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FABRICATION AND EXPERIMENTAL ANALYSIS OF PINEAPPLE LEAF FIBER BASED COMPOSITE MATERIAL

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ABSTRACT

In recent years natural fibres appear to be outstanding materials which are abundant and come as viable substitute for the expensive and non-renewable synthetic fibre. Pineapple leaf fibre (PALF) is one of them that has good potential as reinforcement in thermoset composite. The objective of the present work is to determine the mechanical properties of Pineapple leaf fibre (PALF).This study highlights the fibre preparation using alkali method with different concentrations. It is determined that long fibres with fillers show better tensile strength with 10% conc. NaOH displays higher strength with lower elongation when compared to fibers treated with other concentrations.

Keywords:PALF,Rapic Two-Roll Mill,Alkali Method (NaOH),South India Textile Research Association, INSTRON 5500R

INTRODUCTION

Overview of composites: Composites are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure.

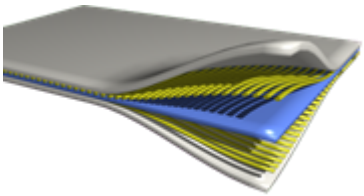

Fig.1.Example of a composite material

Fig.2.Pineapple plants

Composites are generally very unique materials of light weight and high corrosion resistance. They also display properties of high fatigue resistance and low coefficient of thermal expansion.

Constituents: Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials

Matrix phase: It is the part of the composite material in which the fiber materials are embedded. It surrounds and supports the reinforcement materials by maintaining their relative positions.

Reinforcement phase: It is the part of the composite material which carries the majority of loads. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties.

Types of fibers:

- Synthetic fiber
- Natural fiber

Synthetic fibers: Synthetic fibers are those fibers which are man-made. They are often non-biodegradable.

Natural fibers: Natural fibers are those fibers which are taken from naturally occurring plants, animals etc.

Major constituents and methodology:

Reinforcement: The part of the composite that provides strength, stiffness, and the ability to carry a load make-up the reinforcement. Among various natural fibers, we have chosen Pineapple Leaf Fiber (PALF).

Pineapple Leaf Fiber (PALF) serving as reinforcement fiber in most of the plastic matrix has shown its significant role as it is cheap, exhibiting superior properties when compared to other natural fiber as well as encouraging agriculture based economy.

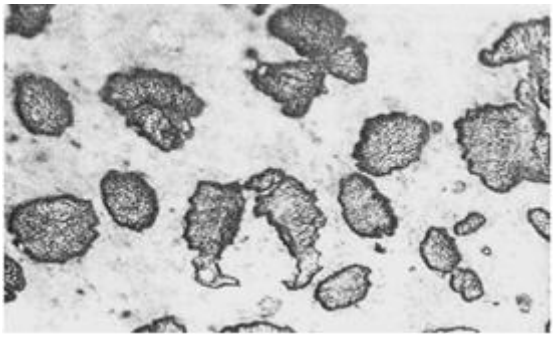

Fig.3.Optical Micrograph of Cross Section of PALF (× 160 magnification) (Mukherjee et al., 1986)

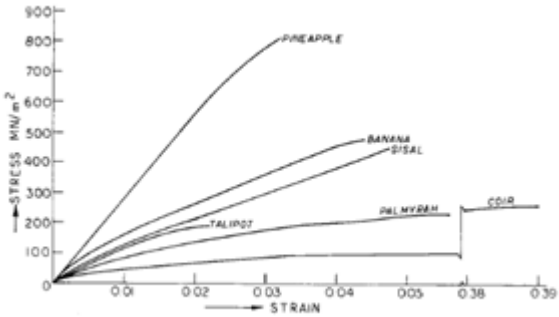

Fig.4.Stress-Strain curves of natural fibers

Figure 2.2 shows that the PALF is a multicellular fiber like other vegetable fibers. Their study also found that the cells in this fiber have average diameter of about 10 μm and mean length of 4.5 mm with aspect ratio of 450. The thickness of the cell wall (8.3 μm) lies between sisal (12.8 μm) and banana leaf fiber (1.2 μm). The excellent mechanical properties of PALF are associated with this high cellulose and low microfibrillar angle.

Table.1.Properties of PALF

Properties	Value
Density(g/cm^3)	1.526
Softening point(℃)	104
Tensile strength (MPa)	170
Young's modulus (MPa)	6260
Specific Modulus (MPa)	4070
Elongation at break (%)	3
Moisture regain (%)	12

Table 2.1 indicates the physical and mechanical properties of PALF obtained from South India Textile Research Association (SITRA), Coimbatore, India. From the graph in Fig 2.3, it is very obvious that Pineapple leaf fiber has superior strength when compared with other natural fibers.

Matrix: The major role of the matrix is to transfer load acting on it to the fiber. This requires the matrix to have good adhesive properties. Epoxy shows great adhesion which is essential when using natural fiber. Owingto the availability of various grades, LY556 is chosen as the matrix material.

Resin: LY556 Hardener: HY951: As, the epoxy grade LY556 shows best compatibility with the hardener HY951, it is used for fabrication of the specimen with both hand lay-up as well as with compression moulding.

MATERIALS AND METHODOLOGY

Fiber extraction: PALF is contained in the spiky leaves of pineapples. The pineapple leaves are very fibrous and have high contents of hemicellulose, pectin and lignin. The wax content available in the leaves must be retained in order to retrieve high strength and hence the method of fiber extraction must be adopted with utmost care.

The leaves are pressed using two-roll mill to remove circa and 90 % of the water content.

Fig.4.Rapic Two-Roll Mill Machine

Fig.5.Long PALF Extracted from Raw Leaf

Figure.4.shows the Rapic Two-roll Mill machine that was utilized for extracting the fibers from the leaves. The long fiber (fig 3.2a) extracted from the leaf and the chopped PALF are shown below. The fibers are washed thoroughly in 2 % detergent solution at 70°C followed by tap water. Basically this removes most of the foreign

objects and impurities inside the fibers. They are later dried in an oven at 70°C for 24 hours before characterizing and chemical treatment for further processing.

Fig.6.Chopped PALF

Fig.7.NaOH Pellet

Fiber surface treatment: For reasons of ease and availability the alkali method of fiber treatment was adopted. It is the most commonly used treatment for bleaching, cleaning and removing the impurities from the surface of natural fibers to produce high-quality fibers. Hence it is also known as surface embellishment. The fiber surface treatment has an effect on the following:

- Fiber-matrix bond strength
- Interfacial and mechanical properties
- Flexural properties
- Fiber surface area

Procedure of treatment: The following steps are carried out during chemical treatment of PALF:

- NaOH solution is prepared using sodium hydroxide pellets and distilled water.
- Pineapple leaf fibers are then dipped in the solution for 30 minutes.
- After 30 minutes fibers are washed with 1% HCl solution to neutralize the fibers.
- Then it is washed with distilled water.
- It is then kept in a hot air oven for 3hours at 65-70°C.

Fig 3.3 shows the NaOH pellets used for preparing the solution along with distilled water and Fig.3.4 shows the fibers being soaked in the solution as a part of the chemical treatment.

Fiber testing: The fiber testing is very important as it determines the effect of chemical treatment on the fiber as well as its properties and performance parameters. For this reason the fibers were initially segregated into 3 parts. This is done so that the concentration at which the optimum performance parameters are obtained can be determined. Each sample was treated with 3%, 5% and 10% concentration of NaOH individually. The samples were then washed with distilled water. After this the fibers were dried in an oven for 3 hours at 70℃. The treated fibers were sent to the South India Textile Research Association (SITRA) for testing.

Fig.8.Chemical Treatment

Fig.9.Instron 5500R

South India textile research association: The tensile properties of the fibers in terms of the breaking tenacity, stress, percentage of breaking elongation and Young's modulus were determined using tensile testing machine (INSTRON 5500R). Fig 3.5 shows the INSTRON 5500R which was used for the testing. Fiber samples of equal length 15cm were prepared for tensile testing. A gauge length of 50mm and a cross head speed of 10.000mm/min were used for the testing. 20 fibers of each sample were tested for their tensile properties. Table 3.1 shows the sample test results that were obtained from SITRA.

Table.2.Sample test result

Sample particulars	PALF 3% treated	PALF 5% treated	PALF 10% treated
Mean breaking strength (g)	214.16	268.65	283.82
CV% of strength	30.42	41.45	30.42
Mean elongation%	2..60	1.81	2.60
CV% of elongation	21.62	24.02	21.62

The Fig.10 and fig.11 show the graphs that were plotted for various concentrations of NaOH for strength variation and elongation. Hence from the below illustrated graphs it is inferred that the fibers with 10% conc. NaOH displays higher strength with lower elongation when compared to fibers treated with other concentrations.

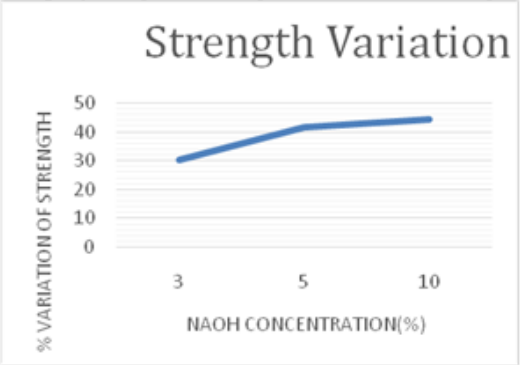

Fig.10.Strength V/s Concentration

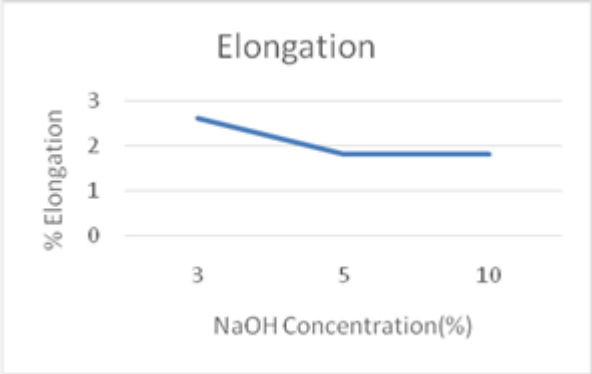

Fig.11.Elongation V/s Concentration

CONCLUSION

The present work proved that PALF has good potential as a reinforcement in bio-composites. It was observed that fibers with 10% conc. NaOH displays higher strength with lower elongation when compared to fibers treated with other concentrations.

SCOPE FOR IMPROVEMENT

For extracting PALF we carried out manual extraction process. This resulted in fibers of comparatively lower strength because of reduced wax content. Hence different methods of extraction like microbial extraction and water retting can be adopted in order to rectify problem. For improving the strength of the fiber, other methods of surface treatment like bacterial treatment, silane coupling can be used.

Fibers can also be oriented in different direction to determine their effect on the physical properties of the composite.

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