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CHEMICAL TREATMENTS IMPACT ON THE MECHANICAL CHARACTERISTICS AND MORPHOLOGY OF BANANA FIBRE

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Abstract: Natural fibres are less expensive than other types of fibre, the greatest replacement for synthetic fibre composites today is a natural fibre reinforced biodegradable composite. For uses in domestic goods, natural fibres like sisal, kenaf, plam, banana, jute, and coir have been employed as reinforcement in polymer composites. At the moment, research into composite materials is focused on employing natural fibres rather than synthetic ones. When used as reinforcing fibres in matrices, natural fibres made from yearly renewable resources have a positive impact on the environment in terms of final disposal and raw material use. Because of their low density, superior mechanical performance, universal availability, and disposability, natural fibres provide an alternative to technical reinforcing fibres. Chemically altering the fibre surface can strengthen the bond between the fibre and matrix. The fibre surface can be cleaned, chemically modified, and given a rougher finish through chemical treatment. Scanning electron microscopy was used to investigate surface analyses on fibre for before and after treatment. The banana fibre's stress–strain curve is identified. As a function of fibre diameter, test length, and testing speed, properties like initial modulus (YM), ultimate tensile strength (UTS), and percentage elongation are assessed. The failure is caused by the pull–out of microfibrils along with the tearing of cell walls, according to scanning electron microscopy (SEM) investigations of the broken surfaces of these fibres; the likelihood for fibre pull–out appears to diminish with increasing testing speed.
Keywords: chemical process, surface examination; natural fibre; banana fibre; mechanical characteristics; alkaline

INTRODUCTION

Natural fibres like banana and coir have low densities and poor mechanical qualities, yet they are renewable resources. About 1.5 million acres of land in India are used for banana plantations, which produce 3 × 10Stons of fibre [1]. Natural Plant–derived fibres and a plastic binder are combined in natural fibre composites. Wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, fibres from banana leaves, bamboo, wheat straw, and other fibrous materials are examples of natural fibre components. Lightweight, low–energy production, and environmental friendliness are a few benefits of natural fibre composites. Natural fibres reduce weight and production energy requirements by 80% and 10%, respectively, while the component costs 5% less than equivalent fibre–glass–reinforced components. Fibre composites combine a plastic binder with fibres produced from plants. Wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, fibres from banana leaves, bamboo, wheat straw, and other fibrous materials are examples of natural fibre components. Lightweight, low–energy production, and environmental friendliness are a few benefits of natural fibre composites. Natural fibres provide weight reduction of 10% and an 80% reduction in production energy requirements, while also costing 5% less than equivalent fibre glass–reinforced components [2]. Banana fibre's mechanical characteristics were investigated by Kulkarni et al. [3]. They discovered that pulling out of microfibrils and ripping of cell walls cause the banana fibre intention to fail.

Natural fibre is one of the ecologically friendly materials that are being taken into consideration for the majority of applications due to their superior qualities when compared to synthetic fibre in terms of eco–relationship [4]. Utilizing materials that are waterproof, moderately strong, and corrosion–resistant, natural fibre is used in the majority of technical components for the production of cars, aircraft, home appliances, and packaging. Global industry researchers predicted that the global market for natural fibres would be worth $6.4 billion by 2022 and rise at a compound yearly growth rate of 10.2% from 2022 to 2026. The purpose of this work is to assess the effects of chemical modification on the fibre surface of Banana by employing some of the common treatments for natural fibres. These steps are intended to separate the technical fibres from the non–structural fibres in the fibre bundles. How these changes affect the banana fibre that is extracted and whether the resulting fibres will have increased stiffness and strength as potential reinforcement for polymer matrices [5].

Natural fibres are categorized into different categories. It provides a substitute for synthetic fibres because of their affordability, low density, and biodegradability. For the development of natural fibre–reinforced composites, a deeper comprehension of the fibre–matrix interface and the capacity to transfer stress from the matrix to the fibre are required [6].

Chemical modifications are seen to be a viable option for altering the surface properties of fibres because they can both lessen natural fibres' water absorption and strengthen the interaction between fibre and matrix. Several researchers looked into chemical treatments for natural fibres [7]. The common chemical treatments are acetylated, H_2SO4, and alkaline treatments. When employed as reinforcement in thermoplastics and thermosets, alkaline treatment is one of the most popular treatments for natural fibres. The sodium hydroxide used in this investigation was selected due to its efficiency and low cost. To get the ideal concentration, three different NaoH percent concentrations were tested [8].

METHODS AND MATERIALS

In order to obtain straight, long fibres, banana fibre were separated through due retting and scraping. The fibre were then properly cleaned with lots of water and dried outside in the sun for hours. Banana pseudo stem were collected from a neighbouring farm in Ikere Ekiti, Ekiti State, south–western Nigeria, during the harvest season, and the fibre was removed utilizing dew retting techniques. The earliest and most popular method of retting used to separate fibres from the appropriate plants is dew retting. Since this procedure requires the proper levels of moisture and temperature, it cannot be applied anywhere. The plants are left in the field after harvesting (scattered out in uniform, thin, no overlapping swaths) so that microorganisms can separate the fibres from the cortex and xylem. To achieve uniform retting, the plants are frequently flipped over. To avoid cellulose destruction by microorganisms, the retting process needs to be watched carefully and interrupted when necessary; if this doesn't happen, it's known as over–retting. Under–retting makes subsequent fibre processing challenging while over–retting decreases the mechanical performance of the fibres. Dew retting typically takes 3–6 weeks and is dependent on the weather.

Figure 1. Banana plant

Alkaline Treatment of fibres

The outer layer of the fibre cell wall is covered by natural oils, waxy substances, and lignin in natural fibres. Sodium hydroxide (NaOH) is the chemical reagent employed in this procedure, which changes the structure of the natural fibres. By cleaning the surface and a procedure known as alkalization, the alkaline reagent is used to change the structure of the cellulose in plant fibres. The banana fibres were treated with NaOH at 50°C for about 4 hours, and the surplus NaOH was subsequently neutralized by washing the materials in distilled water. The treated and untreated fibres' thermal characteristics, surface morphology, and crystallinity index were investigated. According to research, chemically treated fibres demonstrated improved fibre–resin adhesion, which increased interfacial energy and improved the thermal and mechanical properties of composite materials.

Figure 2. Alkaline treatment of the fibres NaOH

Scanning electron microscopy (SEM)

SEM was used to conduct a study on the morphology of the fibre surface both before and after treatment. The goal was to identify the structural alterations brought about by treatment and differential by using different concentrations.

Mechanical Properties of Fibre

At room temperature, tensile tests were performed on both untreated and treated fibres in accordance with ASTM D 3822 utilizing general–purpose Instron testing equipment, model 3369, with a 25 N load cell full range. Fibres were assessed at a gauge length of 10 mm in their as–received state with displacement control and a crosshead speed of 1 mm/min. Density measurements of treated and untreated fibres were taken in accordance with ASTM D3800–99. Using a Zeiss Gemini Scanning Electron Microscope (SEM), plantain fibres, both untreated and treated, were examined to see how chemical treatment altered the surface properties of the fibres.

RESULTS AND DISCUSSIONS

The banana fibre's stress–strain curve is identified. As a function of fibre diameter, test length, and testing speed, properties like initial modulus (YM), ultimate tensile strength (UTS), and percentage elongation are assessed. It is discovered that for fibres with a diameter range from 0.1 to 0.6/m, YM, UTS, and% elongation show little variance in their values.

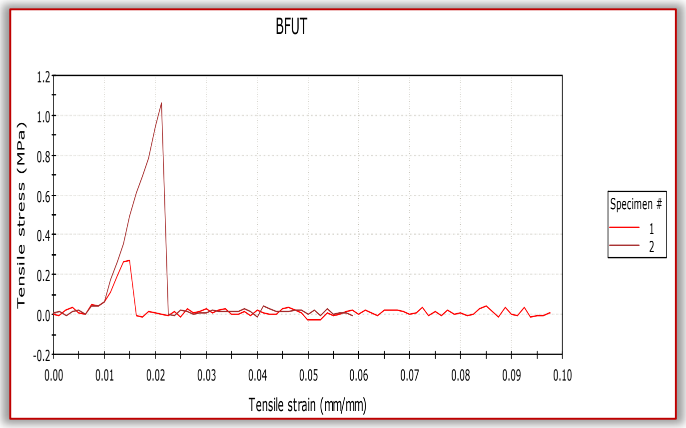

Figure 3. Tensile Strength Test result of physical properties of Untreated Banana Fibres

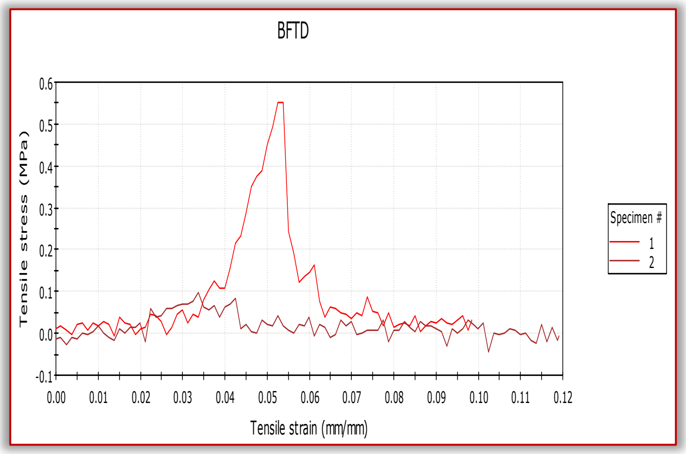

Figure 4. Tensile Strength Test result of physical properties of Treated Banana Fibres

The UTS and breaking strain are observed to decrease as test duration increases, while breaking strength and breaking strain are found to remain constant until test speed increases from 0.0 to 100 x 10–3 m, after which they both decline. These observed characteristics are explained in light of the fibre's internal structure, specifically the quantity of cells and spiral

Optical Microscopy

Figure 5, (b), illustrates how alkali treatment cleans the banana fibres of various artificial and natural contaminants (c). It has been discovered that alkali treatment causes a process known as fibrillation or fibre separation, which results in the disintegration of the fibre composites' bundles into individual fibres. The surfaces after the alkali treatment exhibit a noticeable difference. Following alkali treatment, it was shown that surface contaminants were removed and the final cells were separated as a result of the elimination of the cementing elements, such as lignin and hemicellulose. The inter fibrillar region was expanded and the surface's texture was made rougher by the dissolving of waxy components. The surface of the untreated fibre was smooth and covered in waxes and other impurities. The surface roughness of the fibre increased alkaline solution concentration. This may be due to the fibre's surface being roughened and the prominence of the fibrous region being raised by the limited removal of hemicellulose, lignin, and considerable removal of surface impurities.

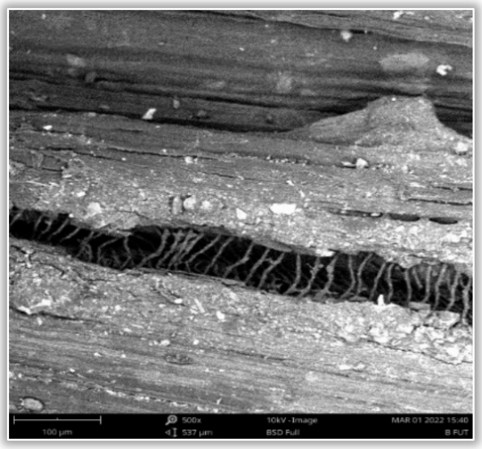

Figure 5 (a) – Untreated Banana fibre

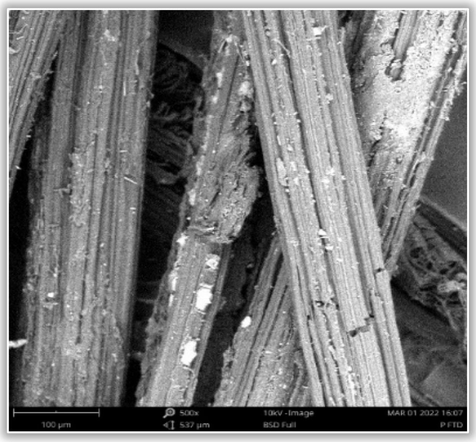

Figure 5 (b) 5% NaOH treated for 1 hour at room temperature

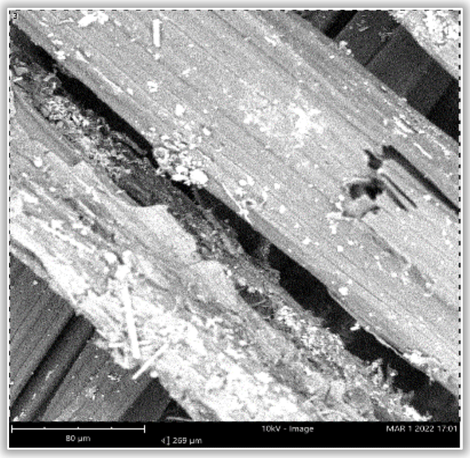

Figure 5. (c) 10% NaOH treated for 10min at room temperature

CONCLUSION

Effect of alkaline treatment has looked at the impact of chemical treatment on the mechanical properties of banana fibre. Although the surface treatment has a negative effect on costing, it may still be able to solve the incompatibility issue. The qualities of natural fibres, such as their surface, ability to eliminate impurities, strength, and improved interaction with the matrix, can be modified by chemical treatments.

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ISSN: 2067-3809