BIO-COMPOSITES: A STUDY ON BEHAVIOR OF OIL PALM MESOCARP FIBER REINFORCED KGG

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Abstract
The use of petroleum based non-degradable polymers and the effect of petroleum products directly impacting lives. Therefore, eco-friendly biodegradable composites are attracting more and more researchers. Biodegradable composites are prepared by using hand layup process using Kondagogu gum(KGG) resin with oil palm mesocarp fiber(OPMF) as reinforcement. Mechanical properties such as tensile, flexural, impact and Thermogravimetric (TG/DTA) of the composites are evaluated. The effect of fiber loading on the mechanical and thermal properties of the composite is also studied.

Keywords: Kondagogu Gum(KGG), Oil Palm Mesocarp(OPMF), NaOH, Mechanical & Thermal Properties.

1. Introduction
The day to day increased awareness of environmental issues based in natural fibers reinforced with plastic polymer composite has been the major priority in many industrial sectors. The ever-growing numbers of biocomposite researchers in each year are well aware of environmental issues. Every researcher is eager to find a solution and substitute traditional materials that can harm our world. Bio-Composites are good flexibility, highest stiffness and low-cost. Bio-composites are the top choice made by consumers and the limited supply of petroleum makes bio composites more popular. Various among natural plant proteins, natural gum, such as kondagogu gum, gum karaya, rosin,soy protein and wheat protein isolated(WPI) all are growing attention in scientific research and industry due to light access and low cost. India has major source of forest gums, namely, gum kondagogu (Cochlospermum gossypium), gum karaya (Sterculia urens roxb). Gum kondagogu belongs to the family of Bixaceae[1]. Substitute natural fibers in replacement of synthetic fibers, such as glass, and carbon are more recent much attention has been paid to tackle this environment issue [2]. Composites are mainly controlled by fiber/matrix interface and ability to transfer loads from matrix to fiber for find a mechanical properties. But the major tendency to apply a natural fibers, it absorbs moisture (hydrophilic) which is less interfacial bonding between matrix and fibre. According to them, Researchers suggest that surface modification techniques improve the interfacial bond between fiber & matrix through a chemical treatment process [3]. As for engineering applications biocomposites find an important place in environmental protection and developing less mass composites for automobiles, structural beams, packaging etc…. [4,5].
V.T.P. Vinod & R.B. Sashidhar Experimental work in the laboratory on this gum has resulted in a special identification of this gum KGG, compared to the well-established and commercially exploited gum karaya and KGG has unique properties as balanced to different gum trees [6]. Dani Jagadeesh et al. Scrutinize the best method conditions for preparing films from Wheat protein isolated (WPI) to Glycerol content was determined by changing 10 to 25% and glutaraldehyde from 0 to 40%. Various factors affecting the structure of these films have been examined by measuring their mechanical (tensile strength and extension), spectral and thermal properties and moisture content[7]. Xue Li et al. and K.obi Reddy et al. In this review, various chemical modification processes are reported to be used to develop compounds such as alkali, silane, acetylation, benzoylation, acrylation, maleated coupling agents, isocyanates, permanganate and other therapies. The interfacial bonding between the fiber surface and matrix may not only modify fibre surface and also improve the strength of fibre. Composites are less water absorption and developed their mechanical properties in the aim of chemical treatment[8,9]. V. K. Thakur et al. research work is focused on the effective use of lignocellulosic natural fibers as reinforcement using polymer resin as a novel matrix. Green composites were prepared using the compression molding technique with different fiber contents. The physico-mechanical and thermal characteristics of the different composite samples were investigated as a function of fiber contents [10]. K Raja Narender Reddy et al. obtained the results the effect of treated and untreated woven century fiber composites are investigated for evaluating their mechanical & thermal properties. Higher tensile, hardness, higher glass transition and thermal decomposition temperatures, and low water absorption properties are reported in alkaline-treated composites[11]. V.T.P Vinod et al. discussed Gum kondagogu (Cochlospermum gossypium), a natural biopolymer, was investigated to assess its solution native gum in aqueous condition, indicating a predominantly liquid-to-solid-like behavior and conformational properties of the gum were determined by deacetylated gum was thermally more stable than native gumand and various physico-chemical properties of this gum are yet to be characterized like scanning electron microscopy (SEM), differential scanning calorimetry (DSC), static light scattering (SLS) [12,13,14]. Jagadeesh Dani et al. biocomposites were prepared using wheat protein isolate (WPI) was cross-linked with glutaraldehyde in the presence of glycerol plasticizer. These polymer composites were subsequently subjected to evaluation for their mechanical, morphological (SEM), thermal (TGA/DMA) properties[15].

Come to the current study, natural gum was extracted from a plenty plants available in India forest, Kondagogu Gum. Kondagogu gum, scientifically known as “Cochlospermum gossypium”, is a newly-identified gum. Similarly natural fibre also extracted from locally-available plant, Oil Palm Mesocarp fibre (OPMF). The OPMF reinforced composites were prepared using KGG as the matrix and investigated their mechanical & thermal properties of the composite thus formed were evaluated as a function of fibre content and matrix in nature. These fibers were collected using simple manual water rewriting procedure prior to alkaline treatment and characterized by tensile, flexural, impact and Thermogravimetric (TG/DTA). The obtained results were then analyzed and compared with other prevalent natural fiber-based composites.
2. Experimental procedure

2.1 Materials

KGG powder (Grade-I) was procured from Nutriroma Pvt.Ltd, Hyderabad, India. Oil palm mesocarp fiber were obtained from 3F oil palm industries located at yernagudem, Devarapalle, West Godavari, Andhra Pradesh. V.T.P Vinod was reported by Analytical profile of gum Kondagogu, 6.1% Crude Protein (g %), 7.3% of ash (g %), Water binding capacity (ml/g) 35.1, pH-4.9 to 5.0[6]. Glutaraldehyde minimum assay is 25% was purchased from Narmada chemical industries, Kukatpally, Hyderabad. Glycerol about 98% purified and ammonia solution 25%, analytical grade sodium hydroxide (NaoH), HCL, deionized water were purchased from Rekha chemicals, Hanamkonda, Warangal, India.

2.2 Alkaline (NaoH) treatment

The chemical treatment of fiber is aimed at improving the adhesion between the fiber surface and the polymer matrix may not only modify the fiber surface but also increase fiber strength. Alkaline treatment or mercerization is one of the most used chemical treatment of natural fibers when used to reinforce thermoplastics and thermosets. The important modification done by alkaline treatment is the disruption of hydrogen bonding in the network structure, thereby increasing surface roughness. This treatment removes a certain amount of lignin, wax and oils covering the external surface of the fiber cell wall, depolymerizes cellulose and exposes the short length crystallites. For treatment process water by volume is taken along with 2% of NaOH mixed with water. The fibers are soaked in the water for 24 hours, figure1. (a) the red oil represents after removing of oil palm mesocarp fibre, then the fibers are washed thoroughly with distilled water to remove the final residues of alkali. Good bonding is expected due to improved wetting of fibers with the matrix. In order to develop composites with better mechanical properties and good environmental performance, it is necessary to impart fibers by chemical treatments.

Figure 1. Alkali treatment of oil palm mesocarp fiber (a) Red oil of mesocarp fibre (b) Treated fiber (c) Untreated or raw fiber
2.3 Preparation of resin

KGG gum was set up by utilizing a throwing technique we depicted beneath. To prepare a resin, the desired amounts of KGG powder was accurately weighed and dispensed into a clean glass beaker containing one liter (by wt. of 2.5 times KGG) of deionized water. Then entire solution was stirred upto 20-30 minutes with help of magnetic stirrer at the room temperature, and then desired amount of 1M NaoH & 1M HCl was added to neutralize the solution of gum. Contiguous incubation for 20 min, Glycerol & Glutaraldehyde weighed separately, mixed with 25-30% times (by wt. of KGG powder) to a final pH of 7.0-8.0 in figure 2. Different quantities glutaraldehyde was added as a crosslinking agent to increase the properties of tensile and thermal stability. To decrease the brittleness of the resin, glycerol was added in different proportions.

![Figure 2. Preparation of KGG Resin](image-url)
2.4 Fabrication of Composite

The bio-composite laminates were prepared at Kakatiya Institute of Technology & Science (KITSW) facility at Yerragattu gutta, Waarangal, India. Prior to the laminating process, extracted raw fibre of oil palm mesocarp to remove the excess of moisture and to prepare the random short fibre-reinforced composites, the OPMF were cut into lengths of 4mm, 8mm & 12mm as shown in Fig. 3(a). The hand layup process is used to prepare the composites, OPMF were subsequently added to the mixture which was evenly mixed before being placed on the mould as shown in Fig. 3(b). The fibres and resins are allowed to cure with in 24 hrs. The process was repeated for OPMF with length ranging from 4mm, 8mm & 12mm. The OPMF/KGG composite laminates were produced with fibre weight of 05, 10, 15% as shown in Fig. 3(c).

![Figure 3](image)

(a) Fiber cutting  (b) Composite Preparation  (c) OPMF/KGG Composites with different weight fractions

2.5 Analysis

2.5.1 Tensile test of the bio-composites

The tensile test specimens were prepared according to ASTM D638 standards. The tensile properties of KGG/OPMF randomly oriented bio-composites were studied an Zwick / Roell Z010 from the fig 4.(a) universal testing machine with a load of 10KN used for testing at a crosshead speed of 3mm/min maintaining a gauge length of 50mm. In each laminate three specimens were tested and the average values are reported for figure 4.(b) & (c), we determined the parameters of maximum stress, modulus, & % elongation at break.

![Figure 4](image)

(a) Universal Testing Machine  (b) After test  (c) Before test
2.5.2 Flexural test of the bio-composites

Flexural properties were characterized using a rectangular bar samples in an Zwick / Roell Z010 machine with a three point bending geometry at a crosshead speed of 5mm/min. The force was measured by a load cell of 10KN and the displacement determined from the movement of the crosshead. Test specimens were prepared and stamped in accordance to ASTM D790. The average values were calculated from three for each sample.

![Image of flexural test setup](image)

**Figure 5.** (a) Three point bending moment (b) Before test (c) After test (d) Dimensions of specimen

2.5.3 Impact test of the bio-composites

The Izod impact test was carried out according to ASTM D256 and supplier is Deepak poly plastic Pvt ltd, impact tester (IZOD/Charpy Impact Tester) used to determine the impact strength of specimens. The sample size is 127 X 12.7 X 3mm³. The average of three values were calculated from each sample.

![Image of impact test setup](image)

**Figure 6.** (a) Specimens placed on Impact test machine (b) Breaking specimens (c) Before test
2.5.4 Thermo-Gravimetric Analysis

Thermogravimetric analysis (TGA) is to understanding the thermal stability of composite materials. It also offers a more precise control of heating condition such as variable temperature range and accurate heating rate and needs only a small quantity of sample for analysis. Data are recorded as TGA curve of weight or weight percentage as a function temperature or time. The instrument used for this analysis is model NETZSCH, STA 2500 Regulus in NIT, Warangal. The samples were heated from 25 – 300 ºC, at heating rate 10ºC/min. For analysis purpose were done under flowing nitrogen at a constant flow rate of 20mL/min.

![Figure 7.(a) TGA (b) Specimens of TGA](image)

3. Results & Discussions

3.1 Tensile test

The strength of the fiber reinforced composites depends on the type of fiber, matrix, fiber length, fiber content and bonding strength between the fiber and matrix. Tensile specimens were tested in the FIE universal testing machine with a crosshead speed of 10 mm/min and the results are tabulated in Table. Yield force is the force where the material begins its permanent deformation. All the laminates have shown increase in the yield force, where mostly the alkaline treated laminates have more yield force when compared to their counter untreated laminates, this decrease in yield force for untreated fiber may be due to the presence of red oil and wax on the fiber which restricts the proper binding of the fiber with the resin, the yield force can even be increased by trying different available chemical treatments. From the figure 8.(a) shows among all the laminates the treated fiber of length 4mm with 10% of weight ratio laminate have more yield force, it can be observed that the yield force has decreased with the increase in the fiber length, as the composites are made of randomly oriented fiber there may be voids created in the laminates with the increase of the fiber length. All the laminates with 10% weight ratio of fiber have increased yield force when compared to 5% and 15% weight ratio of fibers.
The below graph figure 8.(c) is indicates a tensile strength of Oil Palm Mesocarp fiber at different lengths and weights of treated and untreated fiber. The above chart all the laminates have shown increase in the tensile strength, where mostly the alkaline treated laminates have more tensile strength when compared to their counter untreated laminates, this decrease in tensile strength for untreated fiber may be due to the presence of red oil and wax on the fiber which restricts the proper binding of the fiber with the resin, the tensile strength can even be increased by trying different available chemical treatments. Among all the laminates the treated fiber of length 4mm with 10% of weight ratio laminate has more tensile strength, it can be observed that the strength has decreased with the increase in the fiber length, as the composites are made of randomly oriented fiber there may be voids created in the laminates with the increase of the fiber length.

Mostly all the laminates with 10% weight ratio of fiber have increased tensile strength when compared to 5% and 15% weight ratio of fibers except some laminates this may be due to the improper lay-up of laminate or defect in the cutting of the specimen from the laminate which can be overseen as the 4mm length 10% treated fiber has more tensile strength. %Elongation of a material is the measure of its ductility. In composites with the increase in tensile strength there is decrease in % elongation both can be increased with some correction in the cross-linking agent. All the laminates have shown % elongation, where mostly the alkaline treated laminates have less % elongation when compared to their counter untreated laminates in most of the laminates. Among all the laminates the treated fiber of length 4mm with 10% of weight ratio laminate has very less % elongation, it can be observed that the % elongation has increased with the increase in the fiber length except for 8mm length fiber, from the tensile strength graph it is seen that 4mm length fiber has more strength and here it has less % elongation these both can be increased with the increase in the amount of cross-linking agent or by using other cross-linking agents.

Figure 8.(a) Yield force vs % fiber

Figure 8.(b) Tensile strength at treated and untreated fiber
Figure 8.(c) % elongation vs % fiber

From the figure chart 8.(d) shows a Modulus of elasticity measures the stiffness of material. All the laminates have shown increase in the modulus of elasticity, where mostly the alkaline treated laminates have more modulus of elasticity when compared to their counter untreated laminates, this decrease in elasticity for untreated fiber may be due to the presence of red oil and wax on the fiber which restricts the proper binding of the fiber with the resin, the modulus can even be increased by trying different available chemical treatments. Among all the laminates the treated fiber of length 4mm with 10% of weight ratio laminate has more modulus of elasticity, it can be observed that the modulus of elasticity has decreased with the increase in the fiber length, as the composites are made of randomly oriented fiber there may be voids created in the laminates with the increase of the fiber length, mostly all the laminates with 10% weight ratio of fiber have increased modulus of elasticity when compared to 5% and 15% weight ratio of fibers except some laminates this may be due to the improper lay-up of laminate or defect in the cutting of the specimen from the laminate which can be overseen as the 4mm length 10% treated fiber has very high modulus of elasticity.

After analyzing all the tensile testing results of the specimens it can be concluded that the 4mm treated 10% fiber has good tensile properties like Modulus of Elasticity is 65.44 N/mm², Tensile Strength@ Break is 2.19 N/mm², % elongation is lowest of all which is 3.8%, tensile strength at yield is 2.15 N/mm², yield force is 51.42N.

Note: **UM0405**: UM: untreated oil palm mesocarp fiber

**TM0405**: TM: Treated Oil palm mesocarp fiber

04 : Length of the fiber 04 : Length of the fiber
05 : Percentage of the fiber 05 : Percentage of the fiber
3.2 Flexural Test

Flexural strength is the bending strength of the material. All the laminates have shown increase in the flexural strength, where mostly the alkaline treated laminates have more flexural strength when compared to their counter untreated laminates, this decrease in strength for untreated fiber may be due to the presence of red oil and wax on the fiber which restricts the proper binding of the fiber with the resin. Among all the laminates, the treated fiber of length 4mm with 5% of weight ratio laminate has more flexural strength, it can be observed that the strength has decreased with the increase in the fiber length, as the composites are made of randomly oriented fiber there may be voids created in the laminates with the increase of the fiber length. mostly all the laminates with 5% weight ratio of fiber have increased strength when compared to 10% and 15% weight ratio of fibers except some laminates this may be due to the improper lay-up of laminate or defect in the cutting of the specimen from the laminate which can be overseen as the 4mm length 5% treated fiber has more flexural strength and it may be because of the presence of the high amount of resin which increases the hardness.

Stiffness at the initial step of the bending process is known as the flexural modulus, flexural modulus and tensile modulus are calculated individually for composites as they are nonhomogeneous materials. All the laminates have shown increase in the flexural modulus, where mostly the alkaline treated laminates have more flexural modulus when compared to their counter untreated laminates, this decrease in flexural modulus for untreated fiber may be due to the presence of red oil and wax on the fiber which restricts the proper binding of the fiber with the resin.

Figure.8(e) flexural Strength vs % fiber

Among all the laminates the treated fiber of length 4mm with 5% of weight ratio laminate has more flexural modulus, it can be observed that the flexural modulus has decreased with the increase in the fiber length, as the composites are made of randomly oriented fiber there may be voids created in the laminates with the increase of the fiber length. mostly all the laminates with 5% weight ratio of fiber have increased modulus when compared to 10% and 15% weight ratio of fibers except some laminates this may be due to the improper lay-up of laminate or defect in the cutting of the specimen from the laminate which can be overseen as the 4mm length 5% treated fiber has very high flexural modulus. After analysing all the flexural testing results of the specimens it can be concluded that the 4mm treated 5% fiber has good flexural strength which is 1.28 N/mm².
3.3 Impact Strength

The impact strength of the OMPF/KGG bio-composite laminate is tested using impact testing machine. Izod impact test is carried out to analyze the impact energy observed by the OMPF reinforced with KGG bio-composite laminates. The impact testing machine gives the energy loss capability of the material to withstand suddenly applied load. The experiments are conducted with different length and wt% of fiber loading for OPMF reinforced natural fiber composite (see Figure 8(f)). The figure indicates that the increase in length of fibers increases the impact energy which leads to the impact strength. The figure also indicates that the increase is observed only up to 12mm treated length and 5% weight of the laminates, further increase in wt% does not show any improvement in the impact strength of OPMF/KGG bio-composite laminates. From the analysis of the above, it has been asserted that the treated 12mm and 5wt% of composite laminates is performing, better than the other Untreated and treated different length and weight percentage considered. The impact energy normally increases with the increase in length of the treated fibers. It is found that the impact force is uniformly distributed in the unidirectional fiber reinforced composites. In 12mm treated length and 5% weight of composites, the increases in length of the fiber content with sufficient distribution of the matrix leads to the proper crack path and absorb maximum impact energy. Based on the experimental analysis, we are observed treated bio-composites 12mm length fiber and 5% fiber have highest impact strength (i.e 834.64 J/m²) then compared to a overall untreated fibers and the least impact strength 4mm 15% fiber (i.e 135.17 J/m²).

![Impact strength comparison for different length and weight fractions of OPMF/KGG bio-composites.](image)

Figure 8 (f) Impact strength comparison for different length and weight fractions of OPMF/KGG bio-composites.
3.4 Thermogravimetric Analysis (TGA)

Thermogravimetric (TGA) analysis curves as a function of the temperature of treated & untreated Oil palm mesocarp fiber (OPMF) reinforced Kondagogu gum resin (KGG) with the variation of fiber length and wt% are given in Figure 8(g). Thermal decomposition of the composites takes place in the temperature range 25 °C to 300 °C. The percentage of mass temperature curves are shown in Figure 8(g), which shows that increased treated 4mm length (TM0410) fiber content and decreasing remaining fiber, there is also a reduction in the mass loss as a function of temperature.

![Figure 8(g) TGA analysis in treated and untreated fibers of different length and wt% OPMF/KGG bio-composites](image)

The TGA result in weight loss with respect to the temperature of treated and untreated fiber comparison in different length and wt% was illustrated in Figure 8(g). From the experimental analysis treated 8mm length 10% weight of laminate(TM0810) is shows the best results compared to all increased in length and wt% of the treated and untreated laminates. The better results it shows from the treated laminate(TM0810) temperature of 60°C the composite loses only 1.8% of the initial weight, with 120 °C the weight loss is already 8.1 % of mass that corresponds to the removal of solvent KGG in the matrix. Between 150°C and 250 °C the weight loss was approximately 33.63 % due to degradation and volatilization with OPMfibers present in the biocomposites. After that, the composite maintains a linear mass loss up to 300°C, where the final residue is only 51.76% of the original mass. The thermal degradation for all composites display a three-step degradation process, where the first stage is attributed to the decomposition of KGG resin, the second stage is attributed to the decomposition of OPMF fiber and the third step is attributed to the decomposition of Additives(Glutaraldehyde and glycerol).
According to the derivative thermogravimetric (DTG) curves in Figure 8(h), the bettered results are shown from the graph the treated 12mm length and 05% wt of laminate(TM1205) is shows a very less derivative weight loss in comparison to all untreated and treated (TM0415) 4mm length and 15% weight of the fiber is shows the highest derivative weight loss (4mm, 8mm & 12mm length of fibers). Let us explaining (TM0415) in the treated 4mm length and 15% wt of the laminate of small degradation peaks were detected between 213 °C to 230 °C due to decomposition of the organic elements in the composite. The second stage around 240 °C to 267 °C due to decomposition of the hemicellulose constituents of the OPMF content, while the third step degradation between 270 °C to 300 °C shows the decomposition of the bio composite components. From the DTG curve displayed a similar trend for Tm0405 to um1215 around this temperature due to more amount of fiber content.

![DTG analysis in treated and untreated OPMF/KGG bio-composites](image)

**Figure.8 (f) DTG analysis in treated and untreated OPMF/KGG bio-composites**

**4.Conclusion**

This study concerns the characterization of the mechanical and thermal properties of treated and untreated OPMF/KGG biocomposites. The conclusions we obtained from this investigation are as follows:

1. The alkaline-treated fibres are superior strength compared to that of the untreated fibres; tensile testing results of the specimens it can be concluded that the 4mm treated 10% fiber has good tensile properties like
Modulus of Elasticity is 65.44 N/mm², Tensile Strength@ Break is 2.19 N/mm², % elongation is lowest of all which is 3.8%, tensile strength at yield is 2.15 N/mm², yield force is 51.42N. The tensile modulus for 4mm untreated fiber increased and decreased with the increasing weight ratio and the same behaviour is exhibited by the treated 4mm fiber. this may be due to the improper distribution of the fiber. The treated 4mm fiber has increased values when compared to untreated 4mm fiber due to the decrease of hydroxyl and carboxyl in the treated fiber which increases the binding capacity and the load transfer capacity of the fiber. The 8mm untreated fiber has decrease in values when compared its treated one here to it showed an increase and decrease behaviour and the overall values are less when compared to 4mm fiber, the behaviour of 12mm fiber is also same as the above fiber and its overall values are less than 4mm and 8mm length fibers.

2. The flexural strength decreases linearly with increase in length and wt% of fiber. The overall result analysis in treated and untreated analysing all the flexural testing results of the specimens it can be concluded that the 4mm treated 5% fiber has higher strain rate is observed and good flexural strength which is 1.28N/mm². The flexural modulus for 4mm untreated fiber increased and decreased with its increasing length and its values are lesser than the treated 4mm fiber and in it the modulus decreased and increased with increasing length, the same behaviour is exhibited by 8mm and 12mm treated fiber. Oil palm mesocarp is a lignocellulose material, hydroxyl and carboxyl groups are present in cellulose and hemicellulose of the fiber due to which it shows poor adhesion and decrease in load transfer. So, the chemical treatment of the fiber increases the binding and load transfer capacity of the composite

3. The impact energy increases linearly with increase in length and wt% of fiber. When all the bio composite specimens are observed treated mesocarp fibre of 12mm length and 5% fibre have highest impact strength (ie 834.64 J/m²) and 4mm 15% fiber have least impact strength (ie 135.17 J/m²). Among all the untreated mesocarp specimens 4mm length and 10% of fibre specimen have the highest impact strength (ie 656.16 J/m²) and 4mm length 15% fibre have the least impact strength (267.71 J/m²). In the comparison of treated bio-composites 12mm length fiber and 5% fiber have highest impact strength (i.e 834.64 J/m²) then compared to a overall untreated fibers and the least impact strength 4mm 15% fiber (i.e 135.17 J/m²).

4. From the TGA analysis we revealed that treated laminate is TM0810 very less weight loss of mass degraded to comparison of all untreated laminates, similarly differential thermal analysis (DTA) demonstrated that the differential weight loss as a function of time is 0.53% at 149ºC. upto 172ºC, the sample exhibited an endothermic stage. From the analysis, it can be concluded that the crystallisation temperature of the OPMF/KGG bio composite is 213ºC. The lowest peak at 228ºC indicates the melting temperature of bicomposites. After that the fibre exhibits an exothermic in nature as it will release the energy of heat and decrease to a maximum peak level.
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