

Mechanical Characterization of Palmyra- and S Glass Fibre-Reinforced Hybrid Polymer Composites



Navuluri Padma Sravya and S. Sivaganesan

Abstract The need of composite materials is intensive in last few decades as the reinforced polymer composites can be processed easily in many constraints and there are many advantages of using Palmyra fibre. Here, the Palmyra fibre is combined with glass fibre as matrix epoxy resin is taken to improve the properties. In the present work, Palmyra fibre is reinforced with glass fibre and epoxy resin in different ratios by hand lay-up method and is processed and different tests are conducted. This includes evaluation of tensile strength, flexural strength, compression strength and impact strength has been studied and discussed. The characterization of composites reveals that different ratios of Palmyra palm and glass fibre are having significant effect on the mechanical properties of composites. Tensile strength, tensile modulus, flexural strength, flexural modulus, compression strength, compression modulus and impact strength are found to be improved for all treated samples when compared to untreated samples. Flexural and tensile properties are improved due to removal of dust particles on surface of fibre; hence, cell walls of fibre are opened to wet matrix interface.

Keywords Palmyra fibre · Epoxy resin · Hand lay-up method · Characterization · Treated and untreated samples

1 Introduction

Composites are classified into two types by the geometry of the reinforcement and by the type of matrix [1]. According to the type, reinforcement can be classified as particulate composites, flake composites, fibre composites. Fibres are generally classified into two groups: synthetic fibres and natural fibres. The fibres which can be obtained from natural sources such as plants and animals are referred to as natural fibre [2]. The fibres whose structural properties and chemical compositions are significantly modified during the formation and are manufactured artificially are referred

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to as synthetic fibre [3]. The most common advanced composites are polymer matrix composites consisting of polymer reinforced by thin-diameter fibres [4]. The hand layup method is used for the fabrication of polymer reinforced short length palmyra fibres. Initially the composites are made into plate shape by using compression moulding process. The sound absorption test is performed by using impedance test tube method [5]. Composite plates with the fibrous waste material content varying from 30 to 70% by weights were studied. It was observed that the incorporation of pfw in the matrix imparted poor reinforcement effect in tensile. Moisture absorption studies on pfw/glass fibre polyester composites were carried out separately and observed that the composite absorbed 9.23% of moisture in 166 h, 5.57% of moisture in 154 h and 3.5% of moisture in 175 h for the composites with 50% pfw/10% glass fibre, 40% pfw/20% glass fibre and 30% pfw/30% glass fibre, respectively. These Palmyra fibre waste and glass fibre hybrid composites could be moulded into standard size and used as partition boards, panel for windows and cupboards, etc., which need further attention on effect of moisture absorption on properties [6].

2 Experimental Set-Up

Glass moulds are made by different dimensions of ASTM standard which are used to prepare epoxy/glass fibre nanocomposites. For making the composite for testing the tensile strength and flexural strength, the glass moulds prepare as per the ASTM standards (ASTM D 638 and D 618). The glass moulds have the dimensions of (130 × 130 × 3) mm.

For making the composite for testing the impact strength of fibrous composite by conducting the Izod and Charpy test, prepare a glass mould as per the ASTM standard (ASTM D 256) having dimensions of (100 × 100 × 13) mm. For testing the compression strength of composite fibre, make a composite and prepare a mould as per the ASTM standards (ASTM D 695). Glass moulds have dimensions of (10 × 10 × 10) mm (Fig. 1).

2.1 Preparation of Composites

By the rule of hybrid mixtures, composites are prepared by hand lay-up technique. [7]. Initially by ASTM standards with $13 \times 13 \times 0.3 \text{ cm}^3$, the glass moulds are prepared. For the removal of moisture, the filler is kept in oven for half an hour. Before taking out from the oven, the surfaces of the mould are sprayed with polyvinyl alcohol. For curing, at least the mould should be kept aside at least for 24 h [8]. The casting is taken out from the mould using spatulas and knives [9]. According to ASTM standard sizes, the composites are cut for testing. On universal testing machine (3369) tests are performed. The average of results for each tested composition of at least 5 samples is listed. This technique is suitable for low volume production of product

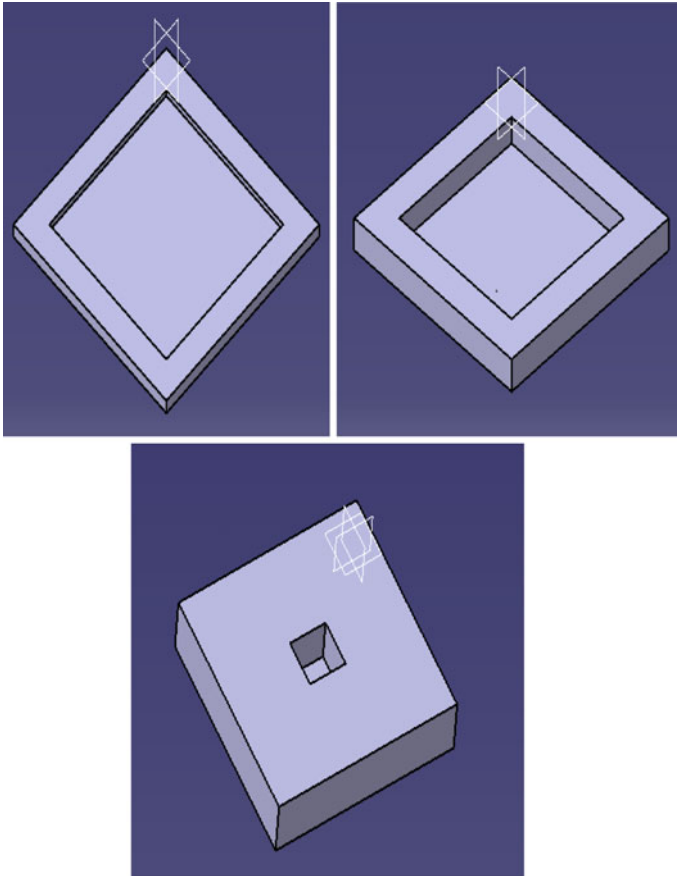


Fig. 1 Tensile, flexural, impact and compression mould

[10]. Reinforcement fibres can be cut and laid in the mould. The amount of resin and direction of the fibres depend on the designer. To make the reaction fast, a catalyst is used. The fibres with the resin are impregnated with the use of a brush or a roller. The quality of saturation and the amount of resin controlling responsibility are taken by the lay-up technician [11].

Characterization of Palmyra-reinforced polymer composites includes tensile, flexural, compression, impact tests. The combination system is given below (Table 1).

As per ASTM standards, samples are subjected to appropriate tests after fabrication (Fig. 2).

Table 1 Combinations of the samples

Sample No.	Epoxy in %	Palmyra in %	Glass fibre in %
1	90	10(25)	10(75)
2	90	10(50)	10(50)
3	90	10(75)	10(25)
4	90	10(100)	10(0)

**Fig. 2** a. Workpieces after taking from the glass moulds. b. Workpieces in the glass moulds after taking out of furnace. c, d, e. Testing samples

3 Results and Discussion

The results of tests which are conducted for various characterizations are listed. Evaluation of mechanical properties has been included. The interpretation of comparison and results of samples are also presented [12]. The different ratios of Palmyra and glass fibre are characterized. Different ratios of Palmyra are presented in the table below.

Table 2 Tensile strength of treated and untreated fibred composites

Sample No.	Tensile strength (Mpa)	
	Untreated	Treated
1	19.63	23.52
2	24.45	28.03
3	13.23	16.52
4	15.10	20.76

3.1 Tensile Strength

From the above results observed tensile strength of all treated samples is showing higher performance. Tensile strength of treated sample is showing higher performance when compared to other samples. Treated sample-2 shows 12.7% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 2).

3.2 Tensile Modulus

From the above results observed tensile modulus of all treated samples is showing higher performance. Tensile modulus of treated epoxy, 10(50) % Palmyra and 10(50) % glass fibre (sample-2) is showing higher performance when compared to other samples. Treated sample-2 shows 29.08% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 3; Fig. 3).

Table 3 Tensile modulus of treated and untreated fibred composites

Sample No.	Tensile modulus (Mpa)	
	Untreated	Treated
1	2333.17	3232.97
2	2607.18	3676.45
3	1650.21	2628.83
4	2407.45	3030.15

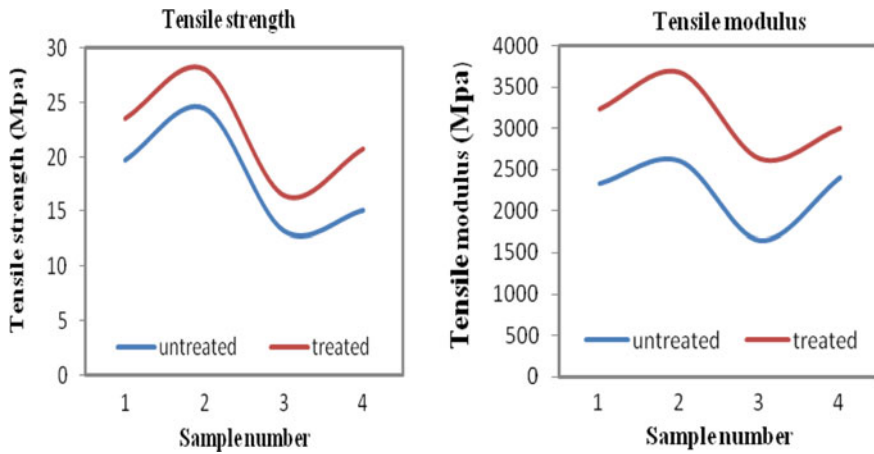


Fig. 3 Sample numbers versus tensile strength and tensile modulus

Table 4 Flexural strength of treated and untreated fibred composites

Sample No.	Flexural strength (Mpa)	
	Untreated	Treated
1	51.33	71.87
2	71.29	95.83
3	64.73	87.86
4	57.39	62.23

3.3 Flexural Strength

From the above results observed flexural strength of all treated samples is showing higher performance. Flexural strength of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 23.8% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 4).

3.4 Flexural Modulus

From the above results observed flexural modulus of all treated samples is showing higher performance when compared to untreated samples. Flexural modulus of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 29.8% more than the untreated sample-2. Removal of

Table 5 Flexural modulus of treated and untreated fibred composites

Sample No.	Flexural modulus (Mpa)	
	Untreated	Treated
1	4448.31	6115.84
2	5509.77	7864.64
3	4399.95	5969.59
4	3797.97	4900.8

Table 6 Compression strength of treated and untreated fibred composites

Sample No.	Compression strength (Mpa)	
	Untreated	Treated
1	31.15	47.36
2	48.37	61.85
3	29.98	40.43
4	34.34	49.60

substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 5).

3.5 *Compression Strength*

From the above results observed compression strength of all treated samples is showing higher performance. Compression strength of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 19.7% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 6).

3.6 *Compression Modulus*

From the above results observed compression modulus of all treated samples is showing higher performance when compared to untreated samples. Compression modulus of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 29.7% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 7).

Table 7 Compression modulus of treated and untreated fibred composites

Sample No.	Compression modulus (Mpa)	
	Untreated	Treated
1	1760.73	2828.25
2	2893.73	4172.78
3	2198.65	3285.35
4	1589.75	2246.18

Table 8 Impact strength of treated and untreated fibred composites

Sample No.	Energy absorbed (joules)	
	Untreated	Treated
1	3.0	4.1
2	4.3	5.6
3	2.1	3.8
4	0.8	1.77

3.7 Impact Strength

From the above results observed impact strength of all treated samples is showing higher performance than untreated samples. Treated impact strength of sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 23.2% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance (Table 8; Figs. 4, 5 and 6).

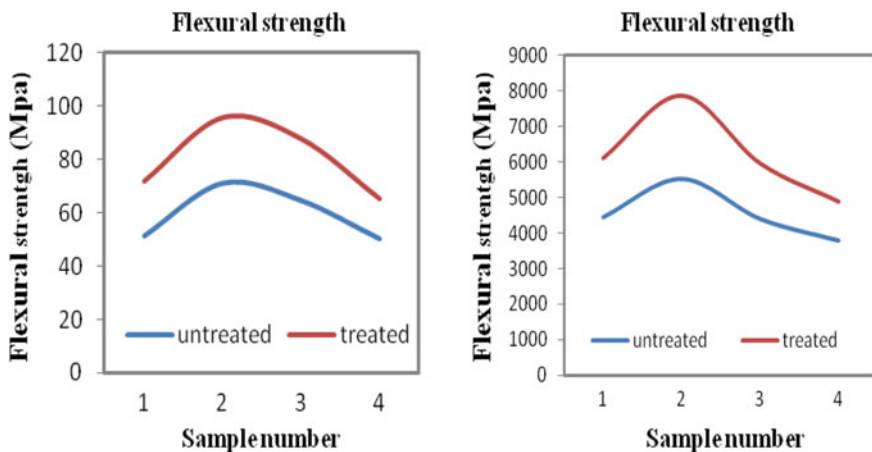


Fig. 4 Sample number versus flexural strength and flexural modulus

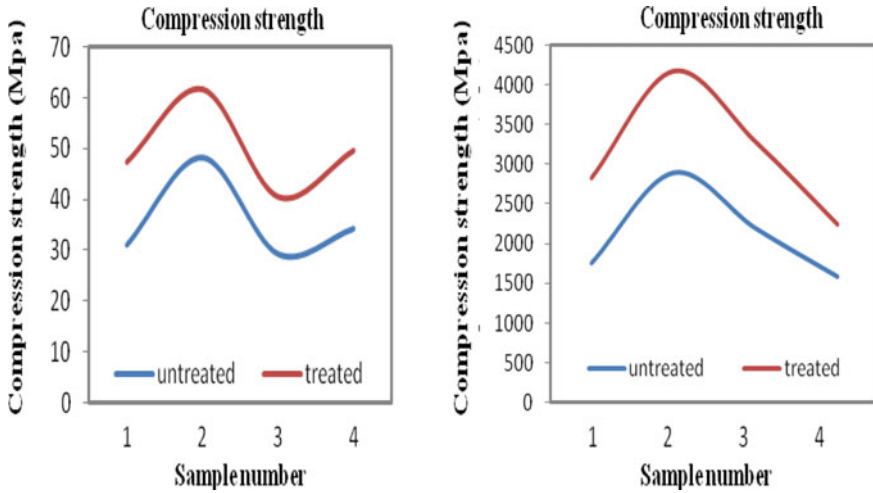
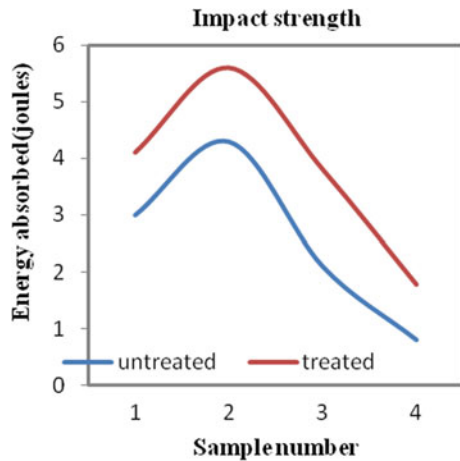


Fig. 5 Sample numbers versus compression strength and compression modulus

Fig. 6 Sample numbers versus energy absorbed



4 Conclusion

The mechanical properties considered are found to be improved for all treated samples when compared to untreated samples. Tensile strength of treated sample-2 which is of ratio 90% epoxy, 10(50) % Palmyra and 10(50) % glass fibre is showing higher performance when compared to other samples. Treated sample-2 shows 12.7% more than the untreated sample-2. Removal of substances which are waxy and the surfaces with impurities of the fibre during chemical treatment provides higher performance. Tensile modulus of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 29.08% more than the untreated

sample-2. Flexural strength of treated 90% epoxy, 10(50) % Palmyra and 10(50) % glass fibre is showing higher performance when compared to other samples. Treated sample-2 shows 23.8% more than the untreated sample-2. Flexural modulus of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 29.8% more than the untreated sample-2. Compression strength of treated 90% epoxy, 10(50)% Palmyra and 10(50)% glass fibre is showing higher performance when compared to other samples. Treated sample-2 shows 19.7% more than the untreated sample-2. Compression modulus of treated sample-2 is showing higher performance when compared to other samples. Treated sample-2 shows 29.7% more than the untreated sample-2. Impact strength of treated 90% epoxy, 10(50)% Palmyra and 10(50)% glass fibre is showing higher performance when compared to other samples. Treated sample-2 shows 23.2% more than the untreated sample-2. Flexural and tensile properties are improved due to removal of dust particles on the surface of the fibre; hence, cell walls of fibre are opened to wet matrix interface.

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