A Study on Mechanical Properties of Treated Palm Seed Fiber Epoxy Composite

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Abstract

Synthetic fibers composite fibers are more widely used because of its great property. Natural fiber epoxy composite is found to be an effective replacement of some kind of synthetic materials. Oil palm seed fiber is chosen as fiber because of its easy availability, less cost compared to other fibers, renewable, environment friendly, non-abrasive, biodegradable and enhanced properties. Palm seed fiber being available easily is also a disposal of fiber from its industries. Being a green composite 0il palm seed fiber epoxy composite was fabricated. In this paper chemical treatment with NaOH and H2O2 and mechanical properties of oil palm seed fiber epoxy composite was studied along with the morphological analysis of SEM images were conducted. Chemical treatments provided better adhesion between the fiber and matrix.
Keywords: Mechanical Properties, Oil Palm Seed Fiber

I. Introduction

Twenty first century demands the necessity of using ecofriendly material for replacing synthetic material. As this replacement can only be done with natural fiber in composite field. Old days a particular material was used for a particular need, later it was replaced with metals. Being stronger and demanding more life it gradually becomes the replacement of the traditionally used material. . The beginning of composite material usage is unknown. It has being stated as if some form of composite material such as straw had been used by Israelites to strengthen mud bricks. Egyptians used plywood as they realize that wood could be rearranged to superior strength and resistant to thermal expansion as well as to swelling owing to the presence of moisture. Medieval swords and armour were constructed with layers of different materials. Later these natural fibres lost their necessity with the introduction of other durable material called metal [1].

The matrix is the “weak link” in the composite, especially because resin do not presently exist that allow utilization of the stresses that the fiber are able to with stand. Natural fiber such as kenaf, hemp, flax, jute and sisal offers such benefit as reduction in weight, cost and recyclability. The energy consumption to produce a flax fiber mat (9.55 MJ/KG), including cultivation, harvesting and fiber separation, amount to approximately 17% of the energy to produce a glass fiber mat [2].

Natural fibers are those with low cost, density and specific properties. They are biodegradable and non abrasive. In compatibility of fibers and poor resistance to moisture often reduce the potential of natural fiber. They pose the tendency to form aggregates during processing. Primarly fibers contain cellulose, hemi cellulose, pectin and lignin. Hemicelluloses are responsible for biodegradation, moisture absorption and thermal degradation of the fiber as it shows least resistance. Lignin is thermally stable responsible for the UV degradation [3].Chemical treatments are considered in modifying the fiber surface properties. As the interface adhesion between fiber and matrix are increased there by increasing the load carrying capacity. Treatments include alkali, silane acetyalation, benzoylation, maleated coupling agents, iso cyanate permanganate etc. [4]. As natural fibers are environmentally superior to glass fibers due to low environmentally impact compared to glass fiber. Natural fibers have high fiber content for equivalent performance, reducing more polluting base polymer. Light weight fiber composition increased improved fuel efficiency [5].

In combination with proper selection of a curing agent and appropriate modifiers, epoxy resin can be specifically tailored to fit a broad range of application. The most widely used epoxy resins are diglycidyl ethers of bisphenol A (DGEBA). The outstanding characteristics of thermo sets derived from bisphenol -A epoxies are largely conveyed by its toughness rigidity and elevated temperature performance. Composites consists of two phases namely fiber and matrix. Fibers are discontinuous phase used to carry the load and matrix is continuous phase used to bind and transmit the load to the fibers. Natural Fiber Composites are durable, have good maintenance, renewable, bio-degradable, combustible and cost effective, as compared to synthetic fiber composites. Due to low density & cellular structure, natural fiber possess very good acoustic & thermal insulation properties & demonstrate many advantageous properties over synthetic fibers like glass fibers in handling & disposal. Traditionally, natural fibers are used and known for rope, twine, and course sacking materials; and they are biodegradable and environmentally friendly crop [6].

This paper is an evaluation of the mechanical property in this combination of epoxy and oil palm seed fiber to be a replacement of the non degradable fiber at low cost and a source of waste disposal.

II. EXPERIMENTAL

A. Material

In this paper is an evaluation of the mechanical property in this combination of epoxy and oil palm seed fiber to be a replacement of the non degradable fiber at low cost and a source of waste disposal.

Fig. 1: Oil Palm Fiber

The materials used in the production of the specimens include: The thermosetting epoxy resin DGEBA (B-11) and hardener (K-59), supplied by M/s Sharon Marketing Agency; Ernakulam. Oil Palm Seed Fiber was obtained from Oil Palm India Limited; Kollam, wax, releasing agent, and other miscellaneous items. The equipments used are abrasive paper, wax, ohp sheet, weighing balance, metallic mould of dimension (130 mm×120mm×3 mm), glass beaker, roller, glass rod, and cloth.

The treatment of fiber with NaOH has two effects on fiber: (1) it increases surface roughness resulting in better mechanical interlocking; and (2) it increases the amount of cellulose exposed on the fiber surface, thus increasing the number of possible reaction site [7]. Consequently, alkaline treatment has a lasting flax effect on the mechanical behaviour of fibers, especially on fiber strength and stiffness[8].Again, alkaline treatment can give an increase in tensile properties (both strength and modulus) for flax fiber-epoxy composites and coincide with the removal of pectin.

Fig. 2: Treated Oil Palm seed fiber

B. Method of Preparation

The fabrication of composite was done by Hand Layup method with treated palm seed fiber. Initially, the fine fibers was extracted from the Oil Palm fruit and washed at 70ºC hot water and dried under sunlight for 3 days to remove undesirables. Finally the dried fibers were cut into length of 1-1.5cm. The mould was cleaned of rust by scrubbing with an abrasive paper and then, the mould was coated with wax. The epoxy resin was mixed in the ratio of 2:1. Oil Palm Fiber was weighed in balance for the required quantities (10phr, 20phr, 30phr) in each case. A thin layer of matrix was applied on the bottom of the mould initially as a base coat spread even by rollers. The Oil Palm Seed fiber was oriented randomly in the mould and pressed as a mat. After that, homogeneously mixed resin was poured into the mould with placing an OHP sheet with releasing agent on one side was applied over the mould to squeeze out the air bubbles. An initial curing of 12 hours and an additional 7 days for post curing at room temperature. The specimen fabricated after post curing was kept in an oven at 60^0 C.

C. Treatment with NaOH

Treating of fiber with NaOH is one of the most used chemical treatments of natural fibers when used to reinforce thermoplastics and thermo sets. Fine filtered fibers immersed in a 5% aqueous NaOH solution for 2 h at room temperature. The treated fibers are washed thoroughly with water to remove the unwanted lignin and pectin content present in the aqueous solution until all NaOH was eliminated that is, until the water no longer indicated any alkalinity reaction. Again the fibers are kept in the oven at 50ºC for 1 h. alkaline treatment has two effects on the fiber. It increases surface roughness resulting in a better Mechanical Interlocking. It increases the amount of cellulose exposed on the fiber surface, thus increasing the number of possible reaction sites [9]. Studies show that 5% NaOH treated sisal fiber- reinforced polyester composite had better tensile strength than 10% NaOH treated composite [10].

D. Treatment with hydrogen peroxide

In Peroxide Treatment alkaline treated and thoroughly washed Oil Palm Seed fibers were subjected to oxidation using 0.05 g NaOH and 18 ml of hydrogen peroxides 30% for 100 ml of solution at 85ºC for 2 h. During this process the fibers were cooked under gradual rise of temperature. Finally the cooked fibers were removed from the mixture. Then the fibers were washed with distilled water thoroughly and dried at 50ºC for moisture removal.

E. Hand Layup Method

In Hand Layup method the mould was cleaned of rust by scrubbing with an abrasive paper and then, the mould was coated with wax. The epoxy resin was mixed in the ratio of 2:1. Oil Palm Fiber was weighed in balance for the required quantities (10phr, 20phr, 30phr) in each case. Polymer has to be applied on the mold with the help of a brush, but before applying there is an important step hardener or catalyst has to be added to the polymer, in order to accelerate the rate of polymerization or curing. In very simplistic terms the process can be described as the hardening process, in which the polymer will have some viscosity, it means it is in a semi solid state or in a liquid state, and from the semisolid or liquid state, it would be converted into a fully solid state, that means it is polymerized or it will cures. An in order to aid that process of conversion from a particular state to another state, that would be accelerated, if we add a particular catalyst or a particular hardener, with a resin or a polymer.

So, this polymer would be added with another, hardener or catalyst in order to accelerate, the rate of polymerization or curing. So, we applied the polymer, we have put the fibrous mat on top of the polymer next to this, at the some specific temperature. Again pour some resin mixed with hardener and press the top portion of the fiber filled mould with roller. Then place a thin layered plastic film coated with releasing gel at one side on the mould. Place some weight on the top of the mould so that it will push out the air bubbles trapped inside the composite fabricated.

Finally, the top part of the mold is removed after full curing and the composite material, if it is a flat plate molds a composite laminate, which would be, in the form of sheet. In case of different shape of the mold we will get a different type of a composite material.

III. RESULT AND DISCUSSION

The effect of chemical treatment on fiber surface was primarily studied.

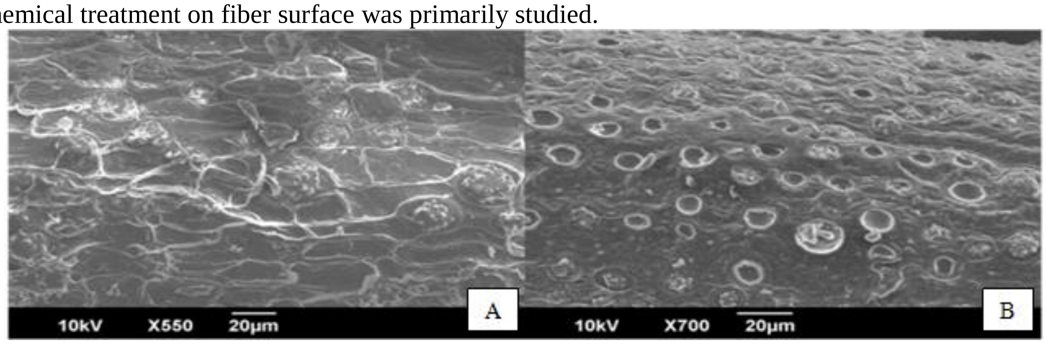

Fig. 3: SEM Image of (A) untreated fiber and (B) treated fiber

The figure shows the morphological view of untreated and treated fiber. In this untreated fiber is magnified at a range of 20μm and zoomed on 550 x at 10kV. This outer surface of fiber with all hemi cellulose, lignin and pectin is present. In case of treated fiber it is magnified at a range of 20μm and zoomed on 700x at 10kV. All unwanted contents are removed partially and some porous cavities are opened which enable better interface adhesion between fiber and epoxy. Several valleys on surface makes more interlocking between matrix and fiber.

A. Tensile Test

(a) (b) (c)

Fig. 4: Specimen prepared for tensile test (A) 10 phr (B) 20 phr (C) 30 phr

The tensile test specimens are cut into required dimension of 100MM x 10MM x 3MM as a rectangular cross section and edges were prepared by using emery paper. Testing of the composite laminates was carried out as per ASTM D3039 standards and procedures. The different Samples were tested in the universal testing machine (UTM) at a load speed of 2mm/ min and gauge length of 60 mm. There are three different kind of specimen was prepared for treated fiber epoxy composite on 10phr, 20phr, 30phr. The samples were left to break till the ultimate tensile strength occurs. It can be seen that 10 phr treated sample shows more strength. The result of the tension test is graphically represented below.

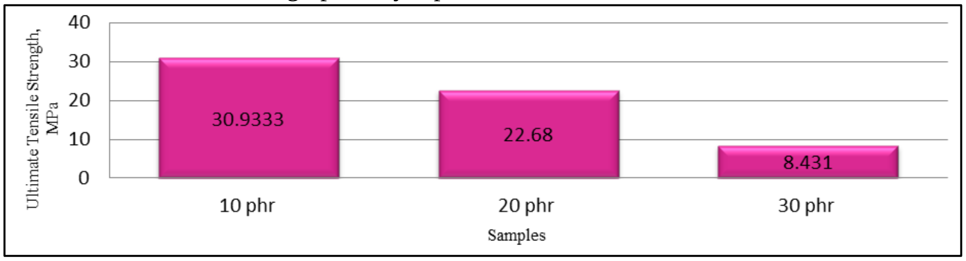

Fig. 5: Result on tensile strength of treated epoxy composite material

B. Hardness Test

Hardness test was done on a Durometer in shore D units. The testing procedure was done according to the ASTM D 2240 standard. The results were shown by graphical representation. Results shows that sample of treated fiber 20 phr shows better hardness when compared to all other samples.

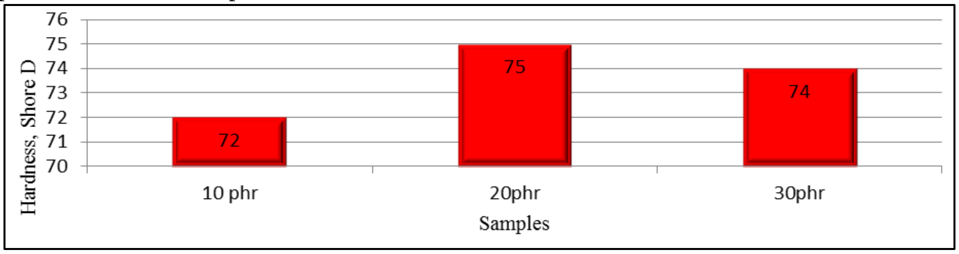

Fig. 6: Result on hardness test of treated epoxy composite material

C. Impact Test

The impact test specimens are prepared as per the ASTM 256 standard on a dimension of 6.5MM x 1.2MM x 3MM by an IZOD impact test with a pendulum of 5.5 J.

Fig. 7: Specimen prepared for IZOD impact test (A) 10 phr (B) 20 phr (C) 30 phr.

There are five samples from each nine specimens of 1phr, 3phr, and 5phr Oil Palm fiber epoxy composite. In treated fiber epoxy composite samples are of 10phr, 20phr, 30phr respectively. The edges of specimen were neatly finished and small "v" notches provided by using machine. It can be seen that 10 phr has shown better property. The comparisons of impact strength for different samples were shown in the figure

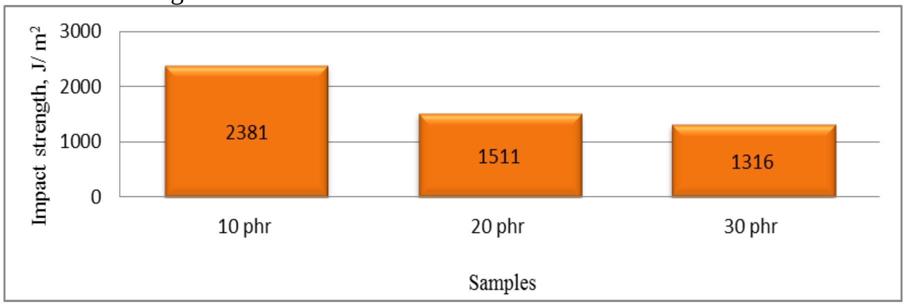

Fig. 8: Result on IZOD impact strength of treated epoxy composite material

D. SEM

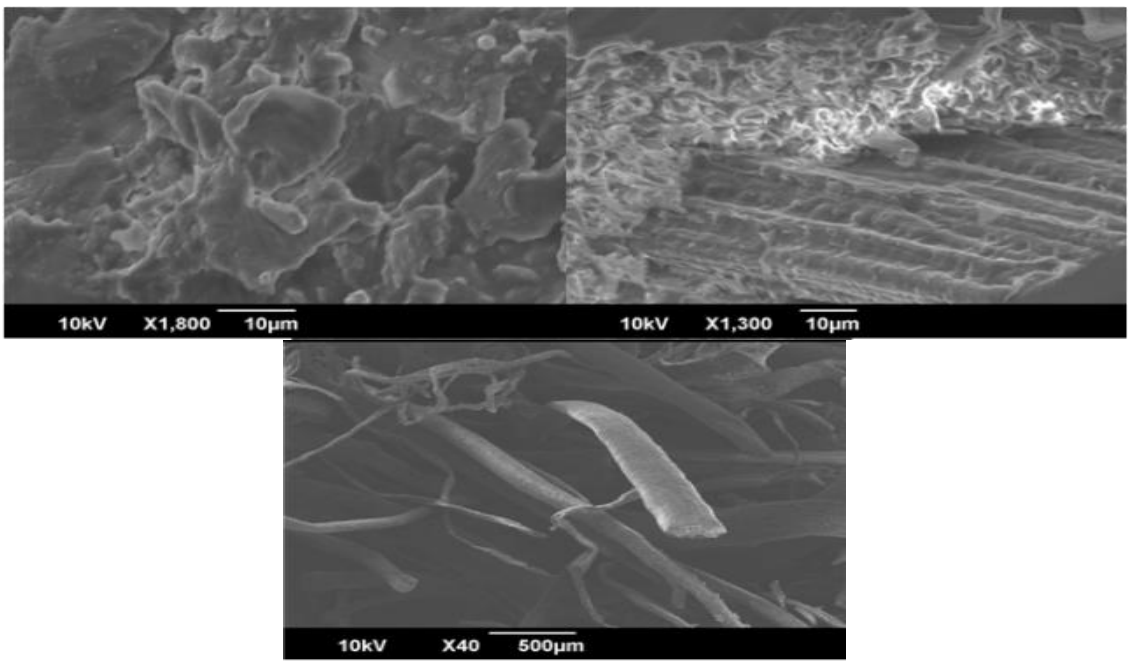

Fig. 9: Result SEM images of treated epoxy composite material (A) 10phr (B) 20phr (C) 30phr.

The morphology of treated oil palm seed fiber epoxy composite samples tested in this experiment is through Scanning Electron Microscopy. The SEM micrographs of the oil palm seed fiber epoxy composite samples at 10phr, 20phr, 30phr fiber content subjected to tensile loading are presented in Fig. 9. From the images, it can be seen that the fracture of fiber is due to the applied tensile load. In 10phr image it is seen as the matrix breakage due to the load applied. In 20phr image there the adhesion between the matrix and fiber is clearly seen in the space formed by the removal of excess material such as hemicelluloses, lignin and pectin from fiber by chemical treatment. In 30phr image the fiber break edge and the exfoliated case with the amount of fiber content increase is also seen.

IV. CONCLUSION

The Oil Palm Seed Fiber Epoxy Composite was fabricated and their mechanical property such as Tensile strength, Hardness strength, Impact strength and SEM analysis was evaluated. The following conclusions have been derived from the experimental investigation.

- The sample 10 phr have more tensile strength of 30.93 MPa.
- The maximum hardness value of 75 Shore D holds by sample of 20 phr.
- The impact strength of 10 phr sample shown 2381 KJ/m^2 on compared with rest of the two samples.
- From, the morphological observation the interfacial characteristics, internal structures of the fractured surfaces, fiber agglomeration are clearly observed.

The main reasons for the better properties are due to the chemical treatment making more interaction between fiber and matrix making the reinforcement stronger. This presence of stronger fiber enables the crack pinning mechanism by which further propagation of the crack is aborted.

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