical and barrier properties. It's also low-cost, biodegradable, and regenerative. NFPC has advanced applications in automotive components, papermaking, flexible optoelectronics, scaffolds, optical devices, pharmaceutical products, substitutes/medical biomaterials, spaceflight, aviation, and tissue repair, to name a few. The automobile uses of natural fiber reinforced polymer composites are summarized. In 2019, Habibi, M., Laperriere, L.MahiHassanabadi, H., et al [66] have analyzedfiber Mechanical characteristics of unidirectional flax fiber composites in place of stitching or weaving in natural fiber reinforcement manufacturing, The pressure short fibers in the composite resulted in a minor drop in longitudinal tensile modulus and strength of around 10%. The tensile strength in the transverse direction on other hand has nearly doubled. In compression loading, a similar pattern was seen with no influence on transverse compressive strength, the transverse modulus was somewhat raised. In tensile loading, the presence of short fibers has a considerable favorable effect on fracture behavior.

In 2019, Rezghimaleki, H., Hamedi, M., et al [67] have utilized drilling of jute fiber reinforced polymer composites have been studied in an experimental setting, short fibers can be used instead of weaving or stitching UD strands in the wetly paper making process. When short fibers are utilized as a binder, the cohesiveness between UD yarns is maintained. The presence of short fibers was found to harm longitudinal mechanical characteristics. Along with the Vud yarns, there is alsoa noticeable reduction in delamination and longitudinal splitting. However,It is widely acknowledged that increased twist has a significant detrimental influence on mechanical properties and impregnation ability. In the new reinforced manufacturing technique, untwisted flax strands are employed (Tex 5000). In 2020, Chandramohan, D., Sathish, T., Kumar, S.D. et al [68] have utilized Jute/aloevera hybrid natural fiber-reinforced composite's mechanical and thermal properties. The impact of cutting settings, drill bit varieties upon axial force, delamination size, or surface roughness while drilling jute fiber reinforced polymer composites was investigated in this work. They are three different types of drill bits and cutting parameters were used to evaluate the drillingbehavior of the produced composites, feed is the cutting parameter that has the highest influence on the thrust force generated by an HSS twist drill when drilling jute fiber-reinforced composites, while CoroDrill 856 has the least impact. Drilling with an HSS twist drill produced less delamination than drilling with the Coro Drill 854 and Coro Drill 856. The size of the texture has a big impact on the size of the detachment. Drilling coarse-textured jute fibers resulted in JFRPs with the smallest delamination size.

In 2019 Naveen, J., Jawaid, M., Amuthakkannan, P. et al [69] have analyzedthe mechanical and physical properties of sisal fiber-reinforced polymer composites, A study of the behavior of natural composites such as aloevera and jute has been attempted. The following thermal and mechanical parameters jute and aloevera are calculated: ultimate tensile strength, flexural strength, and impactstrength, as well as thermal conductivity and heat deflection temperature. The effect of exposing natural composites to water is investigated using a water absorption test. Thermo gravity metric analysis is used to determine how much weight is lost as a result of temperature change jute and aloevera plants were used to extract natural fibers and composites were bonded using epoxy as a resin. Various experiments, including tensile, flexural, and impact tests, were performed on those specimens to better understand the behavior of critical attributes for natural composites. Hybrid laminates were also created to investigate the effects of combining different natural fibers. The heat deflection temperature of the hybrid laminates is lower, and this needs to be increased. The material will deflect more at lower temperatures if the heat deflection temperature is lower. In 2019 Alzebdeh, K.I., Nassar, M.M. et al [70] have analyzed Fabrication parameters have an impact on the strength of fiber polypropylene composites,This chapter examines the breakthrough in sisal fiber-based technologies, as well as the consequences of sisal fiber hybridization with other plant and synthetic fibers on mechanical and physical properties.In addition to its traditional usage, sisal fiber has the potential to be used in the aerospace and car sectors. Source, age, and location, as well as fiber diameter, experimental temperature, gauge length, and strain rate, all impact the physical and mechanical characteristics of sisal fibers. As are suit moisture absorption is reduced and mechanical qualities are improved. Use the sisal fiber effectively in various requests, a link between mechanical qualities and manufacturing technology must be established. Glass-silica fiber hybrid composites' mechanical characteristics were investigated. On high-performance and high-costkevlar, carbon sisal fiber hybrid composites, the impacts of processing parameters, treatments, gauge length, and matrices have still to be studied.

In 2019, Vinayagamoorthy.R, [71] have presented the induce of fiber surface modification of the mechanical characteristics andvetiveriazizanioides reinforced polymer compositions. In this investigation, the natural fiber is processed with a chemical such as an alkali, peroxide, and benzoyl chloride. Chemically treated fibers are used as reinforcements in composites, their mechanical properties are investigated. Three different compounds were used to create new composites, which were then examined for mechanical properties. Benzoyl composites outperform all other composites in terms of tensile, compressive, and impact strength. When comparing the untreated and benzoyl composites, benzoyl enhanced tensile strength by 113 percent, compressive strength by 56.78 percent, and impact strength by 95 percent, according to research. A composite treated with hydrogen peroxide has greater flexural strength than all other composites. The flexural strength was increased by 56.13 percent after being treated with hydrogen peroxide. Although the flexural strength of the hydrogen peroxide-treated composite was somewhat lower than the benzoyl composite, it had a higher elongation capacity in tension, flexure, and compression tests. In 2020, Reddy, B.M., Mohana Reddy, Y.V., et al [72] have utilized Alkali-treated Cordia-Dichotoma natural fiber composites mechanical, morphological, and thermo-gravimetric analyses. Cordia-dichotomafibers were treated with sodium hydroxide (NaOH) in the current work, and composites with varied weight ratios of these fibers bonded with epoxy were created. The composites' tensile and flexural strengths were tested. For a thorough material characterization, IR spectroscopy (FT-IR), scanning electron microscopy, and thermo-gravimetric analysis was used. The tensile and flexural strengths of the composites were assessed. In addition, IR spectroscopy (FT-IR), scanning electron microscopy, and thermo-gravimetric analysis were performed for complete material characterization. The effect of the aforementioned NaOH treatment on the thermal, morphological and mechanical, characterization of the composite material is investigated. Due to their specific application areas and advantages, Cordia-dichotoma natural fiber and epoxy resins were used to make the composite using the hand lay-up method. Five separate composite specimens were created. C5,C10,C15, C20, and C25. Using suitable equipment, several characteristics of the composite were examined, including tensile, flexural strengths, thermal stability, chemical functional group identification, and micro/nanostructures.

In 2019, Vijay, R., Singaravelu, D.L., et al [73] have analyzed a unique natural fiber derived from the grass Saccharumbengalense. In the current work, the fiber isolated from the stem of the SaccharumBengalense grass was examined for physicochemical, thermal, tensile, and morphological qualities (SB). The result indicated that fiber has good chemical ingredients, such as cellulose (53.45%), hemicellulose (31.45%), and lignin (11.7%), as proven by chemical analysis and Infrared Spectroscopy using Fourier Transform (FTIR). The thermal stability of the SB fibers was determined using thermogravimetric analysis (TGA). which revealed that maximal degradation occurred at 336°C char residue was 16.4%. The morphological properties are studied using scanning electron microscopy (SEM). SB fibers might thus be employed in natural fiber-based polymer composites as reinforcement. SB fiber has a density of 1165 kg/cm3, making them a good substitute for synthetic fibers in lightweight applications. According to the chemical analysis, the proportion of lignin was somewhat greater, causing brittle fracture duringa tensile test. The SB fibers were thermally stable up to 336°C. SB fibers havea rough exterior surface with small fissures, according to SEM investigations. SB fibers can be utilized as a natural fiber in an environmentally friendly composite. In 2019, Liu, Y., Xie, J., Wu, N., Wang et al [74] have presentedmechanical, tribology and morphological aspectsof corn stalk fiber reinforced polymer composites after silence treatment. The influence of the concentration of the silent solution on the mechanical, tribological, and morphological properties of corn stalk fiber (CSF) reinforced polymer composites were investigated in this study. The silence-treated CSF reinforced polymer composite (CMS) revealed a potential low-density characteristic, according to the results. Water absorption and perceived and perceived porosity of polymer composite systems may be successfully reduced by silence solution treatments of the CSF. The friction performance of the silence-treated CSF was not significantly improved. SEM was used to examine the worn surface, and the results showed that silence-treated CSF promoted the formation of secondary plateaus on the polymer composite surface, which could improve tribology and morphological characteristics. From 100 to 150 degrees Celsius, the friction coefficient increased, rapidly reduced as the temperature rose to 350 degrees Celsius. During the fade and recovery tests, the silence-treated CSF did not increase its friction performance but also did not reduce it much. The wear rate of polymer composites might be improved greatly by CSF treatment with silence solution. The creation of contact plateaus during the friction process is not visible in raw CSF, resulting in a rather rough surface. The foregoing finding is that silence-treated CSF may be used in biopolymer composites successfully.

In 2019, Balaji, A, Sivaramakrishnan, K., Karthikeyan,B., et al [75] have utilized mechanical and morphological features of hybrid polymer composites reinforced with sisal, banana, and coir fibers. Compression molding was utilized to make hybrid polymer composites reinforced with fibers such as sisal (SF), banana (BF), coir (CF), and sisal/banana/coir (SBCF). E, E/SF, E/BF, E/CF, and E/SBCF laminates were made by stacking 30% SF, BF, and CF with 70% E and 10% of each fibre with 70% E in the following stacking order: E, E/SF, E/BF, E/CF, and E/SBCF laminates. A Fourier-transform infrared spectroscopy approach was used to examine the chemical production of the novel polymer composites and hybrid polymer composites. The mechanical findings revealed that E/SF polymer composites outperformed the other polymer composites in terms of strength.The physic-mechanical characteristics of epoxy polymer composites reinforced with SF, BF, CF, and SBCF were investigated. The following conclusion is drawn from the result discussion given. In this study the recommended that hybrid polymer can be employed in the manufacturing of vehicle and furniture applications based on the finding. In 2020, Kumar,S.S., [76] have present for engineering purposes a data collection of the mechanical characteristics of natural fiber reinforced polyester composites.In this datasetthe mechanical characteristics of sisal, Sorghum bicolor, and coconut coir reinforced polyester composites are included. By altering the weight percentages of sorghum bicolor and coconut coir from 5 to 25 wt. Percent, The mechanical dataset shows the strength of natural fiber composites in terms of tensile, flexural, impact, and hardness. Hand layup was used to create the composite samples. In-plane tensile, flexural, impact and hardness of natural composites were used to determine mechanical characteristics. The information in this dataset will assist the reader in natural fiber reinforced polyester composites' main properties. The inclusion of sisal and coconut coir fiber, on the other hand, appears to improve the characteristics.

In 2019., Liu, Y., Lv, X., Bao, J., et al [77] have utilized the natural cellulosic fiber from corn stalk waste that has been silence treated and untreated as a possible reinforcement polymer composites. Silence's impacts on Corn Stalk Fiber (CSF) chemical, surface morphological, and mechanical characteristics, as well as the impact strength and impact fracture surface morphology of CSF, reinforced polymer composites, were studied. The chemical result revealed that silence treatments remove a specific percentage of hemicelluloses and lignin from the CSF surface while also increasing the CSF's Crystalline Size (CRS). The tensile strength of CSF treated with a 5 wt. percent silence solution is 2.43 Gpa. Treatments that boost fiber-matrix interfacial bonding and polymer composite impact strength include silence 41.22 MPa and Young's modulus of 18.98 GPa 223.33 MPa. SEM scans demonstrated that the surface morphology of the treated CSF was minimally rung and relatively clean after silent treatments. The Si-O-Si stretching vibration was observed in the spectra of 9 wt percent and 13 wt percent silent treated CSF, confirming that some of the hemicellulose and pectin were removed from the CSF surface. Silence concentrations that were appropriate for the fiber-matrix interfacial bonding of the fiber and matrix enhanced the impact strength of the polymer composites. In 2020., Kenned, J.J., Sankaranarayanasamy,K., et al [78] have utilized the goal of this research to use a unique process form fabricating natural fiber reinforced polymer composites that can compete forglass fiber composites in tars of thermo-mechanical characteristics without use an of any chemicals. The reinforcing fibers were taken from the endian banana plant's pseudo-stem. Later, a non-woven fabric composite comprised of banana fibers reinforced with an unsaturated polyester (UPE) matrix was created using a needle punching process. To assess mechanical properties, composite specimens were subjected to tensile, flexural, hardness, quasi-static indentation (QSI), and dynamic mechanical analysis (DMA) tests. However, needle-punched banana fiber composites (NPBFC) had the best attributes at 40% fiber content, increases in tensile and flexural strength of 36% and 33%, respectively, when compared to random banana fiber composites (RBFC). Infrared spectroscopy is usedto depict the distinctive bonds of cellulose, X-ray diffraction analysis is used to depict the distinctive bonds of cellulose, and X-ray diffraction analysis was usedto reveal the crystalline index. A thermal study was also performed, and the improved NPBFC was shown to be stable up to $260°C$. In addition, a link between morphology and characteristics was discovered. Finally, theoretical models were used to validate the experimental results. This research finds that the unique NPBFC synthesized has the potential to be used as a possible reinforcement for industrial safety helmets, automobile door panels, and lightweight structural applications.

In 2020, Chen, C., Yang, Y., et al [79] have utilized the reinforcement of reinforced concrete beams, natural fiber reinforced polymer and carbon fiber reinforced polymer is used. This article compares the permanence of natural fiber reinforced polymer (NFRP) and carbon fiber-reinforced polymer (CFRP) in the flexural strengthening of RC beams using a multi-objective approach. Because the elastic modulus of NFRP laminates and concrete is comparable, the NFRP-strengthened once. Increasing the NFRP reinforcement ratio and NFRP width enhanced ultimate load and ductility substantially. Narrow NFRP has a greater strength-to-weight ratio than broad NFRP. The cost advantage of natural fiber was significantly negated by the huge volume of impregnated epoxy resin, and the overall cost efficiency of NFRP laminates ranged between 60% and 160 percent that of CFRP laminates. The environmental impact of NFRP laminates was likewise raised by epoxy resin, and the environmental impact of NFRP and CFRP strengthening was identical. Flax FRP has a lesser environmental effect than jute FRP in general. To enhance cost efficiency and reduce environmental impact, prefabrication of NFRP laminates utilizing the vacuum infusion process is advised. In 2020, Sumesh, K.R., Kanthavel, K. et al [80] have utilized extraction and use of mechanical and thermal properties of cellulose fiber produced from peanut oil cake in pineapple/flax natural fiber composites. This fiber powder is utilized to improve the applications of natural fiber epoxy composites made from pineapple (P) and flax (F). CMF had a better Crystalline Index (Crl) of $70.25° and$ crystalline size of 5.5mm, according to X-Ray Diffraction (XRD) findings. The presence of cellulose in functional groups of filler was confirmed by FTIR findings, which showed peaks at 1058cm-1, 1162cm-1, 1370cm-1. Mechanical studies showed that incorporating CMF into PF hybrid fiber composites had a good influence. The addition of CMF to the thermal stability equation improved the degradation temperature, residual percent, endothermic peak, and enthalpy. The filler substitution increased the degradation temperatures T50, T70, T70 from 387.73–391.08°, 434.81–454.81°, and 468.91–553.36° in the 30%PF combinations. The usage of cellulose filler generated from peanut oil cake in mechanical and thermal applications of natural fiber composites was investigated in this study. The extraction of cellulose microfibers from peanut oil cake and the insertion of cellulose filler into natural fiber composites are still in the works. Cellulose micro filler was created by powdering these cellulose fibers in a high-energy ball mill (CMF). Pineapple and flax fiber epoxy hybrid composites are combined with this filler powder. This feature causes a greater stress point during loading, resulting in unequal fiber/filler mixing in the epoxy matrix material. With 3 percent CMF, the greatest enhancement in tensile, flexural, and impact characteristics was 45.56 percent, 34.11 percent, and 45.1 percent in 35 percent PF. These qualities are enhanced by CMF's high crystalline structure, wide surface area, and dimensional stability. With a filler addition of up 3%, the combination with 35 percent PF showed an increase in degradation temperature and residual percent. The substitution of CMF resulted in an increase in endothermic peak and enthalpy as measured by DSC. 30 percent PF/2CMF untreated fibers 28 and 35 percent PF/3 percent PF/3 percent the results revealed a significant improvement in the characteristics. This technology canbe used to produce low-cost composites that are more thermally stable.

In 2019, Prabhu, L., Krishnaraj, V., et al [81] have analysis mechanics, chemistry, and acoustics of sisal–tea waste–glass Fiber reinforced epoxy based hybrid polymer composites were investigated. Natural fiber-reinforced composites are replacing metals in this study due to their low weight, high strength-to-weight ratio, non-corrosive nature, and stiffness. Natural fibers have limited in their application due to weak interfacial adhesion between fiber and matrix, a low melting point, and a lack of moisture resistance. Hybridization allows you to fine-tune the characteristics of composites to meet specific needs and get the best results. Customers are also searching for environmentally-friendly automobiles, thus many in the automobile industry are transitioning to a "Green view." Natural fiber-reinforced polymer (GFRP) is becoming more used in automobile parts. Because of their eco-friendliness and sound absorption qualities, sisal (S) and waste tea fiber (T) were chosen for this investigation. Hemicellulose, waxes, and lignin are all hydrophilic compounds found in both fibers. As a result, the fiberis chemically treated with 5% alkaline (NaOH) and then hybridized with GFRP using an epoxy matrix. The mechanical characteristics of the material were studied, including tensile strength, impact strength, and flexural strength. Scanning electron microscopy (SEM) examination was also used to look at interfacial features such as internal fractures, blowholes, and fiberpullouts.The mechanical characteristics of sisal-tea-glass fiber reinforced hybrid composites, such as tensile, flexural, and impact, are studied using varied weight ratios of sisal and tea fibers. The composites' tensile strength, tensile modulus, flexural strength, flexural modulus, and impact strength all increased when more sisal content was hybridized with glass fiber. These enhancements to the investigated material's properties might make it appropriate for usage in car components such as dashboards, seat bases, frontal and rear bumpers, aircraft interior paneling, brake pedal, speaker compartment, soundproofing materials, and furniture. In 2019, Binoj, J.S. and Bibin, J.S., [82] have utilized a failure investigation of Agave tequilanafiber polymer composites that were discarded. In this the present study examines are thermo-mechanical characteristics of waste Blue Agave Fiber (BAF) and uses it as reinforcement in composites.Composite specimens were made with varying fiber and matrix composition to achieve a consistent fiber length. Meanwhile, when the examined composites had high fiber content, they had better mechanical characteristics. The high specific strength demonstrated their suitability for composite fabrication in locomotive and basic applications, and the fiber composition was determined to be ideal in terms of weight percent. The reason for fractured tensile and flexural test specimen failures was also investigated using scanning electron microscopy (SEM). The flexural strength and modulus of the BAFC are 56.25 MPa and 1.12 GPa, respectively. In addition, the failure examination is carried out of SEM, which revealed the reasons for the fiber and matrix's poor compatibility. Finally, when compared to existing natural fiber reinforced polyester composites, its newly designed BAFC material has reduced weight, superior mechanical, and thermal qualities. As a result, this unique material with 40 percent fiber content and 60 percent matrix content, manufactured BAFC, may be suggested fora wide range of industrial and home applications.

2.5 Literature on the effect of chemical treatment of natural fiber/filler

In 2020, Lokesh, P., Kumari, T.S., et al [83] have researched the mechanical characteristics of a bamboo fiber-reinforced polymer composite were investigated. In this study natural fiber reinforced polymer composites (NFPC) have a high affinity substituting synthetic fiber composites. Because of advantages such as lightweight, non-toxic, non-abrasive, simple accessibility, low-costbiodegradability, When compared to synthetic fiber-based composites such as lightweight, non-toxic, non-abrasive, easy availability, cheap cost, and biodegradability, natural fiber's intrinsic mechanical qualities, such as particular tensile modulus and other distinguishing features, provide a satisfactory result. In this case, natural fiber's inherent mechanical properties, such as specific tensile modulus and other distinctive traits, give a satisfying outcome when compared to synthetic fiber-based composites. Bamboo strands of various lengths are glued together with epoxy resin to make composite materials. To make composite materials, bamboo fibers of various lengths and contents are bonded with epoxy resin. The impact of fiber length and content on composite mechanical behavior is investigated. It has been successful to fabricate epoxy-based composite materials reinforced with bamboo fibers.The mechanical parameters of the composites, such as tensile strength, flexural strength, and impact strength, are significantly affected by the NaOH treated fibers used. Excessive fibers in composite materials reduce the mechanical properties of the composite due to a lack of appropriate bonding between the matrix and fiber at the interface. According to the current study, increasing the treated content of fiber in composite materials improves impact, tensile and flexural strength. In 2020, Narayanasamy, P., Balasundar, P., et al [84] have analyzed a characterization of unique natural cellulosic fiberis derived from the fruit bunch for use in environmentally friendly polymer composites. The alkali treatment is found to minimize amorphous levels is remove non-cellulosic components that were detected by FTIR analysis. According to the X-ray diffraction pattern, the crystalline index of alkali-treated CGFB fibers was greater than raw fibers. Alkali-treated materials thermal degradability and stability the fiber content of the fruit bunch was higher than the untreated fiber. SEM and atomic force microscopy images revealed a somewhat roughened surface of the fiber due to the removal of non-cellulosic components and surface impurities after alkali treatment.

In 2019, Herrera, F.V., Pinheiro, I.F., et al [85] have utilized environmentally polymer composites based on PBAT in natural fibers from the Amazon forest were used. Natural fibers are removed by mechanical processing, and composites are made by melting them together. All composites had a greater modulus of elasticity than the pure polymer, with the improvement varying based on the kind of fiber used as reinforcement. The addition of Fiber C enhanced the polymer's modulus of elasticity by 48%, while the addition of Fibers M and T raised the PBAT'S modulus of elasticity by 48%, 70, and 72 percent, respectively. The research created biodegradable composites using PBAT was three distinct natural fibers from the Amazon rainforest. To our knowledge, these composites are the first to successfully incorporate fibers from C. Lanjouwensis, T. Micrantha as fillers in polymeric systems is give mechanical reinforcement. Using more crystalline fibers with a structural organization aligned in a given direction produces the highest reinforcing effect. In 2019, Selvakumar, K. and Meenakshisundaram, O., [86] have analyzed jute and human hair-reinforced polymer composites mechanical and dynamic mechanical. Carbon emissions may be lowered in autos by replacing metallic components with lightweight natural fiber-reinforced composite-based components, according to this study. Heat and dynamic stresses applied simultaneously to polymer composite materials alter crystalline, resulting in material characteristics and weight deterioration. Many researchers are interested in using biocomposites for car parts that have superior mechanical and thermal qualities compared to traditional materials. The current study focuses on the fabrication of five distinct fiber compositions of jute and human hair-reinforced epoxy-based polymer composites.For assessing the viscoelastic behavior of composites, the influence of fiber composition frequency and dynamic behavior of novel combinations of natural compositesis investigated. Mechanical characteristics of the composites improved as the human hair content increased.The glass transition temperature (Tg) for all composites is between 80 and 95°C, as determined by storage modulus, loss modulus, and damping curve. More stress transmission in the interface was seen as a result of the higher fiber concentration in the matrix, resulting in high dynamic mechanical properties. the amount of human hair in a composite rises, mechanical parameters suchas tensile strength and impact strength improve. It increases the inter-locking of fiber with epoxy matrix, resulting in increased stress transmission at the interface, due to the hydrophobic nature of human hair. The storage modulus values are primarily influenced by the fiber mix in all composites. Chemical interaction between cellulose fiber and keratin fiber improves the viscoelastic behavior of human hair and jute fiber-reinforced polymer composites. When compared to Composites A, D, and E, the loss modulus qualityinthe transition area for Composites B and C is relatively high. In addition, the E00 value shows a sharp decline inthe transition zone is smaller for all composite.

Conclusion from literature

From the above literatures, it is found that the addition of natural fillers increases the mechanical properties and decreases the volume of polymer usage in the composite. The Almond shell natural fillers are available in larger quantity in India and have not been explored by researchers. Among the basalt fibers possesses higher cellulose content than almond, pistachio, and groundnut available in India. Further, the chemical treatment of natural fibers improves the adhesion between the matrix and the fiber, and thereby increases the properties of the composite. In addition, the chemical treatment reduces the hydrophobic nature of the fiber by chemical reaction with the hydroxyl group in cellulose.

2.7 Research gap

Fillers used to improve the composite's strength, according to the above literature. The interface adhesion between the filler and the matrix is also improved by surface treatments on the reinforcement. As a result, the purpose of this study is to investigate the effect of natural fillers Almond shell on the properties of Sal tree resin composites containing filler, in order to reduce polymer consumption in the composite and thus increase biodegradability.

The main objectives of this research work are:

- To determine the effect of filler loading (5,10,15,20, and 25%) on the mechanical properties of Almond shell reinforced composites, and to predict which filler is better.
- The purpose of this study was to see how filler volume percent affected the mechanical properties of a filler reinforced epoxy composite.

3. INTRODUCTION

In recent decades, natural fibres are employed as reinforcement material for enhancing mechanical properties. Due to the advantages of natural fibres and fillers, the researchers are concentrating on the utilization of natural fibres like flax, hemp, jute, straw, bagasse, bamboo, sisal, etc., and fillers like groundnut, rice husk, coconut shell powder, wood, etc., in polymer resins. Plant fibres and natural fillers are commonly used as reinforcement because of their biodegradability, which helps to a healthier ecology, as well as their low cost and acceptable qualities. Natural materials and composites are environmentally beneficial and renewable, but they suffer from poor wettability, incompatibility with some polymeric matrix, and a high moisture absorption capacity.

3.1. MATERIALS

Almond Shall Particulate Reinforced *Sal tree resin* Blended Epoxy Hybrid Matrix Composite was used as material. Composite samples were fabricated using hand layup moulding method followed by compression. The materials used in this work for fabrication of composites are given below:

- Resin used : *Sal tree resin*Blended Epoxy Hybrid Matrix(Natural 40 % resin60% with Epoxy)
- Reinforcement : *Almond shall powder*
- Specimen plate dimension : 300 × 300 × 3 mm

Almond Shell Particulate Reinforced Sal Tree resin Blended Epoxy Hybrid Matrix Composite was used for the filler and matrix ingredients. Powdered Almond Shell and Sal Tree resin were supplied by PV fibres in Kanchipuram. Hand layup moulding was used to make composite samples, which were then light-cured compression. A variety of volume fraction percentages of composite specimens were created. Blended Epoxy Hybrid Matrix of Sal Tree resin, as stated in table There were experiments carried out to examine the mechanical and dynamic mechanical features of the composite. The sample needed by ASTM

3.1.1. Almond Shell

The foundation material is a composite commercial grade of poly. A Melt Flow Index (MFI) of 20 to 34 g/(10 min) and a density of 1.26 g cm3 characterise this industrial grade. Jesolo Materias Primas provided us with almond shell powder/flour To acquire a homogenous particle size of 150 m, the provided powder was sieved in a vibrating sieve RP09 CISA®. Vandeputte provided VEOMER LIN, a Maleinized Linseed Oil (MLO). It has a viscosity of 10 DPA and an acid value of 105–130 mg KOH g1 when tested at 20°C.

3.1.2. Effect of Almond Shell Waste:

INZEA® polyester is commercial grade with a density of 1.23g cm3 when tested at 23°C. It was graciously provided with a moisture content of 0.5% and a melt flow rate of 19g/10 min (2.16 kg, 190°C). Nortel is a word that comes to mind when thinking Foam provided the almond shell (AS) waste for filler. as a by-product of agriculture, crushed by high-speed rotor mill RETSCH mill ZM 200. The particles were sieved once they were acquired, with the diameters of the particles being determined. Fine-grain and coarse grain ground shells range are 125–250 m to see how particle size affects composites.

3.2. Almond shell varieties studied & Properties of MATER-Bi DIO1A

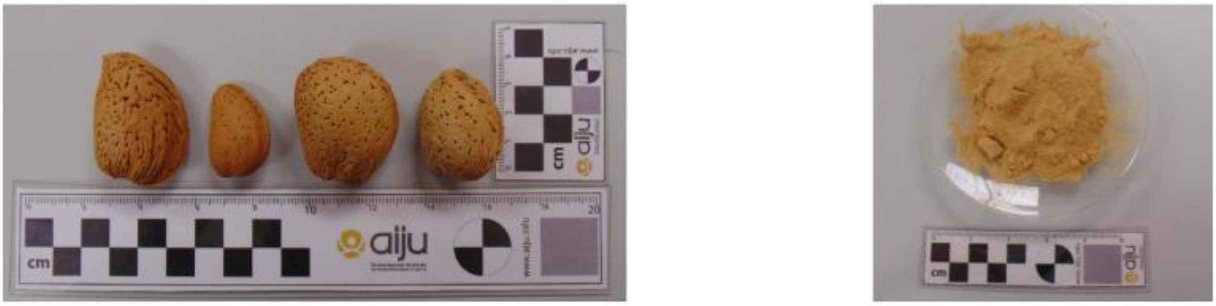
In this investigation, Mater-Bi DI01A of Novamont, a widely available starch-based polymer, was employed. This bio-based and biodegradable polymer has a melt flow index of 35 g/10 min (190 C/2.16 kg) and a density of 1200 kg/m3. There isn't a lot of scientific knowledge on it, however, it's known to be mostly made up of a TPS and PBAT mix. This reference was chosen because it has polypropylene-like characteristics. Mater-Bi DI01A is made up of up to 80% renewable materials. The parameters of the material as received are shown in Table 1.

Table 1. MATER-Bi DI01A properties extracted from Novamont datasheet

Characteristics	Test	Values
Minimum Processing temperature (°C)	Novamont test	170
Maximum Processing temperature (◦C)	Novamont test	260
Melting temperature (◦C)	ASTM-D3418	160
Melt viscosity (Pa.s) (T=190◦c,γ =1000 s−1)	ASTM-D3835	140
Tensile strength (MPa)	ASTM-D638	20

Maximum tensile strength (MPa)	ASTM-D638	48
Extension at break (%)	ASTM-D638	22
Extension at max strength	ASTM-D638	2.5
Young modulus (MPa)	ASTM-D638	2700

The kind of shell is a typical way of classifying almond variations, therefore there are two sorts of almonds, soft-shelled and hard-shelled. It was thought that it would be interesting to see if this trait may impact the final qualities of the biocomposites being created, thus four almond kinds were chosen for the study: Desmayo Rojo, Largueta, Marcona, and Mollar, all from Spain (Figure 1).



(a) (b)

Figure 1: The Effects of Almond Shell Variety on Starch-Based Polymer Biocomposites' Mechanical Properties

Because it's difficult to separate almond kinds in fields and shells by cracking/shelling factories, the most common way to get this trash on the market is a shell variable. Then, compare to findings with the isolated ones, biocomposites were created utilising a blend of various types. Hermen Europe, S.L. offered a combination as a powder with particle sizes ranging from 0.05 to 0.125 mm.

Figure 2: (a) Desmayo Rojo, Largueta, Marcona, and Mollar (from left to right) almond shell types investigated; b) commercial combination powder

3.3. Almond Shell Milling

Almond Shell Powder (ASP) was milled in two phases using a milling shini model SG-1621 and a Milling ZM 200 before processing. The resulting powder was sieved to achieve distinct particle sizes using a set of sieves. Almond shell has a moisture content of 10–13 weight per cent. It can have a big impact on processing, producing hydrolytic reactions and lowering the mechanical characteristics of the biocomposites being made, such as tensile and flexural capabilities, and impact strength. As a consequence, the almond shell powder was dried as much as possible to remove any remaining moisture. Before processing, this was done in an air-circulating oven at 105°C for 24 hours. Following the drying procedure, the moisture content of the ASP is less than 1wt%.

3.4. Plant-based materials

They comprised 54 almond cultivars, the majority of which came from the island of Majorca's autochthonous genetics, Each variety is represented by three trees from the Sa Canova collection, which were grafted on the rootstock INRA GF-677 and kept in commercial almond orchards. The majority of the cultivars originate from the Granja Experimental de la Ciutat de Mallorca's collection, which was founded in the 1950s and 1960s and expanded by Joan Rallo's introductions.

The research was conducted on the 2017 crop. When the almond nuts were fully mature, The peduncle abscission is easy, and the mesocarp separated to disclose the inner endocarp. Each cultivar's costume of unique trees yielded a total of 100 nuts. Before any measurements, the nuts were kept at room temperature until uniform moisture (6%) was achieved, because of breaking force in almonds as well as other nuts and grains like pistachio and oat decreases with increasing moisture content.

3.4.1 Shell-cracking pressure

The shell-cracking load (SCL) was measured using the Zwick Z100 compression test equipment, which was fitted with a 100 KN charge cell (Fig.3). The shell shattering load per cultivar was determined to be ten nuts. Each almond nut is put on a fixed metal plate at the Z100 instrument's base, with the nut's suture plane parallel to the metal plate and perpendicular to the compression force's direction (Fig.3). The nut was then compressed from above, using a 2 N pre-charge and a 25 mm min1 compression speed. As a result, the almond nut was compressed perpendicular to the transverse portion. The load of shell-cracking was the greatest force during the compression test was used to determine the force required to shatter the nutshell.

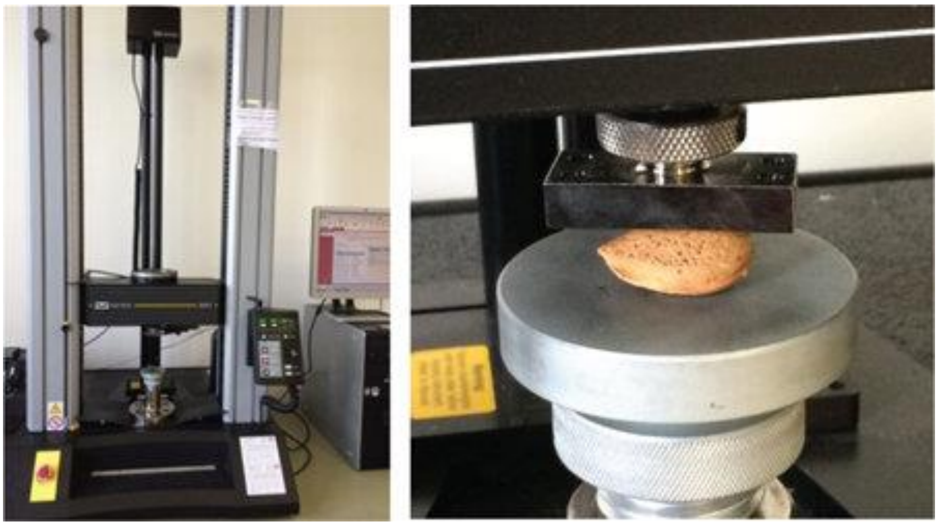


Figure 3. When impact shelling almonds, conditioning prevents kernel damage.

Because prior experiments revealed that the shell had already fractured in hard-shell cultivars after this run,with a 3 mm limit, the compression force was halted when it reached 60% of the maximum value seen during the experiment (Fig. 4). For soft shell cultivars, the end of the measurement determined when a sustained force was detected at the screen after a sudden decline, followed by a rising force when the load was no longer supplied to the shell, but the kernel.

3. Results and discussion

Tensile test was performed as per ASTM D 638 standard with a test speed of 2 mm/min. Flexural test and Impact test were performed by ASTM D 790 and ASTM D 256, respectively.

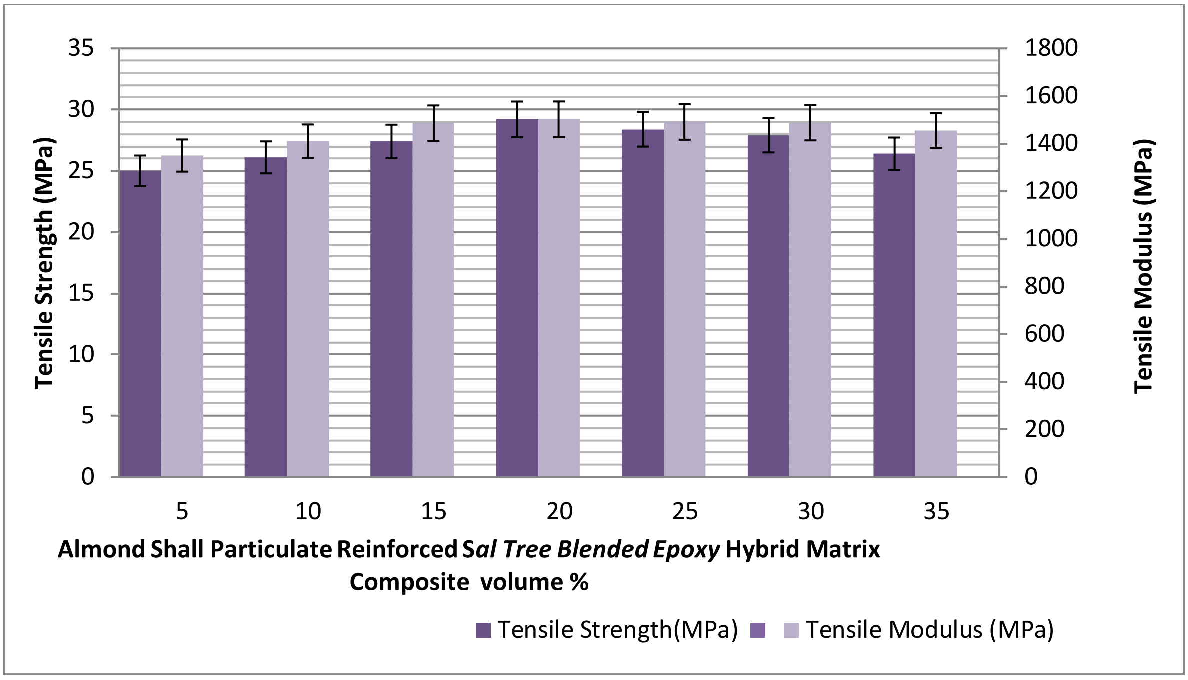


Figure 1 Tensile properties of almond shall powder with Sal tree resin Blended Epoxy Hybrid Matrix

The mechanical properties (Tensile, Flexural and Impact strength) of Sal tree resin Epoxy Hybrid Matrix composites with different vol % of almond shall powder shown in fig2 to 3. It can be noted that the incorporation of filler material improves the mechanical properties of composite material to certain extent the different volume 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40 % of the fiber material.

The addition of filler material up to 20 % increases the tensile property of composite. Further addition of filler material reduces the tensile strength. The addition of almond shall powder with *Sal tree resin* Blended Epoxy Hybrid Matrix material above 35 % reduced the tensile strength of the epoxy composite. This is due to the fact that filler materials are in particulate form and they cannot actively participate in carrying the applied load.

Flexural strength

The flexural strength results also indicate that the addition of almond shall powder with *Sal tree resin* Blended Epoxy Hybrid Matrix had improved the stiffness of the composite. The improvement in flexural strength properties was also observed for the filler loading of up to 20 vol%.

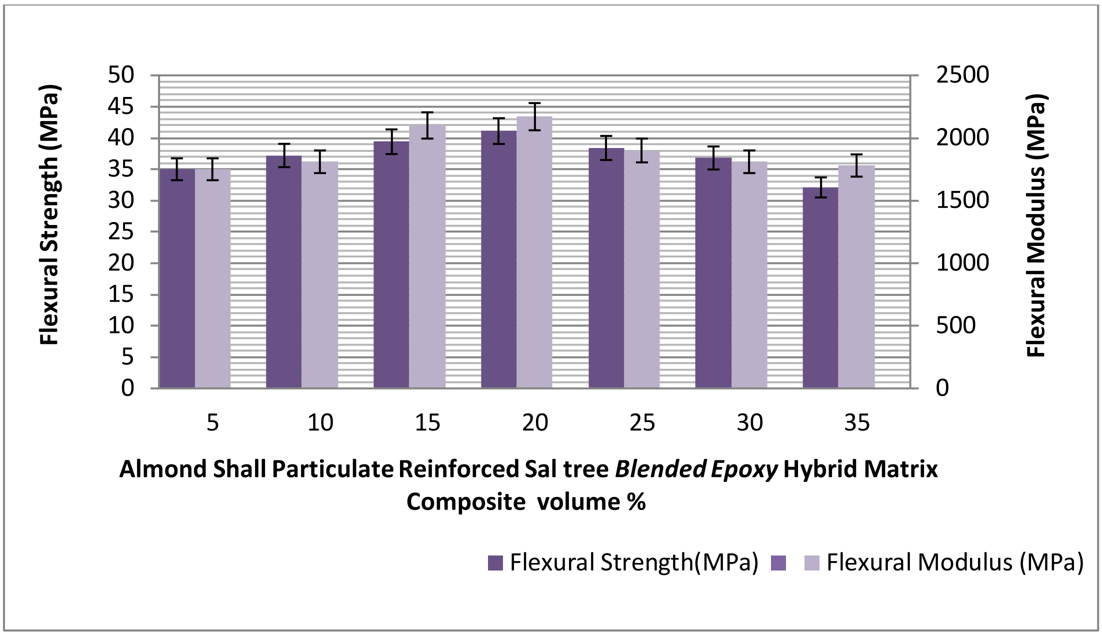


Figure 2 Flexural properties of almond shall powder with *Sal tree resin* Blended Epoxy Hybrid Matrix

The Addition of almond shall powder with *Sal tree resin* Blended Epoxy Hybrid Matrix More than 25 vol% resulted in decreasing of the tensile properties. This is due to the agglomeration of the natural filler in the epoxy matrix this is evident from SEM images 4 and 5. It was due to the brittleness of the composite material. In addition fiber may suppress necking and initiate yielding in crazes or more exactly in craze-like zone if the particles were treated by an anti-adhesive and their bonding with a polymer was weakened. The increase in properties is due to the addition of filler materials in the composite material.

Toughness of a material is defined as the energy absorbed during the fracture when the material is subjected to impact loading. Natural filler are generally added to improve the stiffness (modulus) and toughness of the composites. When the load is applied, the matrix and natural filler are separated which requires energy, this energy required depends on the bonding strength between the filler and hybrid matrix material.

Impact strength

The influence of almond shall powder with Sal tree resin Blended Epoxy Hybrid Matrix on Impact properties of composite is shown in fig 3.And it provides an interesting observation that the addition of filler up to 35% does not improve the impact strength of composite material. However further addition of filler increases the impact strength of composite material moderately. It is due to brittleness of the composite material.

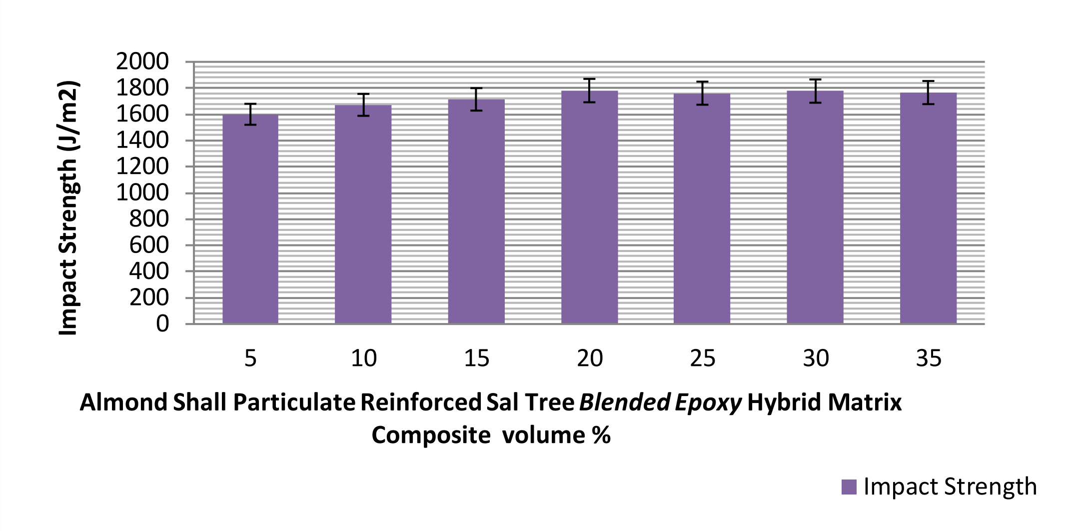


Figure 3 Impact strength of almond shall powder with *Sal tree resin* Blended Epoxy Hybrid Matrix

Further addition of almond shall powder with Sal tree resin Blended Epoxy Hybrid Matrix reinforced decreases the impact strength of the composite material, but the value is still higher that neat epoxy. It is observed from the figure that the addition of filler up to 25 vol %, improvement in the impact strength of composite material is very less. However the addition of filler above 25 and 30 vol % causes a moderate increase in the impact strength of the composite materials. It was due to the brittleness of the composite material. Further the addition of almond shall powder above 25 vol% decreased the impact strength of the composite material; however, the value was still higher than neat epoxy resin.

4. Conclusions

In this research the influence of different volume fraction of almond shall powder with Sal tree resin Blended Epoxy Hybrid Matrix reinforced filler addition in the composite on the mechanical properties was investigated. It can be observed that the incorporation of filler material enhanced the mechanical properties of composite material to certain extent. It is noted that the 20 % volume fraction of almond shall powder with Sal tree resin Blended Epoxy Hybrid Matrix results in maximum tensile strength. While maximum flexural strength and impact strength are achieved with 20 to 25volume fraction filler material respectively. However further addition of almond shall powder with Sal tree resin blended Epoxy Hybrid Matrix resulted in reduced the mechanical properties which may be due to the non-uniform dispersion in filler in the epoxy matrix.

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