

Investigation of mechanical behaviour of natural composites (snake grass and elephant grass) with poly lactic acid

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Abstract

The Poly Lactic Acid (PLA) is a completely biodegradable potential alternate of plastics applied in Civil infrastructural field because it posses very good “Ultimate Withstanding” properties. It can also be stated that hybrid fiber composite is having higher Mechanical and Physical characteristics compared with Mono fiber reinforced composite. Naturally existing Snake Grass (SG) and Elephant Grass (EG) reinforced PLA matrix fabrication is being narrated in this research article. By experimentation and analysis of results, it is proved that the Tensile strength, % Elongation, Flexural strength, Impact strength and Water absorption properties of SG & EG reinforced PLA composite is better than that of pure PLA Matrix.

Keywords: Poly Lactic Acid, elephant Grass, Snake Grass, mechanical properties, flexural properties.

1. Introduction

The use of natural fibers as reinforcement in composites has considerably increased during recent decades. Even though there is a very large variety of fibers, matrices and manufacturing techniques used to produce natural fiber composites. Presently Fibers that are available plenty in nature are finding most applications rather than the utilities of artificial Fibers because of its bio degradability, affordable price, less light and improved Mechanical and physical properties. In spite of high cost, few artificial fiber composites are now being applied in specific areas like aeronautical and military utilities. H.Anuar [1] stated in his article that PLA is a linear aliphatic thermo plastic polyester manufactured by the way of circular opening polymerization of Lactic Acid (LA) monomer which can be achieved from fermentation of renewable resources such as corn, sugar, beet, wheat, sugarcane or any starch-rich source material

J. P. Mofokeng, [2] examined it as being due to the incompatibility between the fibers and the matrix, which promoted micro crack formation at the interface as well as no uniform stress transfer due to fiber agglomeration in the matrix. The reports on this had indicated an increase in the thermal stability of the PLA in the presence of Fibers. Rafael A. Auras [3] gives the properties of PLA such as glass transition temperature (T_g) of PLA ranges from 50 to 80°C while the melting temperature (T_m) ranges from 130 to 180°C. K. Murali Mohan Rao, [4] had explained the extraction process of Elephant grass fiber and properties of elephant grass fiber. The tensile strength and the modulus of chemically extracted elephant grass fiber composites have increased by approximately 1.45 times to those of elephant grass fiber composite extracted by retting process. Kovier. K [5] researchers have reported the tensile properties of elephant grass fibers in literature. K. Ramanaih [6] narrated in this article about

information on thermo physical properties of natural fiber reinforced composites over and above room temperature. TP. Sathish Kumar narrated in the article [7] that the SG Fibers have been extracted by traditional water soaking process. B. Vijaya Ramnath [8] gives the details about the preparation of composites and matrix mixture ratio. Herrera-Franco and Valadez-Gonzalez [9] presented in their article that there is a vast improvement in Tensile properties in the case of small and breaking fibers rather than long and unbroken fibers. Rigoberto et al. [10] discussed in detail about the importance of natural fibers in this article. Sergio et al. [11] proposed that SG and EG natural fiber composites are being considered extensively as an alternative to the number of internal and external parts of automobile vehicles. M. Boobalan's [12] research was on the fabrication techniques of natural fiber composites at different compositions and detailed on the analysis part of Mechanical, Physical and Thermal characteristics of those composites.

VS Sreenevasan's [13] [14] work described the tensile, flexural and impact characteristics of roughly merged SGF composites. The Composites were manufactured using basic SG fibers including the differencing fiber by volume and mass %. of fiber analyzed the micro structural, physic-chemical and mechanical properties of SCFs. K. Murali Mohan Rao [15] described in this article on Test procedures for finding Tensile strength, Flexural strength and then compared with composites which are made under laboratory conditions. N.Venkateshwaran [16] determined Tensile, flexural, impact and water absorption behaviors of fiber composites were carried out by optimum fiber length and weight percentage. Kasama and Nitina [17] studied the effect of glass fiber hybridization on properties of sisal fiber-polypropylene composites. Incorporation of glass fiber increases the mechanical, thermal and water resistance properties.

Recent studies in respect to mechanical behavior of reinforcement fibers in composites show that these materials can present structural and non-structural applications. The compression and

injection molding processes were performed in order to evaluate the better mixer method for fiber and matrix. In this research article, the complete process fabrication of composites and PLA matrix reinforced with SG and EG at different volume fractions by water soaking process. With these specimens, experimentations have been conducted to check Tensile strength, Flexural strength, % elongation, Impact strength and Water absorption properties.

2. Materials

2.1. Natural fibers

A natural fiber is a nature bound in fibrous materials, especially cellulosic types such as cotton, wood, grains, and straw used for textile products or other industrial purposes. Apart from the economic considerations, the usefulness of a fiber for commercial purposes is determined by such properties as length, strength, pliability, elasticity, abrasion resistance, absorbency, and various surface properties. There are two major groups of natural fibers which are in present use. They are fibers from animals and fibers from vegetation plants. Usually vegetation plants are cheaper and easily available for reach.

2.1.1. Elephant grass fiber

Elephant grass (Botanical term: Pennisetum purpureum) is nothing but a long grass. Origin of this plant was Africa in the early 20th century. It was cultivated along the river bed and Lake slides and grow upto 300 cms long. Colour is pale yellow. Stem at the base is having 2.5 cms diameter and leaves are as long as 100. The extracted elephant grass fiber is shown in fig. 1(a). Although the elephant grass is renewable and it is available abundantly in the nature, its potential and economical source could be compared to other fibers which are still underutilized. The physical and Mechanical Properties of Elephant grass fiber is shown in Table 1.

2.1.2. Snake grass fiber

In south zone of our country, Snake Grass fiber is recently introduced fiber which is extracted by water soaking technique. The Properties of Snake grass fiber is shown in Table 1. For achieving improved mechanical and physical properties, the technical parameters that influences being the lignin, pectin and angle of micro fiber. The extracted elephant grass fiber is shown in fig. 1(b). In this, micro fibril angle of SG is lower in comparison with other fiber. Adhesiveness property of fiber is depending on the Lignin availability in the fibers.

Table 1: Properties of Elephant Grass and Snake Grass Fibers

Fibers	Density (kg/m ³)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Elongation %
Snake Grass	887	287-545	9.7	2.87
Elephant Grass	817.53	185-327	7.4	3.23

Table 2: Mechanical Properties of Poly Lactic Acid (PLA)

Material	Density (g/cm ³)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Elongation %	Melting Point (°C)	Glass Trans. Temp (°C)
PLA	1.9	50	3.5	6	160	60

2.2. Poly lactic acid (PLA)

PLA is a biodegradable and bioactive thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in United States and Canada), tapioca roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). In 2010, the PLA was the second highest consumption volume of any bio

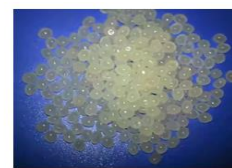
plastic of the world. The properties of PLA are given in Table 2. The name "polylactic acid" does not comply with IUPAC standard nomenclature, and is potentially ambiguous or confusing, because PLA is not a polyacid (polyelectrolyte), but rather polyester. The pelletized PLA is shown in Fig. 1(c).



a) Extracted elephant grass fiber



b) Extracted snake grass fiber



c) PLA

Fig. 1: Materials

3. Preparation of composites

The Poly Lactic Acid 3051D is round compressed model and Elephant Grass are being manufactured by Natural Fiber Industries in Salem. Length and diameter are the critical parameters of Fiber. Fibers were cut by the 3mm average length for preparing composites. The PLA and the SG/ EG fibers were kept in a furnace at 120°C for about 300 minutes before put in use. Composition of PLA and Fiber are given in Table 3. With the help of the machine Brabender Plasti-Corder type 814402, Poly Lactic Acid, Snake Grass and Elephant Grass fibers were fabricated by Extrusion process just after doing conventional mixing at 185°C. Then this rounded compacted composite was put in the process of recrystallisation at 120°C for 30 minutes. Afterwards this

composite underwent injection moulding process at 185°C. In this process the test specimens are prepared in the size of 25 x 2.5 x 0.3 cms for conducting Tensile, Flexural, Impact and Water absorption experimentations.

Table 3: The Formulation of Composites Prepared

Composition	PLA	Fiber
1	90	10
2	85	15
3	80	20
4	75	25
5	70	30
6	100	-

4. Experimentations and analysis

4a. Experimentation for finding strength on Tension test

The Test specimens are prepared as per the standard ASTM D3039 corresponding to different compositions as prescribed in Table 3. Series of tests have been conducted to find Tensile strength, % Elongation and Breaking point. The size of specimen is machined a standard size of 25 x 2.5 x 0.3 cm. The schematic diagram of tensile test specimen is shown in fig. 2(a). The tests were carried out using a kalpak universal testing machine. It has the specification of KIC 2-1000-C maximum capacity 100KN. Required test samples are manufactured based on SG and EG fiber composite. The findings have been consolidated based on the 6 similar experimentation samples.

4b. Experimentation for finding flexural strength

The Test specimens of 12.5 x 1.3 x 0.3 cm have been prepared as per the standard ASTM D790 which are shown in figure 2b and

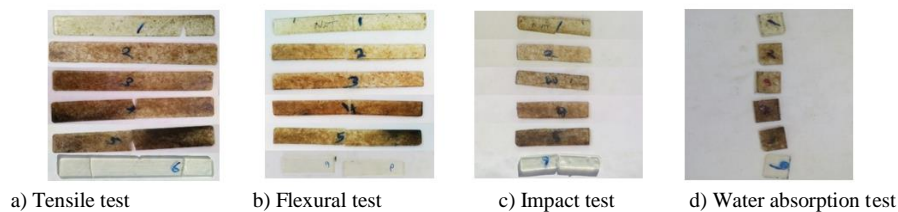


Fig. 2: Tested Specimens

5. Tests outcome and discussions

5.1. Tensile characteristics

From these Tensile test experimentations, results have been taken for calculating the stress and strain with respect from PLA matrix upto PLA with 30%vf. These values had been used to plot the graph which is depicted in figure 3. From the trend of the curve it goes, it resembles the behavior of brittle nature with elastic

the series of tests to different compositions as prescribed in Table 3 have been conducted in the same universal Testing Machine where the tensile tests were conducted to find Flexural strength and Bending modulus.

4c. Experimentation for finding impact strength

The Test specimens of 6.5 x 1.3 x 0.3 cm have been prepared as per the standard ASTM D256 which are depicted in figure 2c and the series of tests to different compositions as prescribed in Table 3 have been conducted in the Impact Testing Machine with IZOD method and the readings have been recorded for further analysis.

4d. Experimentation for finding Water absorption strength:

Water absorption is evaluated in terms of weight increase the composite specimen immersed in water at 48 hours in room temperature as per freshly cut samples of dimension 20mm x 20mm x 3mm used for measure of water absorption. The tested specimens are shown in fig. 2(d).

characteristics. It is clearly shown in figure 3 that the Stress is increasing when the Strain is increased upto the PLA with 25% reinforcement. Afterwards it starts reducing.

Similarly from the figure 4a, it is evident that Tensile strength increases steadily for the increase in vf up to 25%. Then it starts reducing further when comparing with the pure PLA matrix.

Also from the figure 4b, it is evident that Elongation increases steadily for the increase in addition of vf up to 25%. Then it starts reducing further when comparing with the pure PLA matrix.

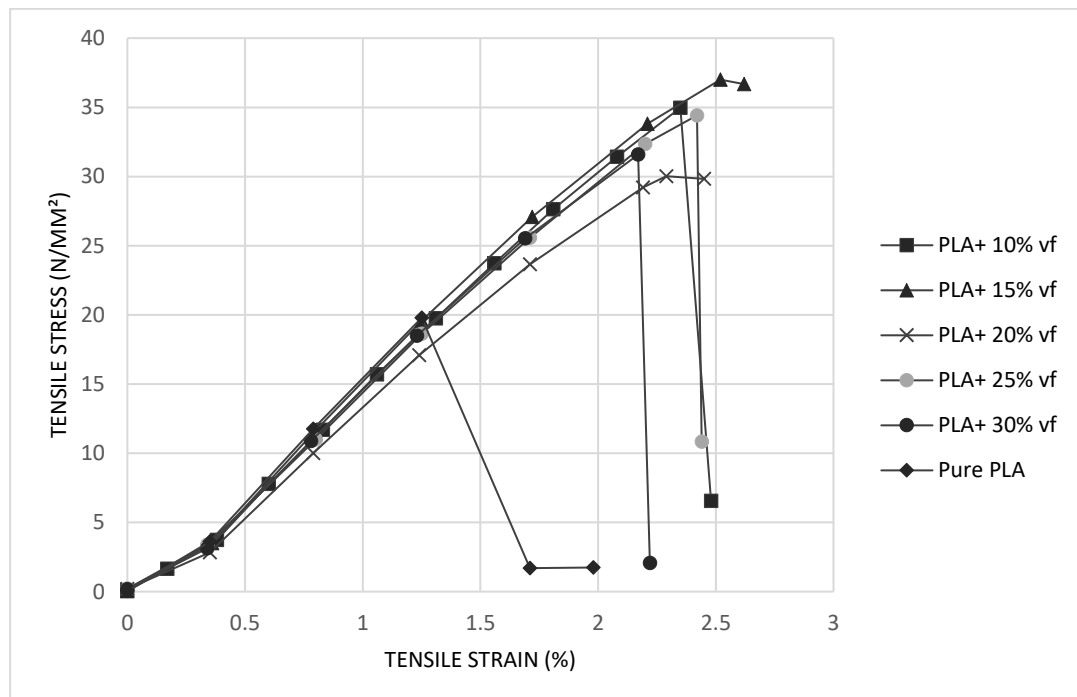


Fig. 3: Stress-strain behavior of PLA composites at different fiber weight percent's

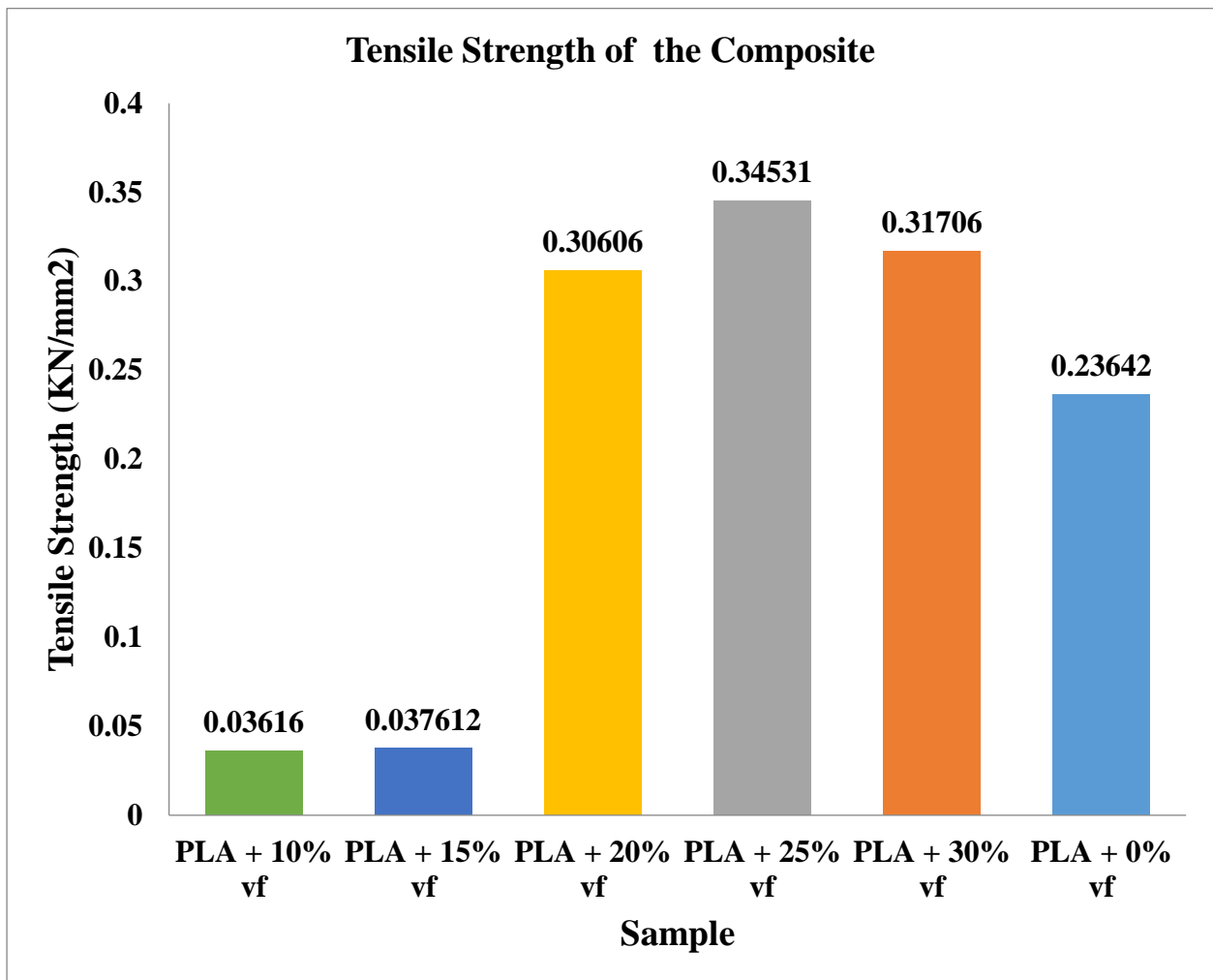


Fig. 4a: Comparison of Tensile strength for various fiber weight compositions of PLA composites

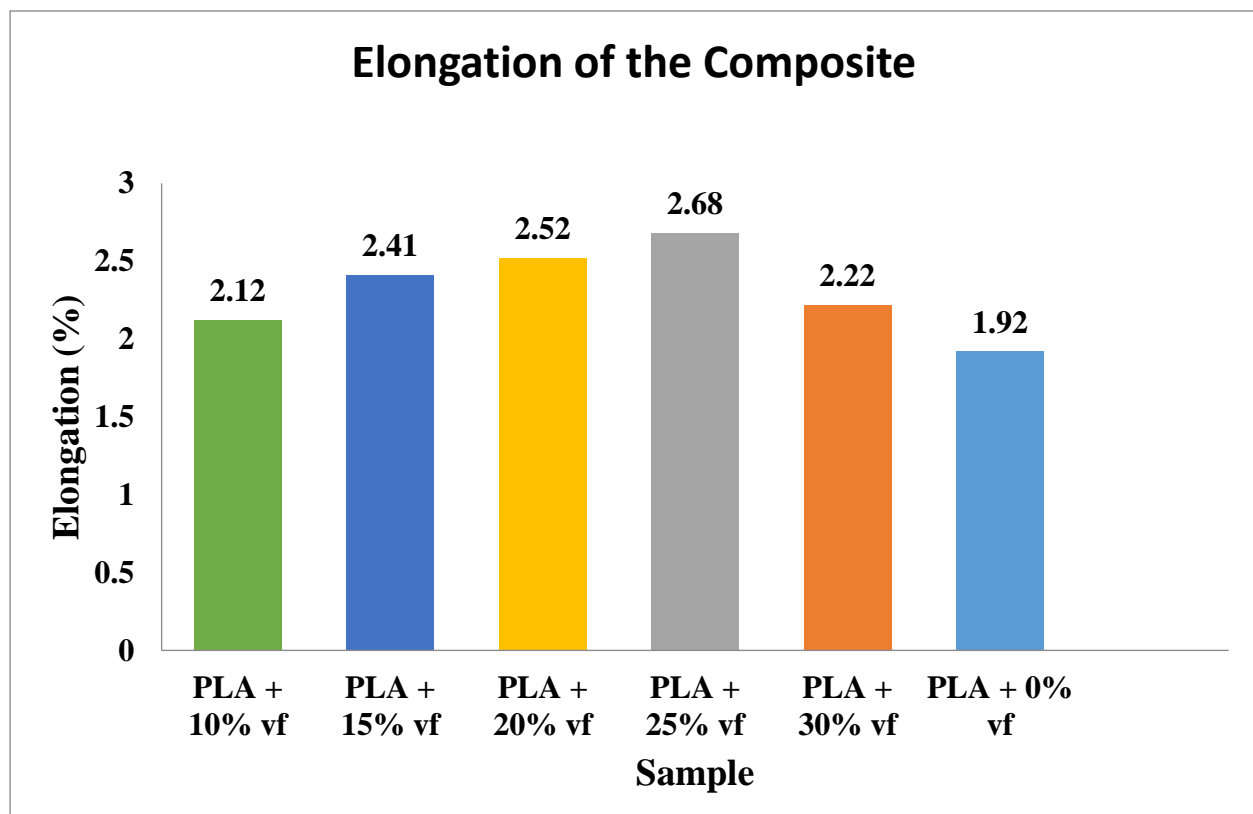


Fig. 4b: Comparison of Elongation for various fiber weight compositions of PLA composites

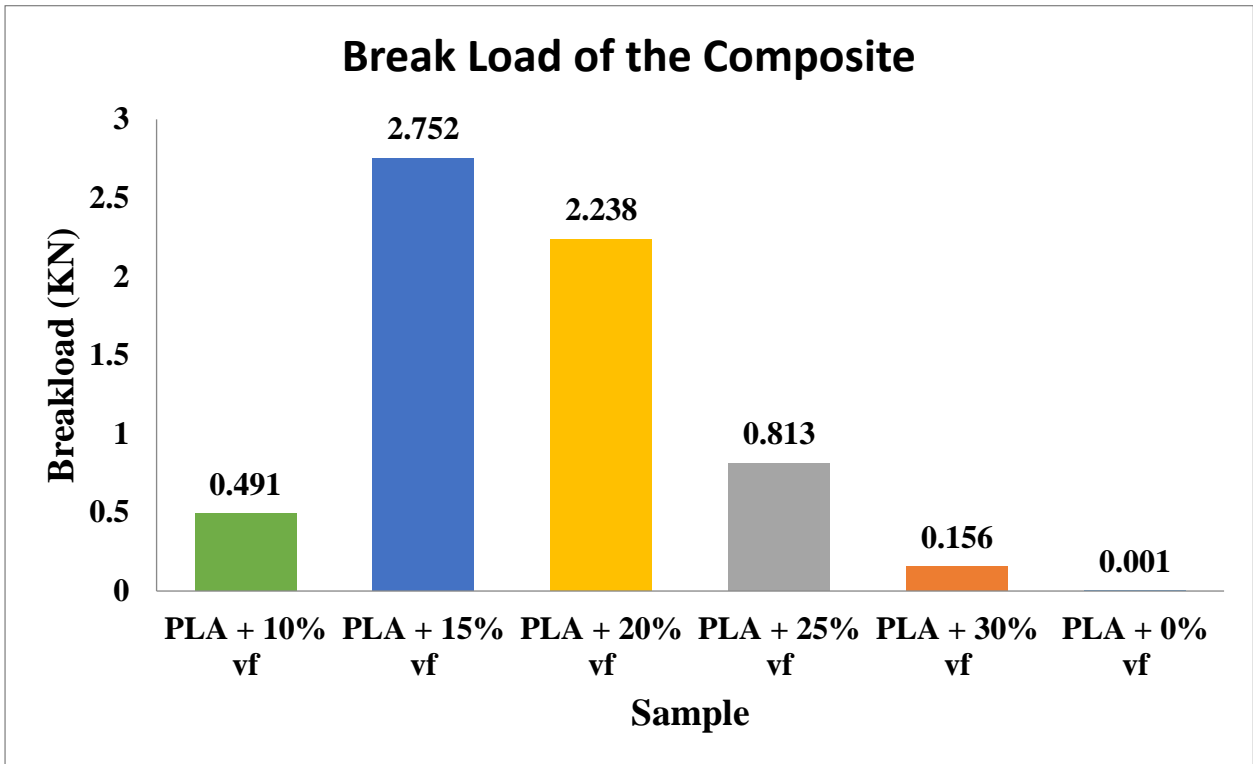


Fig. 4c: Comparison of Break load for various fiber weight compositions of PLA composites

Figure 4c depicts the pattern of Break load with respect to the composition of each PLA and % of vf. It describes that the break loads get highest value in the 15% of vf and then decreases up to 30% of vf. The pure PLA has the lowest value of break load.

5.2. Flexural Properties

The influence of reinforcement – Fiber addition on PLA matrix are being seen from the figure 5 which was plotted in a linear graph based on the readings obtained from the Flexural experimentations. From the figure it is evident that the Flexural strength increasing steadily when the % of vf with PLA matrix is increased from 10% upto 20% and then there is drop at 25% addition which is further taken forward. But maximum strength is obtained at the addition of 20% vf. In order to make the discussion strong, with the same readings, Column chart is also plotted for this Flexural strength which is shown as figure 6a. Here also it is

clearly understood that, Flexural strength increasing steadily for the addition of fiber with PLA matrix upto 20% and then there is drop at 25% vf which is further taken forward. Again the statement can be reinstated that maximum Flexural strength is obtained at the addition of 20% vf.

The effect of Modulus of Bending can be seen from the figure 6b which is plotted from the readings obtained from the experimentations. Bending modulus is increasing when the addition of fibers vf upto 20% with the PLA matrix. Afterwards there is slash in Bending modulus at 25% addition which is then getting raised upto 30% but slightly lesser than that of Bending modulus obtained at 20% addition. Hence it is observed that the maximum Bending modulus is obtained at 20% addition of fibers with PLA matrix.

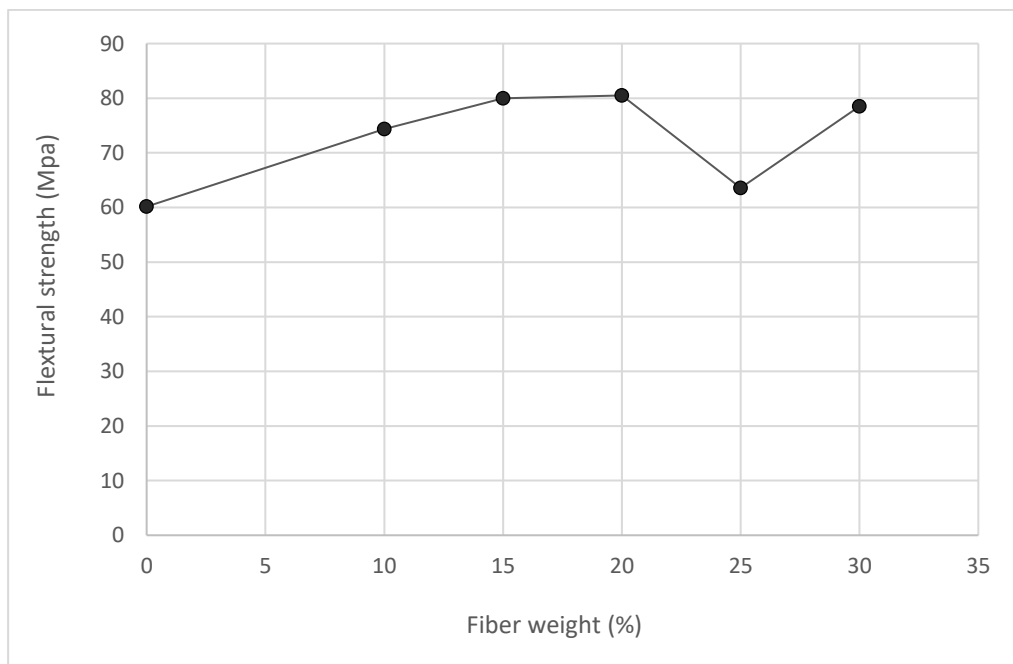


Fig. 5: Variation of flexural strength with various fiber weight percent of PLA composites

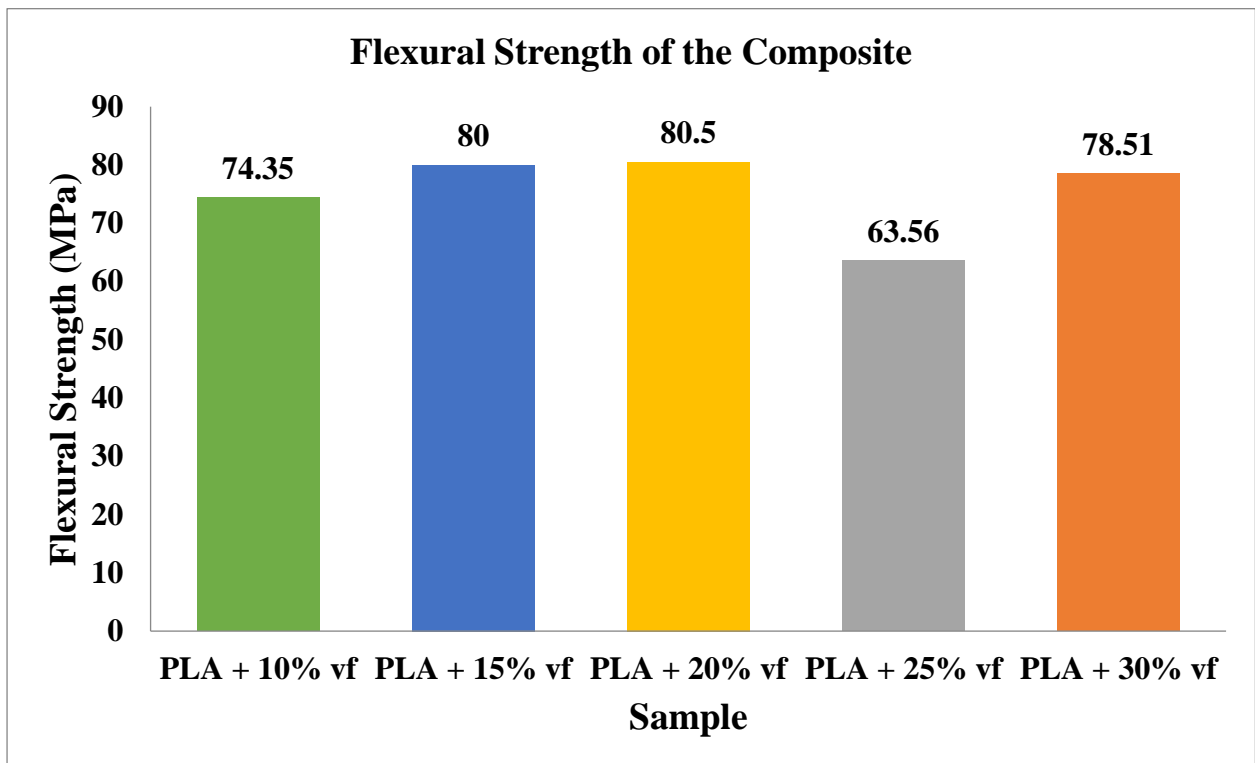


Fig. 6a: Comparison of Flexural strength for various fiber weight compositions of PLA composites

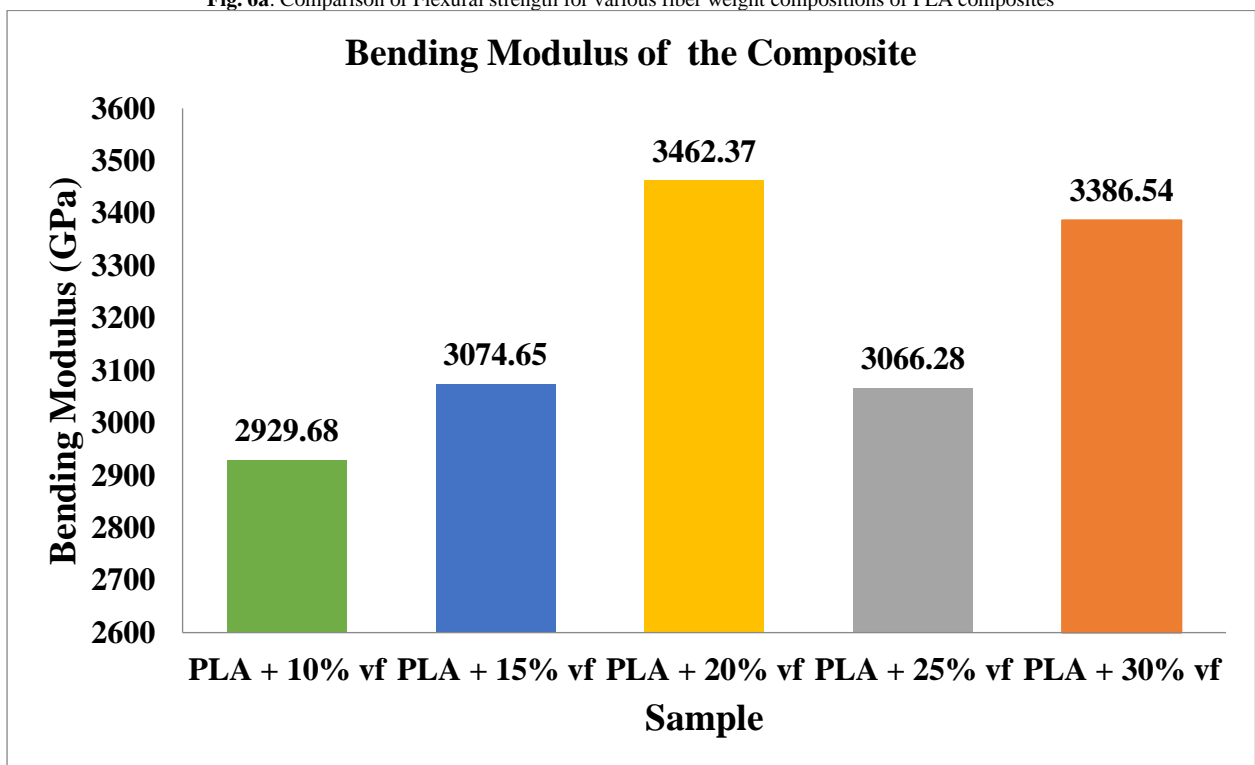


Fig. 6b: Comparison of Bending Modulus for various fiber weight compositions of PLA composites

5.3. Impact properties

For a specific fiber length, the impact strengths which are obtained for various fiber weight % have been plotted in a graph and the same is shown in figure 7. The impact strength is getting

decreased in comparison with pure PLA matrix upto 10% vf. Afterwards upto 30% of vf reinforcement, the impact strength is steadily increasing and goes to the maximum value of 0.55 joules whereas the impact strength of pure PLA matrix being 0.46 joules.

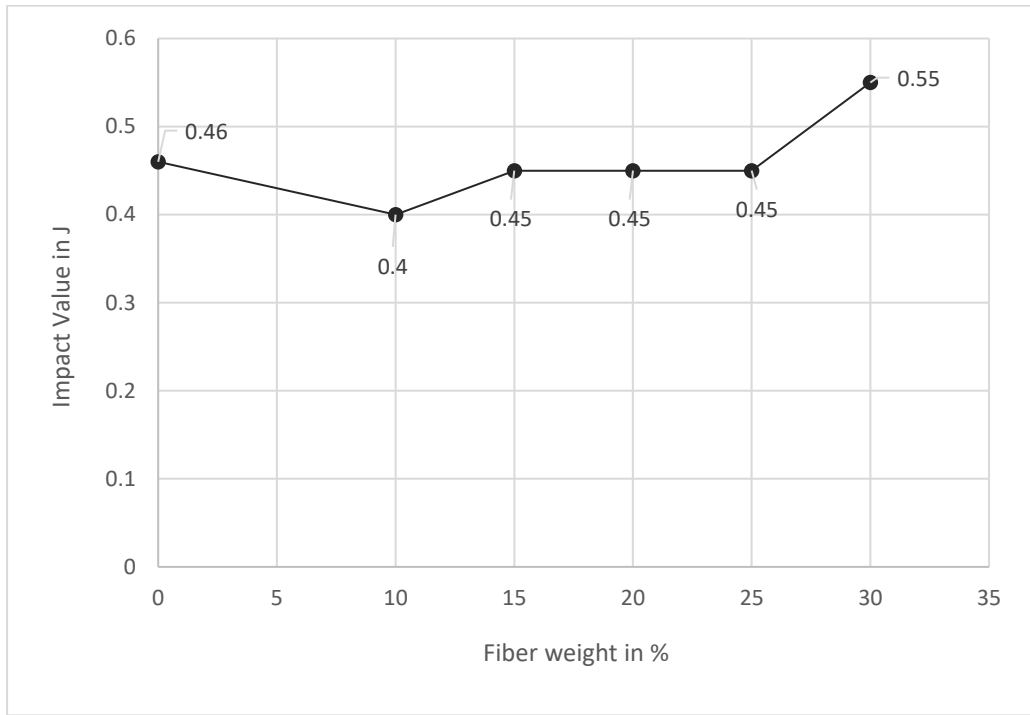


Fig. 7: Variation of impact strength with fiber weight percent for PLA composites

5.4. Water absorption properties

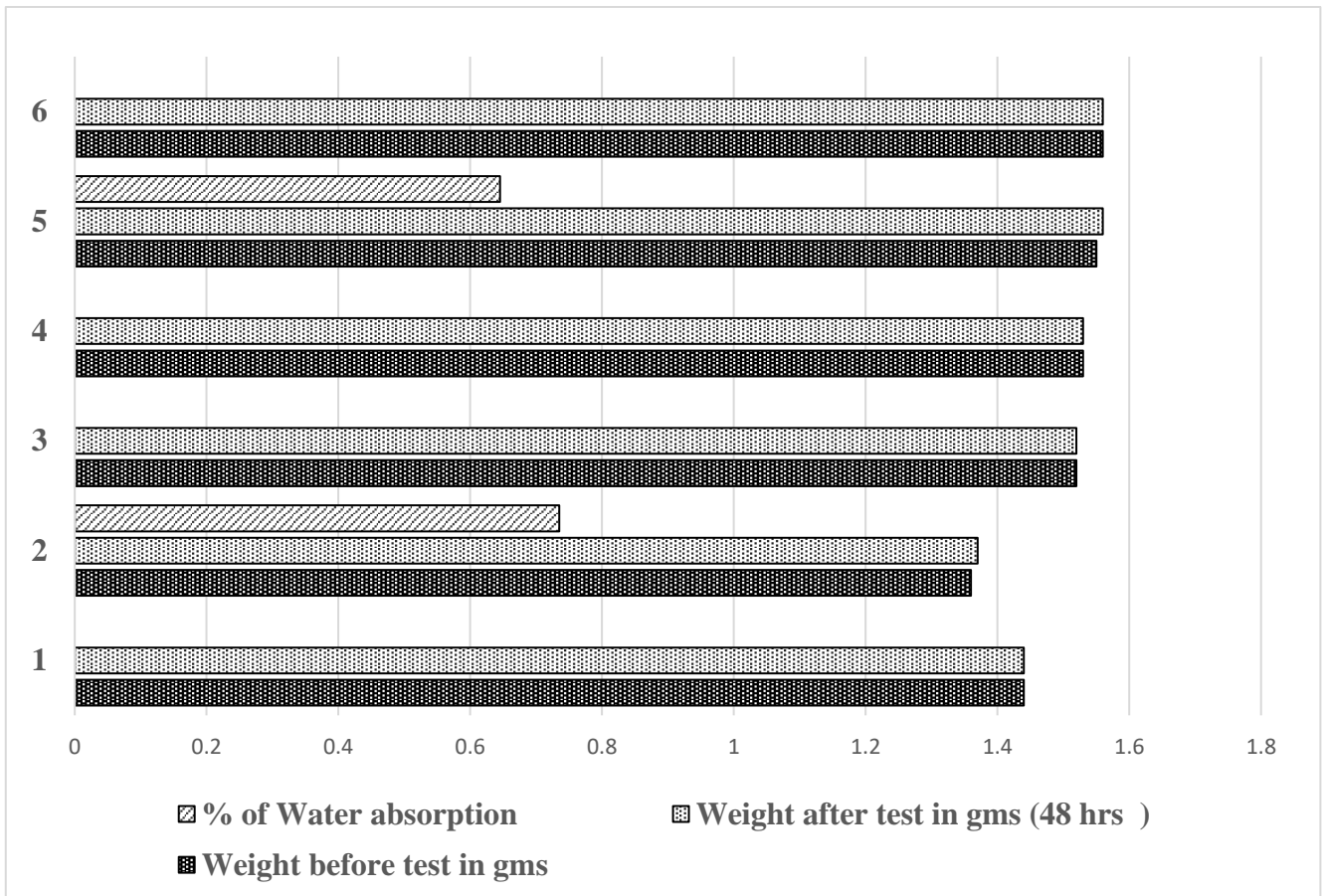


Fig. 8: Comparison of water absorption properties of fiber composites

The water absorption behavior of all five specimens was immersed in water at 23°C as per ASTM D 570. The increase in weight percent were compared in the Fig. 8.

6. Scanning electron microscope (SEM) analysis

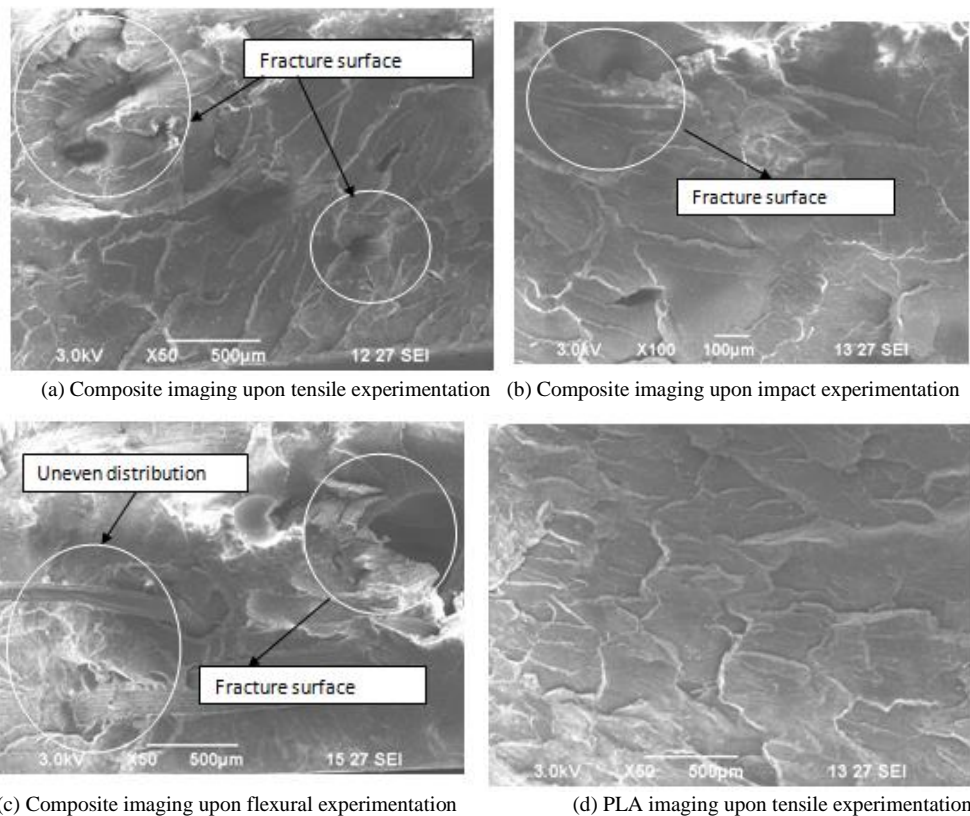


Fig. 9: Scanning electron microscope (SEM) analysis

By means of SEM, the cross sectional surface texture of SG,EG,PLA composite was being analysed and the same is depicted in figure 9.

Before doing SEM analysis, the composite specimens were being given with conducting material lining. Purpose of SEM analysis is to observe the fractured surface structure and any defects like crack, blow holes etc.

Figure 9a depicts the images after doing tensile test of composite material. Figure 9b depicts the images after doing Impact test of composite material where the material is getting disintegrated at breaking point is being observed. Figure 9c depicts the images of composite after doing Flexural test. Figure 9d depicts the images of PLA after doing tensile test.

7. Conclusion

The Bio composite was manufactured with Poly Lactic Acid with the reinforcement of Snake Grass, Elephant Grass fibers. It was also proved that for Poly Lactic Acid with the fibers reinforcements have improved the physical, Mechanical properties and Water absorption properties in comparison with that of matrix material.

- Tensile experimentation outcome reveals that @ 25% vf, SG and EG composites showed maximum Tensile strength of 345.31 N/mm²
- Flexural experimentation outcome reveals that @ 20% vf, SG and EG composites showed maximum Flexural strength of 80.5 MPa and Flexural modulus of 3462.37 GPa @ 20%.
- Impact experimentation outcome reveals that @ 30% vf, SG and EG composites showed maximum Impact strength of 0.55J
- Tensile experimentation outcome reveals that @ 25% vf, SG and EG composites showed maximum % elongation of 2.68

- From these experiments it was well established that there were good interaction between Snake Grass , Elephant Grass and Poly Lactic Acid matrix.

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