EFFECT OF ALKALI TREATED BANANA FIBERS ON TENSILE PROPERTIES OF BIO-COMPOSITE MATERIAL

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Abstract - *Demand for the use of plastic based materials is decreasing day by day due to changing environmental norms. As an alternative, natural fiber-based bio-composite materials are gaining importance. Bio-composites are suited to wide range of applications in automobile, aerospace, consumer products and medical industries. These materials show good mechanical properties along with degradability and low production cost. It consists of matrix along with reinforcement of natural fibers. Different types of matrix and natural fibers can be used as per the varying applications. In this research work, epoxy resin is used as matrix and banana fibers as reinforcement in equal proportion. Some amount of banana fibers were alkali treated in 5% NaOH solution for 24 hours. Then the bio-composite specimens for tensile test were made as per ASTM 3039. Two different sets of specimens were made, one with simple banana fibers and other with alkali treated banana fibers. Hand lay-up method was used for making specimens. They were then tested on Computerized Universal Testing Machine (UTM) to get tensile properties of the material. It was found that the average tensile strength of non-alkali fiber specimens was 21.8 N/mm^2 and that of alkali treated fiber specimens was 28.4 N/mm^2. Thus, it was inferred from the readings that there was 28% increase in tensile strength in material with alkali treated banana fibers. This indicates that the properties of bio-composites can be increased substantially with use of such methods. These methods will help bio-composites to match mechanical properties of other conventional plastic-based materials.*

Key Words*: *Natural fiber, Resin, Bio-Composite, Epoxy, Tensile properties.

1. INTRODUCTION

Global harm caused by the extensive use of plastic reinforced composites have urged researchers to find an alternative material that will possess environment friendly nature. Use of bio-composite materials has therefore found its way in today's industries. Research is being carried out on bio-composites materials since last few decades. They possess several advantages like bio-degradability, non-toxic nature, low density, stiffness, renewability, low production cost, high strength to weight ratio, etc.

Bio-composite materials consists of a matrix and reinforcement of natural fiber. The availability of natural fibers in abundance has triggered the use of these material in many industries. Sisal, coir, pineapple, bamboo, banana, jute, etc. are some of the natural fibers being used.

2. LITERATURE REVIEW

Reza Mahjoub et.al studied change in tensile properties of kenaf fibers after alkali treatment. It was seen that the properties of bio-composite seem to increase in case of fibers treated with alkali. They further stated that, as the concentration of the alkali solution, used for treatment, was increased to 10% and 15% there was damage to the fiber texture as they were twisted more and hence showed a decrease in properties. These properties were also seen to decrease as immersion time of fibers in the alkali solution increased over specified limit [1].

Navdeep Kumar et.al performed experiments on bio-composite made from neetle fiber and Poly Lactic Acid resin and found that tensile, bending and impact properties tend to increase until 50wt.% of nettle fiber and then decreased as the proportion further increased [2]. Laurent Puech et.al investigated the micro-cracks propagation and the energy absorbed by polypropylene-hemp fibers bio-composite (PP-H) and polypropylene-glass fibers composite. It was observed that the energy absorbed by PP-H is more than that absorbed by polypropylene-glass fibers composite [3].

Researchers reviewed the availability and developments made in the field of kenaf fiber bio-composites. They also found that by using this bio-composite we can provide employment to major population in rural areas [4]. Ajith Gopinatha et.al that there will be 60-80 percentage of component weight reduction if steel is replaced by bio-composites and 20-50 percentage of weight reduction if the bio-composite is used instead of aluminium [5].

T. Gurunathan et.al stated that natural fiber-reinforced bio-composites can be considered as an alternative or even more superior to synthetic fiber composites. As they have low cost and can provide a good solution to the waste-disposal problem of synthetic fiber composites [6].

3. BANANA

3.1 Banana Plants

The tropical and sub-tropical climates are well suited for the production of banana. The production of banana found in nearly 135 countries. Primarily it is cultivated for their fruit, while secondary purpose of production is to make fiber, wine, beer and ornamental plants. India and China are the countries producing large amount of banana plants in the world. According to a survey conducted by APEDA(Table-1), the production of these two countries when combined formed 38% of the total worldwide production of banana plants.

Table -1: Major producing countries of Banana in the world

Countries	Production ('000 MT)	Percentage Share in World
India	29780.00	29.19
China	9848.90	9.65
Philippines	9101.31	8.92
Ecuador	7931.06	7.77
Brazil	6962.79	6.82
Indonesia	5755.07	5.64
Tanzania	2924.70	2.87
Guatemala	2637.57	2.59
Mexico	2103.36	2.06
Colombia	2034.34	1.99
Other Countries	22949.05	22.49
World Total	**102028.17**	**100.00**

3.2 Banana fiber

Banana fibers are generally extracted from the stem and leaves of the plant. These fibers are being used in Indian textile industries since 16th century. The material properties of the fibers vary with its location in the stem. The innermost fibers are much softer than the outermost fibers. These fibers are now being used in vast range of industries all over the world.

Banana fiber used in this researched work was procured from Amit Fibers Pune, India. These banana fibers were obtained by mechanical extraction from banana stem by using fiber extraction machine. These fibers were further separated with hand. Figures 1 and 2 shows the banana fibers. The diameter of the fiber used in this work was measured by using tools makers microscope. The average diameter of the fibers was 300μm.

Fig -1: Raw Banana Fibers

Fig -2: Separated Banana Fibers

4. EPOXY RESIN

Epoxy resins are the thermosetting polymers containing at least two epoxide groups (glycidyl or oxirane group) per monomer. It is a synthetic type of resin which can be used as adhesives, fluxes, coatings, matrix in composites, etc. Many additives, reactives, non-reactives can be used in the solution for optimizing the properties delivered by the resin. Epoxy resins possess several properties like good chemical resistance, low shrinkage on cure, good electrical insulation, corrosion resistance, outstanding adhesion, superior fatigue strength, etc. They also impart high tensile, flexural and compression strength to the component [7].

The epoxy resin used in the experiment was purchased from Chemocrats Sales in Pune. Epoxy resin and hardener were used in the proportion of 2:1 in the specimens.

5. ALKALI TREATMENT ON FIBERS

In order to remove lignin, hemicellulose, oil covering and wax from banana fibers alkali treatment is carried out. According to a study, 10% and 15% alkali solution can cause damage to the fiber surface. Whereas, 5% alkali solution causes no tension on the fiber texture and structure [1]. Hence, 5% alkali solution was selected for the treatment. This treatment helps in increasing the surface roughness of the fibers which gives better bonding to the matrix. NaOH used for the alkali treatment has pH 12-13 and boiling point of 100^{0}C.

100 g of NaOH was dissolved in 2 liters of distilled water. A bundle of banana fiber was immersed in the solution and kept for 24 hours. Then the fibers were removed and washed with distilled water. They were further kept in distilled water for next 24 hours. Fibers were then removed and dried in sun.

6. PREPARATION OF BIOCOMPOSITE SPECIMEN

First the separated fibers were cut with cutter into the specified length as required for the specimen. These fibers should be kept in clean place. The epoxy resin and the hardener with 2:1 proportion were mixed vigorously in a plastic glass. Precaution must be taken as this resin formed may be harmful to skin. One should wear protective gloves while handling this resin to avoid injuries. This mixture should be used within specified limit of time as it undergoes exothermic reaction and becomes hard when kept alone for long time.

Initially, the flat transparent glass plate was kept on the flat surface. The transparent plastic cover of 1 mm thickness was placed over this glass properly. The resins solution was then poured on this plastic cover slowly. This resin was uniformly distributed on the cover with the help of brush so that it forms of uniform 1 mm thick layer. The fibers were then placed over this layer of resin.

The care should be taken that the fibers are placed uniformly throughout the length and do not accumulate at one area. 40 wt.% of resin results in good resin distribution and good lamination. The mechanical properties decrease on further increase in the resin proportion [8].

The fibers were placed unidirectional over the resin. This helps in delivering the desired mechanical and physical properties of the material. Again, the resin was poured on this fiber. The roller is then rolled over these layers. Rolling is done in order to avoid the air gaps in between the bio-composite structure. The presence of this air gaps results in decrease in the strength of the formed plated and could not deliver the desired properties.

This may result in failure of the material at the time of operation. Hence, proper care should be taken so that there are minimum air gaps in the structure. Similarly, one more layer of fiber was formed on the first layer. Then another transparent plastic cover was placed on top of this layer and the glass is place on this cover. It is then kept to dry for 5 hours. The transparent covering and the glass help the sunlight to pass through it and triggers the process.

After drying, this plate was cleaned and cut according to ASTM standards for specimen testing. Cutter is used to cut these plates into the desired dimensions. Care should be taken in order to avoid bending of the plate while cutting.

7. TESTING AND RESULTS

Specimens used for tensile test were prepared as per ASTM D3039. The experiment was performed on the universal testing machine TUF-C-1000 manufactured by Servo with the crosshead 2 mm/min speed and at standard temperature and pressure (shown in figure 3). Three specimens were tested for test configuration. The tensile test set-up is shown in figure 4.

Fig -3: Universal Testing Machine

Fig -4: Tensile Test Set-up

After the specimens were tested on UTM, the readings shown in table no 2 were obtained.

Table -2: Tensile Test Results

SPECIMEN No.	Alkali treated fiber bio-composites(N/mm^2)	Non-alkali fiber bio-composites(N/mm^2)
1	24.4	21.1
2	28.9	21.4
3	30.8	22.0

The table shows that the tensile strengths for the specimen of Alkali Treated Fiber Bio-composites (ATFB)was high as compared to Non-alkali Treated Fiber Bio-composites (NTFB). The average tensile strength of ATFB was found to be 28.033 N/mm^2 and that of NTFB was 21.833N/mm^2 as shown in Chart 1.

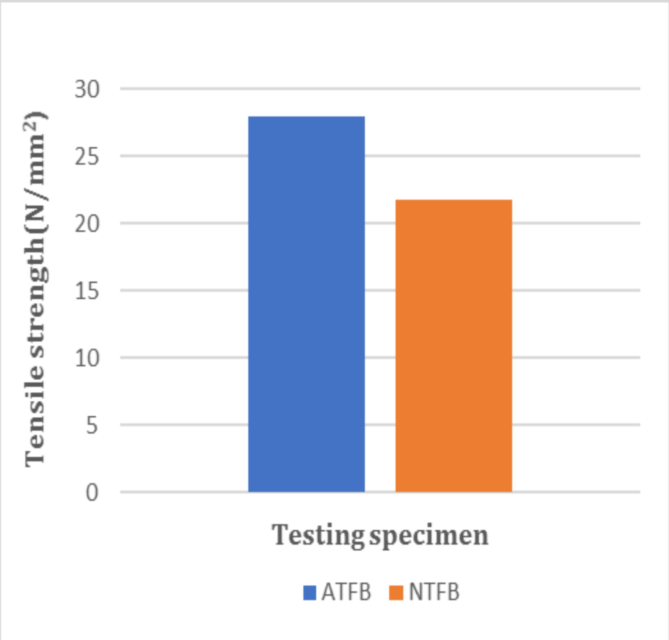

Chart -1: Tensile strength

Also, the specimen starts yielding at higher loads in case of ATFB. The load at yield was 1.93 KN, 2.31 KN, 2.45 KN for the three specimens of ATFB and 1.7 KN, 1.75 KN, 1.75 KN for the specimens of NTFB as shown in Chart 2.

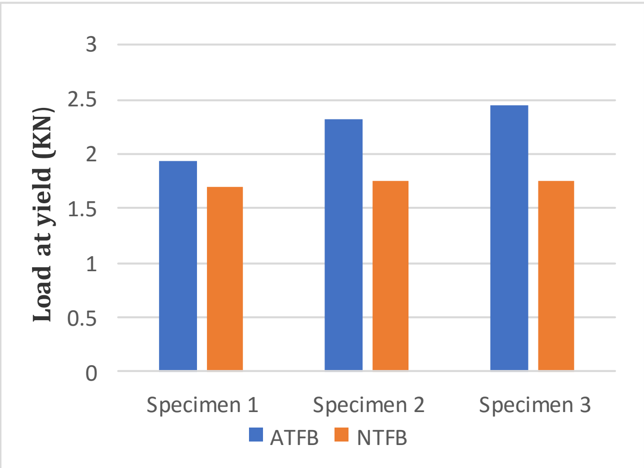

Chart -2: Load at yield

8. CONCLUSIONS

The average tensile strength of the biocomposite made up of alkali treated banana fibers was 28.033 N/mm^2 and that of non-alkali treated was 21.833 N/mm^2. Thus, it can be inferred from the readings that the tensile properties of the material increased by 28.39% when alkali treated fibers were used. Also, other properties like load at yield, yield stress were increased.

Therefore, by using such methods various properties of bio-composite materials can be increased to the desired level.

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