

Tensile Properties of Polymethyl methacrylate Coated Natural Fabric *Sterculia urens*

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Abstract

The newly identified natural fabric from the tree of *Sterculia urens* was coated with Polymethyl methacrylate. The tensile properties of both the uncoated and Polymethyl methacrylate coated fabrics were studied. The tensile parameters such as maximum stress, Young's modulus and % elongation at break were determined using a Universal Testing Machine. The effect of alkali treatment and the Polymethyl methacrylate coating on tensile properties of the fabric was studied. The morphology of the fabric before and after alkali treatment and Polymethyl methacrylate coating was studied using the scanning electron microscopy and polarized optical microscopic techniques respectively. The improvement in the tensile properties on Polymethyl methacrylate coating was attributed to the filling up of the void regions of the uniaxial fabrics with Polymethyl methacrylate facilitating continuity.

Keywords: Fabric technology, Polymer, Electron microscopy, Coatings, Mechanical Properties.

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1. Introduction

In recent years, the usage of lignocellulosic or plant fibers as replacement for synthetic fibers such as carbon, aramid, and glass fibers in composite materials has gained interest among researchers throughout the world. Extensive studies done on lignocellulosic fibers such as sisal [1], jute [2], pineapple [3], banana [4], and oil palm empty fruit bunch fiber (EFB) [5] show that lignocellulosic fibers have the potential to be effective reinforcements in thermoplastics and thermosetting materials. The lignocellulosic fibers are abundant in nature and are also renewable raw materials. They also provide a high strength-to-weight ratio in plastic materials. The usages of lignocellulosic fibers also provide a healthier working condition than the glass fibers. This is due to the fact that, the glass fiber dust from the trimming and mounting of glass fiber components causes skin irritation and respiratory diseases among workers. Recent studies on the properties of Polycarbonate, polystyrene, epoxy coated *Hildegardia populifolia* fabrics [7] suggest that they are favorable for making the green composites. For toughening of epoxy resin the thermoplastics such as Polycarbonate and polymethyl methacrylate were used and these blends are found to possess better properties [8-9].

In the present work, the newly identified *Sterculia urens* fabric was coated with Polymethyl methacrylate (PMMA). The tensile strength, modulus and % elongation at break of the uncoated and polymer coated fabrics were determined. The effect of alkali treatment and coupling agent on the tensile properties of the fabric was also studied, to ascertain whether the PMMA and *Sterculia urens* fabric system could effectively be used for making green composites. The morphology of the untreated and alkali treated fabrics was studied using Scanning Electron Microscopy and that of coated fabric by Polarized Optical Microscopic techniques.

2. Experimental

2.1. Extraction of the fabric from the tree

Samples of the fabric were extracted from the branches of the tree *Sterculia urens*. They were kept in agitated water to remove the dirt and other foreign materials. They were then thoroughly washed and dried in the sun for a week

Table1. Maximum stress, Young's modulus and % elongation at break of untreated and alkali treated *Sterculia urens* natural fabric coated with Polymethyl methacrylate in the absence and presence of coupling agent.

Sterculia urens Fabric	Maximum Stress		Young's Modulus		Elongation at break	
	(MPa)		(MPa)			
	WOCA	WCA	WOCA	WCA	WOCA	WCA
Untreated	10.0	----	640.7	----	2.0	----
(S.D.)	(0.6)		(32.4)		(0.2)	
Alkali treated	18.9	----	2018.7	----	2.5	----
(S.D.)	(1.2)		(98.6)		(0.4)	
Untreated and Polymethyl methacrylate coated	12.1	17.2	1803.9	2721.3	1.7	2.1
(S.D.)	(0.8)	(1.1)	(90.6)	(110.3)	(0.2)	(0.2)
Alkali treated and Polymethyl methacrylate coated	23.0	27.1	2301.6	3671.1	2.6	2.8
(S.D.)	(1.3)	(1.4)	(111.5)	(120.6)	(0.4)	(0.3)

WOCA: Without Coupling Agent; WCA: With Coupling Agent; (S.D.): Standard Deviation

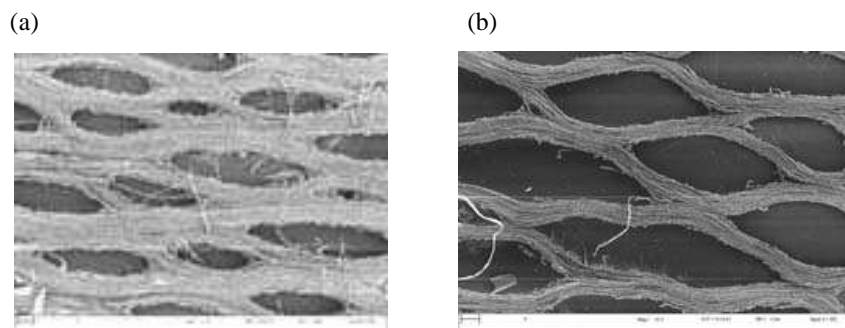


Fig.1. Scanning Electron Micrograms of *Sterculia urens* fabrics (a) untreated (88 X) and (b) alkali treated (88 X) with 5% NaOH for half an hour.

2.2 Sample Preparation

Some fabric samples were treated with 5% aq NaOH solution at room temperature for half an hour to remove the hemicellulose and any other greasy materials. Some fabrics were sprayed with silane coupling agent - 1% triethoxymethylsilane in acetone and dried. The fabrics were then coated with 10% PMMA solution prepared with dichloromethane as the solvent using a thin layer chromatographic spreader. The average thickness of the coating was found to be 0.15mm. The coating on the fabric was allowed to dry at room temperature. The above procedure was followed for both untreated and alkali-treated fabrics.

2.3. Microscopic Analysis

The scanning electron micrograms of the untreated and the alkali-treated fabrics were recorded on a JOEL JSM 820 microscope (Akishima, Japan). The samples were coated with gold before their micrograms were recorded. The optical micrograms of the polymer coated fabrics were recorded using a Leica DMLP polarized optical microscope.

2.4. Tensile properties

The tensile properties such as maximum stress, Young's modulus, and % elongation at break were determined using an INSTRON 3369 Universal Testing Machine (Norwood, Massachusetts, U.S.A) at a

crosshead speed of 3mm/min maintaining a gauge length of 50mm. In each case, ten samples were used and the average values are reported.

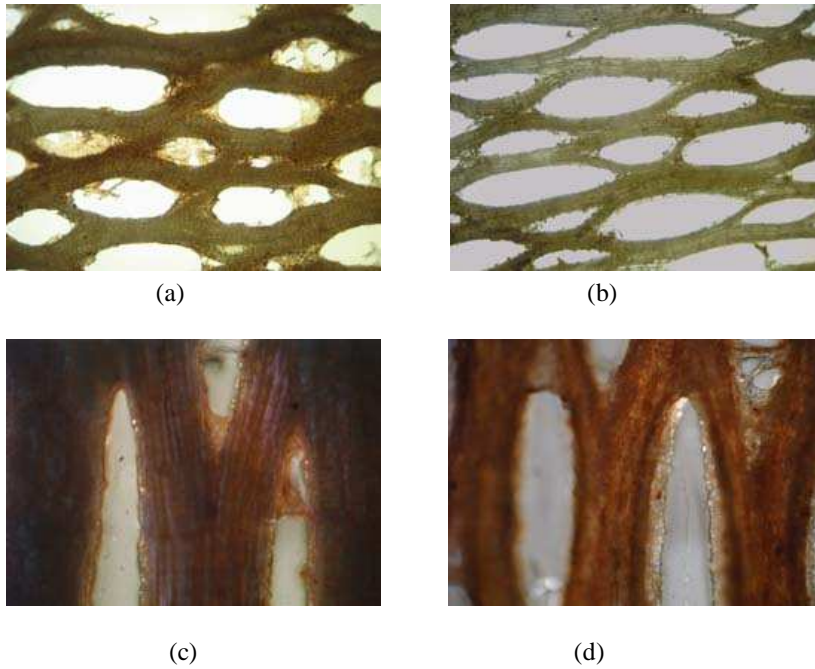


Fig.2. Optical Micrograms of *Sterculia urens* natural fabric (a) untreated and uncoated (b) alkali treated (with 5% NaOH for half an hour) and uncoated; (c) Untreated and PMMA coated; (d) Alkali treated (with 5% NaOH for half an hour) and PMMA coated.

3. Results and discussion

The ultimate maximum stress, modulus, and elongation at break of the uncoated and the PMMA coated fabric with and without coupling agent are presented in Table 1. The corresponding values for untreated and alkali treated fabrics are also presented (Table1).

It is evident from the data that the maximum stress of the uncoated fabric increased on alkali treatment from 10.0 MPa to 18.9 MPa. Similar observations were made by Dipa and Sarkar [10] in the case of jute fibres. They attributed this to the increase in crystallinity and removal of hemicellulose of the fabric on alkali treatment.

In order to investigate this further, the SEMs of both the untreated (88 X) and alkali treated (88 X) *Sterculia urecs* fabrics are presented in figure 1. From this figure, it is evident that the thickness of the fibers in the fabric decreased with alkali treatment. Thus the removal of amorphous hemicellulose, increase in crystallinity and thinning of the fibers on alkali treatment may be responsible for improved tensile properties. The modulus of the fabric also increased from 640.7 MPa to 2018.67 MPa on alkali treatment. In the case of PMMA coated fabric, the maximum stress and modulus also increased over that of the uncoated samples both in the absence and presence of the coupling agent.

The polarized optical microgram (POM) of both untreated and alkali treated fabrics are presented in figure 2. In the same figure, the micrograms of the PMMA coated fabrics with coupling agent are also presented. From these micrograms, it is evident that the light intensity of the POM of the fabric increased with alkali treatment, indicating an increase in birefringence leading to higher crystallinity. Further, the fibers in the fabric have become thin after alkali treatment. From figure 2 (c and d), it is also evident that the void regions of the fabric are covered by the polymer coating thus creating continuity in it.

In the case of untreated and Polymethyl methacrylate coated fabric, the maximum stress has increased from 12.07 MPa to 17.2 MPa in the presence of a silane coupling agent. Further, In the case of alkali treated and PMMA coated fabric, the tensile values are found to be further increased. This increment is found to be more when the coupling agent was used. From table 1, it is also evident that the elongation at break as also increased with alkali treatment, polymer coating and a coupling agent. These observations suggest that PMMA matrix and *sterculia urens* reinforcement are suitable components for making the green composites.

4. Conclusions

Alkali treatment, PMMA coating and silane coupling agent increased the tensile properties of the *Sterculia urens* natural fabric. The elimination of amorphous hemicellulose by alkali-treatment and filling up of the void regions of the fabric by polymer may be responsible for this behavior. The optical micrographs confirmed the formation of the polymer film on the surface of the coated fabric and also filling up its void regions. The presence of silane coupling agent further enhanced the tensile properties. The improved bonding between the fabric and PMMA by the coupling agent may be the reason for this improvement.

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