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# Effect of Alkali Treatment on Kenaf Fibre Quality

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***Abstract**: The quest for quality fibre is the burning desire in the mind of every kenaf grower and this is a function of retting technology employed. This study was carried out to investigate the effect of alkali treatment on ribbon fibers and the effect of post retting alkalization on fibers. Four treatments (2.5%NaOH, 5.0%NaOH, 7.5%NaOH and Control) were applied at different soaking times (one and three hours). The ribbon fibers had significantly higher tensile strength and moduli than the non-ribbon fibers. In an hour soaking (1HS) interval, the ribbon fibers had significantly higher tensile strength and tensile moduli which increase with the increase in concentration of sodium hydroxide: 7.5% NaOH > 5.0%NaOH > 2.5%NaOH>Control. At 3HS, there was significantly lower tensile strength and modulus than that of 1HS even with the same treatment for ribbon fibers. The increase in concentration of sodium hydroxide resulted in higher tensile strength and moduli but these decreased as the soaking time increased. Unlike the ribbon fiber, at 1HS, the tensile strength and moduli were significantly higher than that of 3HS. Soaking kenaf fibers in NaOH solution for three hours had drastic reduction in its physico-mechanical properties. In both treatments, 2.5% NaOH had the highest tensile strength (58.88MPa and 45.30MPa for 1HS and 3HS respectively) while the Control had least tensile strength and moduli.*

***Keywords**: Alkalization, Kenaf fibre, Soaking time, sodium hydroxide*

## INTRODUCTION

Synthetic fibres are non-biodegradable and environmentally unfriendly whereas its natural counterpart is ecofriendly. High level of environmental degradation in developing countries like Nigeria occasioned by the use synthetic products is worrisome and this calls for total replacement of synthetic fibres with its natural counterparts. However, natural fibre is safer and very useful for many industrial applications. Natural fibres has various advantages over synthetic fibres and they are: renewable, environmental friendly, low cost, low density and flexibility of usage (John & Anandjiwala, 2008; Rowell, 1991). Treatments of natural fibre is a prerequisite for quality products. Retting and post -retting treatments of kenaf bast fibres are essential processes when considering the uses of kenaf fibre for rope, twine, and produce bags, pulp, paper, woven and non-weaving materials. Kenaf fibre is not devoid of impurities because its biomass components can affect the quality of the fibre. Degradation and /or total removal of such impurities through farm gate processing will enhance its fibre quality. Few literature documentations had emphasized on the relevance of this farm gate treatment of kenaf fibre. Kenaf (*Hibiscus cannabinus L.*) as a natural fibre crop and has been found to be an important source fibre for different applications. Farm gate treatment of kenaf fibre would boost its potential uses for composites reinforcement. However, modification of fibre processing method is required as to improve mechanical properties for composite products (Pott et al., 2000; Karlsson *et al.,* 2004). The effectiveness of the fibre products is function its farm gate processing (Pradeep et al., 2010). In attempts to meet the increasing demand for quality fibres for all applications, the chemical treatment of agro-fibres is predicted to prevent degradation of the fibres due to water absorption and removes impurities.

### 1.2: Objectives:

i. To evaluate the effect of alkalization on kenaf fibre quality

ii. To determine the impact of the process on the properties of the yarns and weaving materials produced from kenaf fibres

iii. To compare the effect of alkali treatment on ribbon fibres with that of post retted fibre.

## 3: METHODOLOGY:

Ribbon fibres and post retted fibres were soaked in sodium hydroxide solutions at different concentration of: 2.5% NaOH, 5% NaOH and 7.5 % NaOH for 1 and 3 hours and another (control) is without sodium hydroxide but water.

### 3.2: Chemical Procedure for Retting

The chemical treatment used in this project was sodium hydroxide (NaOH) solution. The ribbon fibers and post retted fibers were soaked in 2.5%, 5.0% and 7.5%NaOH at different intervals (1and 3 hours) and then the fibers were washed thoroughly with water and oven at 70$^{o}$C dried for 24 hours.

### 3.3: Fibre Treatment

Ribbon fibres and already retted fibres were chemically treated in 1M sodium hydroxide in water while some were left as control samples. 120 g of each of the freshly chopped fibre was chemically treated at 70$^{o}$C for 1 and 3 hours in a water shaker bath. After the appropriate soaking time, the fibres were rinsed in tap water until the pH of the rinse solution stabilized at 7 so as to remove the excess of the chemicals sticking to the fibres. The fibres were later oven dried. Fiber treatment in this study, involved the use of NaOH solution to soak, washing, and drying. The concentration of sodium hydroxide and soaking time were the key factor affecting the treatment. There are four chemical treatments compositions/concentrations (2.5%, 5.0%, 7.5%NaOH and control at 1and 3hours soaking time) used in this as shown in Table 3.1. The fibers were washed thoroughly with tap water for seven times after soaking in sodium hydroxide solution and then dried in room temperature for 24 hours.

Table 1: The Chemical Treatments

| Treatment | NaOH(%) | Soaking time( hours) |
|---|---|---|
| 1 | 2.5[1] | 1hour |
| 2 | 5.0[1] | 1hour |
| 3 | 7.5[1] | 1hour |
| 4 | Control[1] | 1hour |
| 5 | 2.5[3] | 3 hours |
| 6 | 5.0[3] | 3hours |
| 7 | 7.5[3] | 3hours |
| 8 | Control[3] | 3hours |

**Alkali treatment**

The fibers were treated using different concentrations of aqueous solution of sodium hydroxide (2.5%, 5.0%and 7.5 NaOH). The fibers were soaked in sodium hydroxide (NaOH) solution for the period of 1and 3 hours for each treatment together with the control. Subsequently, the fibers were washed 6 times with distilled water and oven dried at 80°C for 24hours.

**Tensile testing** The tensile properties were measured using an Instron 3365 electronic universal testing machine (Instron Co., Norwood, MA, USA) according to ASTM D 638(2010). The tensile strength and tensile modulus were calculated from strain vs stress curve.

**Ribbon Fibre**

The bast fibres were manually decorticated from the kenaf stalk.

**Chemical Procedure**

The chemical treatment used in this project involved soaking the fibres in NaOH solution, for a given time and thoroughly washed with water and thoroughly washed again tap water and dried in an oven at $100^{o}$C until they are dried.

The concentration of sodium hydroxide was the key factor affecting the treatment. In all the chemical treatments, the fiber-to-liquid (w/v) ratio was 1:20.

**Statistical Analysis:**

Statistical analysis was done using SAS. Analysis of Variance (ANOVA) was used to determine if fibre properties differ significantly at 5%.

## RESULTS AND DISCUSSION

**Table1:** Physico-mechanical properties of ribbon fibres soaked for one hour

| treatment | Tensile strength(MPa) | Young modulus(GPa) | |
|---|---|---|---|
| 2.5% NaOH[1] | 66.04[c] | 21.1[b] | |
| 5.0%NaOH[1] | 69.32[b] | 22.5[b] | |
| 7.5%NaOH[1] | 82.85[a] | 24.7[a] | |
| Control[1] | 20.36[d] | 10.7[c] | |

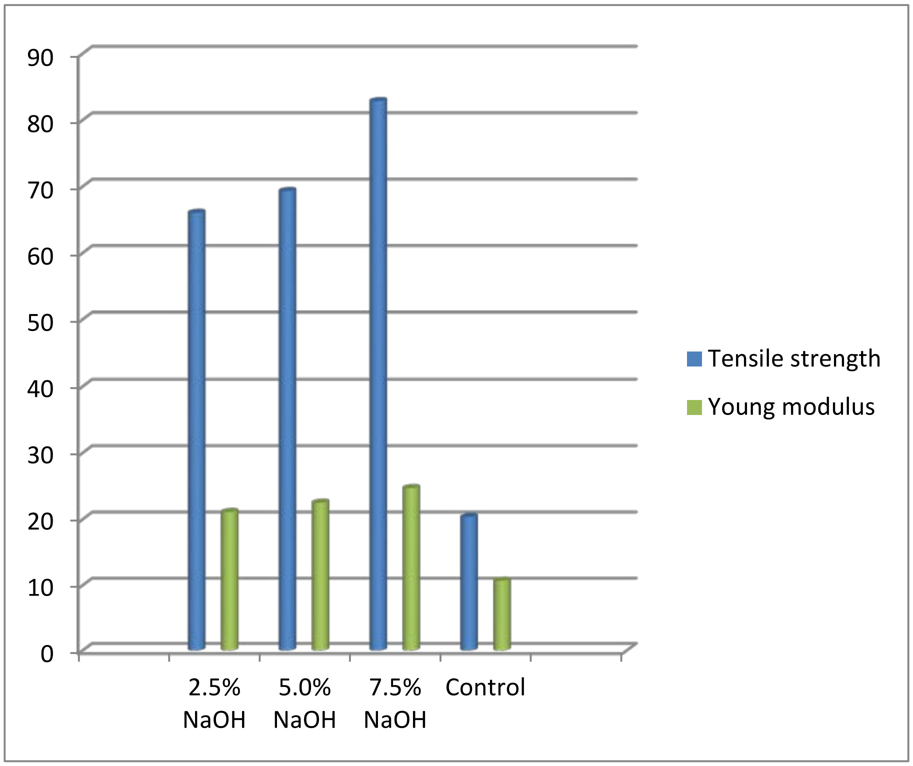


**Figure 1:** Tensile strength and modulus of each treatment for one hour

**Table 2:** Physico-mechanical properties of ribbon fibres soaked for three hours

| **Treatment** | **Tensile strength(MPa)** | **Young Modulus(GPa)** | |
|---|---|---|---|
| 2.5%NaOH[3] | 29.84[c] | 16.5[c] | |
| 5.0%NaOH[3] | 57.12[b] | 20.0[b] | |
| 7.5%NaOH[3] | 74.95[a] | 27.7[a] | |
| Control[3] | 30.22[c] | 21.6[b] | |

[3]Represents each treatment for three hours

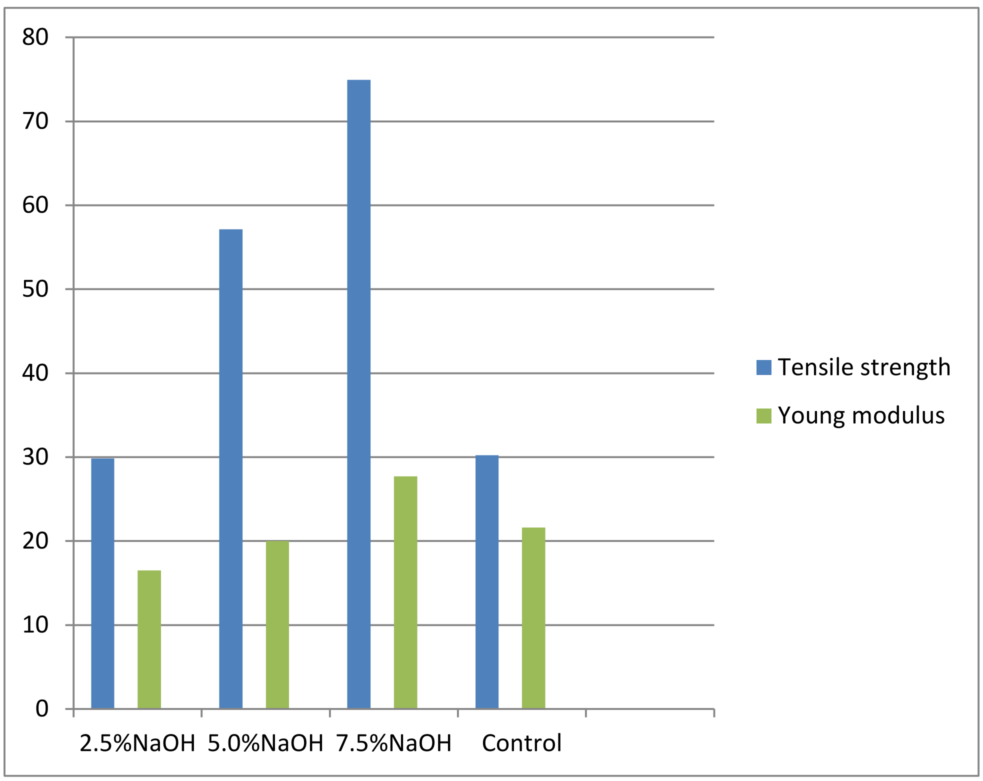


Figure 2: Tensile strength and modulus of each treatment for three hours

**Table3:** Physico-mechanical properties of post retting treatment on fibres soaked for one hour

| Treatment | softness | Fineness | Colour | Tensile strength(MPa) | Young modulus(GPa) |
|---|---|---|---|---|---|
| 2.5%NaOH[1] | B | C | brown | 58.88 | 30.5 |
| 5.0% NaOH[1] | C | C | Light brown | 35.72 | 17.2 |
| 7.5%NaOH[1] | C | C | Dark brown | 33.90 | 12.2 |
| Control[1] | A | B | white | 20.35 | 10.7 |

[1]Represents each treatment for one hour

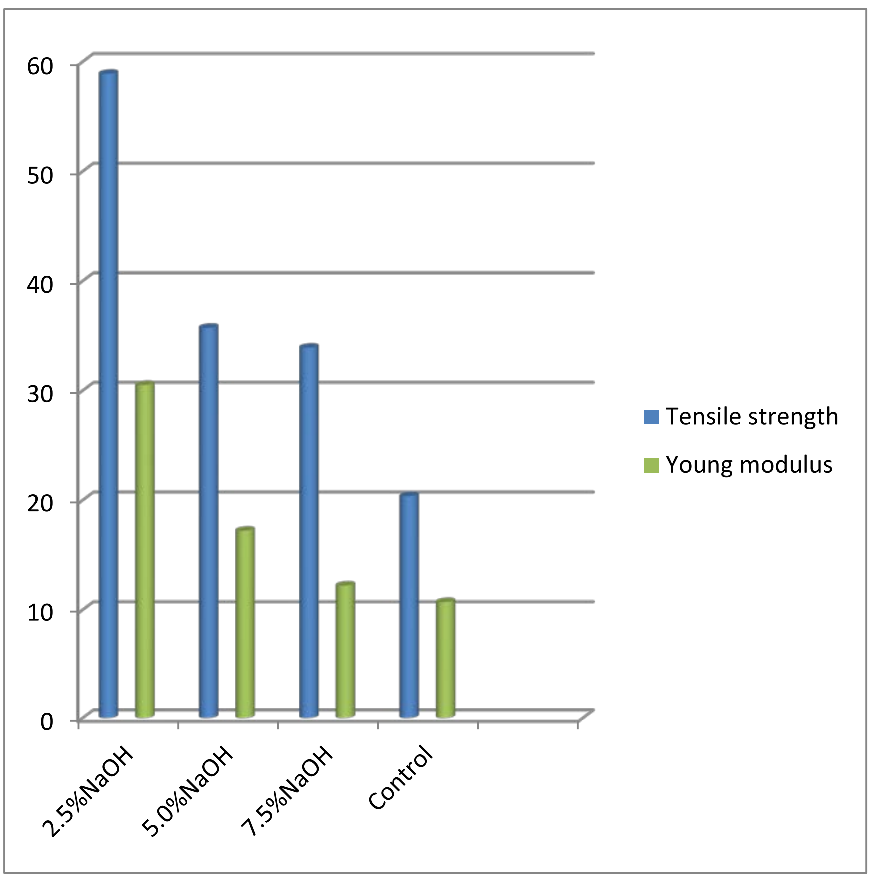


**Figure 3**: Effect of post retting alkalization on fibre tensile strength and modulus for one hour

**Table 4**: Physico-mechanical properties of post retting treatment on fibres soaked for three hours

| **Treatment** | **softness** | **Fineness** | **Colour** | **Tensile strength(MPa)** | **Young modulus(GPa)** |
|---|---|---|---|---|---|
| 2.5%NaOH[3] | C | B | Dark brown | 45.30 | 16.9 |
| 5.0% NaOH[3] | B | C | Sharp brown | 35.23 | 15.7 |
| 7.5%NaOH[3] | B | C | Deep brown | 30.09 | 11.9 |
| Control[3] | A | B | white | 20.11 | 10.0 |

[3] Represents each treatment for three hours

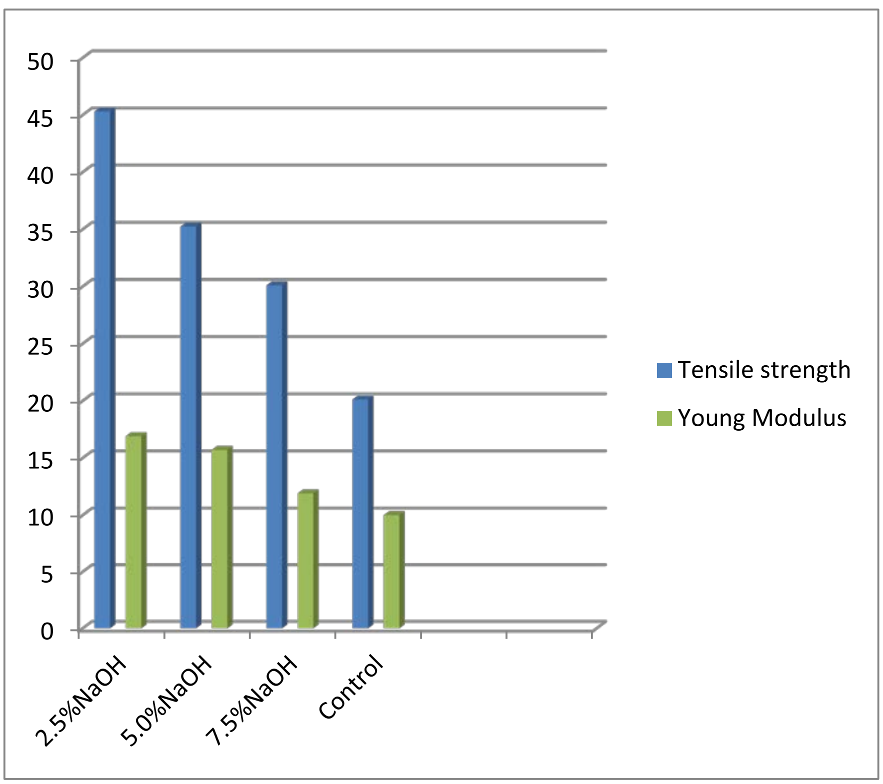


**Figure 4**: Effect of post retting alkalization on fibre tensile strength and modulus for three hours

### 4.1: Effect of alkalization on ribbon fibres

The fibers were treated with different concentrations of NaOH solution at various soaking times. The alkalization of ribbon fibres had significant effect on the tensile strength and modulus of the fibers. The treatments in 1HS had significantly higher tensile strength and modulus but this parameter increased with increasing concentrations of sodium hydroxide solution and this was in consonance with the reported data by Mohd *et al.* (2011). At 3HS, the duration of soaking had reduced the tensile strength and young moduli of the fibers. Though, increase in concentration of sodium hydroxide solution increases the tensile strength and which cleaned them and provided a rougher surface; however, it softened the inter-fibrillar matrix, which negatively affected the stress transfer in the fibres (Thomas & Pothan, 2009; Brouwer, 2003). Alkali treatment uncovers the fibrils and gives the fibers a rough surface topography (Susheel et al., 2009; Wang et al.,2009). Alkali treatment also changes the fine structure of the native cellulose to cellulose-II by a process known as alkalization (Pradeep et al., 2010). The reaction of NaOH with cellulose is shown in Equation (1). Figure 2a shows the surface of an untreated fiber. The fiber surface is smooth as a result of oils and waxes. Figure2b shows kenaf fibres treated with 2%NaOH. It is clear that the treatment removes a certain amount of hemicellulose, lignin, wax, oils, and other impurities, and the surface becomes rougher. Similar observations were found in a previous study. It has been demonstrated that TPU is not compatible with NaOH treatment according to Susheel et al. (2009). NaOH treatment was used in this study to compare COMP2 with COMP4, Alkali treatment of natural fibers has several advantages for the removal of undesired substances; it affects the properties of the fibers and fiber-matrix interlocking (Van De-weyenberg et al., 2003, Cheng et al., 2008). Isocyanate has also shown a positive effect when used as a coupling agent between natural fibers and polymers. Previous studies have used isocyanates as coupling agents and reported their positive effect on fiber-matrix interfacial bonding (Thomas & Pothan, 2009; Sahoo et al.,2011). Alkalization of the fibre helps in improving chemical bonding between the resin and the fibre resulting in superior mechanical properties.

$$\text{Fiber –OH} + \text{NaOH} \longrightarrow \text{Fiber –O–Na} + H_2O + \text{(Surface impurities)} \qquad (1)$$

### 4.2: Effect of chemical treatment on the tensile properties of kenaf fibre

Figure1 shows the effect of various treatments on the tensile properties of NaOH treatment of 2.5% or decreased the tensile strength and strain; however, it slightly increased the tensile moduli. The 2.5% chemical treatment of resulted in a slight increase in the tensile strength and modulus and a slight decrease in the strain. The tensile strength of 2.5% or showed a significant increase from 33MPa for the untreated composite

**Table3:** Effect of alkali treatment on the physico-mechanical properties of kenaf fibre

| Treatment | | Colour | Young modulus(GPa) | Tensile strength(MPa) |
|---|---|---|---|---|
| 2.5% NaOH[1] | | Light brown | $30.5^a$ | $58.88^a$ |
| 5.0% NaOH[1] | | Light brown | $17.2^b$ | $35.90^b$ |
| 7.5% NaOH[1] | | Dark brown | $12.2^c$ | $33.72^c$ |

| | | | | |
|---|---|---|---|---|
| Control[1] | | White | 10.7[d] | 20.35[d] |
| 2.5%NaOH[3] | | Light brown | 21.9[a] | 45.30[a] |
| 5.0% NaOH[3] | | Light brown | 16.9[b] | 35.23[b] |
| 7.5% NaOH[3] | | Dark brown | 15.7[c] | 30.09[c] |
| Control[3] | | White | 15.4[c] | 30.11[c] |

Values are means of triplicate determination

### 4.3: Effect of alkali on tensile strength of kenaf fibre

The tensile strength of the fibres from each treatment was compared with the untreated fiber (control), the tensile strength increased with increasing concentration of NaOH solution. The fibre soaked in 7.5% NaOH had significantly higher tensile strength in both one hour and three hours soaking periods than others while there was also a significant difference decreased. The maximum temperature value was found at 140 °C. With increasing heat treatment temperature, the appearance color of the fibers became brown and black gradually by the observation of naked eye, and moreover the fibers became easily brittle and broken. This was considered the thermal degradation of the fiber could occur in light of the TG analysis, especially at 220°C. (Pott et al., 2000, Pradeep et al., 2010; Jiang et al., 2009)

### 4.4: Effect of alkali treatment on tensile moduli of kenaf fiber

The different concentrations of alkali solution affected the tensile properties of Kenaf fibers. After alkali treatment, all the diameter of the treated fiber decreased. In the case of 10 and 15% NaOH solution, the tensile strength decreased, Young's modulus changed slightly and fracture strain increased drastically, which were two to three times higher than that of the untreated. This was considered the modification of the fibre structure occurred due to alkali treatment, and finally led to influencing the tensile properties of the treated fibre. However, the tensile strength increased and young modulus displays typical stress-strain diagrams of untreated and the treated kenaf fibres. This result is in agreement with the publication report by Susheel et al. (2009) which stated that alkali treatment had drastically increased the tensile moduli

## 5. CONCLUSION:

Alkali treatment has improved the mechanical properties of Kenaf fibre. The results showed that NaOH solution was effective in removing the impurities of the fibre. However, increasing the soaking time in NaOH solution appeared to have caused damage on the fibre surfaces.

## REFERENCES:

- Brouwer, R. (2003). Natural Fiber Composites-state of the art, joint meeting of the 32nd session of the Intergovernmental group on jute, kenaf and Allied fibers. Salvador, Brazil,23-38
- Chen, F, Liu, L. S. Cooke, P.H., Hicks, K.B. and Zhang J. (2008). Performance enhancement of poly (lactic acid) and sugar beet pulp composites by improving interfacial adhesion and penetration. Industrial and Engineering Chemistry Research, 47, 8667–8675
- Jiang,L., Chen, F., Qian, J. Huang, J., Wolcott, M., Liu, L., Zhang J. (2009). Reinforcing and toughening effects of bamboo pulp fiber on poly (3-hydroxybutyrate-co-3- hydroxyl-valerate) fiber composites*. Industrial and Engineering Chemistry Research*, 49, 572–577.
- John and Anandjiwala R.D. (2008). Polymer Composite Intl' J.Res. 29,187.
- Karlsson, S., Espert,A. and Vilaplana. F. (2004). Comparison of water absorption in natural cellulosic fibres from wood and one-year crops in polypropylene composites and its influence on their mechanical properties. *Department of Fibre and Polymer Technology, Royal Institute of Technology*, SE-10044 Stockholm, Sweden. 55-65.
- Pott, G.T., Hueting, D.J. and J.H. Van Deursen.J.H.(2000) "Reduction of Moisture Sensitivity in Wood and Natural Fibers for Polymer Composites," in 3rd International Wood and Natural Fibre Composites Symposium. Kassel. 15-18
- Pradeep, K., Kushwaha, and Rakesh Kumar (2010). Studies on Water Absorption of Bamboo-Polyester Composites: Effect of Silane Treatment of Mercerized Bamboo. Polymer-Plastics Technology and Engineering, 49, (1), 45 - 52
- Rowell. R.M. (1991). Natural composites, Fibre Modification. In: International Encyclopedia of Composites. S. M. Lee, Ed., VHC. New York, 4,35-37
- Sahoo, S., Misra, M and Mohanty.A.K.(2011). Enhanced proper- ties of lignin-based biodegradable polymer composites using injection moulding process. Composites Part A: *Applied Science and Manufacturing*, 42, 1710–1718.
- Susheel, K., Kath, B.S. and I. Kaur,I.(2009). Pretreatments of natural fibres and their application as reinforcing materials in polymer composites-- a review. *Published in Polymer Engineering Science* as a Technical Report.
- Thomas, S and Pothan L. (2009). Natural fibre reinforced polymer composites: From macro to nanoscale. Old City Publishing,
- Van De Weyenberg, J. Ivens, A. De Coster, B. Kino, E. (2003) Baetens, and I. Verpoest. Composite Science Technology. Pp 63 -124.
- Wang, Z. Wang, S. Zhang, Z. Wang, and Ren. Y. (2009). Effects of cross-linking on mechanical and physical properties of agricultural residues/recycled thermoplastics composites. Industrial Crops and Products, 29, 133–138.