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Investigation of Mechanical Properties of Luffa Cylindrical and Flax Reinforced Hybrid Polymer Composite

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ABSTRACT

In this present work the luffa and flax fibers reinforced with epoxy polymer was fabricated and their mechanical properties investigated experimentally. The composite were prepared by three plies where luffa is placed in between the flax mat. Laminates, were prepared by the hand layup technique of size 300*300*4mm. Epoxy LY556 and Hardener HY951 been used as a resin and hardener for the fabrication of composite laminate. Standard tensile, flexural and impact properties of the composite were studied. The experimental result shows that the hybridized bio composite exhibited a higher order of mechanical properties.

Keywords - Tensile strength, Hybrid composite, flexural strength, impact strength.

1. INTRODUCTION

Modern days the industrial, automotive and many more relevant sectors are moving toward natural fibre reinforced polymer materials due to its Eco friendliness, cheaper in cost, easy availability and light weight [1]. Polymer matrix composites are reinforced with natural fibres exhibit moderate mechanical properties, in fact these are agricultural wastages can be reused as fibre reinforcement. Beside synthetic fibre shows better properties than that of natural fibre but it can be equalized by hybridizing natural fibres such as flax, hemp, sisal, coir, etc. Table .1 and Table .2 shows the chemical and physical properties of luffa fibre [3].

Table 1 Chemical composition of Luffa fibre

Cellulose (%)	Lignin (%)	Hemi cellulose (%)	Ash (%)
63.0±2.5	11.69±1.2	20.88±1.4	0.4±0.10

When compared with synthetic fibre the mechanical properties of natural fibre is less so it's not suitable in structural applications [2]. These properties can be improved by suitable chemical and physical modifications of natural fibre. Sudhir et al. evaluated that the alkali treatment of luffa fibre increase the tensile strength of about64%and grafted fibre shows a 100% improvement in tensile strength [3].

Table 2 Physical properties of luffa fibre

Density (gm/cc)	Diameter (µm)	Aspect ratio	Micro fibrillar angle (°)
0.92±0.10	270±20	340±5	12±2

Table 3 Chemical composition of flax fibre. [11]

Cellulose (%)	Hemicellulose (%)	Pectin (%)	Lignin (%)	Waxes (%)	Water (%)
64–74	11–17	≈1.8	2–3	≈1.5	8–10

Mohanta et al. investigated the mechanical properties of the luffa and glass fibre reinforced epoxy composite and found that maximum properties were obtained in laminate i.e., two plies of luffa fibre in between the both the sides of the glass fibre. It is reported that the tensile strength and flexural strength were improved in the hybridized composite laminate [4]. Fiore et al. studied the effect of basalt outer layer in the flax reinforced composite. The result shows that addition of basalt outer layer increased better stability of composites both in static and dynamic loads [5] and the chemical composition of flax fibre is shown in table 3.

Panneerdhass et al. studied the mechanical properties of luffa and groundnut reinforced epoxy composite and found that chemically treated 40% fibre content laminate exhibited higher mechanical strength and then decrease in mechanical strength with fibre content due to insufficient wetting between fibre and matrix [6]. Akil et al. optimized the compression moulding parameter for flax reinforced bio composite and found out that moulding pressure of 30bar, time 3min and moulding temperature of 200^{o}Cshow the maximum impact energy of 48.902 kJ/m^{-2} [7]. There is less researchers are worked and scarcity of literature towards the luffa and flax based hybrid composite. In the present study the mechanical properties of the luffa and flax reinforced epoxy composite.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

Epoxy LY556 and hardener HY951 were used to prepare the polymer matrix. Wooden mould of 300 x 300 x 4mm was fabricated to prepare the composite laminate. Mansion wax is used for easy release of laminate from the mould. Luffa fibre and flax fibre mat were bought from sakthi fibres, Chennai. Fibres were cleaned from dirt and impurities. Luffa fibres are cut down and removed the seeds and made them into mat form. Alkali solution of (NaOH) 0.1 N was used to treated the fibres for a 1 hour and dried off. Then the treated fibres were washed with distilled water and dried in sunlight. From the Fig. 1 shows the untreated and treated flax fibres.

Fig. 1 Untreated and treated flax fibres

Composite laminate can be fabricated using a hand layup technique. Fibre and resin volume percentage can be calculated from the rule of mixture equation based upon the volume fraction for each layer of fibre and resin can be prepared. Epoxy and hardener are mixed in the ratio of 10:1. Treated and untreated fibres were used by 30% of the fibre content of laminates was prepared. Fig. 2 shows the mould used for fabrication of the laminate.

2.2 Fabrication of laminate

Fig. 2 Wooden mould setup

2.3 Preparation of samples for mechanical testing

Tensile samples were prepared according to ASTM standard D638 standard of size 250mm x 25mm x 4mm. The specimens were tested in the universal testing machine (Instron) with feed rate of 0.01mm/min. Flexural samples of size 64mm x16mm x 4mm was prepared by the ASTM standard of D790-10. Impact strength of the composite calculated from the Charpy impact test setup and the specimens was prepared ASTM standard of D6110-10 of size 75mm x 15mm x 4mm. The specimens were shown in Fig. 3

Fig. 3 Samples for mechanical testing

The water absorption test can be conducted based upon the ASTM standard D570 the samples were cut down on the size of 25mm x 25mm. The specimens were immersed in distilled water for 2-24 hours. Then the water absorption capacity of the specimens can be calculated by using a formula,

Water absorption capacity = (final mass of composite – initial mass of composite)/initial mass of composite (1)

3. RESULTS AND DISCUSSION

3.1 Tensile and Flexural strength

Fibre content and bonding between the fibre and matrix are the influential parameter for the tensile and flexural strength of the polymer composite. Fig. 4 show that the tensile strength of the alkali treated composite shows higher tensile value of 24 MPa. The average tensile value ranges from 19 to 24 MPa. When the load is applied along the flax side of the composite laminate, it shows higher flexural strength value of 59mpa is shown in Fig. 5 and M.Gouda et al made similar observations on the jute fabric-reinforced polyester composites [8].

Treated fibre shows an improved strength of the composite due to the removal of hollo-cellulose, pectin, wax and other impurities from the fibre. During the treatment of fibre retting action takes place and the surface was rough, so the bonding between the fibre and resin was good [9].

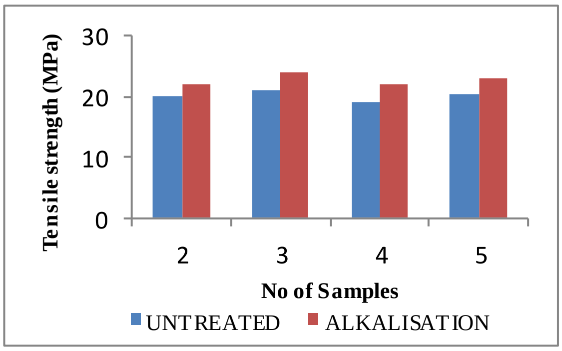

Fig.4 Tensile strength of the composite

3.2 Impact strength

Impact strength of the composite shows the maximum energy required to break the material. Chemically treated fibre shows improved impact strength than the untreated fibre. The chemically treated specimen’s shows the impact strength varies from 1.2 to 1.9 joules shown in Fig. 6, the improved values are due to the removal of hemicellulose content in the fibre [10].

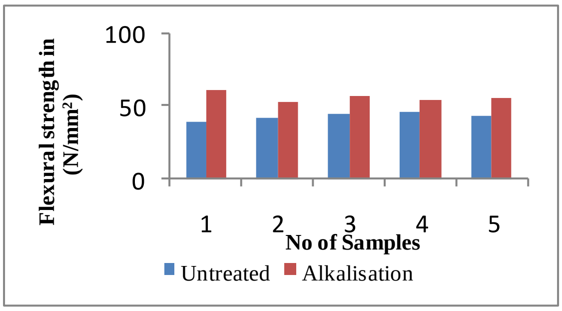

Fig.5 Flexural strength of the composite

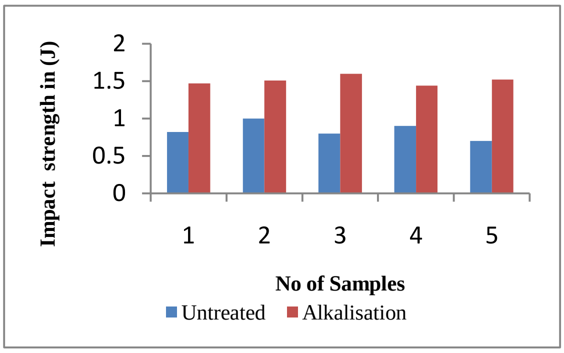

Fig.6 Impact strength of the composite

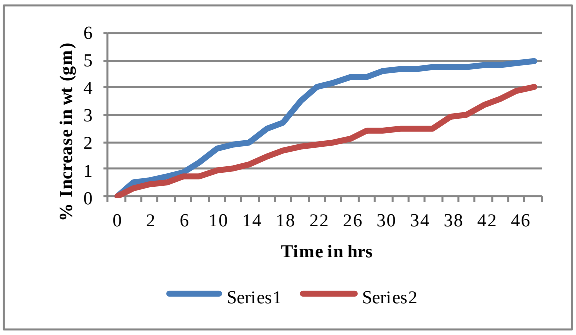

Fig.7 water absorption of the composite

3.3 Water absorption

Water absorption capacity of the composite increased based upon the fibre content in the laminate. Fibres which are hydrophilic in nature, so they have increased water absorption tendency due to the presence of pectin and homocellulose content. It can be removed by suitable chemical treatment process [12]. Fig. 7 shows alkali treated board shows less water absorption tendency due to removal of impurities in the fibre.

4. CONCLUSIONS

In this work the luffa cylindrical and flax reinforced hybrid epoxy composite can be fabricated using hand layup technique. This research clearly shows that the mechanical properties such as tensile, flexural, and impact strength of the alkali treated fibre shows an improved value than the untreated laminates due to the presence of hemicellulose, pectin and other substance. After chemical treatment the retting action takes place and it removes the unwanted materials in the fibre. There is an improved mechanical property of the flax and luffa based epoxy composite.

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