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Effect of Fiber Loading & Walnut Filler on Mechanical Properties of Sisal-Kevlar Hybrid Epoxy Composite

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Abstract— In the current research, the effects of walnut filler and fiber loading on mechanical properties of sisal-kevlar fiber based hybrid polymer composites were evaluated. Composites were fabricated by simple hand-lay-up technique. This research work describe the development and charcterization of new set of bidirectional hybrid polymer composite consisting of sisal-kevlar mat as reinforcement, walnut shell as filler and epoxy as matrix material. Experiments are carried out to study the influence of fiber loading and natural filler on mechanical behavior of these composites. Result shows the considerable effect of fiber loading and filler on the mechanical properties of composites. Sample KSWC3 (6 wt % sisal + 6 wt % Kevlar + 3 wt % walnut filler) gives optimum results among all the composites which are fabricated in this work.

Index Terms— Natural fiber, Sisal fiber, Conventional fiber, Kevlar fiber, Hybrid composite, Walnut filler, Mechanical properties.

1 INTRODUCTION

NAtural fibers are the best substitute of synthetic fiber in many applications due to their low cost, abundantly available in nature and less human hazard. Despite of the above advantages they have some limitation also, such as high water uptake tendency and low mechanical strength as compared to conventional fibers like Kevlar, carbon and glass. These properties of natural fiber based composites can be improved by hybridiazation of such fiber with high strength synthetic fibers and also give flexibility to the design engineer to tailor the properties of material as per as requirements. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases [1-2]. Hybrid composites that contain two or more types of fibre, the benefits of one type of fibre could compliment with what are lacking in the other so to take advantages of both natural and conventional fibre, they have been added conjointly to the matrix so that superior, optimal and economical composite can be obtained.

In present work composite is made up of Sisal fibre, Kevlar fiber and walnut shell fillers. Sisal fibre is belonging to the plant fibre family which extracted from the leaves of the *Agava sisalana*. In recent year sisal is the widely used biodegradable fibre in polymeric materials, the advantageously effects of sisal fibre in thermoplastics have seen by the various researchers [3-6]. Kevlar 49 is used in this work which has high fracture toughness, high tensile strength and high modulus of elasticity. In this study walnut shells is used as filler, Walnut (juglans regia L.) is an important crop that is cultivated throughout the world's temperate regions for its eadible nut [7]. A valuable research has been done on hybridization of sisal and kevlar fibre in polymeric materials by researchers but there are lacks of research on effects of natural filler contents in sisal-kevlar fibre based polymer composites. The fracture resistance may not be improve by fillers but they enhance the others properties like tensile strength, flexural strength, toughness and abrasion resistance etc.

Ofem et al. [8] in his research work he focused on bio polymer composites incorporated with periwinkle shell as reinforcement and cashew nut shell liquid as binding material. They observed that tensile strength, flexural strength and impact strength increases with increase of filler loading and give optimum result at 40 wt% periwinkle shell and 400μm particles size. Kumar et al. [9] investigated the effect of mustard cake filler on mechanical properties of glass fibre based hybrid epoxy composites, they showed that wear rate decrease with increase of fibre loading and also the some enhancement in mechanical properties of filled glass fibre composites (mustard cake as a filler) as compared to unfilled composites. Raju et al. [10] performed on potential of using ground nut shell particles as fillers in vinyl ester composites. The result declared that the addition of the particles improved the mechanical properties up to some wt % and further decreased with increased particles content in the sample, this work gives the solution to enhancement the mechanical properties of viny ester polymer composites to be used in particleboard used in indoor envi-

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ronment. Khalil et al. [11] Exploring the biomass based carbon black as filler in epoxy composites, they revealed that the flexural filled epoxy composite exhibit better flexural strength as compared to unfilled polymer composite.

In this research walnut shell particles as minor contents are used to prepare hybrid composite to enhance the mechanicalproperties of composite which contains only sisal and kevlar fibre. The hand lay-up technique is used to prepare sets of composite. Mechanical tests are tensile strength, flexural strength; hardness and impact energy were carried out.

2 Materials and Sample Preperation

2.1 Materials

Sisal and Kevlar fiber mat were purchased from the local market of roorkee, India while walnut shells are collected from villages of Uttarakhand, India. Epoxy resin having density 2.55 g/cm^3 is obtained from Amtech pvt. Ltd. Delhi, India.

2.2 Sample Preperation

The fabrication of the various composite materials is carried out through the hand lay-up technique. The composite fabrication consist of three steps: (a) mixing of epoxy resin and filler using a mechanical stirrer, (b) mixing of the curing agent with the filled epoxy resin, and (c) fabrication of composites. Resin and hardener mixed in a ratio of 10:1 by weight as recommended. Six different types of composites have been fabricated with different (2 wt %, 4wt % and 6 wt %) of sisal and kevlar fibre loading and walnut shell as minor contents (3 wt %). The designations of these composites are given in Table 1. The specimens of suitable dimension (uses of diamond cutter) are cut from the composites for the mechanical.

TABLE 1
COMPOSTIONS AND DESIGNATION OF COMPOSITES

S.no	Compositions (wt %)	Designation
1	96% Epoxy + 2% Sisal + 2% Kevlar	KSC1
2	92% Epoxy + 4% Sisal + 4% Kevlar	KSC2
3	88% Epoxy + 6% Sisal + 6% Kevlar	KSC3
4	93% Epoxy + 2% Sisal + 2% Kevlar + 3% walnut shell filler	KSWC1
5	89% Epoxy + 4% Sisal + 4% Kevlar + 3% walnut shell filler	KSWC2
6	85% Epoxy + 6% Sisal + 6% Kevlar + 3% walnut shell filler	KSWC3

2.3 Mechanical Testing

The ASTM standards are used for mechanical testing of the specimens. The tensile test was carried out using Instron 1195. The flat specimens are mainly used for tensile test. A uniaxial load is applied on both the ends. The tensile property of fibre - reinforced polymer composites are identified by the ASTM standards has the designation D 3039-76. Toughness measurement is done using Charpy tester. In charpy method the sample size 55mm×10mm×10mm and V notch is t/3 were taken.

3 Result and Discussions

These studies present the result of mechanical properties of Sisal-Kevlar fibre reinforced polymer composite with and without walnut shell powder used as filler. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here:

- Tensile test
- Hardness test
- Impact test
- Flexural Strength

3.1 Mechanical characterizations of composites

The mechanical characterizations of sisal-kevlar fiber reinforced epoxy composites (with & without filler) with different fiber loading are shown in Table 2.

TABLE 2
MECHANICAL CHARACTERIZATIONS OF COMPOSITES

Composite	Tensile Strength (MPa.)	Hardness (BHN)	Flexural Strength (MPa)	Impact Energy (Joule)
KSC1	22.32	55	11.00	7.05
KSC2	31.45	65	15.12	9.10
KSC3	45.08	85	17.67	13.45
KSWC1	30.94	60	13.02	9.00
KSWC2	42.36	72	16.91	11.00
KSWC3	58.73	95	19.81	15.71

3.3.1 Effect of fiber loading & walnut shell filler on tensile strength of composites

This investigation reveals that the presence of walnut shell filler and wt% of sisal and kevlar fibre has varied effect on the sisal-kevlar fibre polymer composite in term of mechanical properties. The tensile properties of the composites both filled and unfilled composites are presented in Fig 1. It has been seen that the composites with increases of fibre loading give better result and fillers are also affected the tensile strength. KSWC3 composites give maximum value of tensile strength as compared to other ones. This may be due to better stress transfer between fibres mats and good chemical bonding between fibre and matrix, filler also improvising their strength. Similar results have seen by Sarki et al. [12] performed on potential of using coconut shell particles fillers in eco-composite materials. The result obtained in testing the tensile strength and modulus increases with increase the percentage of coconut shell particles content. Mirbagheri et al. [13] has studied the tensile strength kenaf fibre polypropylene composites hybridization with wood flour and conclude that it is possible to enhance tensile strength by adding kenaf fibre in wood flour composites. It is clear that addition of filler in sisal fibre composites improves the load bearing capacity of the composites.

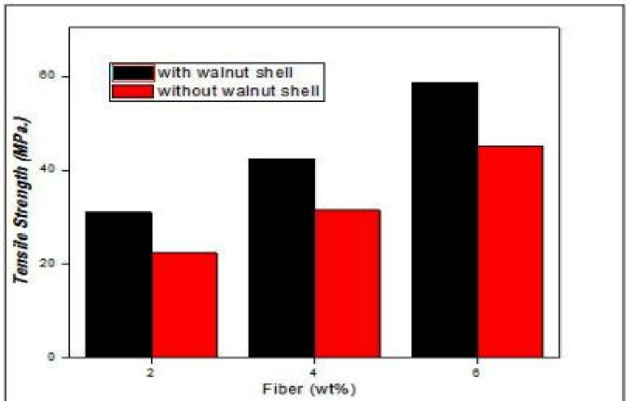

Fig 1. Variations of tensile strength with fiber loading

3.3.1 Effect of fiber loading & walnut shell filler on flexural strength of composites

Figure 2 shows the comparison of flexural strength of the Sisal-Kevlar fiber reinforced epoxy composites with and without filler obtained experimentally by the bend test. Composite materials used in structure are prone to fail in bending and therefore development of new composites with improved flexural characteristics is essential. It clearly indicates that inclusion of kevlar fiber improves the load bearing capacity and ability to withstand bending of the composites. The flexural strength of KSWC3 is more superior as compared to KSC3. This may be again due to the good chemical reaction at the interface between the filler particles and matrix.

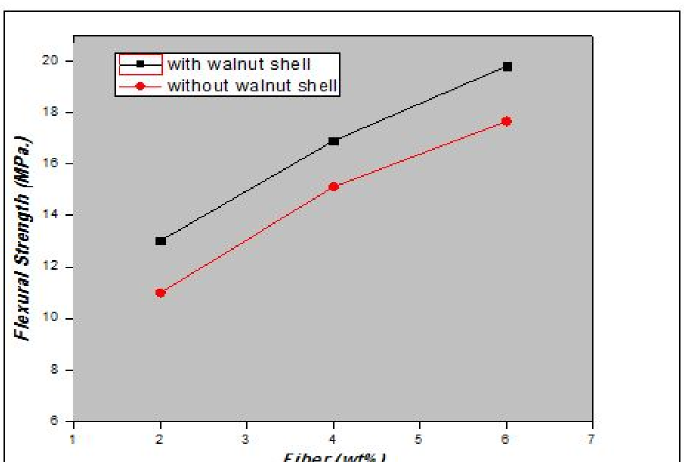

Fig 2. Varitaions of Flexural strength with fiber wt %

3.3.1 Effect of fiber loading & walnut shell filler on hardness and impact energy of composites

Surface hardness of the composites is considered as one of the most important factors that concern the erosion behaviour of the composites. From the fig 3, it is observed that mono KSWC composite have minimum hardness and such properties increases with particulates content in hybrid composite. KSWC3 composite gives optimum hardness among all the composites. The enhancement in hardness is due to the fact that during hardness test, a compressive load acts on the specimen, and due to this filler phase and matrix phase of the composite will force down together and touch each other more compactly.

The ability of materials to absorb energy under shocking or loading condition is known as impact energy. The KSWC3 sample gives maximum value (15.71 joule) of impact energy. The impact energy of composites is depending on the factors like chemical bonding between fiber and matrix and toughness of fiber reinforcement, similar observation is seen by Biswas et al [14], where red mud is used as filler in bamboo-epoxy composites. Fig 4 shows the variation of impact energy with different fiber wt %.

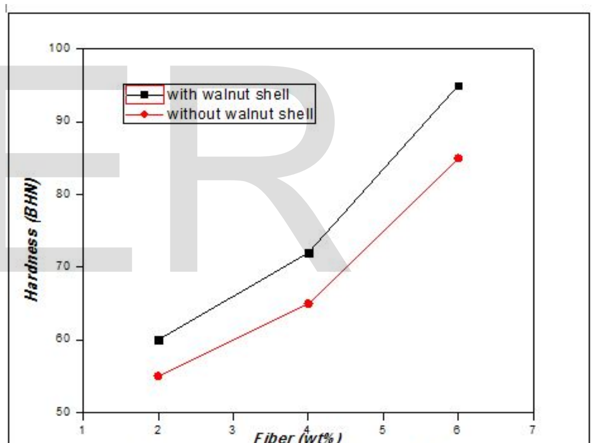

Fig 3. Variation of Hardness with fiber loading

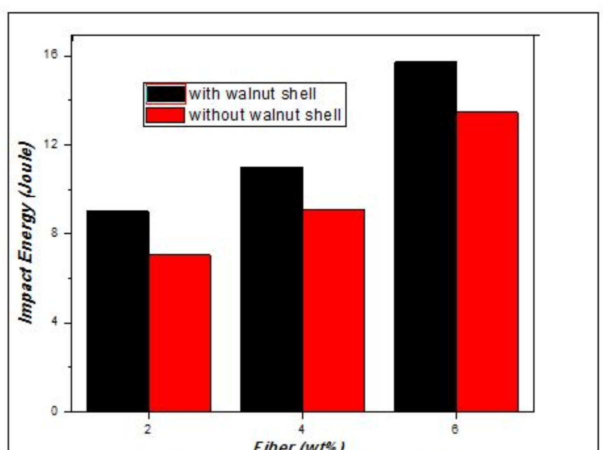

Fig 4 Variation of Impact energy with fiber wt %

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4 Conclusion

This research gives feasibility of using walnut shell which is eadible nut waste in the fabrication of sisal-kevlar fibre hybrid epoxy composites. It was observed that the walnut filler content sisal-kevlar fibre epoxy composite give better tensile strength, impact energy, flexural strength and hardness in comparisons to unfilled sisal-kevlar fibre epoxy composites, these properties are also affected by the sisal/kevlar fibre wt% in composites. At 6 wt% of sisal fibre and Kevlar in composites give superior mechanical properties as compare to 2 wt% and 4 wt% of sisal and kevlar. A sample KSWC3 has optimum results (58.73MPa- Tensile strength, 19.81MPa- Flexural strength, 15.71 Joule-Impact energy and 95 BHN -hardness) among all specimens. It is concluded that a hybridization of sisal – Kevlar fibre reinforced polymer composites with the uses of eadible-waste filler has a potential in applications which requires medium mechanical strength.

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