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Physico-Thermal Properties of Chemically Treated Ladies Finger Natural Fiber

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Abstract: Natural fibers are becoming good substitute of synthetic fibers due to Environmental consciousness and increasing awareness of green technology. In present research, natural fiber obtained from the stem of ladies finger plant. Ladies finger fiber was later chemically treated with 5% NaOH. Both raw and chemically treated fibers were subsequently characterized using structural (Fourier transform infrared spectroscopy and scanning electron microscopy) and thermal (thermogravimetric) analysis. Fourier analysis showed the presence of (NaOH) group in the ladies plant fiber. Alkali treatment decreased the amount of lignin and hemi-cellulose from the fiber. Scanning electron micrographs revealed cleaner and smoother surface in case of alkali treated fiber due to the removal of impurities. Thermogravimetric analysis indicated higher level of thermal stability for treated ladies finger fiber as compared to that of raw fiber.

Keywords: *Ladies Finger Natural Fiber; FTIR; SEM; TGA*

Introduction: Natural fibers are gaining interest as renewable, environmentally acceptable and biodegradable starting material for industrial applications, technical textiles, composites, pulp and paper, as well as for building activities. Natural fiber reinforced polymer composites are composite materials consisting of a polymer matrix embedded with high-strength natural fibers, like jute, oil palm, sisal, kenaf, and flax. Usually, polymers can be categorized into two categories, thermoplastics and thermosets. Natural fiber reinforced composites combine acceptable mechanical properties with a low density [1].

Recently wide range of research has been carried out on fiber reinforced polymer composites. The researchers concentrated on the effect of the fiber surface modifications as well as manufacturing processes in improving fiber/polymer compatibility. On the other hand, some researchers studied and compared between different natural fiber composites and their stability in various applications [2-4].

Typical reinforcements for composites with plastic matrix are various synthetic fibers such as glass, graphite, boron, metallic and ceramic materials. These materials are heavy, expensive and harmful to environment. The replacement of inorganic fibers with comparable natural fibers provides weight and cost reduction. The advantages of using natural fibers also include high specific stiffness and mechanical strength, availability, reduced energy consumption, low

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hardness which minimizes the wear of processing equipment, renewability, recyclability, non-hazard, biodegradability and so on. Natural fiber reinforced composites are suitably applicable for aerospace, leisure, construction, sport, packaging and automotive industries [5-7]. However, the main drawback of natural fiber reinforced polymer composites is the incompatibility between the hydrophilic natural fiber and hydrophobic matrices. This leads to undesirable properties of the composites. It is therefore necessary to modify the fiber surface by employing chemical modifications to improve the adhesion between the fiber and matrix [8-10]. The objective of present research is to characterize raw and chemically treated ladies finger natural fiber by finding out their physical and thermal properties. The properties of raw ladies finger fiber are also compared with those of chemically treated ones.

Materials & Method:

Chemical Treatment of Fiber: Ladies finger fiber was initially chemically treated with 5% NaOH. Firstly the dried extracted fiber were drowned into the solution and stirred properly, so that fiber was wet by the solution. Then the beaker containing the solution with fiber was heated at 70^oC for about two and half hours. Then the fibers were washed with tap water and then with distilled water. The fiber containing water was taken to the oven and heated at 70^oC for about two hours for complete evaporation of moisture.

FTIR Spectroscopy: The infrared spectra of ladies finger fiber were recorded on a Nicolet 380 spectrophotometer with co-addition of 32 scans. Powdered sample was taken for FTIR spectroscopy. Then potassium bromide (KBr), which acts as a reagent, was mixed (KBr: sample = 100: 1) with them in a mortar pestle. The mixture was then taken in a dice of specific dimensions. The pellet was formed by pressing with a hand press machine and was placed on the sample holder. The IR spectrum obtained is presented in the result and discussion section.

Scanning Electron Microscopy: Scanning electron microscopy (SEM) analyses the surfaces of materials, particles and fibers so that fine details can be measured and assessed via image analysis. Surface morphology of the raw and chemically treated ladies finger fibers was observed under a scanning electron microscope (Philips XL 30). The fiber surface was initially made conductive by applying gold coating using a sputtering machine. The fiber was then taken inside SEM, vacuum was created and micrographs were taken.

Thermo Gravimetric Analysis: Thermo gravimetric analysis was carried out for determining thermal stability of ladies finger fiber. TGA method used was based on continuous measurement of weight on a sensitive balance (called a thermo balance) as sample temperature was increased in an inert atmosphere. This is referred to as non-isothermal TGA. Data were recorded as a thermo gram of weight versus temperature.

Results and Discussion:

FTIR Spectroscopic Analysis: Cellulose, hemicelluloses and lignin, i.e., the main constituents of any lingo cellulosic fiber, are composed of alkanes, esters, aromatics, ketones and alcohols with different oxygen-containing functional groups. FTIR spectra of raw and treated ladies finger fiber is shown in Figure 1. The IR spectrum for raw ladies finger fiber (Figure 1 (a)) clearly shows the strong and broad characteristics band of (-OH) at the regions of 3600-3200 cm^{-1}, lignin and hemicelluloses at near about 1737.5 cm^{-1}, (C-H) aromatic rings and alkane at 2919.7 cm^{-1} [11]. The alkali treated fiber (Figure 1 (b)) shows the characteristics band of (-OH) of high concentration at around 3296 cm^{-1} and aromatic rings and alkanes at around 2917.1 cm^{-1}. Pick for lignin and hemicelluloses were not very significant. This indicates that alkali treatment decreased the amount of lignin and hemi-cellulose from the ladies finger fiber.

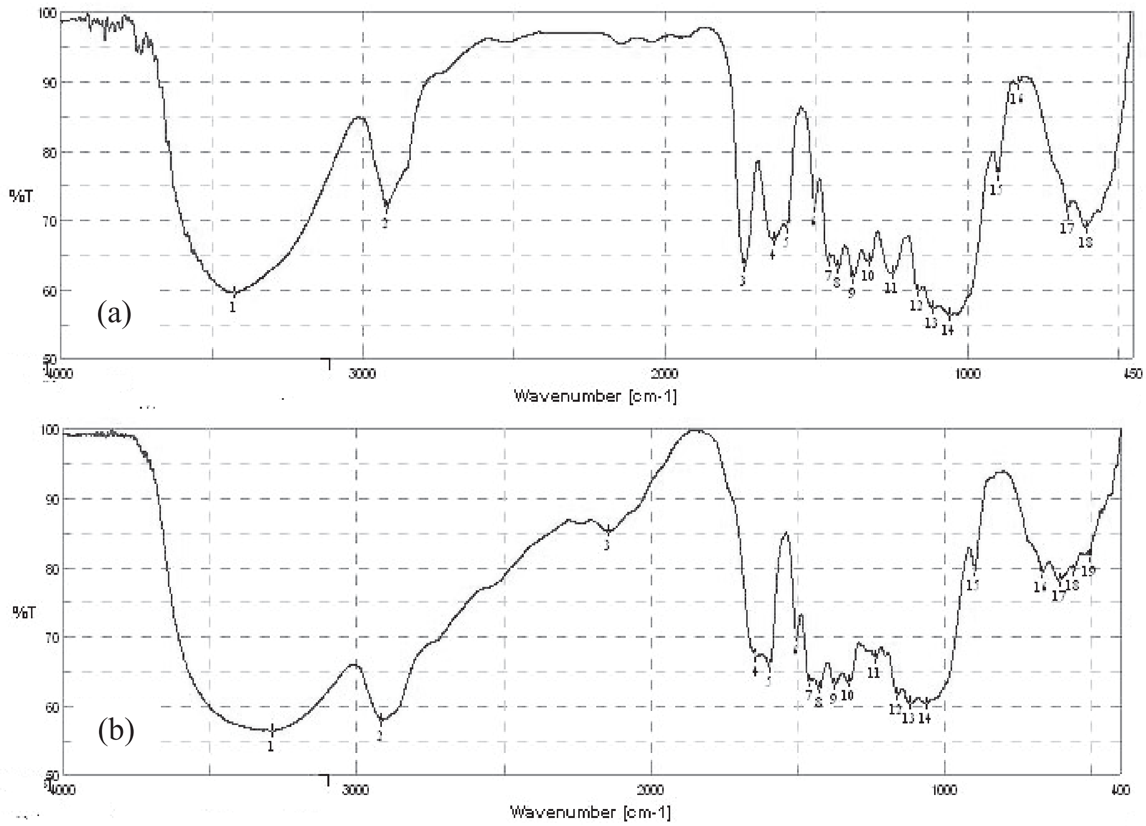


Fig. 1: FTIR spectrum of (a) raw and (b) alkali treated ladies finger fiber

Surface Morphology: Surface morphology of raw and alkali treated ladies finger fiber was observed under SEM and are shown in Figure 2. Figure 2 (a) shows cellular structure and these cells together form fibrils with tissues connected with each other at several locations along the length to form fibers. After alkali treatment, the surface of the ladies finger fiber become cleaner and smoother as compared the raw fiber because of the removal of impurities from the surface (Figure 2 (b)).

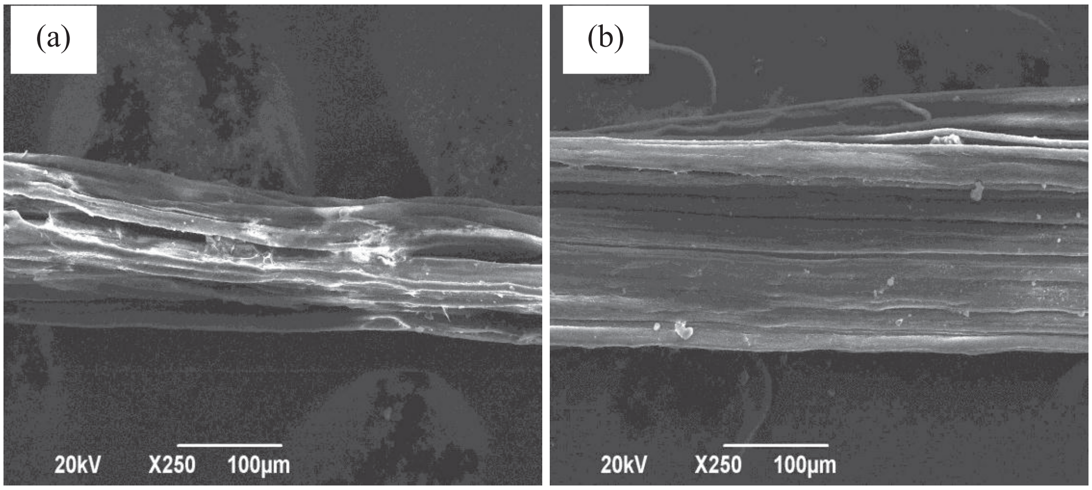
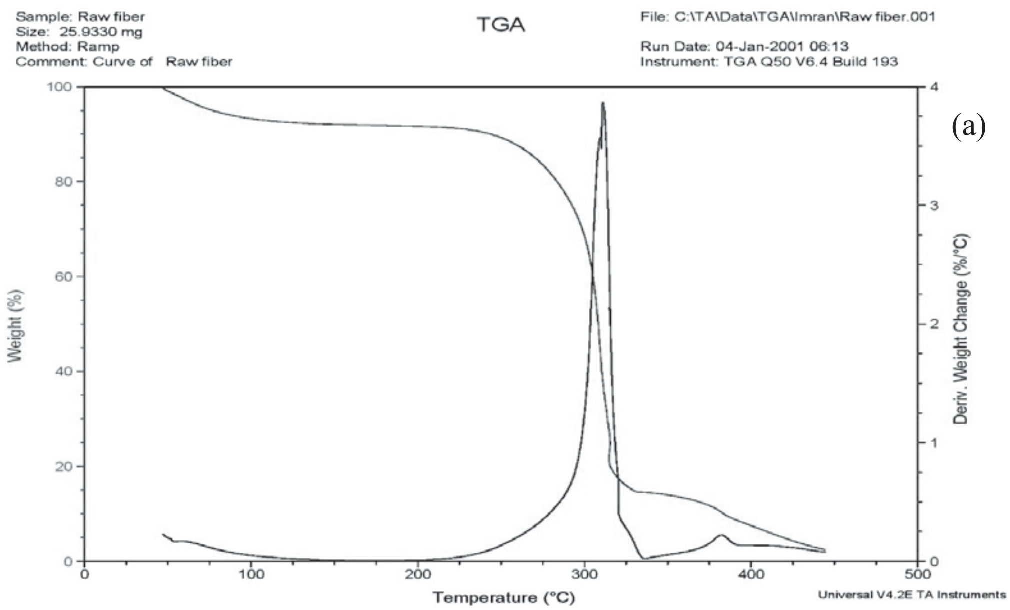


Fig. 2: SEM micrographs of (a) raw and (b) alkali treated ladies finger fiber

Thermo Gravimetric Analysis: Thermo gravimetric analysis was performed on the raw and alkali treated ladies finger fiber in order to find the effect of chemical treatment on the thermal stability of the fiber. TGA curves of raw and treated ladies finger fiber are shown in Figure 3. The first very small peak at <100^0C corresponds to the heat of vaporization of water absorbed in the fiber. There was a huge weight change at around 240-260^0C indicating the start of thermal decomposition of ladies finger fiber. Thermal decomposition for raw fiber started at around 240^0C, while the same for alkali treated fiber happened at around 262^0C. Thus thermal stability of the ladies finger fiber increased after alkali treatment.



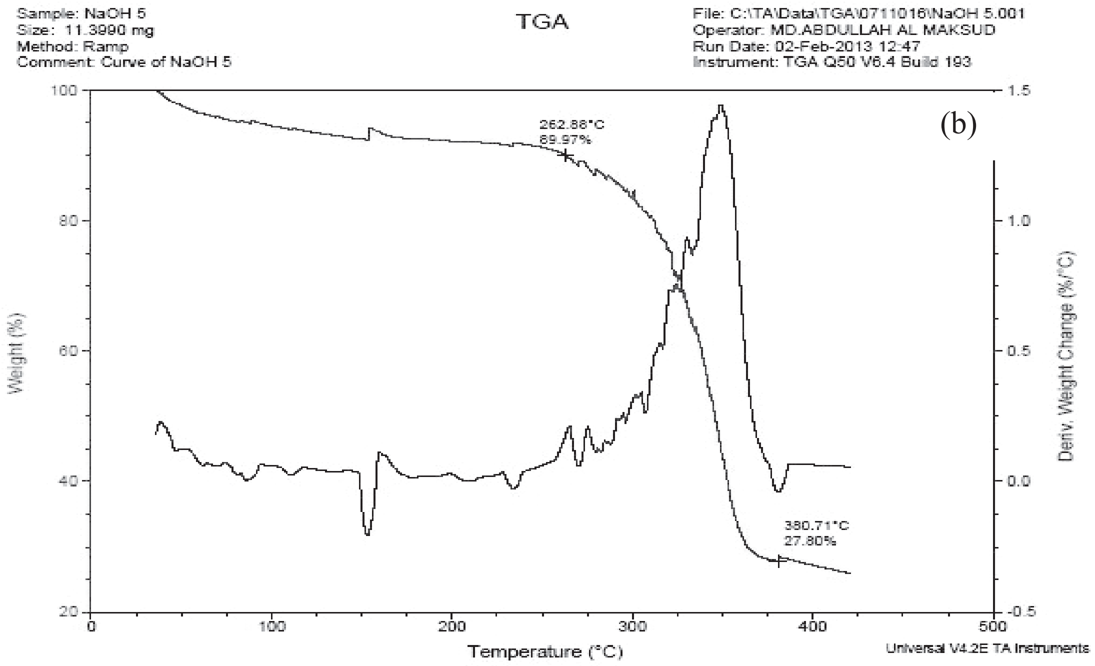


Fig. 3: TGA curves of (a) raw and (b) alkali treated ladies finger fiber

Conclusions: Present research demonstrated that alkali treatment clearly affected the physical and thermal properties of ladies finger fiber. FTIR analysis showed that alkali treatment decreased the amount of lignin and hemi-cellulose from the fiber. Scanning electron micrographs revealed cleaner and smoother surface in case of alkali treated fiber as compared to raw fiber. On the other hand TGA analysis revealed thermal stability of ladies finger fiber increased after alkali treatment.

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