Evaluation of Tensile and Flexural Properties of Sisal/ Coconut Coir Reinforced with High Density Polyethylene Hybrid Composite

Nikhil
Student
Department of Mechanical Engineering & Technology
Punjab Collage of Engineering & Technology
Lalru, Punjab, India.

Dr. Beant Singh
Professor
Department of Mechanical Engineering & Technology
Punjab Collage of Engineering & Technology
Lalru, Punjab, India.

Dr. Lakshay Aggarwal
Astt. Professor
Department of Mechanical Engineering
M.M. University, Ambala Cantt., India

***Abstract*— here the study of developed hybrid composite investigates the effect of reinforced natural fiber with high density polyethylene. Here HDPE were used fresh and recycled with reinforced natural fibers. To manufacture hybrid composite material and investigation, the sisal and coconut coir fibers are washed and treated with chemical NaOH solution and SEM used to investigate chemical modification on fiber surfaces. Here the sisal and coconut coir fibers are used either alone or simultaneous. The result defines that the reinforced sisal and coconut coir fiber with HDPE gives great tensile and flexural properties as comparison to use single fiber reinforced with HDPE. Further result shows that when the content of sisal and coir fiber in composite is taken 10wt% and HDPE is 80% then the tensile strength are 21.6 MPa and flexural strength are 18.5 MPa obtained as in comparison with content 5% sisal and coir and 90 % HDPE which gives tensile strength are 19.5 MPa and flexural strength are 17.5 MPa. Where as in solo usage of natural fibers also gives some decrement in tensile and flexural strength power of developed composite. Here with 30% sisal and 70% HDPE results tensile strength are 12.4 MPa and flexural strength are 14.3 MPa. Similarly, in case of only 30% coir and 70 % HDPE we get tensile strength are 12.0 MPa and flexural strength are 14.6 MPa. So in short form we say that sisal and coir fibers are the primary reinforce content that gives great tensile and flexural properties of composite together as in comparisons of others.**

Keywords*— *Natural fibers; HDPE; Chemical Tretment; Hybrid Composite; Tensile Strength; Flexural Strength.

I. INTRODUCTION

Today every industry need and demands good quality materials, but light in weight, low in cost and strong, stiff, environment friendly. Due to this many investigators produced such type of material having high strength, toughness and better surface properties. These materials are widely used in automobile, defense, aerospace industries and these materials are known as composite. Composite material can be developed in many ways by using different techniques and methodology. From surveying previous literatures and found that different kind of composites are developed with different composition's like natural fibers, synthetic fibers, metals, alloys, polymers, wood, chemical agents etc. hybrid composite developed by combining reinforcement phase into matrix phase. Many investigators use synthetic fibers instead of natural fiber to develop composite material, but natural fibers are cheap and environment friendly as in comparison with synthetic fibers. Natural fiber has one disadvantage, it is hydrophilic in nature and due to these natural fibers are not making strong interface with polymer matrix [1-3].

Many experiment have conducted to get tensile and flexural properties of reinforced natural fibers on polymer matrix hybrid composite. Singh N.P et al (2015), [1] investigate the effect of chemical treated sisal/coir fiber reinforced with high density polyethylene on the tensile strength of hybrid composite. Li Yan et al (2008), [2] conducted Interfacial studies of sisal fiber reinforced high density polyethylene (HDPE) composites. Hristov et al (2004), [3] investigate mechanical properties after modification into composite by addition with maleated polypropylene as compatibilizer and poly (butadiene styrene) rubber as impact modifier. Li Yan et al (2000), [4] study the effect of sisal fiber (natural fiber) on polymer matrix composite properties. Shubhashini Oza et al (2011); [5] investigate the effect of chemical treatment of coir fiber on thermal and mechanical properties of coir fiber composites with recycled high density polyethylene matrix. The chemical composition effect on surface modification of composite was analyzed by Fourier transform infrared spectroscopy (FTIR) and the thermal stability of composites properties were studied by thermos-gravimetric analysis (TGA). The mechanical properties of the composites were tested according to ASTM D790 with fiber volume fractions in the range of 20-40%. Harish et al (2009), [6] investigate mechanical properties of developed composites by using coconut coir. SEM (Scanning electron micrographs) are used to get interfacial properties of coir/epoxy and compared with glass fiber/epoxy. Mulinari et al (2011), [7] here in this study, mechanical properties like tensile and fatigue test evaluated on developed composite. a chemical modification of the coconut fibers done by NaOH and composite developed by compression molding technique. Modified fiber also evaluated by (SEM) scanning electron microscopy, X-ray-diffractometry, thermal analysis and Fourier Transform infrared spectroscopy. Also fractured surface of specimen was examining to assess the fracture mechanism. Romlia et al (2012), [8] in this investigation coir based composite developed and tensile test performed and analyzed. This experiment setting is based on full factorial design of experiment, so total 18 numbers tensile test carried out on 18 specimens. The result of experiment was obtained based on three parameters, that are fiber volume fraction, curing time and compression load during fabrication. Sood M. et al (2015), [9] investigate chemical treatment effects on the tensile and flexural properties of developed composite by reinforced treated sisal fiber with fresh and recycled HDPE matrix. the chemical treatment of fiber done with NaOH + Maleic Anhydride (MA) and NaOH + Benzoyl Peroxide (BP) + MA. By treatment the result obtained composites containing 30 wt.% of NaOH + BP + MA treated sisal fiber shows higher tensile strength as in comparison of NaOH + MA treated sisal fiber composites. But at lower fiber content of 7.5 wt.%, both the treated fibers composites exhibit almost comparable tensile strength. flexural strength of NaOH + BP + MA treated sisal fibers composites is significantly higher at 30 wt. % of sisal fibers but relatively lower at 7.5 wt.% of sisal fibers when compared to the corresponding composites with the same amount of NaOH + MA treated sisal fibers. SEM images reveal that in both the composites the primary failure mechanisms responsible for tensile failure is fiber pull-out apart from some other secondary mechanisms like fiber breakage and fiber delamination. Singh S et al (2014), [10] in this investigation composite fabricated by injection molding, which Coir fiber reinforced into polyethylene (fresh and recycled) with varying fiber contents from 10wt% to 30%. then Tensile and flexural tests are conducted on composite specimens, accordingly to the ASTM D638 and ASTM D790 standards to get result on poor tensile fracture and poor interfacial adhesion between coir fiber and HDPE matrix. The results obtained are compared with specimens made of 100% fresh HDPE and mixture of virgin and recycled HDPE (50% each). here the tensile strength of coir fiber composite decreases respectively by 0.53 MPa to 2.20 MPa with the increase in coir content from 10wt% to 30% when compared with specimen made of 50% fresh and 50% recycled HDPE. The flexural strength of composite containing 10wt% and 30% coir fiber are reduced respectively by 3.82 MPa and 4.99 MPa.

In most of researches, it is found that composite fabricated by reinforcing natural fibers into polymer matrix and to get their better tensile and flexural properties, some chemical modification treatments are performed. However, composite fabrication by using natural fibers like sisal and coconut coir with high density polyethylene (fresh and recycled) are still limited. Further in most researches, it is also found that only one natural fiber is reinforced into polymer matrix to fabricate composite. But from study of previous literature's it is revealed that by using two natural fibers fabricated composite gives better mechanical properties as in comparison of single fiber polymer composite.

In the present work, we have investigated tensile and flexural strength of developed composite by using natural fibers (sisal and coconut coir fibers) as reinforced with high density polyethylene (fresh and recycled) as matrix. To get better mechanical properties and interfacial adhesion, natural fibers are treated with chemicals (NaOH (sodium hydroxide) solution). The tensile and flexural properties of fabricated composite have been compared with single fibers (sisal and coir) reinforced in HDPE composite.

II. MATERIALS AND METHODS

A. Material Used

Sisal fiber were purchased from "CHANDRA PRAKASH & COMPANY FROM JAIPUR (RAJASTHAN)" in the form of long thread fibers having density 1.45 gm./cc and were cut in pieces from 4 to 5 mm approx. manually. which were further chemically treated. The purpose of keeping fiber length close to 5 mm is motivated by the earlier studies [1], similarly Brown coconut coir taken in the form of long thread fibers from waste and were cut in pieces from 4 to 5 mm manually. which also were further chemically treated. HDPE (High Density Polyethylene) fresh and recycled with density range: 0.93 – 0.95 g/cm³ (ISO 1183) were purchased from "MAA LAKSHMI TRADERS, PLOT NO: 406, PHASE-II, INDUSTRIAL AREA Chandigarh-160002, and India".

B. Chemically Surface Modification

Due to hydrophilic nature of natural fibers they produce poor interfacial adhesion bonding with polymer matrix. Due to this poor bonding, mixture of natural fibers with matrix materials are not easy and develop week fiber matrix bond. therefore, to get good bonding between fibers and matrix materials chemical modification treatment process performed. As detailed by Aggarwal L et al (2017), [11], and Easwara Prasad et al (2017), [12] The sisal and coir fibers were first washed with distilled water at room temperature for 1 hrs. and then dried in an oven at 100 °C for 5 hrs. The dried sisal and coir fibers were soaked in 10 wt% NaOH solution for 24 hrs at room temperature, after that washing with distilled water until a pH value of 7 was achieved. The sisal and coir fibers were finally dried in hot air oven at 80 °C for 24 hrs.

C. Specimen Samples Fabrication

The composite specimens for tensile and flexural testing was fabricated by using injection molding machine (Model: BH-100, Make: JB Industries Pvt. Ltd.). The different specimens were fabricated by varying the amount of coconut coir and sisal fibers in HDPE (50% fresh+50% recycled) matrix, as per composition Table 1 given below. For comparison, the specimens were also fabricated for 100% pure HDPE and recycle. The dimensions and geometry of tensile and flexural specimens conform according to ASTM D638 and ASTM D790 standards. The ASTM D638 represent geometry of specimen like dog bone type and ASTM D790 represents geometry for testing sample like rectangular bar. The density for sisal, coir and HDPE are 1.45 gm/cc, 1.2 gm/cc and 0.94 gm/cc respectively.

Table 1. Composition of Tensile Specimens

S.NO	HDPE		*sisal (wt%)*	*coir (wt%)*	*Sample Density (gm/cc)*
	fresh (wt%)	*recycle (wt%)*			
1	100	0	0	0	0.94
2	45	45	5	5	0.979
3	40	40	10	10	1.017
4	35	35	0	30	1.018
5	35	35	30	0	1.093

D. Tensile and Flexural Testing of Prpared Specimen

The tensile and flexural testing of fabricated various specimen was conducted according to ASTM D638 and ASTM D790 standards. The testing of specimen was conditioned for 40hrs in an environment test chamber (3A/191/2K, kasck

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industries, pune, india) maintained at 23°C and 50% RH. Both the test was performed on universal testing machine (UTM-1205, P.S.I, Sales, delhi, india) at a crosshead speed of 2mm/min. the tensile test were conducted till fracture of the specimens and the elongation was reported over a gauge length of 57mm. during the flexural test, the specimen were subjected to three points loading over a span of 127 mm with a preload of 0.1 MPa.

E. SEM (Scanning Electron Microscopy)

The scanning electron microscope was used to examine fiber surfaces before and after chemical treatments. This is done under jeol make (model: JSM JSM6510LV) scanning electron microscopy (SEM) at a magnification of 105 X. For SEM investigation, all the samples were coated with 4 nm thick layer of Gold and Platinum using JEOL fine coater (Model: JFC-1600).

III. RESULT AND DISCUSSION

A. Effect of Chemical Treatment on Fibers

Both untreated and treated (NaOH solution) sisal and coir fibers were observed under SEM to determine the effect of chemical treatments on the fibers surface. Fig 1(a and b) shows respectively the surfaces of sisal and coir fibers before treatment. The fiber surfaces appear very smooth due to the presence non-cellulosic components like hemi-cellulose, pectin, lignin and wax on the outer surface of the fibers. However, after NaOH treatment the fiber surface gets roughened and cleaner and fibers bundle break down into sub fibers Fig 2 (a and b). It may be attributed to the removal of non-cellulosic components from the fiber surface due to alkaline treatment.

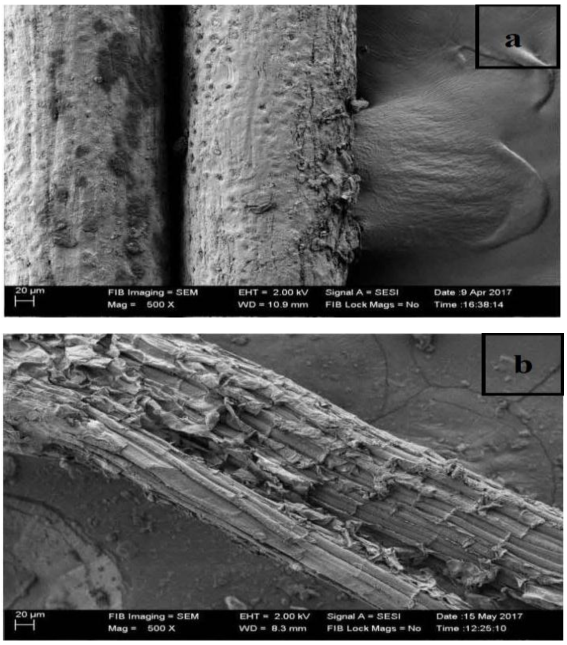

Fig. 1 Untreated Fibers (a) Coir; (b) Sisal.

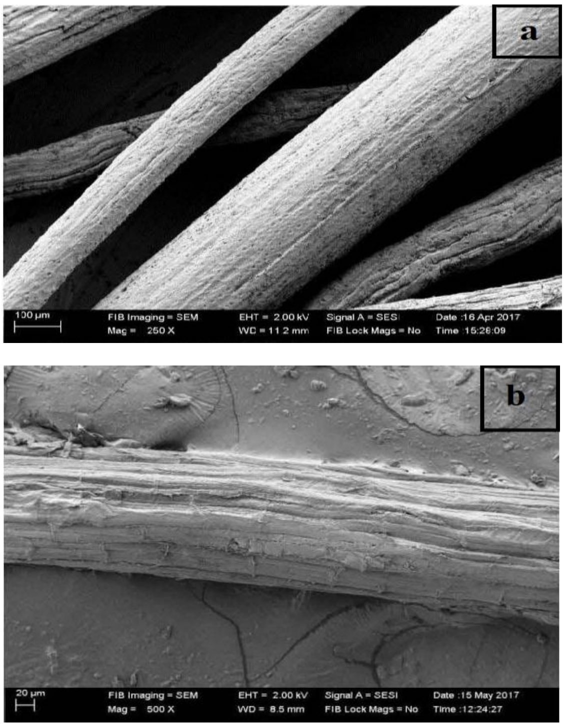

Fig. 2 NaOH treated fibers (a) coir; (b) sisal.

B. Tensile Strength

The tensile strength of different composite samples is obtained after testing and shown in Table 2.

Table 2 – Tensile Strength of Different Composite

Specimen code	Compound			*Tensile strength (MPa)*
	HDPE (wt%)	*Sisal (wt%)*	*Coir (wt%)*	
T1	100	0	0	15.2
T2	90	5	5	19.5
T3	80	10	10	21.6
T4	70	0	30	12.4
T5	70	30	0	12.0

The comparison of tensile strengths of various specimens, as coded in Table 2, is shown in Fig 3. From table we observed that the tensile strength of hybrid composite with 10wt% sisal and 10wt% coir fibers (Specimen-T3) gives 21.6 MPa tensile strength which is higher than (specimen-T2) gives 19.5 MPa tensile strength with 5wt% sisal and 5wt% coir fiber content in composite. In short it is noted that On increasing further, the amount of sisal and coir fibers in hybrid composite the tensile strength is further increased. The hybrid (Specimen-T3) with 10wt% sisal and 10wt% coir fibers possesses the maximum tensile strength of 21.6 MPa, on other side with 30 wt.% coir fiber alone we get tensile strength is about 12.4 MPa and with 30 wt% sisal fiber alone, tensile strength is about 12.0 MPa.

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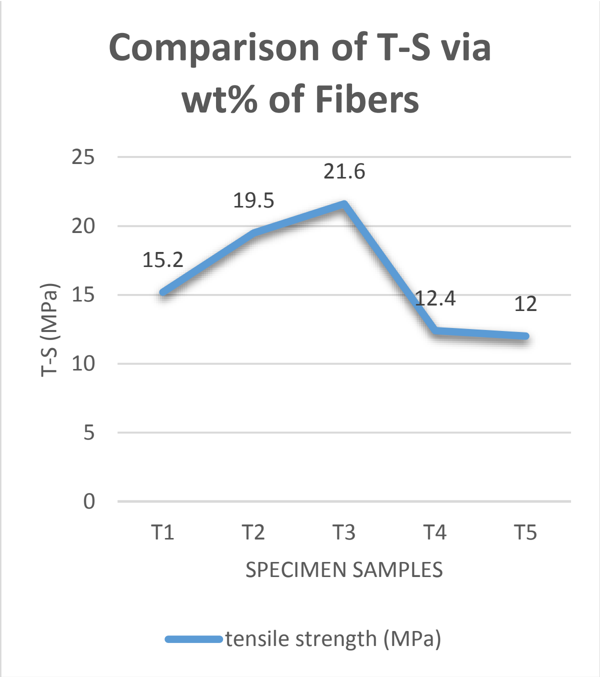

Fig 3: Tensile Strength Result for Different Volume Fraction

C. *Flexural Strength*

The flexural strength for different composite samples is given in table 3.

Table 3 – Flexural Strength of Different Composite

Specimen code	Compound			*Flexural strength (MPa)*
	HDPE (wt%)	*Sisal (wt%)*	*Coir (wt%)*	
F1	100	0	0	16.8
F2	90	5	5	17.5
F3	80	10	10	18.5
F4	70	0	30	14.3
F5	70	30	0	14.6

The comparison of Flexural strengths of various specimens, as coded in Table 3, is shown in Fig. 4. From table we observed that the flexural strength of hybrid composite with 10wt% sisal and 10wt% coir fibers (Specimen-F3) gives 18.5 MPa, flexural strength which is higher than (specimen-F2) gives 17.5 MPa, flexural strength with 5wt% sisal and 5wt% coir fiber content in composite. In short it is noted that On increasing further, the amount of sisal and coir fibers in hybrid composite the flexural strength is further increased. The hybrid (Specimen-F3) with 10wt% sisal and 10wt% coir fibers possesses the maximum flexural strength of 18.5 MPa, on other side with 30 wt.% coir fiber alone we get flexural strength is about 14.3 MPa and with 30 wt% sisal fiber alone, flexural strength is about 14.6 MPa.

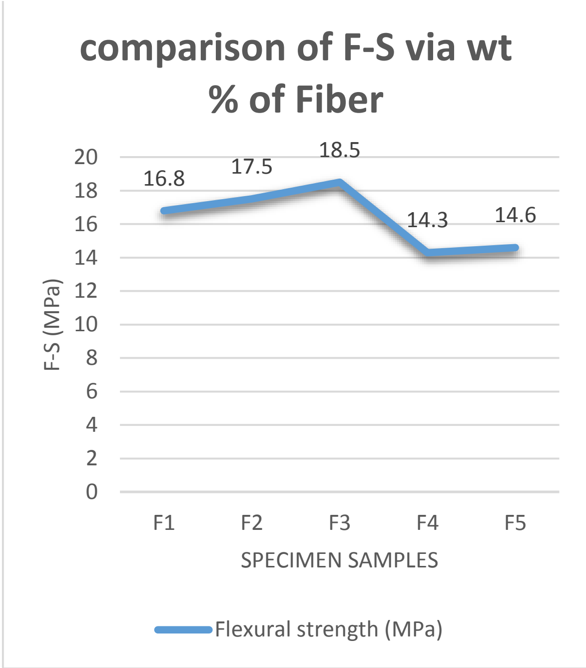

Fig 4: Flexural Strength Result for Different Volume Fraction

IV. CONCLUSION

A. *Conclusion*

In the present study tensile strength and flexural strength of the sisal-coir fibers reinforced HDPE matrix (containing 50%fresh + 50% recycled) hybrid composite investigated. Here sisal and coconut coir fibers were chemically modified with NaOH solution to improve interfacial bonding properties with HDPE matrix, and specimen was fabricated by injection molding machine. Number of specimen samples were fabricated and performing tensile and flexural strength test by UTM (universal tensile testing machine) according to standards ASTM D638 and ASTM D790. the investigation revels that the hybrid composite containing 10wt% sisal, 10wt% coir and 80wt% HDPE (50%F+50%R), exhibits the highest tensile strength and flexural strength as in comparison of other specimens.

The present investigation proves that recycled HDPE and fresh HDPE could be used to manufacture fiber reinforced hybrid composites with higher tensile and flexural properties.

Abbreviations

F	Fiber
UTF	Untreated Fiber
HDPE	High Density Polyethylene
NaOH	Sodium Hydroxide
ASTM	American Society for Testing and Materials
UTM	Ultimate Tensile Testing Machine
MPa	Mega Pascal
T-S	Tensile Strength
F-S	Flexural Strength
SEM	Scanning Electron Microscopy
BP	Benzoyl Peroxide
MA	Maleic Anhydride
FTIR	Fourier Transform Infrared Spectroscopy

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