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Abstract: The ligno-cellulose natural fabric from the polyalthia cerasoides tree was analyzed by FTIR, chemical, X-ray and thermo gravimetric methods. The morphology of the fibers was studied by scanning electron microscopic and polarized optical microscopic methods. The tensile properties were also studied. The effect of alkali treatment on the properties of the fabric was studied. The FTIR and chemical analyses indicated lowering of hemi-cellulose and lignin content on alkali treatment of the fabric. The tensile properties were found to increase on alkali treatment. The x-ray diffraction revealed a slight increase in crystallinity of the fabric on alkali treatment. This uniaxial fabric has sufficient tensile modulus and can be used as reinforcement in the development of green composites.

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Properties of Natural fabric *Polyalthia Cerasoides*

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Abstract: The ligno-cellulose natural fabric from the *polyalthia cerasoides* tree was analyzed by FTIR, chemical, X-ray and thermo gravimetric methods. The morphology of the fibers was studied by scanning electron microscopic and polarized optical microscopic methods. The tensile properties were also studied. The effect of alkali treatment on the properties of the fabric was studied. The FTIR and chemical analyses indicated lowering of hemi-cellulose and lignin content on alkali treatment of the fabric. The tensile properties were found to increase on alkali treatment. The x-ray diffraction revealed a slight increase in crystallinity of the fabric on alkali treatment. This uniaxial fabric has sufficient tensile modulus and can be used as reinforcement in the development of green composites.

Keywords: natural fabric, ligno-cellulose, *polyalthia cerasoides*, FTIR, TGA, morphology, crystallinity, reinforcement.

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INTRODUCTION

In recent years, significant efforts have been made to use natural fibers / fabric as reinforcement in green composites. Natural fibers / fabrics have several advantages such as low cost, low density, high toughness, acceptable specific strength, enhanced energy recovery, biodegradability etc. Several workers used, plant and vegetable based fibers / fabric as reinforcement in the development of green composites. [1–18]

The performance of a composite depends on the properties of the reinforcement and matrix and the bonding between them. As the natural fibers / fabrics are renewable and environmental friendly, it is desirable to identity and study the properties of new natural fibers. Varada Rajulu et al. [19-20] studied the properties of lingo–cellulose fabric *Hildegardia*. They reported improvement in properties on alkali treatment. Varada Rajulu et al. [21] also studied the properties of ligno-cellulosic bilayered vegetable fabric from Ridge gourd. They reported the suitability of this fabric as reinforcement. Goda et al. [22] improved the plant based natural fibers by alkali treatment for toughening green composites. Xu et al. [23] modified wood fiber using steam explosion. They observed a reduction in crystallinity, thermal stability and mechanical strength. They attributed this to the destruction of crystals and crosslinks of macromolecular chains in the fiber. Dupres et al. [24] investigated the electrostatic properties and wetting behavior of human hair surface at the nanometric scale using atomic force microscopy. It the present work, the authors studied the properties of the natural lingo-cellulose fabric *polyalthia cerasoides*. The authors selected this fabric, as the fibers in it are uniaxial in nature. As much data is not available on this natural fabric, the authors studied some of its properties such as chemical composition, spectral, thermal stability, morphology and tensile. The effect of alkali treatment on these propertied was also studied and the results are reported in this paper.

Experimental

Extraction of the fabric from the tree

The fabric was extracted from the branches of the tree *polyalthia cerasoides*. The fabric samples were kept in water for about one week to remove the dirt and other unwanted material. They were then thoroughly washed and dried in the Sun for nearly one week. Some of the fabric samples were treated with 5% Aq.NaOH solution and dried before analysis.

FTIR Spectral Analysis

The fabric samples were cryogenically cooled and powdered. These powders were diluted to 1% using KBr and pellets were prepared using a Hydraulic press. The FTIR spectra of the untreated and alkali treated samples were recorded in 4000 – 500 cm^{-1} region on a Perkin Elmer 16PC FTIR instrument with 32 scans in each case at a resolution of 4 cm^{-1}.

Chemical Analysis

The chemical analysis of the untreated and alkali treated fabrics was carried as per the standard procedure[25]. In this analysis, the % of α-cellulose, hemicellulose and lignin were determined. In each case, five samples were used and the average values are reported.

Thermogravimetric Analysis

The thermograms of the untreated and alkali treated fabrics were recorded on a Perkin Elmer TGA-7 instrument in nitrogen atmosphere at a heating rate of 10 ^{o}C/min.

X-Ray Analysis

The X-ray diffraction spectra of the untreated and alkali treated fabrics were recorded on a Rigaku Dmax 2500 diffractometer. The system has a rotating anode generator with a copper target and wide-angle powder goniometer. The generator was operated at 40 kV and 150 mA. All the experiments were performed in the reflection mode at a scan speed of 4^o/min in steps of 0.05^o.

Morphology

The scanning electron micrograms of the untreated and alkali treated fabrics were recorded on a JOEL JSM 820 microscope. The fabric samples were gold coated before recording the micrograms. The optical micrograms were recorded using a Leica DMLP polarized optical microscope.

Tensile properties

The tensile properties such as – maximum stress, Young's modulus and % elongation at break were determined using INSTRON 3369 Universal Testing Machine at a crosshead speed of 3mm/min maintaining a gauge length of 50mm. In each case, 10 samples were used and the average values reported.

Result and discussion

The plant from which the fabric was extracted belongs to Annonaceae family. The morphology of the untreated fabric is shown in Figure 1a, b and c and that of alkali treated fabric in Figure 1d, e and f at different magnifications. The polarized optical micrograms of the fabric before and after alkali treatment are shown in Figure 2. From these figures, it is evident that the fabric is made up of uniaxial roughly parallel fibers. Further, at higher magnification, the void regions present in the fabric are visible. The scanning electron micrograms also reveal that the untreated fabric has a white layer, which may belong to its hemi- cellulose content. On alkali treatment, the white layer content decreased. This may be due to the reduction in hemi-cellulose content on alkali treatment. The FTIR spectra of the untreated and alkali treated *polyalthia cerasoides* fabric are presented in Figure 3. The band positions and possible assignments are presented in Table1. From Figure 3, it can be observed that well defined bands around 3400, 2900, 2400,1630,1260 and 1030 cm^{-1} are present in the spectra. But in the case of untreated fabric, an additional band at around 1740 cm^{-1} is also present which corresponds to hemi-cellulose. On alkali treatment, the intensity of this band is found to decrease indicating lowering of the hemi-cellulose. From Table 1, it can be seen that the band around 3400 cm^{-1} and 2930 cm^{-1} correspond to α-cellulose whereas the remaining bands belong to lignin. Further, the intensity of the bands corresponding to α-cellulose is increased on alkali treatment.

The chemical analysis of the untreated and alkali treated *polyalthia cerasoides* fabric is presented in Table 2. From this table, it is evident that the content of hemi-cellulose and lignin decreased on alkali treatment. This is in agreement with the observations made in FTIR analysis.

The X-ray diffractograms of the untreated and alkali treated fabrics are shown in Figure 4. From this figure, it is evident that the crystallinity of the fabric increased on alkali treatment. This is understandable, as the amorphous hemi-cellulose and lignin decreased on alkali treatment. This is in agreement with the FTIR, chemical and polarized optical microscopic analyses.

The primary thermograms of untreated and alkali treated *polyalthia cerasoides* fabric are presented in Figure 5. From these thermograms, it is evident that the thermal stability of the alkali treated fabric is slightly higher than that of the untreated fabric. This may be attributed to the increase in crystallinity of the fabric on alkali treatment.

The tensile parameters of the untreated and alkali treated *polyalthia cerasoides* fabrics are presented in Table 3. From this Table, it is clearly evident that the maximum stress, Young's modulus and % elongation at break of the fabric are increased on alkali treatment. Further, due to the higher modulus values, this uniaxial natural fabric *polyalthia cerasoides* can be put to use as reinforcement in the preparation of green composites.

Conclusions

The properties of the uniaxial natural fabric *polyalthia cerasoides* were studied. The FTIR and chemical analyses indicated lowering of hemi-cellulose and lignin content on alkali treatment. The XRD and optical microscopic analyses revealed the increase in crystallinity on alkali treatment. The thermal stability and tensile properties of this fabric increased slightly on alkali treatment. Due to the higher modulus, this natural fabric can be put to use as reinforcement in green composites.

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Table 1. Band positions and assignments of chemical groups in the untreated and alkali treated *Polyalthia cerasoides* Fabrics

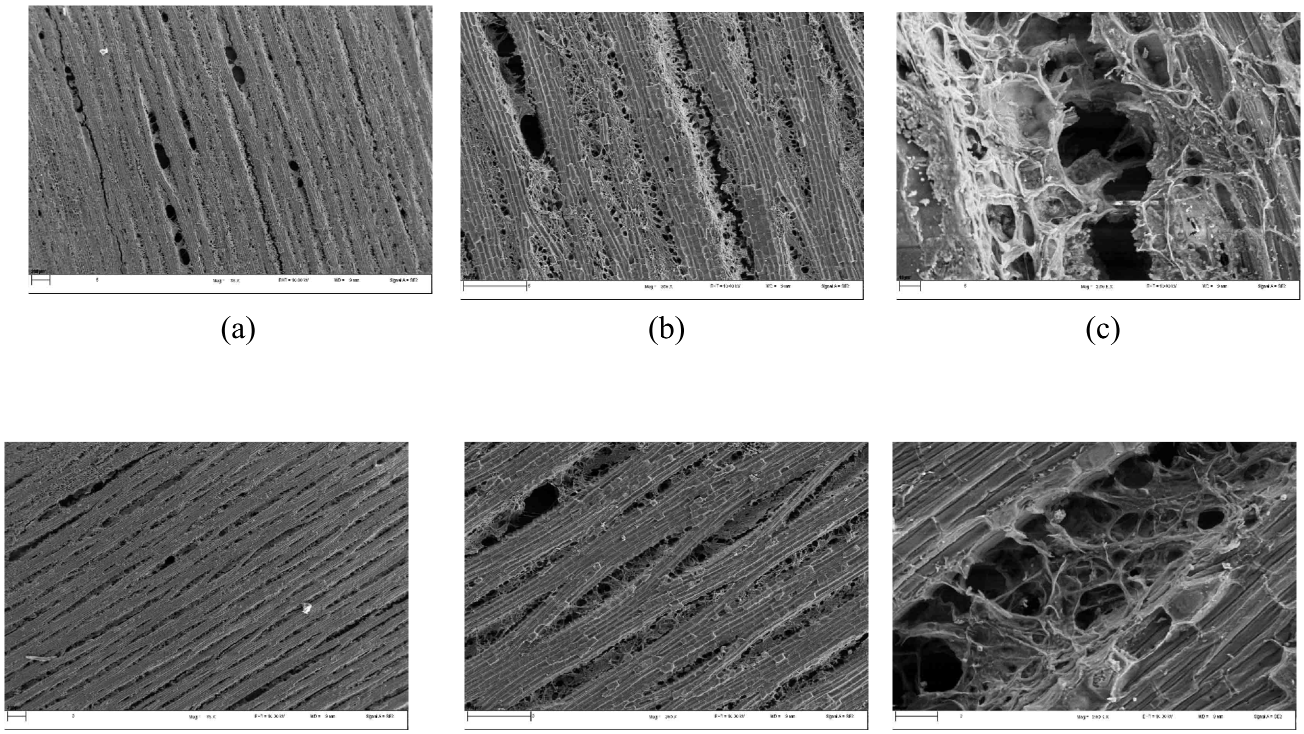
Untreated Wavenumber (cm^{-1})	Alkali Treated Wavenumber (cm^{-1})	Assignments
3386	3393	OH-stretching of α –cellulose
2928	2928	Alkyl CH stretching
2347	2352	C=C Stretching
1738	--	CO stretching of hemi-cellulose
1629	1637	CO stretching of lignin
1259	1247	Asymmetric C-O-C stretching of lignin
1034	1034	Symmetric CO stretching of lignin

Table 2. Chemical analysis of untreated and alkali treated *Polyalthia cerasoides* Fabrics

Component	Untreated	Alkali Treated
α – Cellulose	64.5%	70.5%
Hemicellulose	22.7%	18.5%
Lignin	12.6%	10.7%

Table 3. Tensile Properties of untreated and alkali treated *Polyalthia cerasoides* Fabrics

Parameter	Untreated	Alkali Treated
Maximum Stress (MPa)	44.3	51.6
Young's Modulus (MPa)	3467.7	5713.8
% Elongation at Break	2.5	2.7

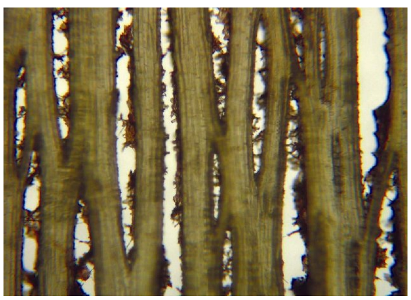


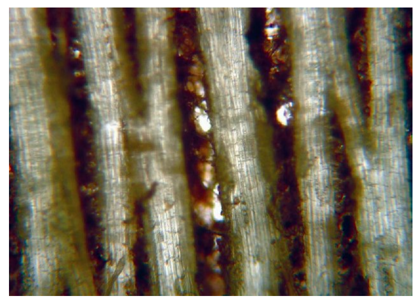
(a) (b) (c)

(d) (e) (f)

Fig 1. Scanning Electron Micrograms of *polyalthia cerasoides* fabric – (a), (b) and (c) for untreated and (d), (e) and (f) for alkali treated fabric at different magnifications.

(a) (b)





(b) (d)

Fig 2. Polarized Optical Micrograms of *polyalthia cerasoides* fabric – (a) and (c) for untreated and (b) and (d) for alkali treated fabric at different magnifications.

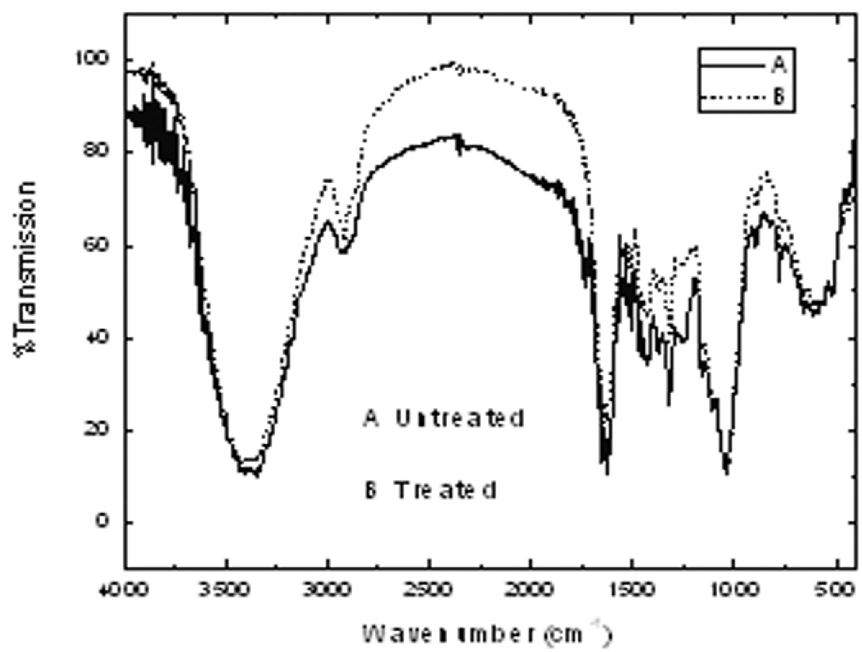


Fig 3. FTIR spectra of untreated and alkali treated *polyalthia cerasoides* fabric.

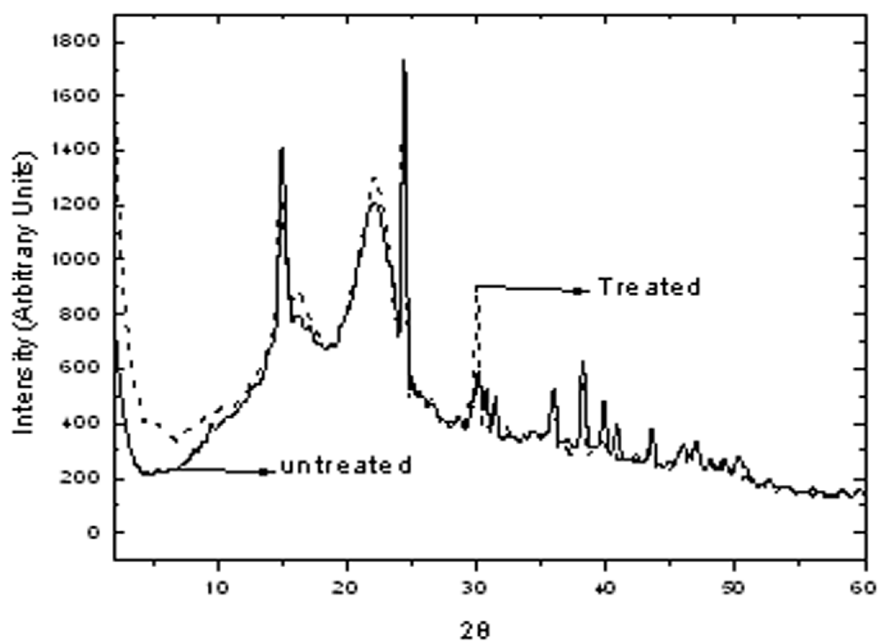


Fig 4. X-ray Diffractograms of untreated and alkali treated *polyalthia cerasoides* fabric.

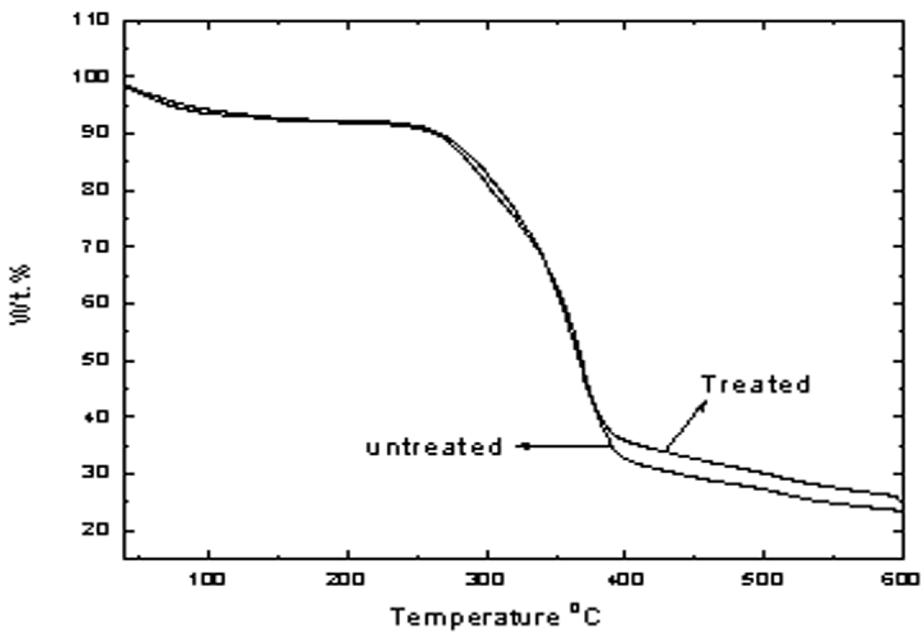


Fig 5. Thermograms of untreated and alkali treated *polyalthia cerasoides* fabric.