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# Study on Chemical Treatments of Jute Fiber for Application in Natural Fiber Reinforced Composites (NFRPC)

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***Abstract*— *Research and studies on the use of natural fibers as replacement to man-made fiber in fiber-reinforced composites have increased and opened up further industrial possibilities. Natural fibers have the advantages of low density, low cost, biodegradability, recyclable, low pesticide and thus environmentally friendly. However, the main disadvantages of natural fibers in composites are the poor compatibility between fiber and matrix and the relative high moisture sorption. Therefore, chemical treatments are considered in modifying the fiber surface properties. In this paper, the different chemical modifications and treatments on jute fibers for use in natural fiber-reinforced composites are reviewed. Chemical treatments including alkali, permanganate treatments and others are discussed. The chemical treatment of fiber aimed at improving the adhesion between the fiber surface and the polymer matrix may not only modify the fiber surface but also increase fiber strength. Water absorption of composites is reduced and their mechanical properties are improved.*

***Keywords*— *fiber-reinforced composites, natural fiber, chemical treatments, sodium hydroxide, and potassium permanganate.***

**The Jute plant**

**Jute fiber being dehydrated after retting**

## I. INTRODUCTION

Processing of plastic composites using natural fibers as reinforcement has increased dramatically in recent years. Fiber-reinforced composites consist of fiber as reinforcement and a polymer as matrix. Plastic polymers including high density polyethylene (hdpe), low density polyethylene (ldpe), polypropylene (pp), polyether ether ketone (peek), etc. have been reported as the matrices. Traditional fiber-rein forced composites use various types of glass, carbon, aluminum oxide, and many others as reinforcing component. Natural fibers, especially bast (bark) fibers, such as flax, hemp, jute, henequen and many others

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were applied by some researchers as fiber reinforcement for composites in recent yea. Advantages of natural fibers over man-made fibers include low density, low cost, recyclability and biodegradability etc. These advantages make natural fibers potential replacement for glass fibers in composite materials. Mechanical properties of natural fibers, especially flax, hemp, jute and sisal, are very good and may compete with glass fiber in specific strength and modulus. Natural fiber-reinforced composites can be applied in the plastics, automobile and packaging industries to cut down on material cost. A better understanding of the chemical composition and surface adhesive bonding of natural fiber is necessary for developing natural fiber-reinforced composites.

Natural fibers are considered as potential replacement for man-made fibers in composite materials. Although natural fibers have advantages of being low cost and low density, they are not totally free of problems. a serious problem of natural fibers is their strong polar character which creates incompatibility with most polymer matrices. Surface treatments, although having a negative impact on economics, are potentially able to overcome the problem of incompatibility. Chemical treatments can increase the interface adhesion between the fiber and matrix, and decrease the water absorption of fibers. Therefore, chemical treatments can be considered in modifying the properties of natural fibers. some compounds are known to promote adhesion by chemically coupling the adhesive to the material, such as sodium hydroxide, silane, acetic acid, acrylic acid, maleated coupling agents, isocyanates, potassium permanganate, peroxide, etc. fiber modifi- cation methods discussed in this paper have different efficacy in causing adhesion between the matrix and the fiber. Yet most chemical treatments have achievedvarious levels of success in improving fiber strength, fiber fitness and fiber–matrix adhesion in natural fiber-reinforced composites.

## II. MATERIALS AND METHODS (METHODOLOGY)

**2.1** The materials used in this study were locally sourced at Onitsha, Anambra State of Nigeria and they are include: The jute fibers, which are used as the reinforcement, sodium hydroxide (NaOH), Potassium permanganate (KMnO4) solid and Acetone liquid are used for chemical treatments, Digit weighing balance for measuring chemicals.

**Materials used are shown in the diagram below:**




*Figure D* *Figure E* *Figure F*

*Figure D, Figure E and Figure F are Potassium permanganate (KMnO4) solid, Acetone liquid and sodium hydroxide (NaOH) respectively for chemical process treatments of jute fibre*

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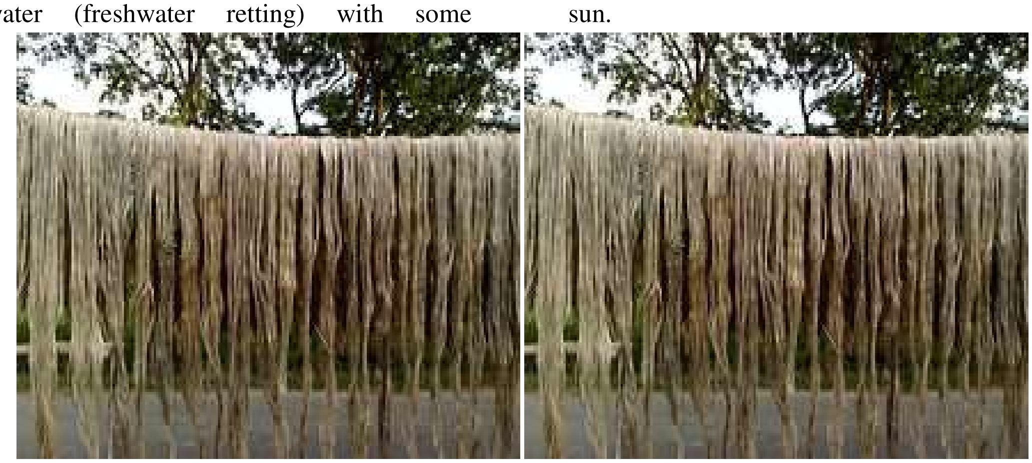
*Fig.1: Digit weighing balance for measuring chemicals*

**2.2 Extraction and Chemical Treatment of Jute Fibers**

Jute fibers used in this work were sourced from the stem of jute plant through a process called Retting. Some other known retting processes include freshwater, saltwater and green decortications and enzymes treatments (Das &Saema, 1988). The jute stem used in this study were soaked in bucket of water (freshwater retting) with some biodegradable material that will increase decomposing organism thereby reducing the retting period to two month instead of normal three months. After the retting process, extracted fibers (jute stem) were separated and washed by removing some residue in water until all slipperiness was lost. The clean Jute fibers are spread to naturally dry in the sun.



**Jute fiber after retting**

For proper fiber treatment to take place, suitable chemicals are used depending on the kind of chemical treatment (Xue, Lope & Satyanarayam 2007) being embarked on. In this study, two major sets of chemicals were used for fibre treatments. They include:

- Aqueous Sodium Hydroxide (NaOH) which is prepared by dissolving Sodium Hydroxide Pellets in water.
- Potassium Permanganate (KMnO4) solution is made by also dissolving Potassium Permanganate (KMnO4) solid in Acetone liquid.

**2.3 METHODS**

**2.3.1 Chemical treatments**

The hydrophilic jute fiber is difficult to combine directly with the hydrophobic polyester matrix in jute fiber reinforced polyester composites. To bring about a reinforcing effect, the surface of the jute fiber has to be changed from hydrophilic to hydrophobic by subjecting the

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jute fiber to alkali treatment and permanganate treatment. Alkali treatment, named also Mercerization, is a common fiber treatment chemical method that is extensively used by researchers (Hashim, Roslan, Amin, Zaidi&Ariffin, 2012; Kalia, Kaith&Kaur, 2009).

**The actual treatment of jute fiber taking place**

**2.4 Aim of chemical treatments**.

The aim of the chemical treatment is to remove the weak boundary layers of the natural fibers which are supposed to protect the fiber particles but have no resistance to the alkali attack. Chemical treatment of jute fiber lowers the water absorption. Jute fibers were subjected to the surface treatments, in order to improve Interfacial adhesion between jute fiber and polyester resin matrix.

The chemical treatment of fiber is aimed at improving the adhesion between the fiber surface and the polymer matrix. Not only modify the fiber surface but also increase fiber strength and reducing water absorption by composites (increasing moisture resistance) & improving mechanical properties of the composite materials. (Xue et al., 2007)

**2.5 Kinds of chemical treatments for natural fiber**

There are many kinds of chemical treatments/processing for natural fiber namely: Alkaline treatment, Silane treatment, Acetylation, Benzoylation, Acrylation& Acrylonitrile Graphting Coupling agents, Isocyanate treatment, Permanganate treatment, Peroxide treatment, Sodium Chlorite treatment etc.

In this study, only two chemical treatments were conducted on jute fiber namely:

- Alkaline Treatment
- Permanganate treatment

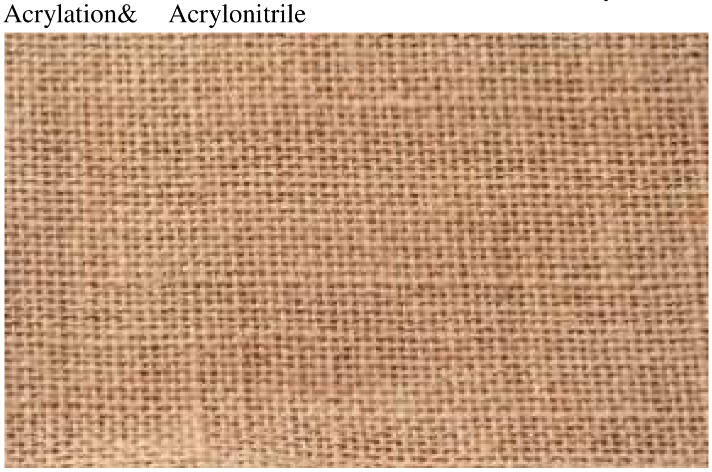
**2.5.1 Alkaline Treatment**

Alkaline treatment or mercerization is one of the most used chemical treatments of natural fibers when used to reinforce thermoplastics and thermo sets. This treatment removes a certain amount of lignin, wax and oil covering the external surface of the fiber cell wall and exposes the short length crystallites.

The important modification done by alkaline treatment is the disruption of hydrogen bonding in the network structure, thereby increasing surface roughness. The treatment changes the orientation of the highly packed crystalline cellulose order, forming an amorphous region. It has been reported that alkaline treatment has two effects on the fiber:

- It increases surface roughness resulting in better mechanical interlocking.
- It increases the amount of cellulose exposed on the fiber surface, thus increasing the number of possible (Xue et al., 2008)

In alkalization, fibers were cut to 260 mm of length and were soaked in a 5% aqueous NaOH solution at room temperature maintaining a liquor ratio of 15: 1 for 12hours for proper depolymerisation of cellulose, removal of lignin and better strength of jute fiber. The fibers were then washed several times with fresh water to remove any NaOH sticking to the fiber surface. Fibers were neutralized with dilute acetic acid and finally washed again with distilled water afterwards the treated fibers were carefully spread on mat and then finally air-dried.



**Alkaline treated Jute Fiber**

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**2.6 Permanganate treatment**

Permanganate is a compound that contained permanganate group MnO4. Permanganate treatment leads to the formation of cellulose radical through MnO3 ion formation (Sivakumarbabu&Vasudevan, 2008). In this study, the alkaline treated jute fibers were dipped in 50% permanganate acetone solution for minutes with liquor ratio 15:1. Fibers were dried at 40 °C for 5 hrs to remove excessive solvent and moisture by spreading on mat and then finally air –dried. As a result of permanganate treatment, the hydrophilic tendency of the jute fiber was reduced, and thus, the water of JFRP composite decreased.

**Measuring the quantity *of* the required sodium hydroxide pellets and Potassium permanganate (KMnO4) solid for permanganate treatments**

*Measuring the required quantity of alkaline water in ml*

*Some quantity of Jute fiber prepared for chemical treatments*

*Measuring the required quantity of Acetone liquid used for Permanganate treatments.*

## III. RESULT, DISCUSSION AND CONCLUSION

### 3.1 RESULT AND DISCUSSION

This study has shown that the chemical treatments performed on natural fiber like Jute fiber is crucial in order to improve the surface characteristics. It was discovered that the weight of treated fiber was reduced to a large extent to compare to the untreated one after the alkaline and Permanganate treatment. The moisture content was removed from the fiber increasing its strength. Chemical treatments eliminate some portion of hemicelluloses, lignin, pectin, wax and oil covering materials. Thus fiber surface became more homogeneous due to elimination of micro voids. Stress transfer capacity between alternate cell improved and increase effective fiber surface area for good adhesion with matrix. It decrease hydrophilic nature of fiber by raising its cellulose content and stabilized the material.

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## IV. CONCLUSION

The purpose of this study was achieved which shows the effects of chemical treatment on jute fiber for use in fabrication of composites. Chemical treatments of natural fiber have been highly beneficial and necessary to improve surface characteristics and mechanical properties of composites material. It has help to remove the weak boundary layers of natural fibers and lowers water absorption. The study has documented that the time of soaking and the amount of chemical solution concentration used for treatment will affect the properties of the produced fibers. Based on this research and previous ones, it was suggested that different concentrations ratio and treatment times will tested on the jute fibers. It was also observed that alkaline treated specimen indicated good improved in impact strength of 20% when compared with untreated fiber. Alkaline treated jute fibers reinforce epoxy composite had better impact strength compared to other length. Untreated jute resulted in low impact strength due to poor interfacial bonding.

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