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Mechanical Engineering

Elixir Mech. Engg. 97 (2016) 42349-42353

ISSN: 2229-712X

Mechanical Characteristics of Palm and Glass Sandwiched Polymer Composite

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ARTICLE INFO

Article history:
Received: 30 July 2015;
Received in revised form:
20 August 2016;
Accepted: 29 August 2016;

Keywords
Polymer composites,
Palm leaf stalk,
Fiber treatment,
Nano filler,
SEM image analysis,
Polyester.

ABSTRACT

The environment friendly natural fibers used in this study are taken from leaf stalk portion of palm tree. Portions of these fibers are alkali treated while the remaining kept raw. Both these fibers are sandwiched separately with glass fibers to form two set of plates by reinforcing into polyester resin matrix blend with coconut shell powder using hand lay-up method. Specimens are tested as per ASTM standards. The results reveal that alkali treatment improved fiber quality and a novel composite was developed to producing automobile parts.

Introduction

The utilization of natural fiber materials has been increased greatly with much focus towards the eco-friendly environment. Natural fibers are bio-degradable in nature and are widely used in many applications [1-3]. It is difficult to compromise the properties of natural fiber reinforced composite in analogous with synthetic fibers as they possess extreme values closer to metals in few cases. development of bio-based polymer composite based products using natural fibers are basic interest among researchers due to their great advantages like high strength to weight ratio, low cost , easily available and fiber matrix adhesion. Eco-friendly composites are alternatives for plastic fiber composites [4-6]. Some natural fibers, like henequen [7], sisal [8], coconut fiber [9], jute [10], bamboo [11], date palm [12], wood [13], basalt [14], and banana [15] have been used as reinforcement agents in different thermosetting and thermoplastic resins. Many researchers manufactured composites with and without chemical treatment [16-18]. Fillers are added to natural fibers in preparation of composites for high strength [19-20]. Increase in percentage of coconut shell filler content usually increases the tensile strength. Limited research was done in using palm as natural composites. Palm fibers residues when added with coupling agent in preparation of composites enhanced the composite characters [21]. Palmyra fruit fiber chemically treated with NaOH whose tensile properties were analysed using FEA [22]. The developed Hybrid composite using Oil Palm Empty Fruit Bunch favoured better mechanical properties and Water absorption behaviour [23]. The tensile properties of Sugar Palm Fibers showed high impact strength [24]. Oil palm empty fruit bunch natural fibers with Copper nanoparticles revealed biodegradability [25]. Usage of palm kernel fibers for production of asbestos-free automotive brake pads was achieved [26].

Composite using long palmyra palm petiole fibers reinforced polyester composites reveals good mechanical property [27]. The influence of date palm fibers and graphite filler on mechanical and wear characteristics of epoxy composites showed appreciable results [28]. The effect of various pretreatments on oil palm empty fruit bunch (EFB) and kenaf core fibers was detailed [29]. Hybrid composites prepared with jute and oil palm fibers using hand lay-up technique finds application in automotive industry [30]. This paper addresses the development of palm leaf stalk fiber sandwiched with glass fiber filled with coconut shell nano filler reinforced polymer composites. Results from the treated and untreated palm leaf stalk fiber sandwiched with glass fiber filled with coconut shell nano filler reinforced polymer composites are compared and presented.

Experimentation

The materials used to develop the sandwiched composites are naturally available fibers extracted from the leaf stalk part of the palm tree Fig.1. To enhance the properties of these fibers 8% KMnO4 solution was used. Commercially available E-Glass fiber mat was used to sandwich these composite.

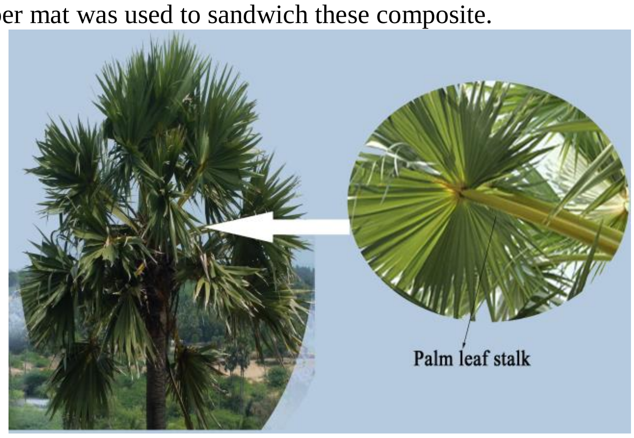

Figure 1. Palm leaf stalk spotted on palm tree

Coconut shell nano filler was added to fill in the voids formed during polymerization of the composites. Polyester resin with cobalt napthanate (hardener), methyl ethyl ketone peroxide (catalyst) forms the base material in the composites. Wax polish as mould releasing agent was used for mould surface coating.

Extraction of fiber and processing

Palm leaf stalk taken from palm tree was soaked in water for two weeks and washed thoroughly to remove the impurities

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sticking on fibers. The fibers were then thoroughly washed with distilled water to remove further impurities followed by sun drying for about one week. One portion of the dry fibers was rolled in rollers to form as mat designated as raw fiber mat. The other portions of the dried fibers are treated with 8% KMnO4solution for about 3 hrs to enhance the fibers properties. The fibers are later washed with distilled water to remove excess of KMnO4 and dried at 80 degree Celsius for 12 hrs. The fibers are then rolled as mat termed as treated fiber mat

Preparation of specimen

Table 1 shows the combinations of Polyester resin, fibers and filler materials in weight percentage. The composite plates A and B are fabricated in this combination

Table 1.Combination of Polyester resin and the natural fiber in weight %

Specimen	Combinations	Weight	
		%	(gm)
A	Polyester resin +	70	1050
	Pure or raw palm leaf stalk fiber mat,E-glass fiber mat, Coconut shell nano filler	30	450
B	Polyester resin +	70	1050
	8% KMnO4 treated palm leaf stalk fiber mat,E-glass fiber mat,Coconut shell nano filler	30	450

8% KMnO4 treated palm leaf stalk fiber mat,E-glass fiber mat,Coconut shell nano filler

Composite plate A was fabricated with the raw fiber mat/sandwiched with E-glass fiber mat/ filled with coconut shell nano filler reinforced into the polyester resin matrix.

Composite plate B was fabricated with the treated fiber mat/sandwiched with E-glass fiber mat/ filled with coconut shell nano filler reinforced into the polyester resin matrix.

Fabrication of Composites for testing:

A standard size moulding box was used and its surface was coated with wax polish which acts as releasing agent. Hand lay-up method was adopted for fabricating both composite plates. Required amount of polyester resin was mixed with 2% cobalt napthanate and methyl ethyl ketone peroxide taken in a vessel, 5% coconut shell nano filler was also added and thoroughly mixed. The glass fiber mat was placed as first layer over the molding board and the required amount of polyester resin/coconut shell nano filler mix was poured over it. The trapped air bubbles were removed by gently rolling a hand roller over the fiber mat surface. The successive layers are made with palm raw fiber mat and the final layer was completed using glass fiber mat designated as plate-A. The same technique was adopted to fabricate composite plate-B using treated fiber mat instead of raw fiber mat. Both the composite plates are allowed to dry at room temperature for 24 hours. Finally the composite plates were removed from the moulding box.

The composite plates A and B are fabricated in this combination are cut into samples as per ASTM D standards for performing various tests to find tensile strength, flexural strength, impact strength and hardness value.

Mechanical properties

Tensile properties

Tensile properties of raw and 8% KMnO4 treated palm leaf stalk fiber/sandwiched glass fiber mat /filled coconut shell nano filler reinforced polymer composites are found by testing the samples of each material on a computerized servo controlled UTM machine with specimen standard ASTM D 638 as shown in Fig. 2 .The samples are placed in the grips of the UTM, the gauge length and cross head speeds are fixed to 50mm and 2mm/min respectively and pulled apart for measuring strength and elongation until the specimen got fractured.

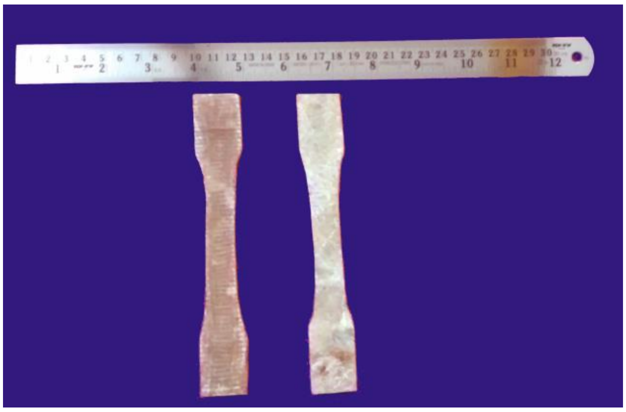

Figure 2. Specimen for tensile test

Flexural Properties

The flexural properties of treated and untreated samples of palm leaf stalk fiber/sandwiched glass fiber mat /filled coconut shell nano filler reinforced polymer composites are measured by conducting Flexural test on computerized UTM using special attachment with specimen standard ASTM D 790 as shown in Fig. 3.

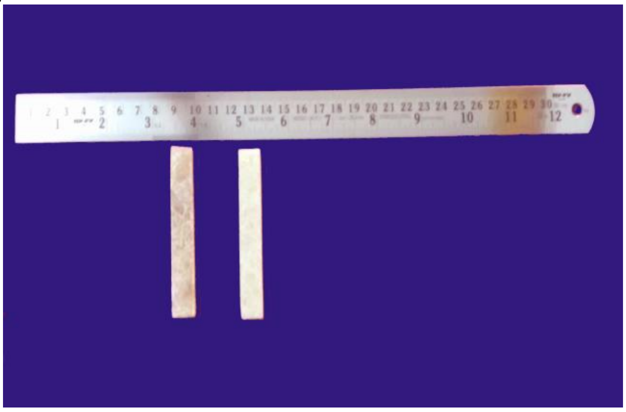

Figure 3. Specimen for flexural test

Impact Strength

The impact strength of both composites was measured using a charpy impact tester with specimen standards ASTM D 6110 as shown in the Fig. 4. The fracture values are calculated by dividing the energy absorbed by cross sectional area of the specimen.

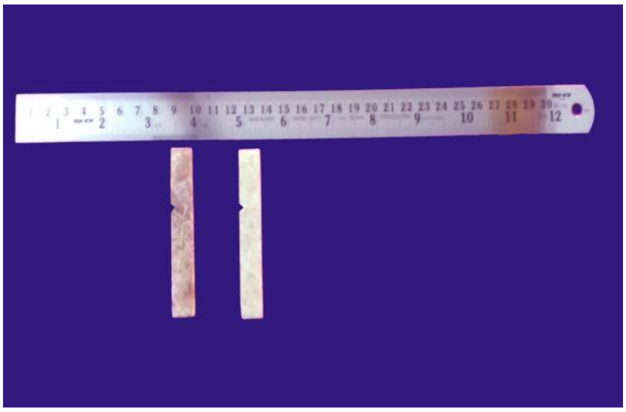

Figure 4. Specimen for impact test

Hardness Value

The hardness test was conducted on both specimens using a Rockwell hardness tester as per specimen standard ASTM D 785 shown in the Fig. 5. Load was applied for 15 seconds and the hardness was measured.

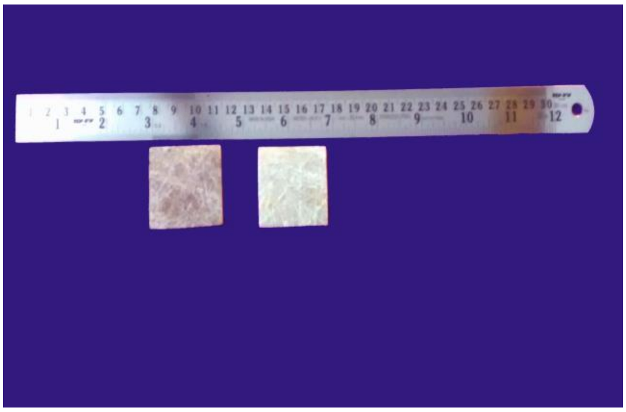

Figure 5. Specimen for hardness test

SEM image analysis

The surface morphology of composites was investigated using scanning electron microscope. The fractured samples were mounted onto SEM holder using double sided electrically conducting carbon adhesive tapes to prevent surface charge on the specimens when exposed to the electron beam.

Results and discussions

The interfacial strength depends on the surface topology of the fibers, because each fiber forms an individual interface with the matrix. Alkali treatment also causes fibrillation i.e., breaking of fiber bundles into smaller fibers which would increase the effective surface area available for wetting by the matrix material. After fibrillation due to the reduced diameter of fibers, the aspect ratio of fibers increases and yields a better fiber-matrix interface adhesion. The addition of nano coconut shell filler material got filled on the gaps and considerably decreased the voids formed during polymerization.

Stress Vs Strain

Figure 6. shows the stress-strain plot of specimens combinations, it can be seen that the untreated palm leaf stalk fiber/sandwiched glass fiber /filled coconut shell nano filler reinforced polymer composite (specimen A) posses relatively lower stress-strain rate than 8% alkali-treated palm leaf stalk fiber/sandwiched glass fiber /filled coconut shell nano filler reinforced polymer composite (specimen B).

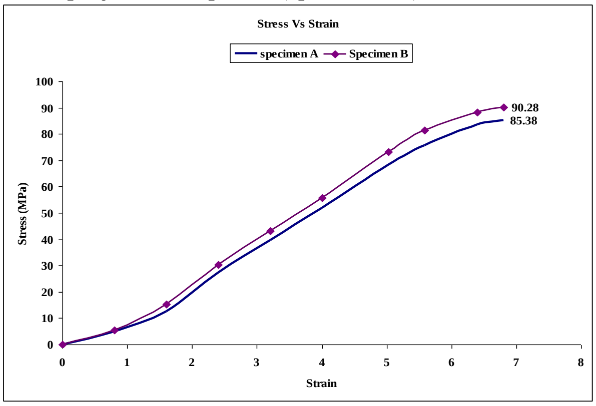

Figure 6. Stress Vs Strain Graph

Specimen Vs UTS

Fig. 7 illustrates the plot of Ultimate Tensile Strength (UTS) in N/mm2 versus specimens combinations, it can be seen that the untreated palm leaf stalk fiber/sandwiched glass fiber /filled coconut shell nano filler reinforced polymer composite (specimen A) yielded 85.38MPa and 8% alkali-treated palm leaf stalk fiber/sandwiched glass fiber /filled coconut shell nano filler reinforced polymer composite (specimen B) yielded 90.28MPa.

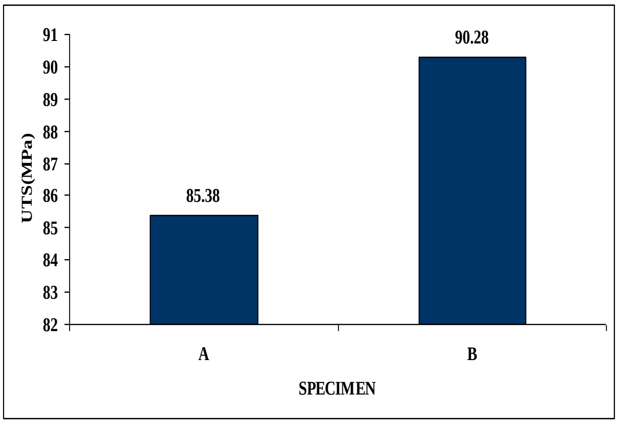

Figure 7. Comparison of Ultimate Tensile Strength

Specimen Vs Flexural strength

The variation of flexural strength for the specimens with and without alkali treatment was shown in Fig. 8. The specimen B recorded increase in flexural strength than the specimen A. This was due to high fiber-matrix compatibility, good fiber-matrix interaction and wetting.

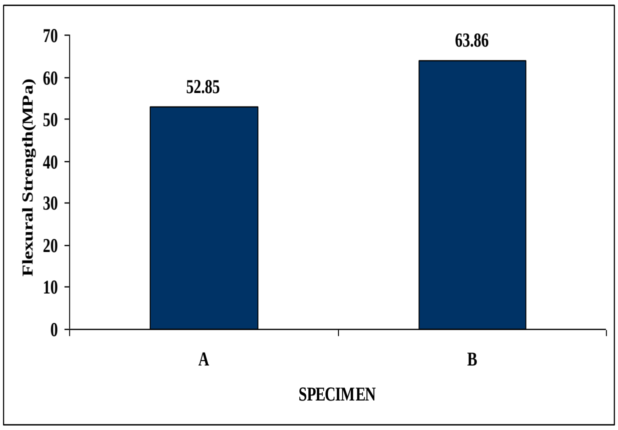

Figure 8. Comparison of flexural strength

Specimen Vs Impact strength

The variation of impact strength for the specimens with and without alkali treatment was shown in Fig. 9. The specimen B recorded increase in impact strength than the specimen A which results in obtaining the enhanced impact properties.

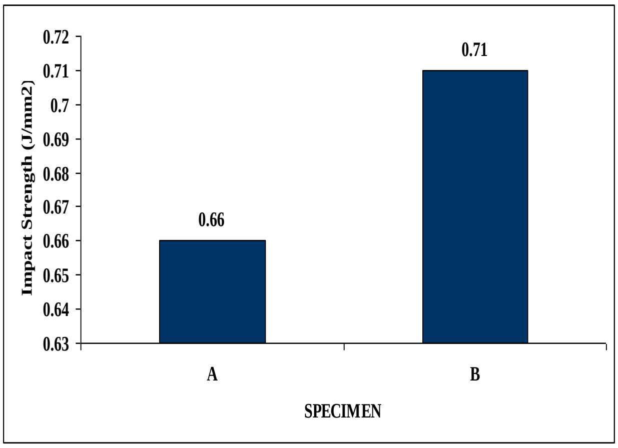

Figure 9. Comparison of impact strength

Specimen Vs Hardness

The variation of hardness for the specimens with and without alkali treatment was shown in Fig.10. The specimen A recorded increase in hardness than the specimen B due to the presence of impurities.

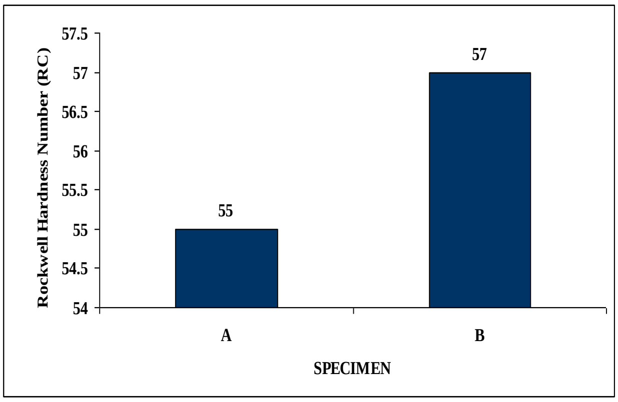

Figure 10. Comparison of hardness value

SEM morphology

SEM micrographs of the treated composites are shown in Fig. 11 and Fig.12. As seen from the micrographs, the large amount of resin adhered to the fiber surface and fewer gaps between resin and the fibers were observed. This indicated that improved the adhesion between and the fibers. Also the fiber pullout shows the improved tensile strength. This result was in agreement with those from mechanical tests.

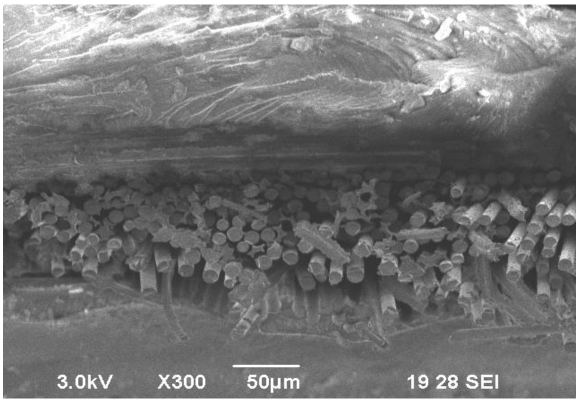

Figure 11. SEM micrographs of the treated composite at 300X magnification

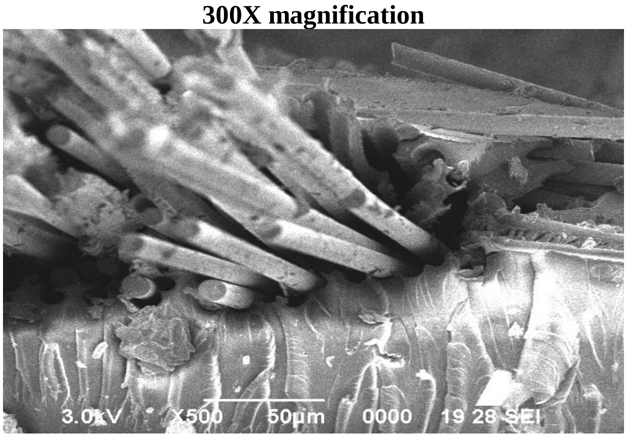

Figure 12. SEM micrographs of the treated composite at 500X magnification

Conclusions

The successful fabrication of sandwiched polymer composite using the un-utilized palm leaf stalk fiber was completed. The fiber treatment by KMnO4 soaking improved the mechanical properties like tensile, flexural, impact strength and hardness value. The various mechanical tests revel that mechanical properties of alkali treated fibers are superior to those of untreated fibers. Alkali soaking significantly removed surface impurities from fibers so a better fiber matrix adhesion was created. The result reveals that, the trend in all the properties increased for alkali treated fibers that are evident by SEM image analysis.

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