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Functional Application for the Corn Leaf Fibre to Make Reinforced Polymer Composites Sheet

Ramratan Guru, Anupam Kumar and Rohit Kumar

Abstract

This research work has mainly utilized agricultural waste material to make a good-quality composite sheet product of the profitable, pollution free, economical better for farmer and industries. In this study, from corn leaf fibre to reinforced epoxy composite product has been utilized with minimum 35 to maximum range 55% but according to earlier studies, pulp composite material was used in minimum 10 to maximum 27%. Natural fibre-based composites are under intensive study due to their light weight, eco-friendly nature and unique properties. Due to the continuous supply, easy of handling, safety and biodegradability, natural fibre is considered as better alternative in replacing many structural and non-structural components. Corn leaf fibre pulp can be new source of raw material to the industries and can be potential replacement for the expensive and non-renewable synthetic fibre. Corn leaf fibre as the filler material and epoxy as the matrix material were used by changing reinforcement weight fraction. Composites were prepared using hand lay-up techniques by maintaining constant fibre and matrix volume fraction. The sample of the composites thus fabricated was subjected to tensile, impact test for finding the effect of corn husk in different concentrations.

Keywords: corn leaf fibre, tensile strength testing, impact strength testing, epoxy resin

1. Introduction

Nowadays, most developed countries are paying special attention to environmental issues, and some of the most important actions to protect the environment are focused on the optimum use of natural resource, the reduction of air pollution, loss of soil moisture, upgrading industrial and agroforestry wastes, etc. [1–3]. All these are with main aim of reducing and utilizing agricultural waste, which may be profitable, pollution free and economically viable for the farmer and industries. The most suitable way is to solve environmental related issues and increase the income of farmers [4–6]. Corn leaf fibre is nowadays exploited as reinforcements material owing to their low cost, fairly good mechanical properties, high specific strength, availability, eco-friendly and biodegradability characteristics

Application of high-performance composites using natural fibres is increasing in various engineering fields. This not only reduces the cost but also saves from environmental pollution [7–10]. These composites are also used in panel for partition and false ceiling, wall sheet, floor, window and door frame. The mainly fibre-reinforced composite is handled to have material properties in all directions and material properties are different in all performances with control of the fibre orientation [11–14].

2. Materials and methods

2.1 Materials

The corn leaf agricultural waste material was collected from local corn farm. The chemical constituent of corn leaves was found to be cellulose of 43%, lignin of 22%, hemicelluloses of 31% and Ash of 1.9% (**Figure 1**).

2.2 Preparation of corn leaf fibre

The corn leaves are cut into 5 to 6 cm length and 1 kg dried leaves are placed in the cooking pot. Make a solution of sodium hydroxide and soda AQ, pour the solution in the pot with leaves and boil for 2 to 3 hour After that, it will become pulp and we will wait for it to cool down and wash it with water three or four times, and then, we will blend with the help of blending machine and squeeze them the help of cotton fabric (**Table 1**) [15, 16].

2.3 Preparation of corn leaf fibre polyester composites

The polyester resin with hardener is mixed in a container and then continuously stirred for 2 to 5 minutes. Then, corn leaf fibre was added with continuous stirring and uniform mixture. Afterwards, this prepared liquid material is placed on the mould, and after 3 hour, mould is removed as composite sheet. This final composite sheet is properly placed in contact with sunlight for 5 to 7 days (**Figure 2**).

Figure 1.
Corn leaf.

S.No	Properties	Range (%)
1.	Cellulose	43
2.	Lignin	22
3.	Hemicelluloses	31
4.	Ash	1.9

Table 1.
 Chemical composition of corn leaf.

Figure 2.
 (a) Resin and hardener. (b) Mould.

Figure 3.
 All natural fibre images.

S.No	Thickness(mm)	Pulp ratio (%)	Epoxy (%)	Hardener (%)
1.	4	35	50	15
2.	4	45	40	15
3.	4	55	30	15
4.	8	35	50	15
5.	8	45	40	15
6.	8	55	30	15

Table 2.
Specimen composition.

2.4 Reason to choose corn leaf

There are severe environmental problems such as air pollution, smoke formation and loss of soil moisture. The main aim to choose corn leaf is utilization of agricultural waste that may be profitably pollution free and economically viable for the farmer (**Figure 3** and **Table 2**).

3. Methods

3.1 Thickness test

Thickness measurement instruments are used as per standard performance ASTM D-1777.

3.2 Tensile strength testing

Tensile measurement instrument is used as per ASTM D—638 standards. This instrument is of very good quality and has properly accurate measurement material sheet with tensile result and easily operating system (**Figures 4** and **5**, **Table 3**).

Tensile strength (TS) = load maximum/specimen of the material.

3.3 Impact strength

The specimen was exposed to a large amount of power for a small intermission of stage. A measurable with more impact energy will have more roughness. This impact measurement instrument is used for as per ASTM D-256 standards (**Figures 6** and **7**; **Tables 4–6**).

4. Results and discussions

Mechanical properties of corn leaf fibre and epoxy resin composites are explained here.

4.1 Density for the composite sheet

It can be observed from **Table 7** and **Figure 8** that with pulp ratio (35%) and thickness of 4 mm and 8 mm, density values are 1.183 g/m³ and 0.987 g/m³,

Figure 4.
Tensile strength testing instrument.

Figure 5.
Tensile specimen shape.

respectively. Further, it is observed that at low pulp ratio (%), density (g/m^3) for composite sheet materials is higher. With pulp ratio of 55% in composite sheet and for both thickness levels 4 mm and 8 mm, lower density is observed. Increase in pulp ratio % in sample results in decrease in density for composite material sheet.

Sr.no.	Symbol	Description	Dimension (mm)
1.	l0	Gauge length	145
2.	l1	Grip distance	160
3.	l2	Overall length	240
4.	b	Width of narrow parallel portion	15
5.	b1	Width ends	30
6.	T	Thickness	4, 8

Table 3.
Tensile specimen dimensions.

Figure 6.
Impact strength testing instruments.

Figure 7.
Impact specimen of IZOD shape.

Sr. no.	Description	Dimension (mm)
1.	Length of specimen	63.5
2.	Centring of notch	2.54
3.	Radius of notch type V	0.25
4.	Angle of notch	45°
5.	Width	12.70
6.	Thickness	4, 8

Table 4.
Impact specimen dimensions.

Sr.no.	Pulp ratio (%)	Various thickness (mm)	Mean thickness (mm)
1.	35	4.16, 4.22, 4.28, 4.26, 4.33, 4.48, 4.56, 4.87, 4.10, 4.21	4.347
2.	45	4.33, 4.42, 4.37, 4.56, 4.68, 4.77, 4.87, 4.66, 5.02, 5.13	4.681
3.	55	4.56, 4.68, 4.72, 4.26, 4.32, 4.37, 4.76, 5.12, 5.33, 5.22	4.734
4.	35	7.66, 7.90, 7.88, 7.97, 8.10, 8.34, 8.44, 8.56, 8.69, 8.78	8.232
5.	45	8.24, 8.33, 8.54, 8.56, 8.76, 8.87, 8.42, 8.19, 9.09, 9.18	9.681
6.	55	8.16, 8.23, 8.36, 8.40, 8.27, 8.26, 8.41, 8.43, 8.53, 8.66	8.371

Table 5.
Sheet thickness results.

Sr.no.	Thickness(mm)	Pulp ratio (%)	Weight (gm)	GSM(g/m ²)
1.	4	35	142	142gm/0.03 = 4733
2.	4	45	136	136gm/0.03 = 4533
3.	4	55	124	124gm/0.03 = 4133
4.	8	35	237	237gm/0.03 = 7900
5.	8	45	223	223gm/0.03 = 7433
6.	8	55	210	210gm/0.03 = 7000

Table 6.
Sample GSM.

Sr.no.	Thickness (mm)	Pulp ratio (%)	Density (g/m ³)
1.	4	35	142gm/120 = 1.1833
2.	4	45	136gm/120 = 1.1333
3.	4	55	124gm/120 = 1.0333
4.	8	35	237gm/240 = 0.9875
5.	8	45	223gm/240 = 0.9291
6.	8	55	210gm/240 = 0.8750

Table 7.
Sample density.

Figure 8.
Effect of the pulp ratio and thickness on density properties.

Figure 9.
Image for composite sheet material.

Figure 10.
Specimen size for composite sheet material.

This may be due to the presence of some voids. It can be seen from the images that void is there between fibre and matrix, which shows less compatibility of corn leaf fibre with epoxy resin at higher pulp ratio (**Figures 9–11**).

Figure 11.
Specimen break after tensile strength test for composite material.

4.2 Tensile strength properties for composite sheet material

Samples are tested on DAK series 7200 machine (a universal testing machine) and tensile strength is recorded. The values are depicted in **Table 8**. It can be observed from **Table 8** and **Figure 12** that at pulp ratio of 35%, a thickness level of 4 mm and 8 mm gives the highest tensile strength value 4.95 Mpa and 7.58 Mpa, respectively. It may be due to the higher density for composite sheet according to **Table 7**. The maximum tensile strength obtained for corn leaf fibre ratio (35%) may also be due to good bonding between epoxy and fibre pulp ratio, and approximately hexagonal structure of cellulose present in the sugarcane leaves fibre gives high flexibility to the fibre. Further, higher tensile strength may be attributed to the more energy transfer to the fibres by the matrix [17, 18].

With pulp ratio (55%) in composite sheet and for both 4 mm and 8 mm thickness, low tensile strength has been observed. It may be due to increase in pulp ratio % decreases density as reported earlier. The decrease in tensile strength with increase in pulp ratio (%) may be due to increase in voids created by air entrapment due to small-size particles. The tensile strength for neat epoxy is very less, which shows that there is decrease in strength in composite and less density that may be due to weak adhesion between fibre pulp and matrix, which causes no proper transfer of energy to the fibres by matrix.

4.3 Impact strength properties for composite sheet material

In order to find the impact capability of sample, impact test is carried out using IZOD – CHARPY digital impact tester machine. Absorbed energy obtained for six

Sr.no.	Pulp ratio (%)	Thickness (mm)	Tensile strength 1 (Mpa)ASTMD-638	Tensile strength 2(Mpa)ASTMD-638	Mean tensile strength
1.	35	4	5.47	4.43	4.950
2.	45	4	2.10	4.17	3.135
3.	55	4	1.98	3.15	2.565
4.	35	8	7.61	7.58	7.595
5.	45	8	4.47	5.10	4.785
6.	55	8	3.88	4.02	3.950

Table 8.
Tensile strength result.

Figure 12.
Effect of the pulp ratio and thickness on tensile properties.

Sr.no.	Pulp ratio%	Thickness (mm)	Impact strength 1(kg. / m2)ASTMD-256	Impact strength 2(kg. /m ²) ASTMD-256	Impact strength
1.	35	4	1.77	1.35	1.11
2.	45	4	1.25	1.49	1.55
3.	55	4	1.22	1.37	1.79
4.	35	8	2.39	2.10	1.89
5.	45	8	1.35	1.67	1.99
6.	55	8	2.43	1.72	2.40

Table 9.
Impact test results.

different (samples) composite sheets from the IZOD – CHARPY machine has been shown in figure. It has been observed from **Table 9** that maximum impact strength of 2.40 Kj/m² is obtained for 55% pulp ratio sheet.

Further, pulp ratio of (55%) with 4 mm and 8 mm thickness has highest impact strength for 1.79 Kj/m² and 2.4 Kj/m² respectively. The impact strength of the composites increases with increase in fibre content (pulp ratio %). It may be due to during impact force, fibre pulls out and fibre breakage occurs at lower fibre loading of the polymer composites. At high fibre loading, the fibre crowding leads to easy debonding, which in turn increases the impact resistance, when compared with the impact energy of neat epoxy which is very less. It is observed that the impact strength increases.

Pulp ratio (35%) in composite sheet for both thickness levels of 4 and 8 mm, lower impact strength has been observed with decrease in pulp ratio % and epoxy resin concentration level. The optimum combination for the impact strength of the composites is pulp ratio of 55% and for both thickness levels as seen in **Figures 13** and **14**, respectively.

Figure 13.
(a). Impact specimen (b). Broken specimen after impact strength testing.

Figure 14.
Effect of the pulp ratio and thickness on impact strength properties.

4.4 Fractured surface morphology using field emission scanning electron microscope (FESEM)

Scanning electron microscope (SEM) is basically measurement the material surface by scanning through high wavelength beams with different wavelengths. The different composite materials are shown in SEM image **Figures 15–17**.

Field emission scanning electron microscope image for sugarcane leaf fibre pulp-reinforced composites is taken to understand microstructure. From the images, the fibre dispersion, matrix without fibres and fibre agglomeration are clearly visible. The images indicate that the failure is due to matrix failure, fibre pull-out and also due to the presence of some voids. The FESEM image of coir fibre-reinforced samples clearly shows the broken sugarcane leaf fibres. It is seen

Figure 15.
FESEM image for pulp ratio and epoxy resin for composite sheet.

Figure 16.
FESEM image for pulp ratio and epoxy resin for composite sheet.

Figure 17.
FESEM image for pulp ratio and epoxy resin for composite sheet.

from the images that void is there between fibre and matrix, which shows less compatibility of corn leaf fibre with epoxy resin. Uniform mixing are pulp ratios and other particles leads to less air voids.

5. Conclusion

This study on the natural corn leaf fibre-reinforced epoxy composites uses pulp ratio (%), thickness level of 4 mm and 8 mm and constant hardness as filler material for the following conclusions: From the present work, it is concluded that the natural corn leaf fibre along with pulp ratio (%), thickness level of 4 mm and 8 mm and constant hardness can be successfully used with epoxy resin to prepare polymer matrix composites with good mechanical properties.

- For composite sheet, it is found that pulp ratio is of 35% and thickness of 4 mm to highest tensile strength 4.95. According to figure, it is found that for pulp ratio of 35% and thickness of 8 mm to the highest tensile strength 7.59. It is observed that the maximum value of tensile strength is obtained for corn leaf fibre ratio (35%) composite sheet. Increasing pulp ration (%) and low density reduce tensile strength due to non-bonding of pulp particles with sugarcane leaf fibre.
- It is found that pulp ratio is of 55% and thickness of 4 mm to highest impact strength for about 1.79. According to figure, it is found that pulp ratio of 55% and thickness of 8 mm give the highest impact strength 2.4. The impact strength of the composites increases with increase in fibre content (pulp ratio %), and this is because on the application of the impact force, fibre pulls out and fibre breakage occurs at lower fibre loading of the polymer composites. The pulp ratio (35%) in composite sheet and both levels of thickness have lower impact strength.
- The FESEM image shows good bonding between fibre, pulp ration (%) and matrix. Also, breakage of fibres shows the load transferred from matrix to the fibres.
- The use of natural sugarcane leaf fibres is to prepare eco-friendly composites. It is utilized as agricultural waste, which may be profitable, pollution free and economically viable for the farmer and industries. These composites are also used in panel for partition and false ceiling, wall sheet, floor, window and door frame.

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References

- [1] Youssef AM, El-Gendy A, Kamel S. Evaluation of corn husk fibers reinforced recycled low-density polyethylene composites. *Materials Chemistry and Physics*. 2015;**152**(1): 26-33
- [2] Shah H, Yang Y. Chemically extracted corn-husk fibers as reinforcement in light weight poly (propylene) composites. *Macromolecular Materials and Engineering*. 2008;**293**:235-243
- [3] Majhi S, Samantarai SP, Acharya SK. Tribological behavior of modified rice husk filled epoxy composite. *International Journal of Scientific and Engineering Research*. 2012;**3**(6):1-5
- [4] Nazrul IM. Physico-mechanical properties of chemically treated coir reinforced polypropylene composites. *Composites Part A: Applied Science and Manufacturing*. 2010;**41**(2):192-198
- [5] Jawaaid MHPS, Abdul HPS, Khalil. Cellulosic/synthetic fiber reinforced polymer hybrid composites: A review. *Carbohydrate Polymers*. 2011;**86**(1):1-18
- [6] Nuruzzaman DM, Chowdhury MA. *Friction and Wear of Polymer and Composites*. Rijeka: INTECH Open Access Publisher; 2012
- [7] Shalwan A, Yousif BF. In state of art: Mechanical and tribological behavior of polymeric composites based on natural fibers. *Materials & Design*. 2013;**48**(1): 14-24
- [8] Isa MT. The Effect of fiber treatment on the mechanical and water absorption properties of short Okra/Glass fibers hybridized epoxy composites. *International Journal of Materials Engineering*. 2014;**4**(5):180-184
- [9] Norashikin MZ, Ibrahim MZ. The potential of natural waste (corn husk) for production of environmentally friendly biodegradable film for seedling. *World Academy of Science, Engineering and Technology*. 2009;**58**(1):176-180
- [10] Menezes PL, Rohatgi PK, Lovell MR. Studies on the tribological behavior of natural fiber reinforced polymer composite. In: *Green Tribology*. Vol. 2(1). Springer Berlin Heidelberg; 2012. pp. 329-345
- [11] Aireddy H, Mishra SC. Tribological behavior and mechanical properties of Bio-waste reinforced polymer matrix composites. *Journal of Metallurgy and Materials Science*. 2011;**5**(2):139-152
- [12] Yousif BF, Nirmal U, Wong KJ. Three body abrasion on wear and frictional performance of treated betelnut fiber reinforced epoxy (T-BFRE) composite. *Materials & Design*. 2010;**31**(9):4514-4521
- [13] Pihtili H. An experimental investigation of wear of glass fiber epoxy resin and glass fiber-polyester resin composite materials. *European Polymer Journal*. 2009;**45**(1):149-154
- [14] Brahim SB, Cheikh RB. Influence of fiber orientation and volume fraction on the tensile properties of unidirectional Alfa-polyester composite. *Composites Science and Technology*. 2006;**67**(1): 140-147
- [15] Brahmakumar M, Pavithran C, Pillai RM. Coconut fiber reinforced polyethylene composite: Effect of natural waxy surface layer of the Fibercon fiber/ Matrix interfacial bonding and strength of composites. *Composites Science and Technology*. 2005;**65**(2):563-569
- [16] Roe P, Ansell MP. Jute-reinforced polyester composites. *Journal of Materials Science*. 1985;**20**(11):4015-4020
- [17] Shah DU. Characterisation and Optimisation of the Mechanical

Performance of Plant Fibre Composites for Structural Applications. United Kingdom: University of Nottingham; 2013. p. 274

[18] Mutasher SA, Poh A, Than AM, Law J. The effect of alkali treatment mechanical properties of kenaf fiber epoxy composite. In: Engineering Materials. Trans Tech Publications; 2011