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The Influence of Different Retting Processes on the Strength of Fibres obtained from *Poliostigma raticulatum, Grewia mollis, Cissus populnea* and *Hibiscus sabdariffa*

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Abstract

The extraction of vegetable fibres from different parts of plants has been a major focal point in the search for natural fibres that would substitute synthetic fibres. Fibres from *Poliostigma reticulatum*, *Grewia mollis, Cissus populnea* and *Hibiscus sabdariffa* were extracted by water and chemical retting. In chemical retting different concentrations of NaOH and NH_4OH were used. The extracted fibres were further purified and their tensile strength measured. The pH of water was measured as retting progresses and observed to increase as the retting time increases. This was ascribed to the secretion of enzymes by microorganisms as they acted on the mucilaginous matter of the bast with the resultant loosening of the fibres. The tensile strength of the fibres was determined using the Shirley Testometric 220D and was observed to gradual decline as the retting time increases. This was attributed to the continual removal of non-fibrous matter and the freeing of the fibres in the composite. However, beyond the fifth week of retting, no appreciable change in tensile strength was observed. This suggested that most of the non-fibrous matter have been solublized and utilized as source of nutrients and energy by the microorganisms. Acidic metabolites were produced due to microbial activities may have changed the pH of the medium and subsequently hindered their growth. In chemical retting, as the concentration of the medium increases the strength of the fibres decreases to a minimum then remain constant. This was accredited to the breakdown of inter- molecular bonds between non-fibrous substances and the fibres. And subsequently, the non-fibrous components separate from the fibres and dissolved in the medium revealing the actual fibres strength. It was therefore, opined that retted fibres in water, 5% NH_4OH and 15% NaOH are clearer and lustrous for all sample except those from Kargo.

Keywords: retting, fibres, microorganisms, tensile strength, mucilaginous matter

1. Introduction

The renewed vigor by scientists to extract fibres from different parts of plants has been on the increase. Efforts to replaced synthetic fibres with natural fibres due to some environmental effects has been advanced. Also, the identification, processing, modification and testing of tensile strength of fibres from sources other are now favoured. However, shrubs, leaves and cocoa nut hairs have been reported as sources of long, stiff natural fibres (Cerchiara et al., 2010). Fibres extracted from different plants are used in the manufacturing of pulp and paper, in cordage, fireboard, filtration products, reinforcing materials in rubber, tires, laminates, ceiling boards concrete and nanobiocomposite (Tarnongo et al., 2008).

Poliostigma reticulatum, Grewia mollis, and *Hibiscus sabdariffa* are perennial plants that grow well in Nigeria whereas, *Cissus populnae (*Soladoye & Chukuma, 2012) is legumes that grows on other trees or shrubs. Different parts of the plants have been reported for use as recipe for medicine (Fernandes & Banu, 2012; Al-Youssef et al., 2012), food, fuel, rope and other domestic applications depending on their availability.

Retting involves the removal of mucilaginous substances such as pectin, lignin, protein, fats, colouring matters from the fibres in the bast. Physical properties such as tensile strength, elasticity, luster, moisture content, dye absorption, etc are known to depend on the efficiency of the retting methods employed (Ajayi et al., 2000). Ezeribe et al. (2009) extracted and tested cellulosic bast fibres in Okro plant *(Hibiseus esculantus),* Dass et al. (2002) studied the influence of pH of retting media on the strength of natural fibres *(Hibiscus sabdariffa),* the effect of chemical retting liquor on the strength and moisture imbibitions of Kenaf (*Hibiscus cannabinus* L.) bast fibres has been reported by Tarnongo et al. (2009) and Ajayi et al. (2000). Chemical retting agents that have been commonly used in natural fibres extraction haven been sodium hydroxide, ammonium oxalate, ammonium hydroxide (Tarnongo et al., 2009; Boryo, 1999; Ramaswang et al., 1994). Some of the chemicals were observed to have adverse effects at high concentrations on the extracted fibres mainly due to the oxidation of the c-o leading to the formation of oxycellulose and degradation of the macromolecules.

This paper reports the extraction of fibres from four different perennial plants by water and chemical retting methods and their effects on tensile strengths.

2. Materials and Methods

The samples of *Poliostigma reticulatum* (Figure 2), *Grewia mollis* (Figure 3),*Cissus populnea* (Figure 1) and *Hibiscus sabdariffa* (Figure 4) were collected at Garko hill in Akko Local Government Area of Gombe State and. The bark was removed from the woody part of the stem mechanically and cut in about 12 cm then transferred in polyethylene bags to the laboratory for further analysis.

2.1 Retting

Water retting: 30 cm long and 100 g of each sample were submerged in water of 20 litres for five weeks to remove ligneous, woody and mucilaginous matters by converting to soluble products. The fibres were separated by washing with detergent solution and raised in overflowing tap water (Ajayi et al., 2000).

Chemical retting: Five difference beakers marks 1, 2, 3 and 4 each contains 600 ml of NaOH at different concentration (i.e. 5%, 10%, 15% and 20%) respectively were prepared and used separately as a chemical retting agent 15.0 g of each sample A (*Hibiscus sabdariffa*), B (*Grewia mollis*), C (*Polistigma raticulum*) and D (*Cissus populnae*) was submerged in solution and heated at 100^0C for 30 minutes in water-bath. The fibres were then rinsed in cold water (H_2O) and to free fibres strands. The fibres were dried up overnight at room temperature to prevent oxidation of fibres macromolecules. The fibres were prepared to 12.0 cm and 1 mg each. The above procedure was then repeated for NH_4OH (Dass et al., 2002; Ezeribe et al., 2009; Tarnongo et al., 2009).

Figure 1. *Cissus populnea* (white Stem)

Figure 2. *Poliostigma raticulatum*

Figure 3. *Grewia mollis* (growing on a hill)

Figure 4. *Hibiscus sabdariffa* (Red stem)

2.2 Tensile Strength Measurement

The bundle test described in ASTM D2524 was used. The Shirley Testometric Tester model 220D was used. Prior to test, the machine was calibrated to a nominal gauge length of 50 mm. pulling champs move at 10 mm/min. The fibres were stretched until rupture when the auto stops mechanism stops the transverse of the cross head. Instant breakage of fibres was not observed and the breaking load and breaking elongation were digitally displayed. 3 tests were carried out for each bundle and the average values recorded. The tensile strength of fibre was calculated using the formula given below:

$$\text{Tensile strength (Psi)} = \frac{\text{Breaking load (gf) x 4.733x10}}{\text{Mass (g)}} \quad (1)$$

3. Results and Discussion

3.1 Water Retting

The effect of pH of water retting on the extraction of fibre from the non-mucilaginous matter is given in figure 5. A gradual decrease in pH of the retting medium as the time (days) increases is observed for the entire sample. This could be as a result of the continuous secretion of acidic components on the substrates by the microbes as they consumed the non-fibrous part of the bast. It has been established that microorganisms continue to act on the mucilaginous part of vegetable fibres even after the fibres have been completely freed from the bast leading to the increase in the acidity of the retting medium due to the production of acidic metabolites and or increase in the hydrogen ion concentration. The C-O bond of the macromolecules is weak and easily broken producing smaller molecules which are either consumed or hydrolyzed to components that would be removed during washing. This allows the separation of fibres from the bast and the subsequent freeing to strands (Ajayi et al., 2000). During the retting, various organic acids and gases were produced thereby making the medium turbid. As the retting progresses, the activities of microbes reduces. This can be seen in curve (Figure 5.) which marginally decline as the retting time progresses. This is assume to be indicative of the approach completion of retting for all samples since fibres easily separate out by washing. However, fibres that cannot separate easily from mucilaginous matter required the change of water which could be liken to the continuation of retting.

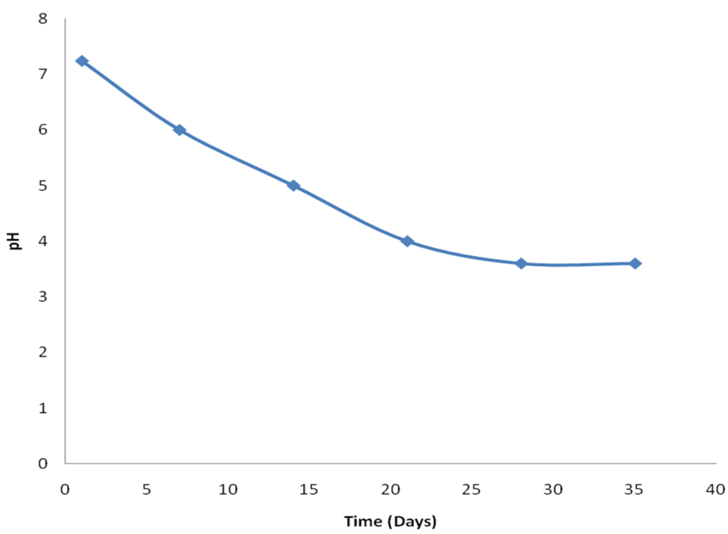

Figure 5. A Plot of the pH of the Retting Medium (H_2O) against Time (days)

Figures 6, 7 and 8 give the effect of retting media on the strength of fibres. In water retting, it revealed that as the retting time in days increases the strength of the fibres decreases to a minimum then remain constant. Several workers have reported that the initial strength of the fibres is due to the presence of inter- molecular bonds between non-fibrous substances and the fibres. However, as the non-fibrous components separate and dissolved in the medium the actual fibres strength is revealed which is seen by the near constancy of some curves. However, not all the sample curves flattens. This may be due to residual pectin, lignin and or others. The dissolution of carbohydrates, glycosides, tannin and nitrogen compounds in solution therefore, give the steady decline in fibres strength. The decrease in fibres strength was observed to significantly reduce by the 25th day of retting and marginally reduced afterwards.

It could be stated that retting has stopped after the fourth week which means that most of the non-fibrous components have been loosened from the fibrous part of the bast thereby making washing of the fibres to remove any soluble components a significant stage in the extraction process. During washing of the fibres have shown that NH_4OH retting agent produced white and more lustrous fibres than NaOH and water medium for all sample except *Poloistigma raticulum*. And at 5% NH_4OH solution the fibres were completely retted (Figure 8) whereas, 15% NaOH (Figure 7) is required. However, fibres from *Poloistigma raticulum* showed declining strength beyond the concentrations of 5% NH_4OH and 15% NaOH stated above (Figure 7). This could be owing to the presence of high level of non-fibrous matter and or strong inter-molecular bonds between the fibres and non-fibrous components in *Poloistigma raticulum* bast (Cerchiara et al., 2010). Also the extracted fibres from *Poloistigma raticulum* bast appear brown in colour suggesting that lignin a component of bast has not been removed completely (Reddy & Yang, 2009). Thereby producing fibres that are not in bundle rather than strands.

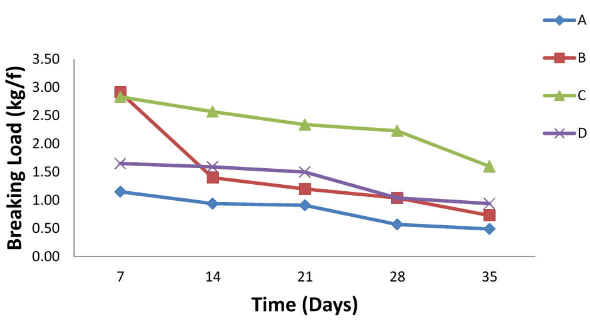

Figure 6. The Effects of Water Retting on the Strength of Fibres

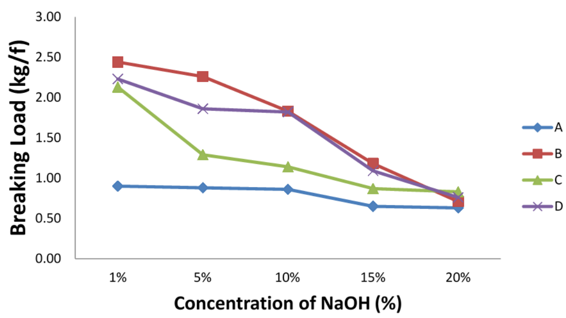

Figure 7. A Plot of Breaking Load (kg/f) against concentration of NaOH (%)

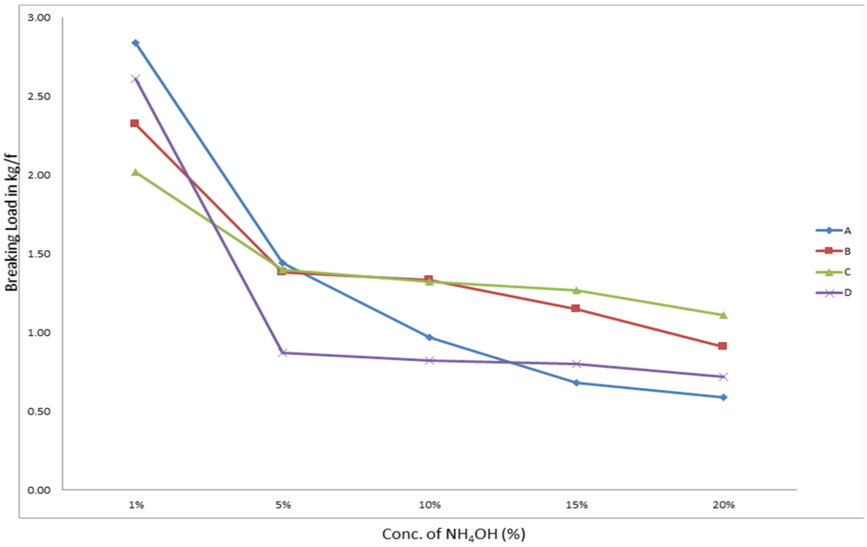

Figure 8. A Plot of Breaking Load (kg/f) against Concentration of NH_4OH (%)

Bundle test was chosen because of the anomaly recorded in the extraction of fibres from *Poloistigma raticulum* bast and the nominal gauge length of 50 mm pulling champs move at 10 mm/min was to allow for other fibres strength to be determined. The removal of non-fibrous components and complete separation from fibrous section during retting process has been shown to depend on the concentration, pH of medium, time and temperature of the reaction which affects the strength of the extracted fibres and other physical properties (Ashokkumar et al., 2011). Therefore, the quality of the fibre for ultimate use in different industrial applications (Reddy et al., 2011) depend on the manner the retting conditions are manipulated (Brindha et al., 2012; Msahil et al., 2006)

5. Conclusion

Perennial shrubs of *Poliostigma raticulatum, Grewia mollis, Cissus populnea* and *Hibiscus sabdariffa* have been utilized in different ways. Depending on the part of the plant, the bast have been used for rope making, sponge and carrier bags by indigenes and water retting has been employed to remove the non-fibrous components and completely free the fibres from other impurities. The actual strength of the fibres were only ascertained after the non-fibrous components have been removed. Retted fibres from all the bast except those from *Poliostigma raticulatum* were clearer and lustrous. The removal of non-fibrous components and complete separation of fibres during retting process depend on the concentration, pH of medium, time and temperature of the reaction. This affected the strength of the extracted fibres, colour, texture and other physical properties. It is therefore imperative to assert that the quality of the fibre for ultimate use in different industrial applications depend on the manner of the retting conditions. Although weak base such as NH_4OH gave good fibres but due to cost and availability of the chemicals, water could considered as ideal medium of retting. The application of these fibres in the manufacturing of carpets and mats is recommended.

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