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Research Article

Dynamic Mechanical Analysis of Banyan/Ramie Fibers Reinforced with Nanoparticle Hybrid Polymer Composite

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Natural fibers are an increasing potential alternative to synthetic fibers in recent research, due to their unique properties and weight ratio in composite materials. In this work, the banyan mat and ramie mat are used as reinforcement phase and the epoxy polymer is used as matrix material, and granite nanoparticles are used as filler for making composite laminates. The two phases of reinforcing and matrix were taken at an equal ratio of 50% in each, and the conventional hand layup process was fabricated making five different sequences of laminates. In this analysis, the dynamical mechanical properties of this hybrid composite are identified with the erratic weight ratio of banyan mat and ramie mat fabrics. The results revealed the maximum storage modulus is 1580 MPa at 93.8°C and a loss modulus of 298 MPa at 93.8°C in sample A, 12% more storage modulus, 17% more loss modulus was obtained in sample A compared to sample B, and 29% E' and 27% E'' more compared to sample E and also using storage modulus, loss modulus, damping factor are the viscoelastic behavior which can reveal the glass transition temperature of hybrid composite laminates by conducting dynamic mechanical analysis, and SEM test was used to identify the failure mode of hybrid composite.

1. Introduction

Fiber has been reliably utilized in development since the beginning of the twentieth century. During the 1960s and 1970s, the utilization of fibers from asbestos diminished the consciousness of the medical issues brought about by the long-haul substantial presentation of these airborne fibers [1]. Aramid is a sweet-smelling polyimide that is a man-made natural fiber for composite reinforcement and is the most generally recognized manufactured fiber. Aramid has excellent mechanical capabilities at low thickness, as well as the added benefit of sturdiness or resistance to harm/sway. When compared to glass and carbon, they are said to have a sensible high elasticity, a medium modulus, and an unusually low thickness [2]. Unidirectional sheets are thin, and different layers are required for most auxiliary applications. Conventional applications for unidirectional reinforcement incorporate profoundly weighted strategic composites, for example, aviation machine parts or race vehicles [3]. The mechanical properties of the material under various loads applied and the conduct of auxiliary reaction of an example can be dissected and examined. Aluminum silicon carbide metal matrix composites are utilized in different fields like aviation, airplanes, submerged cars, the substrate in hardware, golf clubs, turbine cutting edges, and brake cushions [4]. High-throughput robotized methods are these days assuming a key job in polymer composite assembling in various enterprises, for example, cars and aviation. There is a need to deliver high-volume parts effectively; computerized tape layup and mechanized fiber conditions can create composite parts proficiently, and with the approach of added substance production, the intricacy of these segments is expanding [5]. Several factors, including fiber quality, modulus, and fiber length, determine the mechanical properties of a typical fiber-strengthened composite and orientation, as well as the quality of the fiber-network interfacial bond. The developed composite was made of neem/banyan fibers that can be used to improve the dynamical behavior when increasing banyan fiber loading, and the results revealed banyan woven fabric can improve the storage modulus average of 5% compared to chopped neem fiber [6]. High mechanical characteristics of composites require a robust fiber-lattice interface connection. A good interfacial connection is necessary for successful pressure transfer from the lattice to the fiber, allowing the composite to make the most of its fiber quality. The mechanical qualities of common filaments, such as flax, hemp, jute, and sisal, are outstanding, and they may even outperform glass fibers in terms of explicit quality and modulus. The thickness of every one of the overlays and water retention properties are additionally assessed. The six covers of banana and E-glass fabrics of measurement $240 \times 240 \times 3\,mm^3$ are created by hand layup and vacuum stowing strategy. The impregnation of the covers is finished by utilizing polyester tar as the lattice material. At last, relieving is done in the autoclave for 4 hours at 70°C [7, 8].

Dynamic mechanical properties of unidirectional banana/jute mixture fiber-fortified composites and contrast and single characteristic fiber-strengthened composites. The physical and dynamic mechanical properties of the natural fiber composites were acquired by testing the composite for thickness, tensile, flexural, between-laminar shear effect, hardness properties, and viscoelastic properties of the hybrid composite. Consolidation of the filaments into an epoxy grid brought about an expansion in mechanical properties up to 30 wt% of fiber loading. It is discovered that the hybrid composite gives empowering results when contrasting with individual fiber composites; the morphologies of the composites are likewise contemplated by the SEM process, respectively [9]. Due to hybridization and the reduction in hydrophilic nature by the surface treatment process, 10 wt percent ramie (R)/10 wt percent kenaf- (K-) based epoxy composites with 5 wt percent benzoyl chloride treatment (T) showed good mechanical properties with an ultimate tensile strength of 37.39 MPa, an ultimate flexural strength of 63.53 MPa, and impact strength of 70.36 J/m [10]. The filler substitutes fill in the gaps between the fiber and matrix phases, improving the characteristics. The use of TOPSIS for multiresponse optimization revealed that hybrid SP had the most impact on the overall tribological properties of natural fiber composites, with rank 1 being the most important, followed by filler incorporation [11]. Filler mixing improves fiber/matrix adhesion and increases mechanical characteristics. Filler addition also improved the flexural and impact characteristics by up to 22.11 percent and 21.77 percent, respectively. The application of filler powders explains the good bonding nature of the SEM data. The presence of silica and other inorganic components in the polymer composites was confirmed by EDX, which improved the characteristics [12]. The outcomes indicated the improvement of intractable and flexural properties (quality and modulus) of COIR/epoxy composites by hybridization with pineapple leaf fiber, up to 50 vol%. The crossover composites strengthened with equivalent volume substance of pineapple leaf fiber (PALF) and coconut husk fiber (coir) have the most elevated tractable flexural and sway quality. The water retention test uncovered the decrement in sorption fondness with the expansion of coir fiber content. The crossover composite (P50-C50) assimilates 62% and 32% less water than that of unadulterated PALF/epoxy and COIR/epoxy composites [13, 14]. To lift the dynamic usage of common fiber-strengthened composites in basic applications, it is incredibly required to elevate the properties of NFRC by the utilization of a hybridization device. The major outcome to conduct the dynamic analysis revealed the mechanical and viscoelastic properties of thermosetting polymers, thermoplastic polymers, and elastomers of the hybrid composite. Three basic components make up the reinforcing process in particle-filled polymers. Chemical links between polymer chains provide a material with a more rigid structure and, ultimately, a better defined shape. The first is size-independent and involves replacing a fraction of low stiffness polymers with more rigid particles. The second involves stress transfer into nonspherical particles as a result of shear stress developed at the particle-matrix interface, and the third involves chain stiffening as a result of dynamical and parking restrictions at the segment scale, which are both strongly correlated with particle size [15]. The banyan fiber contains more mechanical properties and effective life, which is used to increase the mechanical stability, and the ramie fibers are quite increased to develop composite sections for replacing the synthetic fiber materials [16]. Traditional continuum mechanics cannot be employed with polymers because of their very nonlocal deformation behavior. Instead, higher-order elasticity combined with molecular dynamics has been proposed as a feasible framework to use with amorphous materials [17]. The storage moduli curves for woven PET (PP) and interlaced PET/hemp hybrid (PH) composite specimens started to decline earlier than woven hemp (HH) and interlaced hemp (IW) PET/hemp hybrids (HP). Increasing the temperature over the set-point Tg produces a material transition from one state to another. To change from a glassy to a rubbery state. A composite's constituents in the glassy condition are densely packed and highly concentrated, immobile, and have high intermolecular interactions that contribute to their mobility with a larger modulus of storage. As the temperature rises, the molecule mobility increases and molecular bonding relaxes, resulting in a loss of stiffness and thus a decrease in the storage modulus value. Furthermore, the maximal storage modulus of the composite is reached in the rubber zone, which appears at 100°C and above, since the epoxy resin becomes unstable, dynamical analysis can generate data to define the dynamic mechanical properties of woven and interwoven hybrid composites, which can be utilized to replace concrete, steel, and wood reinforcements in industries such as construction and automotive [18, 19].

The above literature was used to identify the objective of this study which is related to banyan and ramie fibers which are selected as reinforcement and epoxy polymer resin with hardener selected for the matrix phase and granite fine particles used by way of plaster and to construct the hybrid composite through hand layup technique and further to analyze the viscoelastic behaviors of storage modulus, loss modulus, and damping factor this natural fiber hybrid composite by dynamic mechanical analysis and identify the failure mode by conducting scanning electron microscopic experiment.

2. Materials and Methods

2.1. Materials Used. The hybrid composite laminates were developed thru banyan woven mat fabric, ramie fiber mat, and granite nanoparticles along with the epoxy polymer, banyan woven fabric, and ramie fiber mat extracted from a natural source by retting process and it was supplied by Go Green Industry Chennai, India, and the filler material of granite nanoparticles was supplied by Dacss Granite Krishnagiri, Tamil Nadu, India. The matrix material of bisphenol A diglycidyl ether and HY951 hardener was supplied by Javanthee Enterprises, Chennai, India. The general properties of the materials used in this research are given in Table 1, and the chemical properties are given in Table 2. The characteristic attribute of thermosetting polymeric epoxy polymers is cross-linking. Cross-linking is almost always irreversible, and the resulting thermosetting material will deteriorate or burn if heated. Once a substance is cross-linked, it is extremely difficult or impossible to recycle it, especially in the case of commercially used plastics. However, if the cross-link bonds are sufficiently different chemically from the polymer bonds, the process can be reversed in some situations. The connection between μ and Tg was found to be significantly linear in the materials studied for epoxy composites. The cross-link density is calculated by using the equation $\mu = dN/(1.5\,M_c)$, where μ is cross-link density, N is Avogadro's number, and M_c is the prepolymer molecular weight.

2.2. Fabrication Process and Testing of Composite Laminates. The use of natural fiber from a plant for the application of renewable sources in developing composite materials has gained attention over the last decades, and natural fiber polymer composites (NFPC) are generally prepared by the encapsulation of a polymer matrix layered with natural fibers. A void is a pore in a composite material that is not filled with polymer and fibers. Voids are usually the product of poor material manufacture and are generally considered undesirable. Due to the entrapped air from resin mixing (such as bubbles in the resin) that is not eliminated before curing, voids are common in composite materials. Depending on the manufacturing procedure, the trapped air may be found in resin films or liquid resins. For thermoset composites, the most popular way is to use a vacuum bagging system in conjunction with a pressure and heat autoclaves. This works because the vacuum system physically removes the voids from the system [20]. The mechanical behavior and material properties of these nanocomposites using two-step micromechanical homogenization procedures in an energy-based approach that incorporates the strain-displacement relationships of a shear deformable beam, plate, and shell theory. The impacts of various nanofillers are discussed in depth, presenting readers with the most effective ways to improve nanocomposite stiffness [21]. These thermoset plastics are generally cross-linked polymers using heat, pressure, or irradiation. Hence, the structural properties of the thermoset polymers possess high flexibility, modulus, and tensile properties [19]. In this work, the composite laminates of 45% of reinforcement, 5% of filler, and 50% of matrix materials were contained and it was fabricated by hand layup technique with five different sequences of weight fractions of banyan/ramie fibers 250 g/50 g, 200 g/100 g, 150 g/150 g, 100 g/200 g, 50 g/250 g, and 30 g granite nanoparticles used in all samples; the stacking sequence of banyan/ramie fibers are shown in Figure 1 and to quantify the effects of dynamic mode of composite laminates.

The fiber materials of ramie mat and banyan mat were selected for reinforcement and to improve the basic strength and withstand more than the atmospheric temperature of the composite by incorporating the filler material of granite nanoparticles and to increase the bonding between the fibers, fillers by adding the matrix material of epoxy resin with a hardener ratio of 10 : 1 can improve the curing time which is used to reduce the porosity due to atmospheric condition [22]. The materials are prepared as per the fiber volume fraction and by using a steel mold 30 cm × 30 cm box to fabricate the composite laminates; initially, the box has been cleaned and liquid wax was applied for avoiding damage to the laminates during the laminate removal stage and applying the predefined epoxy matrix with filler blended thoroughly by using a magnetic stirrer and then applied the matrix as the first layer on the mold box for bonding between the fibers and good surface finishing by composite laminates, then keep the first layer of ramie fiber mat following with epoxy matrix and the second layer of banyan fiber mat was kept and each layer of fiber material contains 50 g, and the sequence is repeating as per formulated layers of composite sample A and the actual and micro images of banyan, ramie fibers and fabrication process as shown in Figure 2.

After the complete fabrication process, the laminates are compressed by 10 kg weight for 24 h and then removed from the mold box, and the sample can be used for dynamic testing [23]. The process has been repeated for all five samples, and the weight fractions of composite laminates are given in Table 3. The fiber volume fraction for these composite laminates is calculated by using the formula as in [23]

$$V_f = \frac{\left(W_f/\rho_f\right)}{\left(\left(W_f/\rho_f\right) + (W_m/\rho_m)\right)}, \qquad (1)$$
$$V_f + V_m = 1,$$

where V_f is the volume of fiber, V_m is the volume of the matrix, W_f is the weight of fiber, W_m is the weight of matrix, ρ_f is the density of fiber, and ρ_m is the density of matrix.

The banyan and ramie fibers were fabricated to examine the storage modulus, loss modulus, and damping factor as a

Table 1: Physical properties of ramie and banyan fibers [16, 17].

Properties	Ramie fiber	Banyan fiber	Granite particles
Category	Natural fiber	Natural fiber	Ceramic filler
Type	Bidirectional woven fabric mat	Bidirectional woven fabric mat	Nanopowder
GSM	200	200	—
Fiber diameter	0.241 mm (average)	0.196 mm (average)	100 μm (average)
Density	1.50 g/cc	1.69 g/cc	2.65 g/cc

Table 2: Chemical properties of banyan and ramie fibers [17].

Properties	Ramie fiber	Banyan fiber
Cellulose (%)	68.6-76.3	70-76
Lignin (%)	0.6-0.7	3.9-5.9
Moisture (%)	7.5-17.2	6.3-12.7
Hemicellulose (%)	13.1-16	19.2-21.5
Pectin (%)	1.9	0.8
Wax (%)	0.3	0.7

Figure 1: The stacking sequence of hybrid composites.

function of temperature variation, and the experiment was conducted with a single cantilever mode DMA as per ASTM E831-03 standard. The composite samples were prepared as per the standard $25 \times 10 \times 4\,\text{mm}^3$ in each sample of A to E, and this experiment revealed 2% of deflection during the mode of atmospheric temperature from 28°C to 200°C. The viscoelastic behavior of this composite can take from this experiment and examine the storage modulus, complex modulus, loss modulus, and tan delta of the hybrid composite as identified [24]. Tested samples of the hybrid composite are shown in Figure 3.

3. Results and Discussion

3.1. Storage Modulus (E') of an Epoxy Composite. In this work, dynamic mechanical analysis was conducted on the hybrid composite to examine the viscoelastic behavior of laminates. The viscoelastic properties are storage modulus, loss modulus, and tan delta. Figure 4 shows the storage modulus of banyan/ramie fiber laminates. The storage modulus (E') is the most important feature in determining a composite's load-bearing capability since it reflects the elastic component of the viscous elastic material. It also provides information on material toughness, grade of crosslinking, and fiber/matrix interfacial attachment [25].

The solid region indicates that composite laminates are bonded with other materials which are significant properties of all samples; this dynamic mechanical analysis can reveal the developed composite bonding capacity during the increasing of temperature with viscoelastic behavior of hybrid composite [26]. As the ratio of crystalline to amorphous regions increases, cellulose fiber stiffness increases, and flexibility declines. While increasing crystallinity provides more strength, lowering crystallinity means more elongation, more water intake, and more chemical reaction sites available and the degree of long-range order in a material, which has a significant impact on its quality. A polymer's chains are more regularly aligned, the more crystalline it is. Hardness and density rise as the degree of crystallinity increases [27]. However, in this composite, the laminates are amorphous materials, and the above graph revealed, the storage modulus of all samples, the graph between storage modulus and the temperature was used to identify the elastic region of the hybrid composite, and the results have shown that sample A contains more stiffness and has high elastic properties compared with other samples. Sample A consisting of more amount of banyan mat was given significant storage modulus and stiffness over other samples, when increasing this banyan fiber quantity along with ramie fiber and epoxy matrix was given good elastic behavior of composite laminates. Recently, researchers have attempted to decipher the chemical mechanisms that lead to a large increase in elastic modulus when the nanofiller content exceeds the matrix Tg. Mechanical contributions are the primary source of reinforcement in nanofilled glass polymers. At longer durations or higher temperatures, the contribution of molecular stiffening becomes critical and due to substantial chain confinement via interaction with filler surfaces at considerably lower filler content than predicted using uniform particle spacing, random particle packing is critical for boosting chain incremental stiffness [28]. The maximum storage modulus of 1580 MPa was identified during the temperature of 93.8°C and a minimum of 290 MPa at 185°C, and when initiating the experiment at 28°C, the storage modulus of 580 MPa in sample A, which indicates a 12% higher stiffness contained in this sample A at the temperature of 93.8°C compared with sample B which contains 200 g of banyan and 100 g of ramie fibers (2 : 1). Sample E has a 29% lesser storage modulus compared with the sample ratio and different fibers of composites in sample A. Therefore, when increasing the fiber mat of banyan was given significant results in this mode dynamic analysis. The graph also revealed the solid-state, glass transition region and rubbery region of epoxy composite laminates, the starting temperature of 28°C to 80°C having a solid region of all composite laminates, and at a similar period, the glass transition temperature covered at 80°C to

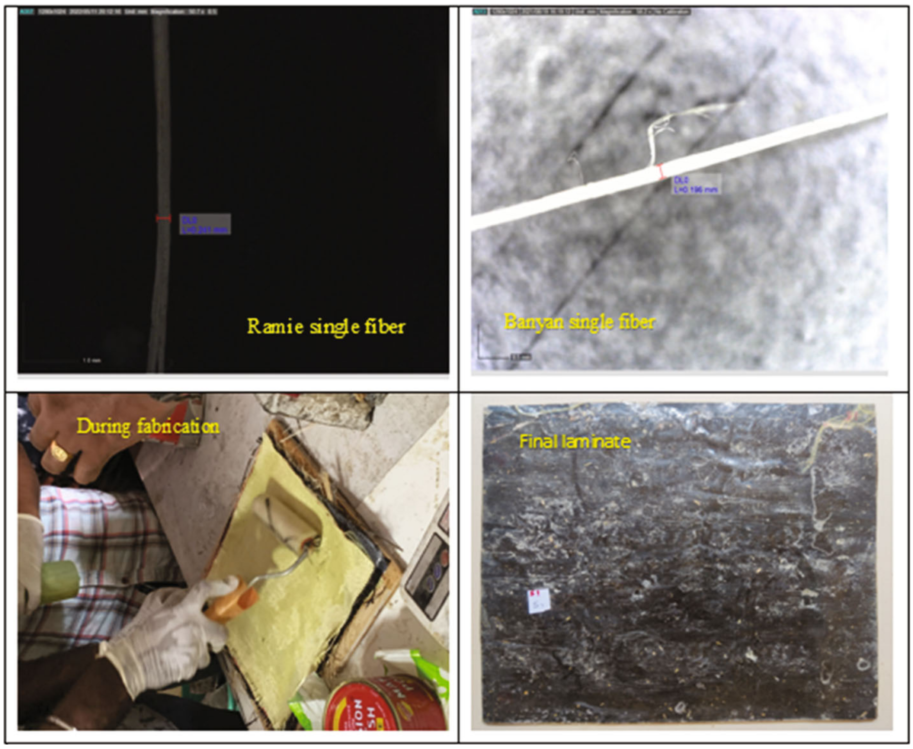

Figure 2: The fabrication process of composite laminates.

Table 3: The weight fraction of ramie/banyan fiber composite laminates.

Sample	Epoxy matrix in g	Granite powder in g	Volume of matrix (%)	Banyan fiber mat in g	Volume of banyan fiber (%)	Ramie fiber mat (%)	Volume of ramie fiber (%)	Laminate weight in g
A	330	30	50	250	37.5	50	12.5	660
B	330	30	50	200	30	100	20	660
C	330	30	50	150	24	150	26	660
D	330	30	50	100	17.5	200	32.5	660
E	330	30	50	50	10.3	250	39.7	660

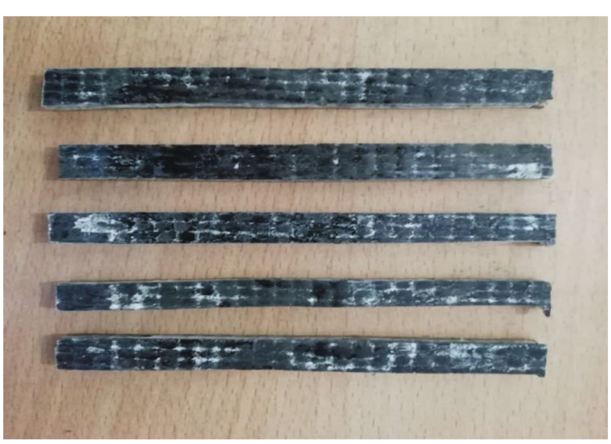

Figure 3: Tested samples of hybrid composite.

110°C of the hybrid composite; after this temperature, the materials move to the rubbery region which was identified from this dynamical analysis. In another work, a composite made of neem and banyan fibers indicates the significant storage modulus of 1150 MPa with more amount of banyan woven fabric, and the chopped neem fiber breaks early when increasing temperature [29]. Pure epoxy has E' of 449 MPa at 25°C and drops to 596 MPa at 120°C when it passes through the glass transition (Tg). The results show that the reinforced fiber significantly reduces modulus drop when traveling through Tg. At 120°C, hybrid composites (bamboo) B : (kenaf) K: 50 : 50 had the greatest E' with 133 MPa, while hybrid composites B : K: 70 : 30 and B : K: 30 : 70 had similar E' with about 76 MPa. In hybrid composites B : K: 50 : 50, the greater E' in the rubbery zone indicates a stronger fiber/matrix interfacial connection allowing stress transmission from the matrix to the fibers [30]. Therefore, the ramie fibers and granite particulates play an important role in this composite laminate, because the banyan fibers are blended with ramie fibers and granite particulate was identified with a maximum storage modulus of 1580 MPa compared with the above work with 27% more stiffness of this hybrid composite. The sample containing an equal amount of banyan and ramie fibers was identified with a 21%

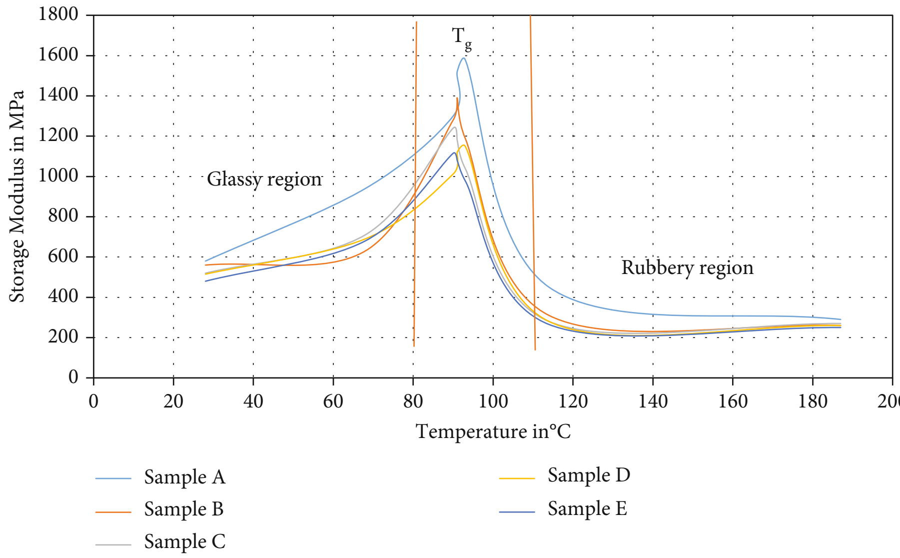

Figure 4: The storage modulus of the epoxy composite.

lower storage modulus compared to the sample A, which indicates when the increasing of banyan fiber weight, the fraction of ramie fiber shows the positive influence of composite laminates. The storage modulus of all samples was decreased with increasing temperature due to the loss of stiffness at more temperatures in the hybrid composite. The free volume of the component grows as the temperature approaches the glass transition area and the molecular mobility increases. The modulus of the glass transition zone drops dramatically; as a result, there were no apparent changes in E' in the rubbery region.

3.2. Loss Modulus (E'') of an Epoxy Composite. The loss modulus revealed the viscous behavior of the hybrid composite and the amount of heat dissipation during the temperature increase by the dynamical analysis. The loss modulus of the developed natural fiber-reinforced hybrid composite will be determined using dynamic mechanical analysis. The heat debauchery of the composite throughout the pressure cycle is defined by the loss modulus, which also specifies the viscous possession of the hybrid composite [29]. The loss modulus of epoxy hybrid composite laminates is shown in Figure 5. In this experiment, five different sequences were selected to quantify the loss modulus by conducting this DMA, and the results show the viscous response and heat dissipation with peak values during the temperature increasing from 28°C to 200°C; the samples are having moderate loss modulus up to 80°C, and once it reached glass transition temperature (Tg), all samples are having high viscous and peak height also more during the temperature between 80°C and 105°C. However, sample A shows a high loss modulus of 298 MPa at 93.8°C; this sample A during the initial stage 140 MPa of loss modulus was identified, and when increasing the temperature, the solid material of composite laminates moves to the glass transition temperature and dissipates high heat to their temperature limit of 105°C and then it moves to the rubbery region and the loss modulus also get reduced to lower value of 40 MPa. Similar work has been carried out using the epoxy matrix without any reinforcement to analyze the dynamic property of epoxy matrix loss modulus given 258 MPa at the glass transition temperature of 79°C. This result shows that the epoxy matrix has a high range of energy dissipation when compared to the composite fabricated with fiber reinforcement [30]. In sample B containing 200 g banyan fiber and 100 g ramie fiber remained the supreme loss modulus of 280 MPa, and this result is 17% lower than sample A; it can indicate that an increase of 7.5% ramie fiber weight fraction in total composite laminates was given the negative influence of loss modulus compared with sample A.

Therefore, the banyan fiber properties have significant viscous compared with ramie fiber during the polymer matrix composite and the other samples C, D, and E also were given a similar response when the increase of banyan fiber weight fraction was identified to improve in loss modulus and dissipating high heat compared with ramie fiber loading of composite. This can be used to determine whether the adding of the usual fibers consumed resulted in an upsurge in free volume and the continuation of the procedure in the polymeric matrix's construction [28]. In the sample, C shows a 20% lower loss modulus during the operating temperature and it can be reduced when increasing the temperature; maximum loss modulus achieved in sample C is 272 at 90.2°C. The difference between the initial stage in peak height is 12% reduced and 10% during the rubbery region in sample C. This sample C was identified with 8% less loss modulus at 90.2°C when compared with sample A during the same peak height temperature of composite laminates. This is evidence that adding natural fibers increases internal friction, which increases the dissipation energy, as documented by other researchers [29]. Among the five samples, sample E was given the lower loss modulus of 215 MPa during the maximum peak height at 91.1°C and it was 27% less than sample A; therefore, when the enhanced fiber loading of banyan was given a positive influence on the viscous behavior and heat dissipation energy at glass transition temperature compared with ramie fiber loading of this polymer composite laminates. The molecular

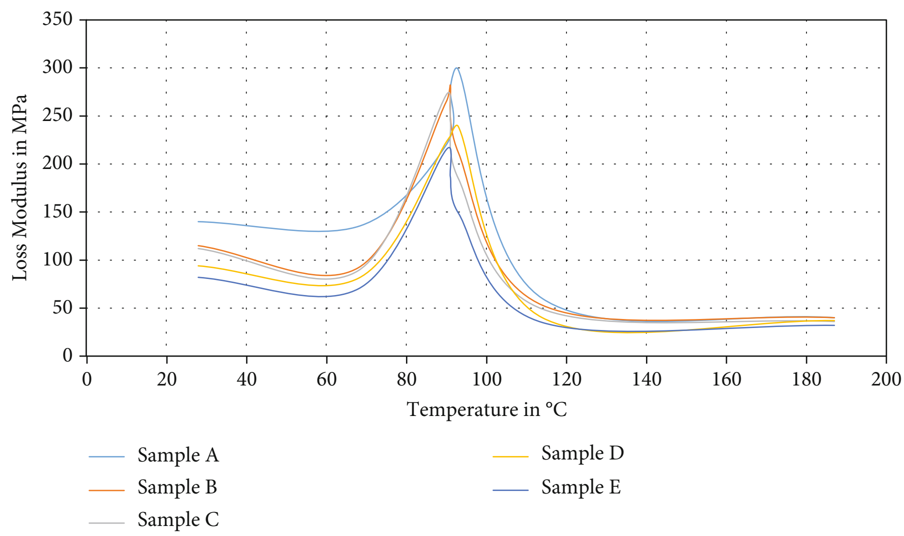

Figure 5: The loss modulus of an epoxy composite.

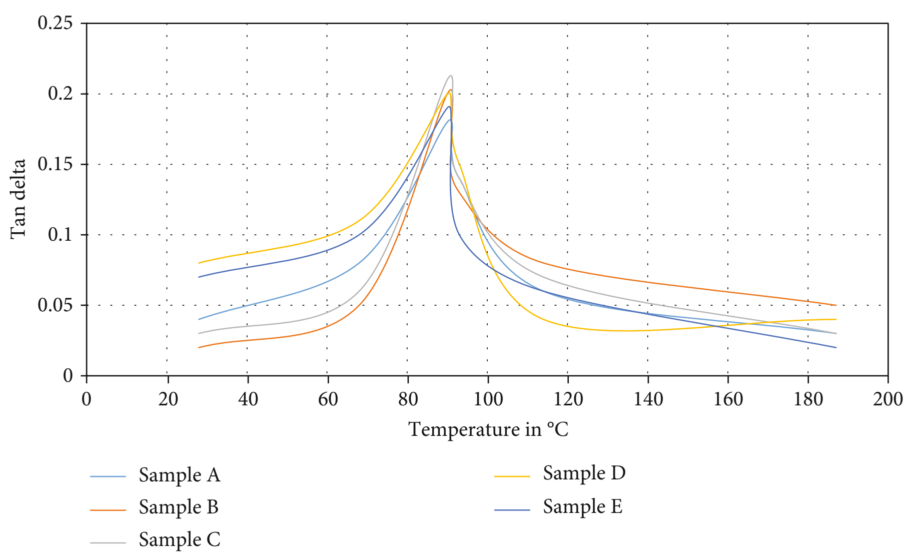

Figure 6: The damping factor of an epoxy composite.

segmental motion is activated as the temperature approaches the glass transition area. When the sample's timescale molecular motion collides with the mechanical deformation, the result is the highest conceivable internal friction and nonelastic deformation [30].

3.3. Damping Factor of Epoxy Composite (tan δ). The graph between tan delta with temperature is shown in Figure 6. The damping factor denoted as tan δ is used to identify the damping capacity of composite laminates, tan delta is the ratio between the storage modulus to loss modulus, and it can reveal the material behavior during their rubbery region. tan delta represents the ratio of elastic (E') to viscous (E'') properties. A high number imply that there is a lot of energy dissipation and, as a result, a lot of nonelastic deformation; on the other hand, a low value shows that the material is more elastic. The tan delta rose with increasing temperature, reaching a maximum in the transition zone before progressively decreasing in the rubbery region. This is because the molecules in the composites are packed tightly and frozen below Tg. The free volume and molecular mobility both rise in the transition area. The molecules in the rubbery zone can move easily with little resistance to the flow; hence, the damping in this region is low [29]. The higher or broader the glass transition behavior, the greater the limitations on the amorphous phase. The highest peak breadth is observed in composites with larger fiber loading, the graph shows increasing the temperature to the response of material damping properties in sample A having more solid material compared with other samples, and the energy dissipation also has a significant peak height and

Table 4: Data of dynamic mechanical analysis.

Properties	Sample A	Sample B	Sample C	Sample D	Sample E
Storage modulus (E') in MPa	1580	1390	1240	1150	1115
Loss modulus (E'') in MPa	298	282	272	239	215
Damping factor (tan δ)	0.18	0.20	0.21	0.20	0.19
Tg (°C)	93.8	91.6	90.2	93.1	91.1

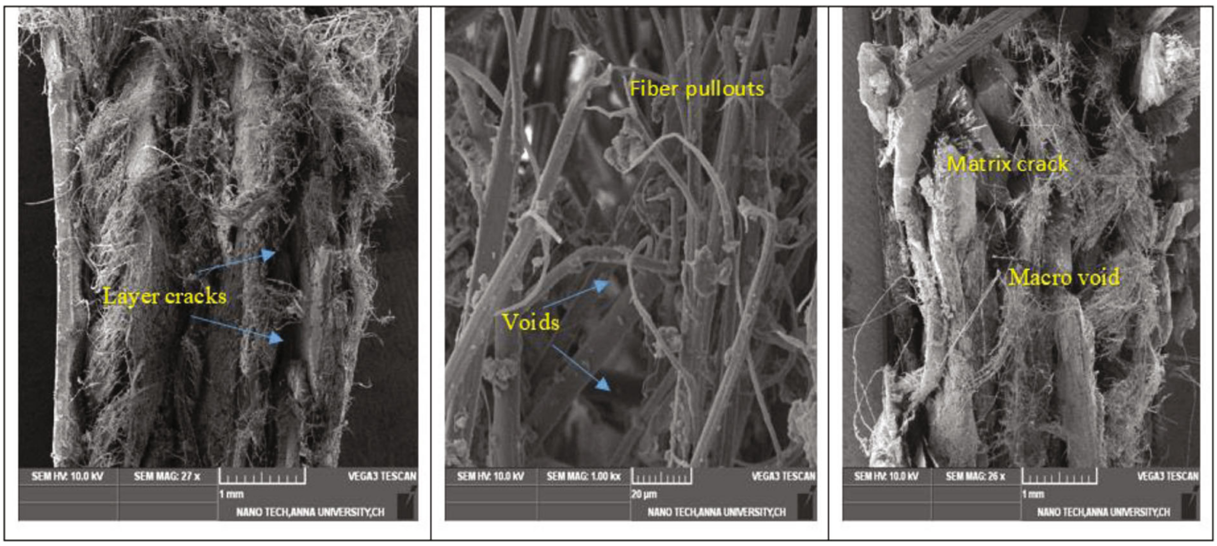

Figure 7: SEM image of hybrid composite.

sample E is showing the more rubbery region and it can indicate the ramie fiber loading is having high elastic property compared with banyan fiber loading.

The tan delta value of sample A during the initial temperature of 28°C is 0.24, and it can be decreased when increasing temperature during the solid-state condition, when the material is having the damping factor of 0.14 and it moves to the glass transition temperature of 80°C to 105°C the value of tan delta range is 0.18 to 0.21. Therefore, it indicates that the banyan fiber loading revealed more solidness of composite laminates when blended with ramie fiber and epoxy composite. In this experiment, the granite filler material was used and it can deliver more solid factors during increasing temperature in all five different samples; however, the fiber reinforcement was given the major impact of this hybrid composite during the dynamical analysis. In the sample, B was given the tan delta value of 0.20 at operating temperature and the same damping factor is continued with the maximum peak height temperature of 91.6°C, and then, it moves to the rubbery region; it reveals the material is more solid and takes more time to attain the elastic stage of the hybrid composite. In sample, C contains an equal amount of fibers placed and it can show similar results like sample B of the tan delta is 0.20 and the lower tan delta value is identified in sample E during their peak height of temperature at 91.1°C is 0.19 and this sample contains 50 g banyan fiber and 250 g ramie fiber loading of composite laminates. Therefore, when increasing the banyan fiber loading was given more solid behavior of the composite and at the same time when the increasing of ramie fiber loading can give more elastic region was identified from this tan delta graph also the granite powder can improve the stiffness of the epoxy composite. Dynamical properties of a pure epoxy matrix at Tg (°C) 79°C: E'—2358 MPa, E''—258 MPa, and tan δ—0.109 [27]. Data of dynamical analysis are given in Table 4.

3.4. SEM Morphology of the Hybrid Composite. The presence of lignocellulosic nature in PCF was confirmed by XRD and FTIR findings. After the addition of PCF, the mechanical test results showed a significant improvement in the characteristics [28]. SEM analysis revealed a drop in filler content, increased load conditions, and increased reinforcement, all of which resulted in larger surface deformations in the composites. The fiber and matrix contents are the most important factors that influence composite characteristics. They have the greatest influence on the composite material's mechanical properties. Although the rule of mixture is not completely accurate, it can be used to estimate the composite material's elastic properties. As a result, fiber and matrix contents are two critical features to assess [29]. The use of a higher weight percentage of banyan fiber in the development of hybrid composites resulted in fewer matrix cracks due to a more uniform stress distribution. Because of the higher level of stress concentration in the material, increasing the weight fraction of ramie fiber in hybrid composites resulted in a more complex level of cracks. SEM image of the hybrid composite is shown in Figure 7.

4. Conclusion

This research work evaluated the dynamic mechanical analysis of banyan fiber and ramie fiber reinforced with epoxy composite and identified the properties of storage modulus, loss modulus, and damping factor of hybrid polymer composite; this experiment was conducted for five different samples and the results were analyzed. The following are major findings of this composite laminates from this dynamical analysis.

(i) The natural fibers of banyan and ramie have significant bonding capacity with epoxy polymer matrix and the granite nanoparticles can improve the stiffness of all hybrid composite samples

(ii) In sample A, the results were improved in the storage modulus of 1580 MPa, due to the addition of more banyan fibers, which can improve the stiffness of the hybrid composite compared to ramie fiber loading

(iii) Similarly, loss modulus shows the viscous behavior of all five samples and sample A contains the high loss modulus of 298 MPa, and this result is an average of 15% higher peak height compared to other samples

(iv) The ramie fiber mat loading is high in sample E showing the damping factor of 0.19, and the rubbery region shows the composite laminates are more inelastic than other hybrid composite samples

(v) Therefore, the results of storage modulus, loss modulus, and damping factor of the tan delta are solidness and glass transition temperature more when increasing of banyan fiber mat layer and at the same time more ramie fiber loading was given the significant elastic property in the rubbery region of hybrid composite laminates

(vi) The dynamical behaviors of banyan/ramie fiber composite were used to develop a natural fiber composite helmet, and it can also be used to develop automobile car interiors due to their retaining capacity during higher temperatures

Data Availability

The data used to support the findings of this study are included within the article. Further data or information is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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