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Mechanical Properties of Okra and Jute Fibers Filled with Groundnut Shell Ash Reinforced Composites with Epoxy (LY556) And Epoxy (XIN 100 IN) Resin Matrices

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Abstract

Now a day's natural fibers are rapidly used as the reinforcement material in polymer matrix composites due to their advantages like low density, environment friendly, higher stiffness, etc over the regular fibers. In present study, two different polymers used as the matrix materials. Okra and jute fibers are used as the reinforcement materials. Each polymer is reinforced with two natural fibers with fixed 15% weight fraction. Groundnut shell ash with weight fraction of 3% and 5% was used as the filler material for all the composites. Composites Preparation and testing were conducted according to the ASTM standards.Tensile, hardness, impact and compressive strengths were conducted to find the mechanical behaviour of the composites.

1. Introduction

Since 1900, Natural fibers emerge because of the strengthened material for the composites. currently, a day's fiber composites area unit employed in the numerous applications that area unit a replacement for the fiber composites as a result of its blessings like low value, abundantly available, high specific strength, high stiffness. Natural fibers are a unit bio and renewable material. Plant, animal, and mineral area unit the categories of natural fibers supported its origin. Mineral fibers avoided in several countries as a result of inflicting health problems to humans. Plant fibers based mostly on polysaccharide, cellulose is the major content of these fiber. Plant fibers area unit obtained from the components of the plant that area unit stem, leaves, bast, seeds, and fruits etc. Banana, jute, kenaf, flax, palm is that the example for the plant fibers. animal fibers area unit protein based mostly fibers, they're obtained from wool or hair of the animal. Alpaca, silk is that the example for the animal fibers. Plant fibers have the higher mechanical behaviour than the animal fibers aside from silk fiber, silk fiber has higher strength, however, the value of the fibers is a lot of compared to the opposite fibers. Jute fiber consist of 59-71.5% cellulose, 13.6-20.4% hemi cellulose and 11.8-13% of Lignin as the chemical properties. Okra fiber consists of 67.5% of cellulose, 15.4% of hemi cellulose and 7.1% of lignin as the major chemical properties [1-9].

The adhesion between the fiber and the matrix plays a serious role within the natural fibre composites. The matrix material transfers the load to the stiff fibers through shear stress at the interface of the composite. If the bonding between the matrix and fiber is poor the fabric might weaken and a life time of composite are ablated. If a more robust adhesion between the fiber and matrix sensible mechanical properties square measure obtained. Mechanical properties not solely depend upon the fiber-matrix interaction conjointly depend upon the matrix and fiber [10-18]. Growth time, the orientation of fiber conjointly influences the mechanical properties of a composite. Fiber alignment and size conjointly poignant issue of the mechanical properties of a composite [19-21]. Fiber properties square measure reckoning on the placement at completely different location fibers have the various properties. Soil type and climate conditions were different from one location to another location. these are influences the chemical properties of the fiber. Chemical properties of the fiber affect the mechanical behaviour of the fiber. As a result of this alteration of properties, same procedure of various location fibers doesn't offer an equivalent mechanical property. As a result of this alteration in properties, same procedure of various location fibers doesn't offer an equivalent mechanical property [22]. Aji et al reported that impact strength was increased by the addition of kenaf fiber also tensile and flexural strengths were increased by the pineapple leaf fiber. Jacob et al reported that up to 30% increase in the sisal/oil palm increases the tensile strength of the composite. Hybridization of these composites enhances the mechanical behaviour of the composites [23-28].The present research is mainly focused on considering two different fibers as okra and jute fibers to study and compare the enhancement in the mechanical behavior of polymer matrix composites for two different resins (Epoxy (LY556) and Epoxy (XIN 100 IN). The groundnut shell ash was used as the filler material for hybridization of composite. Tensile, hardness, impact and compressive strengths were evaluated and compared to find the mechanical behaviour of the composites.

2. Experimental

2.1. Materials

Two epoxy based matrix materials were used for present investigation, resins (LY 556 and XIN 100 IN) and hardeners (HY 951 and XIN 900 IN) were obtained from Araldite pvt, Ltd. Ash was taken from the shell of the groundnut, groundnut shells were kept in the muffle furnace at 500°C for half an hour, particle size of the ash were below the 300 µm. Then this ash was kept at 250°C in an oven for 3hrs. jute and okra fibers were obtained from the local sources in Rajam, Srikakulam, India.

2.2. Chemical treatment

Jute and okra fibers are marinated in 5% of NaOH solution for half an hour. Then these fibers were cleaned several times with distilled water followed by immersing the fibers in very dilute HCl in order to remove the NaOH content. NaOH treated fibers were kept in an oven at 70°C for an hour to eradicate the moisture extant in the fibers [22].

2.3. Preparation of composite

Two different epoxy based matrix materials were prepared, Epoxy resin (LY556) mixed with hardener (HY951) is one matrix material and another matrix material was epoxy (XIN 100 IN) mixed with hardener (XIN 900 IN). These epoxy and hardener were mixed in 10:1 ratio. After mixing of epoxy and hardener 3 and 5 wt. % of groundnut shell ash were incorporated into the matrix material while mixing forming of air bubbles are prevented. After mixing the groundnut shell ash composites are prepared by conventional hand-layup process. Okra and jute fibers are oriented in unidirectional for preparing the composite. In the present study, the total eight samples were prepared. The first two sample (S1, S2) contains Epoxy (LY556) as a matrix and reinforcement with 3% and 5% of wt. of groundnut shell ash along with fixed 15% wt. of okra fiber. The next two sample (S3, S4) contains Epoxy (XIN 100 IN) as a matrix and reinforcement with 3% and 5% wt. of groundnut shell ash along with fixed 15% wt. of okra fiber. The next two sample (S5, S6) contains Epoxy (LY556) as a matrix and reinforcement with 3% and 5% wt. of groundnut shell ash along with fixed 15% wt. of jute fiber. The next two sample (S7, S8) contains Epoxy (XIN 100 IN) as a matrix and reinforcement with 3% and 5% wt. of groundnut shell ash along with fixed 15% wt. of jute fiber [24].

2.4. Standard test methods used

To examine the mechanical performance, tensile, compression, hardness number and impact tests are conducted. Tensile test was performed on INSTRON H10KS at spindle speed of 0.5 mm/min according to the ASTM D 638 standards. Impact strength (Izod test) was performed according to the ASTM D 256 standards. Compression test was escorted according to the ASTM D 695 standards. Rockwell hardness number was performed on the saroj hardness testing machine at 60kgf and 100kgf loads. Both L and M scales were used for finding the hardness number of the composites [17].

3. Results and discussion

Mechanical properties of these samples were evaluated and compared. Tested results of the hybrid composites are tabulated in the table 1. Variation of tensile strength of hybrid composites was shown in figure 1. It is observed that S3 achieves higher tensile strength than other samples. Also observed that 3% wt. groundnut shell ash filled sample have better tensile strength as compared to that of 5% wt. groundnut shell ash filled samples. By addition of 5% wt. filler material to the sample tensile strength shows decreased due to dispersion of filler material along with polymer. Filler weight percentage and elongation of fiber in the composite material are influencing factors of the tensile strength [19]. The mechanical interlocking of the 5% wt. groundnut shell ash filled samples were found poor as compared to the 3% wt. groundnut shell ash filled samples, resulting in low load transfer, low tensile strength and breaking strain. Okra fiber reinforced epoxy (XIN 100 IN) samples have better tensile strength as compared to the reinforcement of okra fiber with epoxy (LY556) samples. Also, jute fiber reinforced epoxy (LY556) samples have better tensile strength as compared to the reinforcement epoxy (XIN 100 IN) samples. It is clearly shows that okra fiber has better adhesion with epoxy (XIN 100 IN) and jute fiber has better adhesion with epoxy (LY556).

Table1: Test results of samples.

Sample	Hybrid Composite	Tensile Strength (MPa)	Impact Strength (KJ/m^2)	RHS		Compressive Strength (MPa)
				60 kgf	100 kgf	
S1	82% E1 +15% Okra fiber +3% Ash	10.01	24.8	50.2	53	22
S2	80% E1 +15% Okra fiber +5% Ash	9.85	26.2	47	48.5	18
S3	82% E2 +15% Okra fiber +3% Ash	11.70	25.2	53	55	27
S4	80% E2 +15% Okra fiber +5% Ash	10.50	26.7	49.2	49.2	22
S5	82% E1 +15% Jute fiber +3% Ash	10.70	51.2	52.4	53.4	18.8
S6	80% E1 +15% Jute fiber +5% Ash	9.90	53.6	48.3	50	12.5
S7	82% E2 +15% Jute fiber +3% Ash	8.65	50.9	40.8	52	29.7
S8	80% E2 +15% Jute fiber +5% Ash	7.85	52.2	35	42	23

(*) E1, Epoxy (LY556); E2, Epoxy (XIN 100 IN); ASH, Groundnut shell ash.

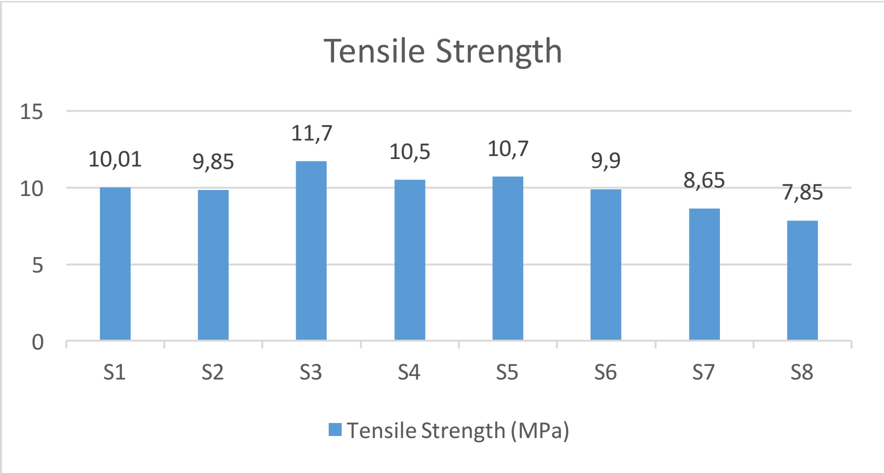

Figure 1: Variation of Tensile Strength of Samples

Impact test determines the amount of energy absorbed by a material during fraction. The absorbed energy is measurement of a toughness of a material and acts as a tool to study temperature reliant on ductile brittle adhesion. Variation of impact strength of the samples was shown in figure 2.

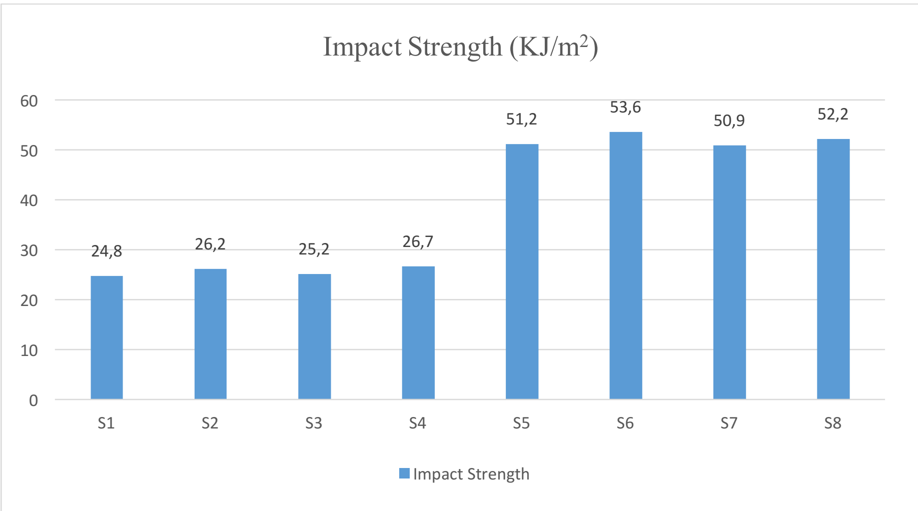

Figure 2 : Variation of Impact Strength of Samples

Among the all samples S6 have the higher impact strength. The addition of groundnut shell ash increases the impact strength of the samples. when compared to okra and jute fibers samples, jute fiber attains higher impact strength. Characteristics of fiber, interfacial adhesion of fiber/matrix, construction and geometry of the sample are influencing parameters of the impact strength.
Variation in Rockwell hardness number of samples was shown in figure 3. Rockwell hardness number was performed on the saroj hardness testing machine at 60kgf and 100kgf loads, at both loads S3 sample attains higher hardness number. The addition of 5% wt. groundnut shell ash filler to the sample results decreases the hardness number. Hardness of a material associates with its strength, wear resistance.

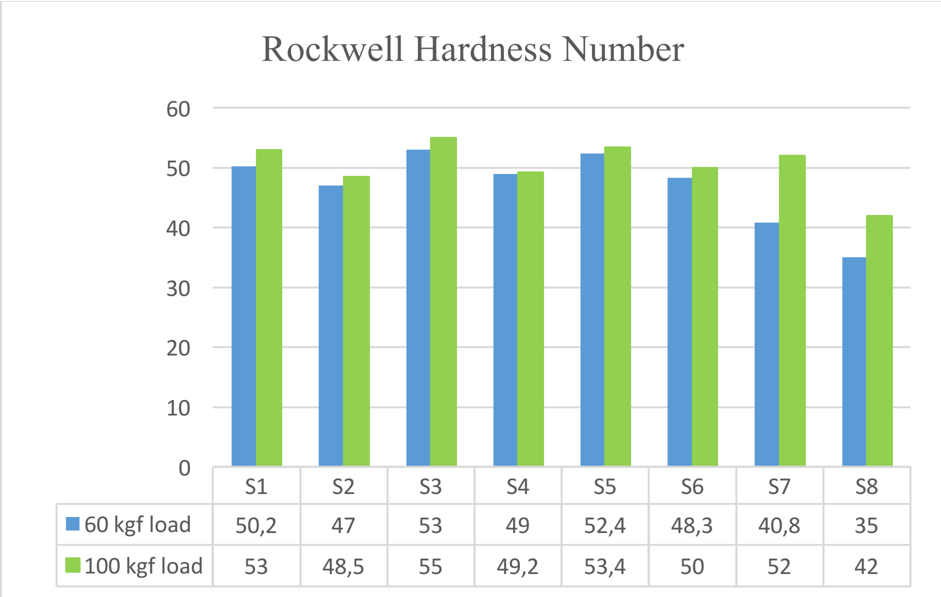

Figure 3:Variation of Rockwell Hardness Number of Samples

Variation in the compressive strength of samples was shown in figure 4. Among all samples, S7 have the higher compressive strength. The flawless adhesion of fiber/matrix gives the better compressive strength. The addition of 5% wt. groundnut shell ash filler to the sample results decreases the compressive strength.

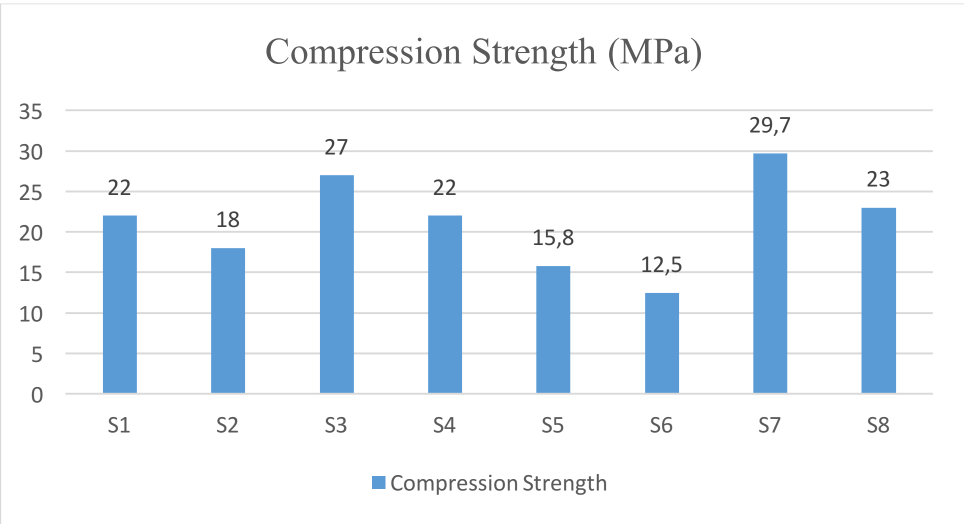

Figure 4 : Variation of Compressive Strength of Samples

Conclusion

In this study, mechanical properties of natural fibers (okra and jute) along with groundnut shell ash (3% and 5% wt.) reinforced with two different polymers [Epoxy (LY556) and Epoxy (XIN 100 IN)] were compared. It is observed that the good interface of fiber/matrix improve the mechanical properties. Okra fibers has good interfacial bonding with the epoxy (XIN 100 IN) also jute fiber has the good interfacial bonding with epoxy (LY556). Compared to the okra fiber, incorporation of the jute fiber into both matrices obtained the better impact strength. Okra fiber reinforced composites obtains slight higher tensile strength compared to the jute reinforced fibers.The addition of 5% wt. groundnut shell ash into the sample exhibits lower mechanical strength due to due to dispersion of filler material along with matrix. In this work, there have some limitations as compared with earlier literature. The main limitation identified in this work is hyperbolic nature. So, this can be overcome by the chemical processing of the fibers. These materials are suitable for structural applications.

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