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Research paper

Modification & optimization of mechanical properties of bio fibers blended composites

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Abstract

ABSTRACT: The synthetic fibers used possess some major hindrance with respect to machine abrasion, recyclability, non-renewable, environmentally safe, energy usage, & health problems. In the present work 10%, unsaturated polyester toughened with 90 % Epoxy is used as matrix blend. The Bio fibres used are Palmyra-Luffa fibres & the bio-composites were fabricated by reinforcing bio fibres with matrix blend using hand lay-up technique. The main intension of the work is to monitor the quantity of bio fibres for the manufacturing of high strength to weight & low cost natural fibers reinforced hybrid bio-composites for the automobile and manufacturing, marine and other industrial applications. The changes in the values of various mechanical properties like; impact, flexural and compressive properties at different quantity of untreated and alkali treated palmyra-Luffa fibers reinforced blended bio-composites have investigated. The changes in the various mechanical properties with respect to quantity of fiber content without and with surface modification have investigaed. At 40% quantity of surface modified palmyra-Luffa fibers the values of mechanical properties have found to be maximum when compared with 10%, 20%, 30%, and 50% quantity of surface modified composites and other untreated bio-composites. Chemical resistance test reveals that resistance towards various chemical was also improved appreciably for all the chemicals excluding carbon tetrachloride & toluene.

Keywords: *Palmyra-Luffa Fibers; Surface Treatment; Chemical Resistance Test; Mechanical Tests.*

1. Introduction

At present the main focus is, identifying a biofiber composite which is lighter in weight, performance oriented, excellent mechanical strength, dimensionally stable, biodegradable, ecofriendly, cost effective, high corrosion resistance, and also suitable for several applications. Non polar polymer composite materials have been used in various fields like military, marine, infrastructure, aerospace, automotive & aircraft industry. Now a days industries show more interest in biodegradable & ecofriendly polymer composites, due to low cost and minimal health hazards [10, 11]. The polymer blend possess many advantages interms of the products for specific end use applications & enhancing resin's effective utilizastion, performance and properties. Epoxy is the widely used & versatile resin material for the manufacturing of various advanced composites, in different applications because of its better bonding, dielectrical, chemical and various mechanical properties. The toughness of epoxy resin has been enhanced by blending with suitable polymers like unsaturated polyester [1-6]. Hence, suitable polymeric materials were needed to improve the, thermal stability, stress-strain properties by retaining stiffness, and glass transition temperature and impact strength of epoxy resin. Among the various polymer blends, epoxy/polyester blend was found to be suitable combination [3]. Because the Unsaturated polyester posses better mechanical, thermal, corrosion resistant properties and low cost when compared to epoxy. Hence the blending technique was used effectively to get superior properties & to overcome some of the inferior properties of both matrices. When compared to traditional artificial fibers, natural fibers have the desired properties like low cost, low health hazards, nonabrasive, low density, high toughness, non-corrosive, ease of processing, enhanced mechanical properties, good calorific value, less wear of machine and are sufficiently available [9], [11]. Palmyra fibers are eco-friendly, inexpensive, posses sufficient specific strength, light weight and lower density compared to glass fiber and Luffa fibers are light in weight, ecofriendly and lower density [8]. These are not only cheaper but also possess good resistance to friction & heat and will withstand many chemicals and solvents [10]. Weak fiber/matrix interface decreases the stress transfer efficiency of the fiber due to lack of stress transfer from the matrix to load bearing fibers. Surface modification by alkali treatments have been proven to be effective in removing impurities from fibers and improving mechanical properties [10-11]. In the present work ten various samples have prepared in which five untreated samples and treated composite samples with the variation of % fiber quantity.

2. Experimentation

2.1. Materials

Resin 1: unsaturated polyester resin Resin 2: epoxy araldite LY 556 Fibers: 1. Luffa
Catalyst: methyl ethyl ketone peroxide hardener: HY 951 [2]. palmyra
Accelerator: cobalt naphthenate

2.2. Fiber treatment

To increase the effectiveness of interfacial adhesion, fiber surface needs to be modified with different chemical treatments, reactive additives and coupling agents. Chemical treatments produce more reactive groups on the fiber surface and which facilitates efficient coupling with the matrix. Surface modification of fibers by alkali treatment with different percentages of NaOH: 5 wt.% and 10 wt% was carried out in this work.

2.3. Fabrication of blended hybrid bio composites

The mould cavity required for the fabrication was coated with a thin layer of hard wax for easy release of fabricated composites. After this a thin coating of aqueous solution of poly vinyl alcohol (PVA) was applied. Biofiber composites, were fabricated with the use of the hand lay-up technique. Then the hybrid biofibers of desired quantities ie., unprocessed & processed Luffa-Palmyra fibers were reinforced into the matrix blend to obtain the needed bio-composite specimens for the investigation of different mechanical properties, then air bubbles if present were removed carefully with the gentle rolling. For complete curing, composite samples were post cured at temperature of 80^0 C for 2 hours by keeping them in hot oven. After curing unprocessed & processed samples of bio-composites of 10%, 20%, 30%, 40% and 50% by volume content were fabricated.

3. Results and discussion

3.1. Compressive strength properties

The outcome of the fiber surface modification and fiber quantity on the compressive property of bio composites were indicated in the fig 1. It was observed that 40% volume of surface modified fibers composite showed higher and optimum value of the compressive property than the untreated composites. In case of untreated biofiber composites due to poor compatibility between hydrophobic matrix & hydrophilic natural fibers which would adversely affects the adhesion between fiber & matrix and decreases the reinforcement capacity of the fibers because of inadequacy of stress transfer from the matrix to load bearing fibers. Previous works revealed that alkali treatment reduces fiber diameter and increases surface roughness [8], [10]. As the surface treatment by means of NaoH cleans the fiber's surface by the elimination of unwanted materials & impurities, like oils, hemicellulose and lignin from the fibers, yields the good percentage of α (alpha) cellulose in fibers [10]. Fragmentation of fiber bundles into smaller fibers (fibrillation) due to alkali treatment of fibers leads to the more availability of effective surface area for wetting by the matrix material [11]. Hence, fiber surface modification results in getting the increased mechanical properties [9], [10].

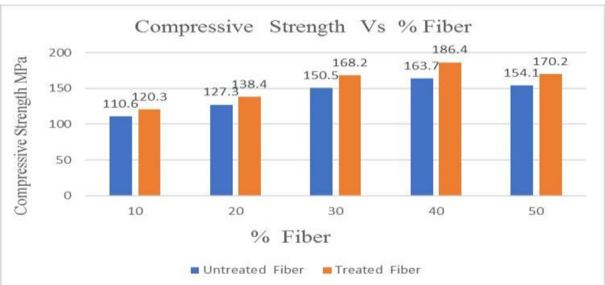

Fig. 1: Indicates The Variation of Compressive Property with Quantity of Untreated and Treated Fibers.

3.2. Flexural properties

The change in the values of flexural strength property with respect to fiber quantity with and without surface modification is shown in the figure 2. Flexural strength property of the both untreated & treated biocomposites increased with the increase in fiber quantity from 10% to 40% and after which decrease in the flexural property was noticed. It was observed that 40% volume of treated bio fibers composite had a higher and optimum flexural strength than 10%, 20%, 30% and 50% treated composites and other untreated bio fiber composites. This is due to high fiber-matrix compatibility, good matrix-fiber interaction & wetting. This great increase in the flexural strength property at 40% volume was due to very good compatability between matrix & fiber and great improvement in the stress transfer from the matrix to load bearing [7]. However, decrease in flexural property of the composite was noticed at 50% fiber quantity. At 50% fiber content (high fiber load), decrease in the flexural property indicates inadequate fiber-matrix interfacial bonding & micro-crack formation at the interface leads to inadequate stress transfer [5-10].

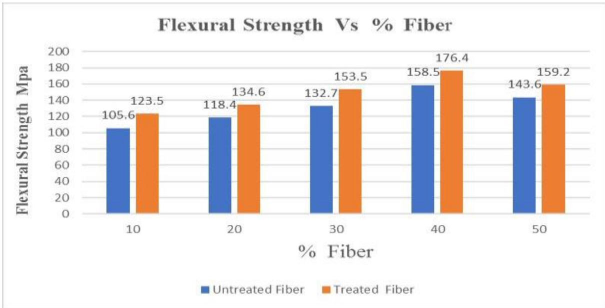

Fig. 2: Reveals The Change of Flexural Property of Unprocessed and Treated Composites with the Variation percentage of Fibers Content.

3.3. Impact strength

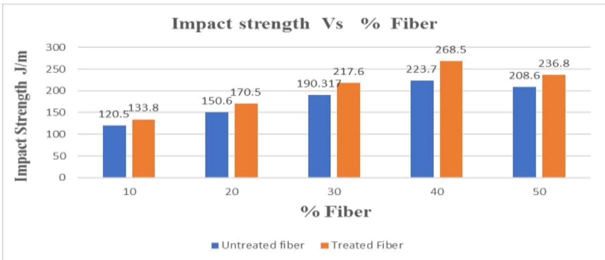

Fig. 3: Reveals the Change in the Values of Impact Strength of Unprocessed and Surface Modified Composites with the Variation of Amount of Fibers Content.

The difference in the values of impact strength with the change of bio fibers loading and surface treatment of bio fibers is shown in the Figure 3. It was observed that 40% volume of treated bio fibers composite had higher values of the impact property than 10%, 20%, 30% and 50% volume of surface modified composites due to better compatibility between fiber-matrix, fine interaction of matrix with fibers & damp the bio fibers fairly. It was also observed that 40% volume of treated bio fibers composite had higher values of the impact property than untreated fiber composites [8]. As the alkali treatments have been proven effective not only in cleaning fiber's surface by removing impurities & hemicellulose from fibers but will also produce coarser surface on the fiber and impart good fibers-matrix interfacial bonding [7].

3.4. Moisture content test

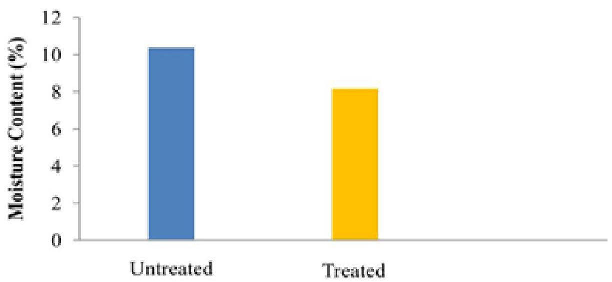

Fig. 4: Indicates the Absorption of Moisture Content by Unprocessed and Surface Modified Composites.

The Figure 4 shows the percentage absorption of moisture quantity by unprocessed fiber composite which was 10.36%, because the natural fibers exhibit hydrophilic properties due to the presence of unwanted and impure materials in contrast with the processed bio fiber composites, which have low moisture absorption quantity [9].

3.5. Chemical resistance test

The chemical resistance test was conducted for both unprocessed & processed Palmyra-Luffa fibers reinforced composites. The effect of below mentioned chemicals on unprocessed & processed fibers reinforced composites was investigated. % Weight loss or % weight gain values of unprocessed & processed bio composites immersed in the mentioned chemicals is shown in the table 1. The chemical test results clearly indicates that gain in weight was observed for almost all the chemicals leaving toluene & carbon tetrachloride. The table clearly indicates that processed bio-composites also have weight loss in carbon tetrachloride [5]. The cause behind the weight loss was due to attack of the chlorinated hydrocarbons on the cross-linked epoxy-polyester system. The gain in weight values indicate that the composites were bulged with the gel formation rather than dissolving in chemical reagents [11]. From the test it was clear that composites were also impervious to water. The chemical resistance test reveals clearly that bio-composites were substantially unaffected by almost all the chemicals excluding toluene and carbon tetrachloride.

Table 1: Indicates Outcome of Chemicals on the Weight of Unprocessed and Processed Bio-Composites.

		Weight loss (-) or gain (+) in %	
Sl No.	Chemical used for test	Untreated Composites	Treated Composites
1	8 % Acetic acid	12.56	12.80
2	40 % Nitric acid	13.35	13.47
3	10 % Hydrochloric acid	15.01	15.78
4	10 % Sodium hydroxide	11.51	11.26
5	20 % Sodium carbonate	9.51	09.18
6	10 % Ammonium hydroxide	8.7	9.5
7	Benzene	2.0	1.86
8	Toluene	-1.34	-0.85
9	Carbon tetrachloride	-0.71	-0.55
10	Water	2.65	2.48

4. Conclusion

The impact, flexural and compressive properties for the different quantity of both unprocessed and processed bio composites were studied. From the investigations it was clear that composites having 40% processed fiber quantity possess optimum and maximum values compared to untreated and other treated biofiber composites. At 50% fiber quantity (high fiber load), even though more fiber quantity is reinforced, decrease in the mechanical properties was resulted which indicate inadequate fiber-matrix interfacial bonding & micro-crack formation at the interface leads to inadequate stress transfer. But in untreated composites because of the poor or incompatibility between hydrophobic matrix & hydrophilic natural fibers which would adversely affects the adhesion between fiber & matrix and decreases the reinforcement capacity of the fibers because of inadequate stress transfer from the matrix to load bearing fibers. But with the chemical treatment or surface modification of fibers, it was found to be possible to enhance the properties of the composites with the removal of impurities, hemicellulose, oils, waxes, and lignin from the surfaces of the fibers, and yields rough surface topography, which improves the aspect ratio of fibers and increases the reinforcing efficiency of the fiber with the improvement of stress transfer from the matrix to load bearing fibbers. Chemical test reveals that the composites have resistance to almost all chemicals excluding toluene and carbon tetrachloride.

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