DEVELOPMENT AND ANALYSIS OF HYBRID RESIN NATURAL POLYMER COMPOSITE

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Abstract

This study explored the qualities of pineapple fiber with (epoxy and polyester resin) polymer composites. The composites were made utilizing a hand lay-up embellishment. The developed composites are used to conduct the mechanical tests like tensile test, flexural test, Interlaminar shear strength and morphological analysis and the testing results are obtained. Mechanical tests showed that Tensile strength of L1, L2, L3 results 36, 38, 41 Mpa. PALF – polymer composite was observed from (SEM) scanning electron micrograph as evidence on compatibility mechanical properties at the intersectional region of composite. Inter laminar shear strength of L1, L2, L3 results 6.61,8.40, 12.85 Mpa. TGA (Thermogravimetric analysis) L1, L2, L3 results 772.6, 780.5, 794.4 ^{0}C are led to concentrate on the properties of the composite.

Keywords: Pineapple fibre, Hybrid resin (epoxy & Polyester), hand lay – up

1. INTRODUCTION

The growing need for environmentally acceptable disposal techniques has led to a rise in the significance of biodegradable materials in recent times. The aforementioned shift has led to a heightened focus on natural fibers, given their critical role in addressing contemporary biological and ecological concerns. The fibers provide a sustainable option to the synthetic reinforcing fibers that are already widely used in many different industries. Natural fiber composites have come a long way since they were first developed and are currently utilized in a variety of sectors, including high-tech manufacturing and consumer goods. The development of new manufacturing techniques has led to the creation of composite parts that are economically appealing. Compared to the aerospace business, the car industry has recognized the substantial commercial prospects offered by composites. Glass fibers cannot match the competitive advantages of natural fibers, particularly when it comes to specific stiffness and strength. Composites were developed as a result of advances in engineering materials to overcome problems with rigid polymers. Because of their superior qualities and accessibility, natural fibers were the subject of intense research in the mid-1960s by industries like automotive and aviation. When it comes to skin irritation, natural fibers are less expensive than synthetic ones like aramid and glass. Blending polyester with epoxy, hybrid resin composites have more advantageous properties that make them appropriate for application in a variety of industries, including home appliances, marine, and aircraft. Currently, researchers are looking at the possibilities of bamboo for durable furniture, inventive support systems, and bicycle and automobile parts. Sisal fibers come in a variety of shapes and are utilized in braking materials because of their exceptional mechanical and thermomechanical qualities. Natural fiber reinforced composites are becoming more and more popular in environmentally friendly building practices, with benefits for living things such as animals and buildings. While epoxy-based composites increase the structural strength of objects, wood fiber reinforced composites are utilized in furniture. Bio-based products are being used by engineers increasingly frequently to reduce environmental damage. Natural fiber reinforced composites are increasingly being considered as a sustainable material choice because of their low cost, high mechanical properties, recyclable nature, and biodegradability. One difficulty is the low mechanical capabilities of natural fiber reinforced composites as compared to synthetic fibers. One effective method for getting over this restriction is hybridization, which blends two or more distinct kinds of fibers or resin. Key elements that affect the performance of hybrid composites include the weight-to-volume ratio, chemical fiber treatment, stacking order, environmental conditions, and individual fiber characteristics [1-4]. More grounded and stiff materials have become more and more necessary since the mid-1960s for application in a range of sectors, such as the construction of automobiles and aircraft. Because of their remarkable qualities and the abundance of natural fibers available worldwide, several application fields are showing a rising amount of interest in natural fibers. Better imitations of natural fibers, such glass, aramid, and other materials with a similar structure, are called synthetic fibers. In addition to being less expensive than synthetic fibers, natural fibers do not irritate the skin or other human tissues. On the other hand, the cost of synthetic fibers is rising over time [5-8]. When compared to synthetic fibers, this form of fiber has greater benefits. Compared to composites composed of only one type of fiber, hybrid resin composites made of natural fiber offer a greater variety of desirable properties. Fiber-reinforced polymer composites, or FRPCs for short, are composites made of polymers, pineapple resin, and hybrid resin with fiber-like reinforcing elements incorporated therein. These fibers are extremely strong. Composites consisting of natural and synthetic fibers are used in a wide range of industries, including the aerospace, maritime, and home appliance sectors. The feasibility of utilizing bamboo for durable furniture, creative geometric auxiliary buildings, and even bicycles, tricycles, and vehicle parts is being studied [9]. Commercial sisal fibers come in many different forms, such as rolls, wire, cloth, strings, and so forth. When it comes to braking materials, a material needs to have sufficient mechanical capabilities in addition to outstanding thermomechanical and chemical stability characteristics. It is crucial to make sure the brake parts are strong enough and resistant to damage because they may have an effect on the driver's general health. Recent years have seen a rise in the use of natural fiber composites in the development and maintenance of structures, animals, and other living things. Wood fiber reinforced composites are being utilized to create profiles for windows and doors, among other furniture uses. The usage of epoxy-based composites to improve the airframes' structural integrity is growing. Engineers have started incorporating bio-based materials into their construction projects to lessen their environmental impact. The development of sustainable materials from renewable and biodegradable natural resources has been the focus of recent scientific endeavors. Among the materials that can take the place of synthetic materials and lessen their negative environmental consequences are natural fiber reinforced composites. Their low cost, high mechanical qualities, low density, recyclability, and biodegradability make them one of the most sustainable materials for a wide range of industrial uses. They also have benefits like affordability. Because of this, the use of widely available fibers found in plants, animals, and minerals has led to the increased significance of bio-based composites [10–13]. The fibers from harvested plants are combined with polymers to create applications that are lightweight and sturdy. One of the main disadvantages of natural fiber-reinforced composites is their inferior mechanical capabilities when compared to synthetic fibers. By creating hybrid fiber-reinforced polymer composites with two or more different types of fibers, this problem can be overcome. Hybridization presents a feasible solution to the drawbacks associated with the usage of natural fibers, and it is one of the most effective methods for doing so. The most important factors influencing hybrid resin composites are the weight-to-volume ratio, the chemical treatment of the fibers, the sequence in which the fibers are stacked, the conditions of the surrounding environment, and the characteristics of the individual fibers. The mechanical properties, moisture absorption, cost, and environmental effect of standard polymers could all be enhanced by hybrid resin polymer composites composed of natural and synthetic materials, provided that the carbon content is lowered. To increase the performance of composite materials, natural fibers can be mixed with synthetic fibers including carbon, Kevlar, glass, and aramid as well as mineral fibers. The order in which they are stacked can help change the properties of composite materials.

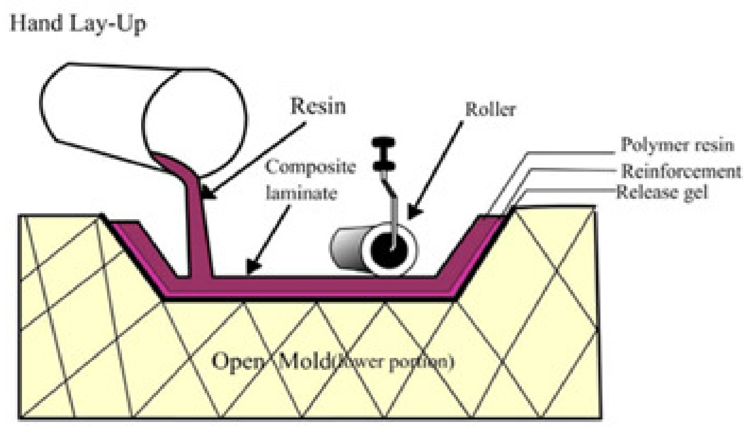


Fig.1 Hand lay – up moulding method

This was shown by an examination of the impact and mechanical properties of the hybrid resins with various stacking sequences. As a result, composite materials may be tailored to fulfil the intended purposes. Since, the pineapple mat has a long-lasting nature, that's why it was utilized for the outside layers. Long-term ageing experiments on pineapple reinforced epoxy composites demonstrated that hybridization of resins with luffa biochar filler and LY556 Hardener improved the durability of natural fibres composite. This was found through the testing of flax supported epoxy composites. The use of composites produced using a blend of regular and manufactured strands has numerous viable purposes in vehicle plan because of its lightweight and financially savvy nature [2, 14-20]. pineapple fiber supported composite the utilization of luffa biochar fillers has brought about huge upgrades to both their physical and mechanical qualities [21]. Materials researchers and designers can profit from utilizing both normal and engineered strands to make lightweight, superior execution polymer composite materials. Regular strands are inexhaustible materials that offer a few advantages, including modest creation costs, biodegradability, low thickness, high unambiguous modulus, overflow, and minimal natural effect. As indicated by the writing survey, pineapple fiber has been utilized as a support for mixture gum epoxy polymer network composite. It needs extra examination. The internal fiber of the pineapple barrel shaped organic product was utilized. A past report shows that as a composite support pineapple natural product fiber displays better mechanical, physical, and warm characteristics. In spite of these discoveries, pineapple as a reinforcing part for epoxy network composite has not been examined, subsequently, requiring more exploration. Subsequently, the current review investigates its prospects with epoxy framework and different compound medicines The ongoing review expects to evaluate the viability of epoxy composites built up with pineapple natural product filaments of fluctuating stacking arrangements for use in car designing. Fig**. 2** is properties of epoxy and polyester resin.

Property	Unit	Epoxy Resin	Polyester resin
Viscosity at 25 °C	Mpa.s	10	150
Density	g/cm3	1.15	1.07
Tensile strength	MPa	74	65
Tensile strain	%	9.4	2.0
Tensile modulus	MPa	2900	4000
Flexural strength	MPa	112	110
Modulus in flexure	MPa	3100	4200
Water absorption after 24h, 23°C	pbw	0.18	-
Water absorption after 168h, 23°C	pbw	0.432	-

Fig.2 properties of epoxy and polyester resin

2. Materials and methods

2.1. Materials

2.1.1 Pineapple leaf fibre

Consistently lots of pineapple leaf filaments are being created, however tiny bits are being utilized in the field of feed-stock and energy creation. The development of bio composites has intensified modern utilization that would deliver the conceivable outcomes to limit the wastage of inexhaustible materials. It advances a non-food-based market for farming industry. It is multicellular lignocellulosic fiber containing polysaccharides, lignin in significant sum, and some digger synthetics like fat, wax, gelatin, uronic corrosive, anhydride, pentosan, variety shade, inorganic substance, etc. Fiber is assortment of flimsy and little multicellular strands which seems like a string. These cells are firmly gotten together with the assistance of gelatin. pineapple fiber comprise cellulose (70-82%) and course of action of strands is equivalent to in cotton (82.7%) [3].

2.1.2. Hybrid resin (Epoxy & Polyester)

The Epoxy LY 556 and polyester resins is broadly utilized as a supporting material because of its medium consistency and synthetic substances resistivity. Property of this saps can undoubtedly be altered inside wide cutoff points with the utilization of luffa biochar fillers and hardeners HY 951. The synthesis of this sap depends on Bisphenol-A which makes it reasonable for elite execution FRP composite applications, for example, pultrusion, pressure shaping, fiber winding, etc. Our tar is known for remarkable mechanical, great fiber impregnation and warm and dynamic properties. Likewise, the Epoxy Gum LY 556 and polyester is having a low propensity to take shape, that is the reason it is liked for airplane and aviation adhesives.

2.1.3 Method of fabrication

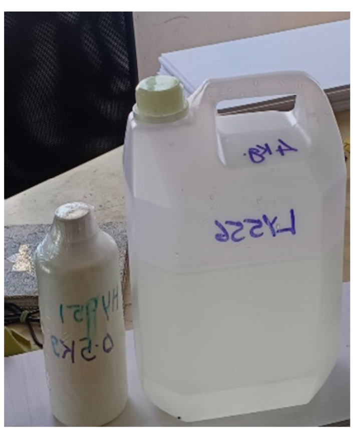
The creation of composite was finished by the strategy for hand layup procedure. The hand layup procedure comprises of a shape of aspect 200x 280x 3 mm. the shape is made of glass. This guarantees the surface is optically plane and smooth. Subsequently, it gives a decent completion and consistency to the composite. The strategy incorporates essentially, utilization of shape discharge wax. For this situation oil jam was utilized as delivering specialist. Fig 3 is displayed mould preparation and composition details of matrix, The delivering specialist helps the simpler expulsion from form. The petrol jam is clumsy with the sap utilized; accordingly, it won't prompt any response.

a) Mould prepared from plane glass

b) Hybrid resin poured into the mould surface

c) Mixed resin and hardener

d) Luffa biochar filler



e) LY 556 Hardener

f) PALF composite after demould

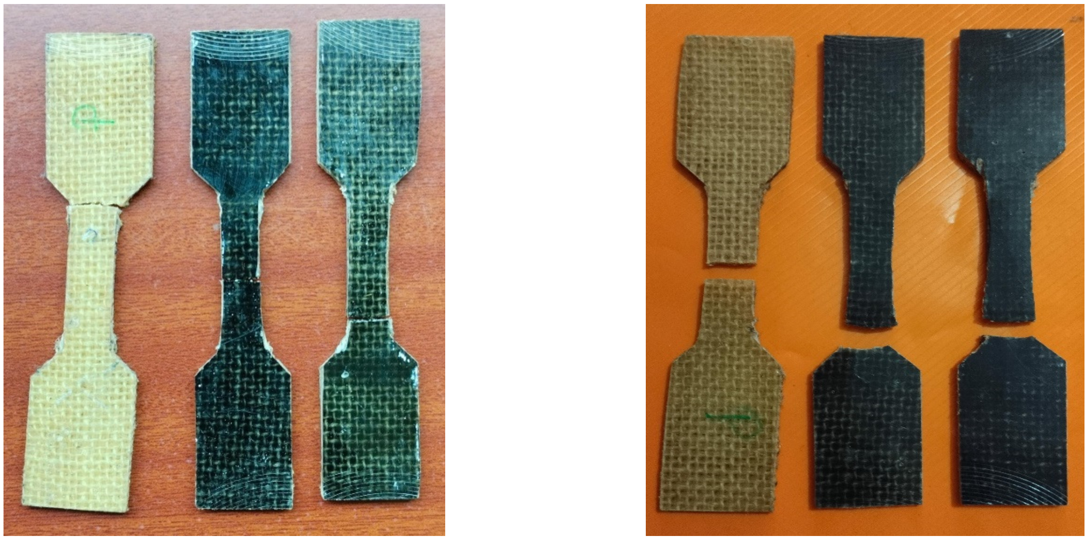
S. No	Epoxy resin (%)	Polyester resin (%)	Filler ratio (%)	Fiber ratio (%)
1	45	25	3	30
2	45	25	5	30
3	45	25	8	30

Fig.3 Composite laminates fabricated in the present study

2.2. TESTING METHODS

2.2.1. Tensile strength

Automobile parts ought to have the option to bear dead and dynamic burdens. elasticity is the limit of a material or design to endure loads having a tendency to lessen size. The rigidity was investigated with ASTM D 638. The examples were square molded of aspects 254x25.4x3 mm. The UTM office that was accessible at Anna college, Chennai. The diversions brought about by applying a load while immovably holding the example are estimated. After an example bombs under a foreordained power, its definitive elasticity is recorded until the heap is taken out [33]. Documentation of elastic anxiety is made, as well as diagrams showing how burden and length connect with one another.



Before test After test

Fig.4 Tensile test specimen before and after test

2.2.2. Thermogravimetric analysis

A gadget alluded to as a warm gravimetric analyzer is utilized to perform thermogravimetric investigation (TGA). A thermogravimetric analyzer consistently gauges mass as an example's temperature changes. In thermo quantitative examination, mass, temperature, and time are viewed as premise estimations, while numerous extra measures might actually be acquired from these three base estimations. A warm gravimetric analyzer is regularly comprised of an accuracy offset with an example dish within a heater with programmable temperature control. To cause a warm response, the temperature is commonly raised slowly (or, at times, keeping a steady mass loss is made due). The warm response can occur in various conditions, including encompassing air, vacuum, latent gas, destructive or carburizing gases, fluid fumes, or "self-created environment." In the examination of polymers, TGA is utilized. TGA is especially preferred to assess the warm soundness of polymers since polymers commonly soften before they breakdown. Before 200°C, most of polymers liquefy or disintegrate. TGA can be utilized to look at a class of thermally stable polymers, which are ready to endure temperatures of no less than 300°C in air and 500°C in idle gases without primary changes or strength misfortune. Use was made of the Anna university college, Chennai.

2.2.3. Scanning electron microscopy (SEM)

The messed-up surfaces of the tensile specimens were dissected utilizing a Hitachi SU 3500 SEM. The finishes of the wrecked examples were managed down to under 10 × 10 × 3 mm3, and a homogeneous covering of carbon and gold was applied to their surfaces. The voids, fiber pull-out, texture lattice interface, reliable blending of filler materials, and glue property conduct between the support and network stages were totally recognized through morphological testing [38-41].test was finished in forevision instruments at Hyderabad.

2.2.4. Interlaminar shear strength (ILSS) test

UTM conducts the ILSS examination as per the prerequisites of ASTM: D2344. It is utilized as an action of value affirmation for covered progressed composites. In layered materials, it addresses the most elevated shear pressure conceivable between the singular layers. Fig.5 shows the example after ILSS test.

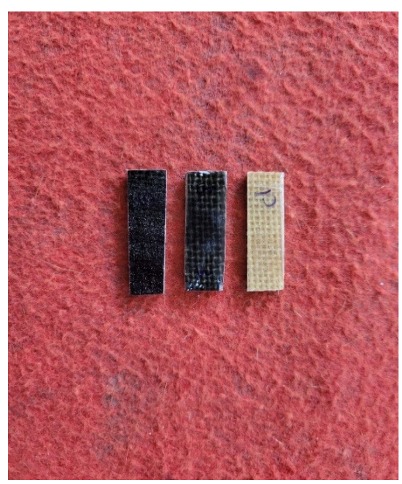


Fig.5 Interlaminar shear test Rig & Sample's

3. RESULTS AND DISCUSSIONS

3.1 Tensile strength

The elastic attributes of the composite L1, L2, and L3 examples are assessed utilizing the UTM, and the outcomes are shown in Fig 6. The superior rigidity noticed for covers L1and L2 contrasted with L3 can be ascribed to the compound treatment of the pineapple strands. The unrivaled elasticity of L1 (36 Mpa), L2 (38 Mpa) and L3 (41 Mpa). This finding is reliable with past examinations on salt treated normal filaments, which showed worked on elastic properties because of the expanded crystallinity and degree of polymerization of the cellulose. Notwithstanding, the perception of diminished elasticity with delayed or higher portion synthetic treatment is in accordance with different reports, where unreasonable delignification and fiber harm can happen, driving to a decrease in mechanical properties. This features the significance of upgrading the treatment conditions to accomplish the ideal fiber adjustment without settling the fiber respectability. These examinations featured the capability of pineapple fiber with half breed pitch and luffa biochar filler as a feasible and financially savvy option to traditional materials in different applications, for example, energy retaining designs and lightweight composites [15-16]. Fig.6 is shown tensile strength results.

S. No	Specimen	Ultimate tensile strength (Mpa)
1	L1	36
2	L2	38
3	L3	41

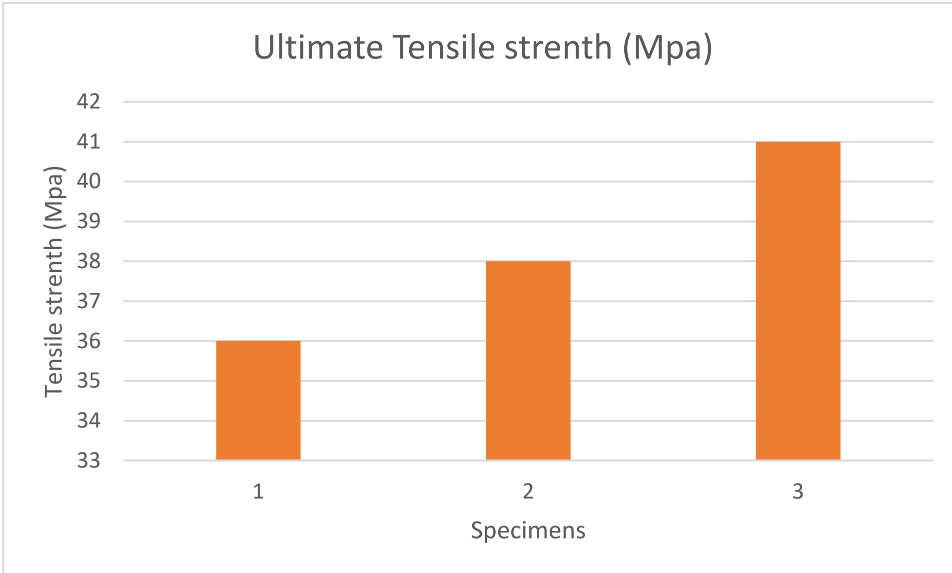


Fig.6 Ultimate tensile strength (Mpa)

3.3. Thermogravimetric analysis

The thermogravimetric examination was finished at blended climate of N2 and O2. The example was of 10mg and was warmed up to 550° C and the mass part lost was determined. The underlying weight reduction was because of volatilization of dampness and low unstable parts. The TGA of 3 % and 5% of filler not set in stone since different creations were closed to be passive in characters when contrasted with 8% of filler. The unadulterated epoxy (3 % filler) had deterioration at 398° C while the 5% of filler began breaking down at 298°C. this is because of the singing of items that are available in the regular filaments. Since the warm disintegration of hemi cellulose it is available in the temperature scope of 150-200°C. The disintegration of cellulose (200-230°C) and decay of lignin happens from 300-350°C. Likewise, the remaining mass was 5.27% in unadulterated epoxy and half-breed pitch (3% filler) while the lingering mass in 5% of filler was diminished to 1.27 %. The unadulterated epoxy (5% filler) in autonomous terms were more steady to warm deterioration however the supported epoxy was not because of the portion being was normal fiber which is warm less steady. The singing of parts has brought about lower remaining mass and thus the 5% of filler was less thermally stable when contrasted with unadulterated epoxy. Fig.7is shown results of TGA analysis.

Sample of luffa biochar filler (%)	Sample of epoxy resin (%)	Residual mass (%)	Temperature (°C)
3	45	10.21 %	772.6
5	45	16.25 %	780.5
8	45	21.22 %	794.4

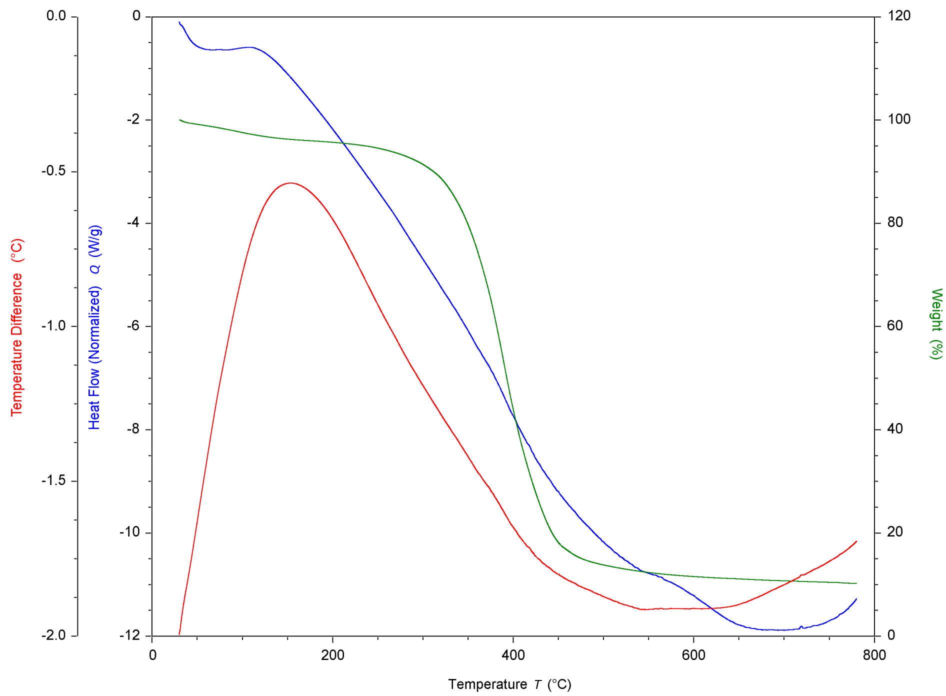


Fig.7 Results of Thermogravimetric Analysis

3.4. Morphological Analysis

While performing mechanical testing on fiber built up materials, a SEM (Fig. 8) can give significant data about the material's hidden construction through miniature underlying investigation. Due to the solid combination that occurred between the framework and the fiber, the PALF couldn't strip away, which brought about an expanded limit with respect to the lattice to move pressure. It tends to be seen rather obviously from Fig.8 that the fiber breaking and take out happened under a malleable stacking condition with complete snatching fiber groups. This can be reasoned from the way that the fiber packs were totally seized. From the micrographs, it was likewise seen that, less significantly, between facial voids were produced, which is something that could have occurred during the manufacture cycle. The luffa biochar filler with crossover pitch epoxy polymer based composite overlays show fundamentally well between facial glue conduct and a more de-holding nature than epoxy-based covers, and this could be the clarification for their sub-par mechanical execution. Fig.8 is a SEM picture that portrays an untreated luffa composite. This composite displays weak disappointment because of fiber breakage, fiber tear, and the expanded modulus of the PALF in the network. Disappointment in the example occurred because of fiber pulling out and fiber tearing. It very well may be gathered that the presence of less voids, further developed attachment between the strands and lattice material, and further developed fiber breaking and take out conduct in composite covers are factors that add to the obtaining of helpful mechanical properties.

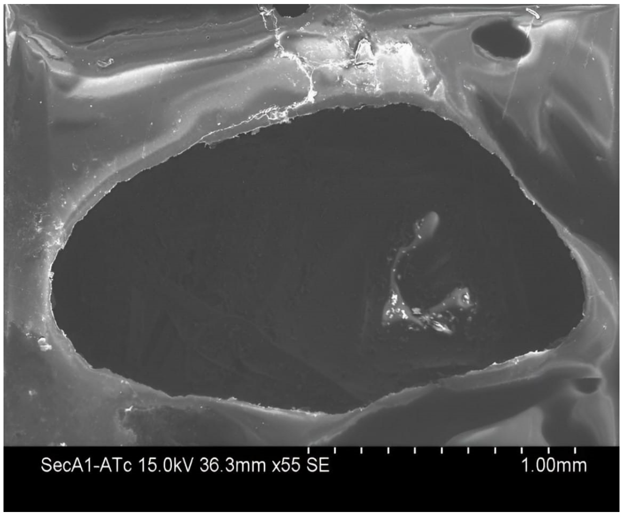


Fig.8 SEM results for Specimen L1

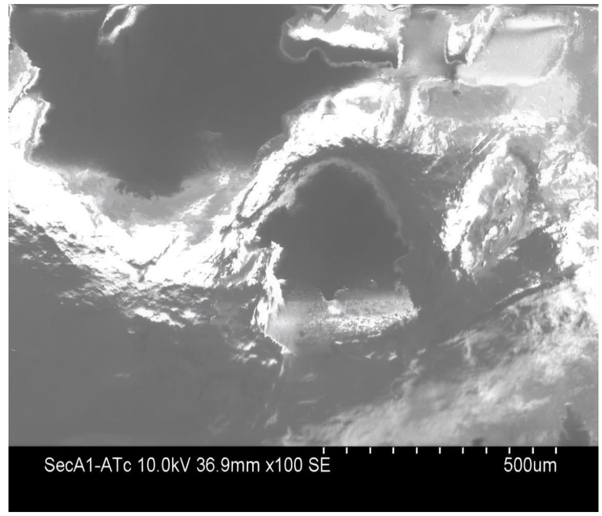


Fig.8 SEM results for Specimen L2

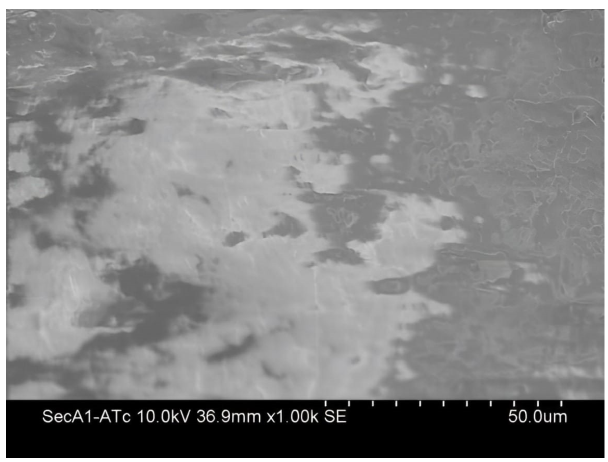


Fig.8 SEM results for Specimen L3

3.5. Interlaminar shear strength (ILSS) test

The aftereffects of the ILSS estimations for the different composite blends are displayed in Fig.9. The higher interlaminar shear strength (ILSS) noticed for cover L3 (12.85 N/mm2) contrasted with L2 (esteem not gave) and L1 (6.61 N/mm2) can be credited to the superior fiber-grid interfacial attachment worked with by the the PALF filaments in L3. Prompting better mechanical interlocking and expanded similarity with the framework material. This superior interfacial holding considers more effective pressure move from the lattice to the filaments, coming about in higher ILSS values, as seen on account of L3. The better ILSS of L3 over L2 (expecting L2 has a lower ILSS than L3) can be credited to the more powerful expulsion of hemi-cellulose and lignin from the filaments by the NaOH treatment. This finding is predictable with past investigations that have detailed higher ILSS values for antacid treated regular fiber composites moderately high ILSS worth of L3 (12.81 N/mm2). This is a typical issue seen in regular fiber-supported composites, where the hydrophilic idea of the filaments and the absence of similarity with the hydrophobic polymer lattices lead to unfortunate pressure move and diminished mechanical properties [6, 7]. Past exploration has shown that the ILSS of normal fiber composites is exceptionally reliant upon the fiber-framework interfacial holding, which can be worked on through different surface medicines, like antacid treatment, silane treatment, or the utilization of coupling specialists. These medicines upgrade the fiber-network grip as well as advance better scattering and wetting of the strands, further adding to the improvement in ILSS. It is quite significant that the ILSS values detailed in this study are practically identical to or much higher than those revealed for other regular fiber-built up composites, featuring the capability of PALF strands as a successful support material [48-52].

S.No	Samples	Inter laminar shear strength (N/mm2)
1	L1	6.61
2	L2	8.40
3	L3	12.85

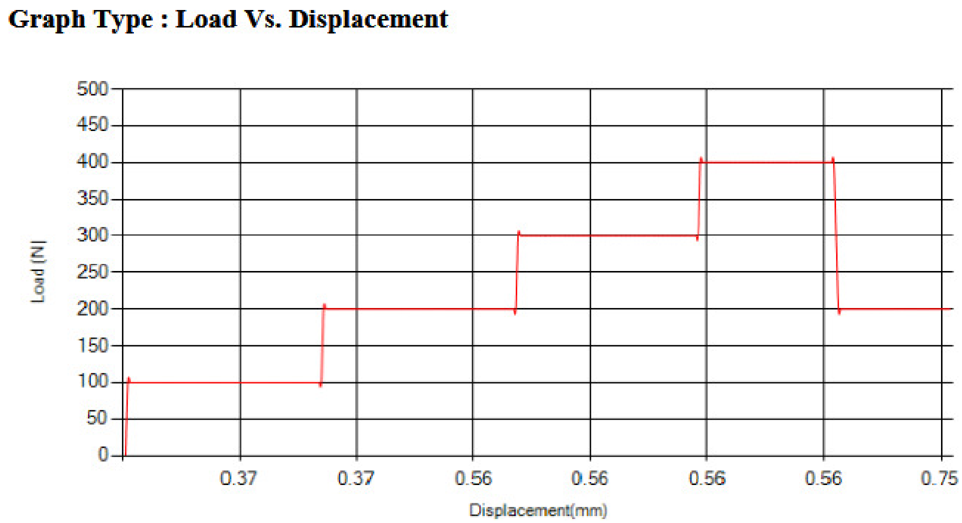


Fig.9 Result of interlaminar shear strength

4. conclusion

This study was centered around the properties of Pineapple Leaf filaments (PALF) built up from hybrid resin epoxy polymer composites for vehicle interior parts applications. The pineapple leaf strands were an expected swap for engineered and non-biodegradable warm applications that are of significant expense and heavier in thickness. The 8% biochar filler showed the most un-warm conductivity of 794°C. In the event of elasticity, the 8 % PALF biochar filler accomplished 40 MPa. Hence, it can bear the dead and dynamic loads that happen during its lifetime. Likewise, the interlaminar shear strength was seen to be 12.85 MPa. The filaments were adjusted unidirectionally to accomplish the ideal properties and flexural strength. The hand - layup procedure likewise empowered the creation to be more centered so the normal design of filaments was not squashed.

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