

Vinyl-ester-participated Transesterification and Curing on the Physicochemical Behavior of Coir-IV.

R. K. SAMAL, S. K. ROUT, B. B. PANDA, B. K. SENAPATI

Macromolecular Research Laboratory, Department of Chemistry, Ravenshaw College, Cuttack-753003 Orissa, India

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ABSTRACT: In this article, we report the transesterification of coir with *n*-Butyl acrylate (BA) and methyl acrylate (MA) under appropriate reaction conditions using NaOH and/or pyridine (Py) as catalyst. The modified vinyllog coir was subsequently cured with benzoylperoxide (BPO) in acetone at 50–60°C. The modified fibers were characterized by Fourier transform infrared (FTIR) spectroscopy. Transesterification and curing of transesterified coir lowered the percentage of moisture regain and imparted improved tensile strength and resistance to common chemical reagents. © 1997 John Wiley & Sons, Inc. *J Appl Polym Sci* **64**: 2283–2291, 1997

Key words: coir; chemical behavior; FTIR; moisture regain; transesterification; tensile strength

INTRODUCTION

The use of abundant cheap agrowaste/lignocellulosics to develop polymeric materials of the present need has been a turning point in the field of polymer research. This is aimed at part replacement of polymers/resins based on aromatics of crude oil and coal origin as there is rapid depletion of the latter deposits. In this regard, some agrowaste/cheap lignocellulosic fibers are being modified chemically for use as good reinforcing materials that could partially replace the pollution-causing conventional fibers like glass, boron, borosilicates, etc., in the fabrication of simple and hybrid fiber-reinforced composites (FP) of commercial importance. Research in this arena of polymer science and technology is, however, in its infancy, and few reports on jute^{1–18} and Coir^{19–27} are available. Much skillful experimental tech-

nique and effort are needed to achieve a full commercial benefit in this area of composite research. In our laboratory, we are now employing simple techniques using cheap chemical reagents to modify coir for use as good reinforcement in developing lightweight, low cost composites. This communication is an aspect of our investigation in this emerging field of polymer research.

EXPERIMENTAL

Materials and Methods

Coir fibers were purified by soxhlation with 1 : 1 benzene-ethanol mixture for 72 hours, followed by washing with acetone and ethanol and air-drying. Butylacrylate and methylacrylate were purified as reported earlier.²⁸ Other chemicals like sodium hydroxide, acetic acid, acetone, ethanol, sulphuric acid, hydrochloric acid, sodium chloride, benzoylperoxide, etc., were of analytical grade (BDH chemicals) and were used after purification by standard methods.

Correspondence to: R. K. Samal.

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Methods of Chemical Modification

Alkali Treatment of Coir

The purified coir was treated with alkali (NaOH, w/v) solution of varying concentrations (2–10%) for 1 h at 35°C with occasional shaking followed by washing with dilute acetic acid and distilled water for a week to leach out the absorbed alkali. The materials were then air-dried.

Transesterification of Parent and Alkali-treated Coir with Butylacrylate

Transesterification of 4% NaOH alkali-treated coir (1 g) was done under reflux with butylacrylate (20 mL) at 50°C for various time intervals ($\frac{1}{2}$ –6 h). While transesterification of the parent coir (1 g) was done under reflux with butylacrylate (20 mL) at 50°C for various time intervals ($\frac{1}{2}$ –6 hours) using 0.4% NaOH (20 mL) solution as a catalyst. Gel-like material was observed during the reflux, which has been identified to be polyacrylic acid formed by thermal polymerization of acrylic acid resulting from the alkaline hydrolysis of butylacrylate. This viscous liquid was removed by washing the material several times with warm methanol. The transesterified fibers were then washed with acetic acid, followed by acetone, and with distilled water, then air-dried.

Direct transesterification of coir was also affected by refluxing the coir (1 gm) with butylacrylate (20 mL) in acetone (20 mL) using pyridine (4 mL) as catalyst at 50°C for $\frac{1}{2}$ –6 hours. The second set of transesterification was done without adding acetone, while keeping the rest of the conditions unchanged. The reacted fibers were washed perfectly with dilute acetic acid and acetone, followed by methanol and distilled water, then finally air-dried.

Transesterification of Parent Coir with Methylacrylate

Transesterification of parent coir (1 gm) was done under reflux with methylacrylate (20 mL) at 50°C for $\frac{1}{2}$ –6 hours using pyridine (4 mL) as a catalyst. The reacted coirs were washed successively with dilute acetic acid, acetone, and distilled water and dried.

Curing of Transesterified Coir with Benzoylperoxide

Curing of butyl acrylate and methylacrylate transesterified coir (0.4 gm) was done under re-

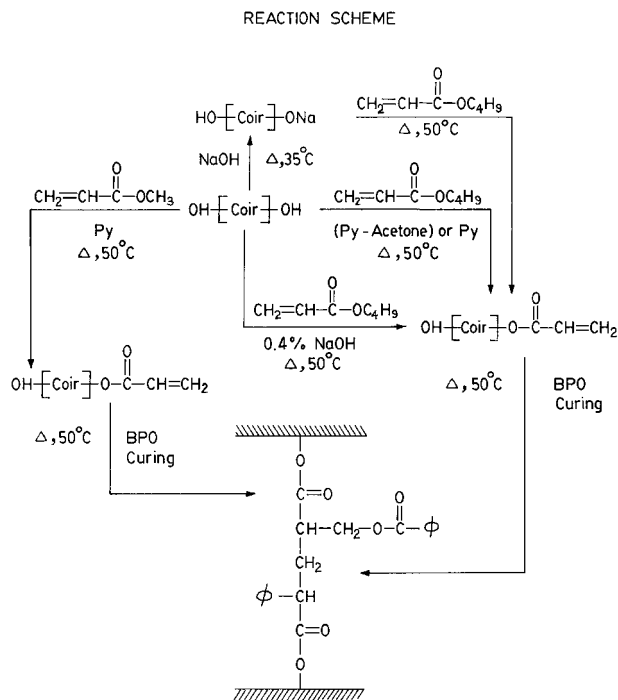


Figure 1 Schematic representation of various chemical modifications of coir fiber.

flux with 10 mL of 0.1M BPO in acetone (40 mL) at 50–60°C for 2 h, washed with fresh acetone and dilute acetic acid, followed by distilled water then air-dried. (See Figure 1 for a schematic representation of the chemical modification of coir fiber.)

TESTING AND CHARACTERIZATION

We observed no significant change in the appearance of the fibers after transesterification with BA/Py-Acetone, BA/4% NaOH, BA/Py, BA/0.4% NaOH, and MA/Py, and curing with BPO of these transesterified fibers; but they acquire a brownish yellow color upon alkali treatment.

FTIR Spectra

FTIR spectra of the samples were recorded in KBr pellets in a Bruker IFS 66V FTIR spectrophotometer. The FTIR spectra of parent, 2%-NaOH-treated, transesterified, and cured fibers were analyzed to ascertain as to whether such chemical reactions have truly taken place in the fiber. The FTIR spectra of parent, 2%-NaOH-treated, transesterified, and BPO-cured coir are shown in Figure 2. The exact position and probable assign-

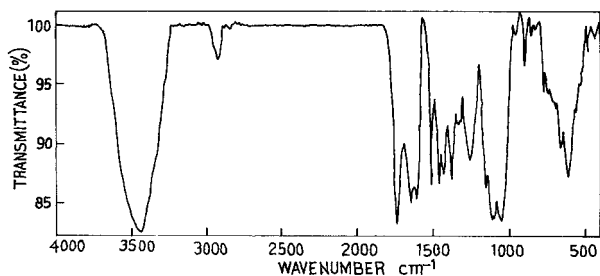


Fig.2(d) FTIR SPECTRA OF PARENT COIR .

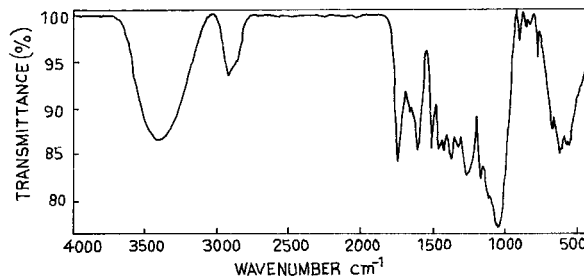


Fig.2(e) FTIR SPECTRA OF MA-COIR/Py .

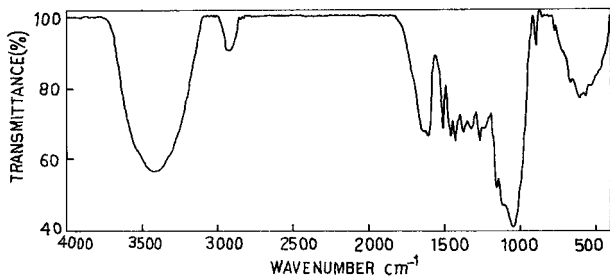


Fig.2(b) FTIR SPECTRA OF COIR-ONa .

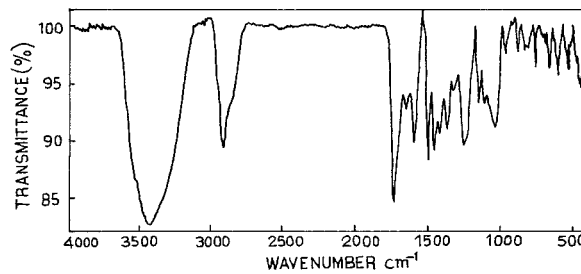


Fig.2(f) FTIR SPECTRA OF COIR-BA (Py-Acetone)-C-BPO .

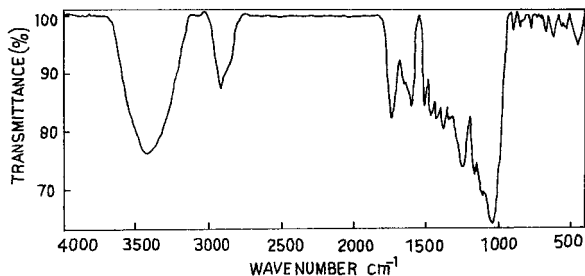


Fig.2(c) FTIR SPECTRA OF BA-COIR/Py-Acetone .

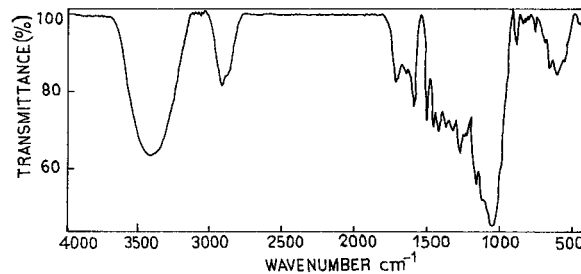


Fig.2(g) FTIR SPECTRA OF COIR-BA (4% NaOH)-C-BPO .

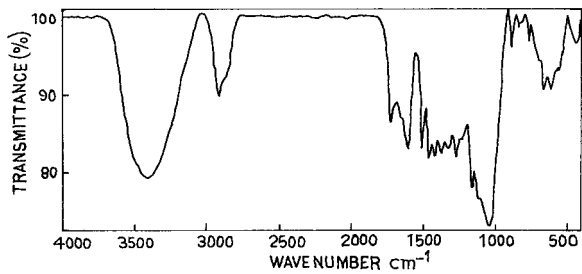


Fig.2(d) FTIR SPECTRA OF BA-COIR/4% NaOH

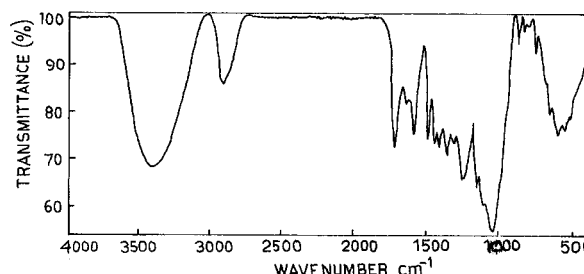


Fig.2(h) FTIR SPECTRA OF COIR-MA(Py)-C-BPO .

Figure 2 FTIR spectra of parent and chemically modified coir fiber: (a) parent Coir, (b) 2%-NaOH-treated coir (Coir-ONa), (c) BA-Coir/Py-acetone, (d) BA-Coir/4% NaOH, (e) MA-Coir/Py, (f) Coir-BA(Py-acetone)-C-BPO, (g) Coir-BA(4% NaOH)-C-BPO, and (h) Coir-MA(Py)-C-BPO.

ments of the bands are given in Table I. In comparison to parent coir, 2%-NaOH-treated coir (coir-ONa), and transesterified coir (i.e., BA-Coir/Py-Acetone, BA-coir/4% NaOH, and MA-coir/Py) and curing of transesterified coir (i.e., Coir-BA(Py-Acetone)-C-BPO, Coir-BA (4% NaOH)-C-BPO, and

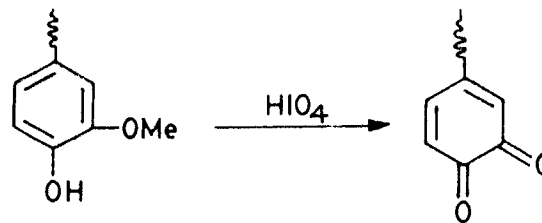
Coir-MA(Py)-C-BPO) showed a reduction on OH-stretching intensity and shifting of the peak position from 3446.2 to 3421.5, 3417.8, 3408.9, 3405.5, 3419.2, 3408.1, and 3409.5 cm^{-1} , respectively, indicating participation of some free hydroxyl group in these chemical reactions. The point of reaction

Table I FTIR Spectra of Parent and Chemically Modified COIR Fiber Absorbance (cm⁻¹)

Parent Coir	Coir ONa	BA-Coir/(Py-Acetone)	BA-Coir/4% NaoH	MA-Coir/Py	Coir-BA (Py-Acetone)-C-BPO	Coir-BA (4% NaoH)-C-BPO	Coir-MA(Py)-C-BPO	Possible Assignment
3446.2 (s, b) ^a	3421.5 (s, b)	3417.8 (s, b)	3408.9 (s, b)	3405.5 (s, b)	3419.2 (s, b)	3408.1 (s, b)	3409.5 (s, b)	O—H stretching vibration.
2928.5 (s)	2926.7 (s)	2921.4 (s)	2922.9 (s)	2921.2 (s)	2924.3 (s)	2923.6 (s)	2922.6 (s)	C—H stretching vibration of cellulose/hemi cellulose.
2849.8 (w)	—	—	—	—	—	—	—	O—H str. vibr. of inter- and intramolecular H-bonded in cellulose/hemi cellulose/lignin, making the entire structure as a network chelaie.
1739.2 (m)	—	1738.6 (s)	1735.0 (m)	1738.7 (s)	1740.5 (s)	1733.4 (m)	1738.1 (s)	C=O str. vibr. of 4-o-methylol glucuronoxylan of hemicellulose.
—	—	—	—	—	1664.2 (w)	1666.6 (w)	1666.8 (w)	C=C str. vibr. of phenyll necleusfrom BPO water absorption of crystalline region.
1642.1 (w)	1641.1 (w)	—	—	—	—	—	—	
1609.4 (w) } 1512.5 (s) } 1464.4 (m) }	1607.6 (w) } 1511.0 (m) } 1464.2 (w) }	1607.9 (m) } 1510.8 (s) } 1463.7 (m) }	1607.9 (m) 1511.0 (s) 1463.3 (m)	1607.4 (w) } 1510.9 (m) } 1466.6 (w) }	1607.9 (m) } 1512.3 (s) } 1464.7 (m) }	1607.0 (m) } 1510.7 (m) } 1463.4 (w) }	1607.6 (m) } 1511.4 (m) } 1463.6 (w) }	Aromatic C=C str. vibrn. of lignin.
1428.2 (w)	1425.3 (w)	1423.2 (w)	1425.1 (m)	1425.5 (w)	1426.5 (w)	1424.0 (w)	1425.2 (w)	CH ₂ bending vibration of glucopyranose residue.
—	—	-1420.0 (w)	—	—	—	—	—	O—H in plane (scissoring) bending.
1382.7 (m)	1375.5 (w)	1380.1 (m)	1382.0 (m)	1377.6 (w)	1381.8 (w)	1374.3 (w)	1377.5 (m)	C—H bending vibration of —CH=CH ₂ .
—	—	1316.7 (w) } 1302.0 (w) }	1316.7 (w)	1316.3 (w)	—	—	—	Aliphatic C—H bending vibration. Vibration of acrylate moiety.
1335.7 (w) } 1269.7 (m) }	1330.2 (w) } 1270.4 (w) }	1249.3 (m)	1272.1 (w)	1334.4 (w)	1333.7 (w) } 1265.6 (w) }	1323.1 (w) } 1270.9 (m) }	1322.1 (w) } 1267.4 (w) }	Interaction between O—H bending and C—O stretching.
1162.6 (w)	1162.7 (w)	1163.8 (m)	1163.7 (m)	1164.8 (w)	1165.6 (m)	1163.5 (w)	1164.4 (m)	Asymmetric C—O—C stretching due to Benzoate Ø—COO— vibration.
—	—	—	—	—	1133.0 (m)	—	—	
1107.0 (w)	1107.9 (w)	1116.6 (w)	1116.7 (w)	—	—	—	—	Asymmetric in phase ring stretching.
1059.5 (w)	1047.8 (m)	1047.4 (m)	1045.7 (m)	1042.5 (m)	1048.8 (m)	1042.0 (m)	1049.2 (m)	C—O/C—C stretching vibration.
960.7 (w)	—	—	—	—	987.4 (w) } 966.6 (w) }	—	—	Wagging (—CH ₂ —) _n stretching vibration.
895.6 (m)	895.9 (m)	895.7 (m)	895.1 (m)	896.1 (m)	893.6 (m)	895.1 (m)	895.5 (m)	β-glucosidic linkage.
826.8 (w)	833.8 (w)	—	—	816.8 (w)	—	—	816.6 (w)	Due to two adjacent aromatic C—H banding vibration in lignin components.

851.9 (w) } 770.6 (w) }	771.4 (w)	848.8 (w) } 771.3 (w) }	850.6 (w) } 770.4 (w) }	850.6 (w) } 770.8 (m) }	850.8 (w) } 771.1 (m) }	851.0 (w) } 770.9 (w) }	851.5 (w) } 770.9 (w) }	C—H out-of-plane vibr. of polyaromatic C—H stretching. Five adjacent aromatic C—H bending vibration. Out-of-plane vibration intermolecular H-Bonded O—H Group.
—	—	—	—	—	698.6 (w)	700.0 (w)	Not Distinguished	
667.2 (w)	667.0 (w)	670.9 (w)	666.9 (w)	662.1 (w)	669.9 (m)	663.3 (w)	667.7 (w)	Torsional vibration of pyranose ring.
617.4 (w) } 520.6 (w) } 480.0 (w) }	607.3 (w)	613.1 (m) } 540.4 (w) } 452.5 (m) } 447.3 (w, b) }	618.1 (w) } 566.7 (w) } 533.3 (w) }	612.7 (w) } 535.1 (w) }	610.5 (w) } 539.8 (w) } 524.6 (w) } 467.4 (w) } 452.2 (w) } 438.8 (w) }	617.3 (w, b) } 436.1 (w) }	608.1 (w) } 559.5 (w) }	

^a s = strong; w = weak; b = broad; m = medium.



Scheme I.

is probably phenolic-OH in lignin components and C₆—OH of the gluco-pyranose unit in cellulose component, but may not be C₂—OH and C₃—OH, as malapradian oxidation²⁹ with HIO₄ is found to be positive with modified coir. However, consumption of HIO₄ by coir cannot be taken as an authentic stand of the noninvolvement of C₂—C₃ glycolic linkage of the glucopyranose unit in cellulose component in the chemical modification since the HIO₄ is a well-patented oxidizer to cause facile oxidation of guaiacol (o-methoxyphenol) to O-quinones^{30–32}; such moiety is also present in the form of coniferyl alcohol units in the lignin components of coir (Scheme I). It is thus difficult at this stage to sketch any positive opinion about noninvolvement of C₂—OH and C₃—OH groups in the chemical reactions. A weak band at 2849.8 cm⁻¹ in the parent coir arising from O—H stretching vibration of inter- and intramolecular hydrogen OH-group in coir, and this almost disappears in all such chemical reactions, indicating its involvement in this reaction. The medium band at 1739.2

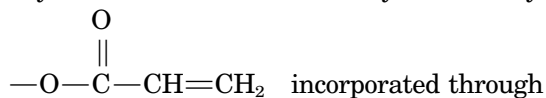
cm⁻¹ due to $\begin{matrix} \diagdown \\ \text{C=O} \\ \diagup \end{matrix}$ stretch in parent coir disappeared in coir-ONa; however, BA-coir/Py-Acetone, BA-Coir/4% NaOH, MA-coir/Py, Coir-BA(Py-Acetone)-C-BPO, coir-BA (4% NaOH)-C-BPO, and Coir-MA(Py)-C-BPO have only shifted $\begin{matrix} \diagdown \\ \text{C=O} \\ \diagup \end{matrix}$ stretch to 1738.6, 1735.0, 1738.7, 1740.5, 1733.4, and 1738.1 cm⁻¹, respectively, due to incorporation of pendant and interlinked ester groups (Fig. 1) during such chemical reaction.

The disappearance of $\begin{matrix} \diagdown \\ \text{C=O} \\ \diagup \end{matrix}$ band in alkali-treated fiber (coir-ONa) is probably due to transformation of the uronic acid residue in the hemi-cellulose components in coir to interlocked network that suffers reversion upon subsequent chemical treatment. A new band of weak intensity appears at 1664.2, 1666.6, and 1666.8 cm⁻¹ in FTIR spectra of Coir-BA(Py-Acetone)-C-BPO,

Table II Percentage of Moisture Regain (RH = 80%) of Parent and Chemically Modified Coir

COIR-ONa		BA-Coir/Py		BA-Coir/Py-Acetone		BA-Coir/0.4%NaOH	
% of NaOH	% of Moisture Regain	Time of Transesterification in Hours	% of Moisture Regain	Time of Transesterification in Hours	% of Moisture Regain	Time of Transesterification in Hours	% of Moisture Regain
0	16.87	0	16.87	0	16.87	0	16.87
2	16.92	$\frac{1}{2}$	13.42	$\frac{1}{2}$	16.33	$\frac{1}{2}$	17.65
4	17.70	1	13.12	1	15.66	1	16.92
6	18.52	2	12.93	2	14.16	2	16.25
8	19.25	3	12.88	3	11.86	3	15.98
10	20.13	4	12.82	4	10.97	4	15.82
		6	12.76	6	10.29	6	15.65

Coir-BA(4% NaOH)-C-BPO, and Coir-MA(Py)-C-BPO [Fig. 2(f)–(h)], respectively. It is due to C=C stretching vibration of the phenyl nucleus incorporated through curing of the transesterified coir with BPO. A weak band at 1642.1 cm^{-1} due to absorbed water in the parent coir disappeared upon transesterification and curing; however, in alkali-treated fiber, this band is shifted to a lower wavelength of 1641.1 cm^{-1} . Bands at different places of FTIR spectra of parent and chemically modified coir in the region of 1609 to 1270 cm^{-1} are almost similar and are due to aromatic C=C stretching vibration of the lignin component, CH_2 bending vibration of glucopyranose residue, O—H in plane bending, aliphatic C—H bending vibration, and interaction between O—H bending and C—O stretching, as indicated in Table I. A new band of weak intensity at $\sim 1420\text{ cm}^{-1}$ in the FTIR spectra of BA-coir/Py-Acetone [Fig. 2(c)] appear due to C—H bending vibration of $-\text{CH}=\text{CH}_2$ group and this ensures transesterification. Very weak new peaks at 1316.7 and 1302.0 cm^{-1} appear in the FTIR spectra of BA-Coir/Py-Acetone [Fig. 2(c)]; similarly, a new weak peak at 1316.7 cm^{-1} in BA-Coir/4% NaOH [Fig. 2(d)] and 1316.3 cm^{-1} in MA-Coir/Py [Fig. 2(e)] appear in the transesterified fiber and may be attributed due to acrylate moiety



incorporated through transesterification; this also supports transesterification onto coir. Other bands in the region of 1165 to 1042 cm^{-1} are almost similar for all the samples and are due to asymmetric C—O—C

stretching, asymmetric in phase ring stretching, and C—O/C=C stretching vibrations (Table I) that are effected to insignificant extent by chemical reactions.

The $-\text{CH}_2-$ wagging vibration at 960.7 cm^{-1} in parent fiber disappears through the reactions; however, very weak peaks appear at 987.4 and 966.6 cm^{-1} in the FTIR spectra of coir-BA(Py-Acetone)-C-BPO [Fig. 2(f)] and may be from the wagging vibration of the newly borned Benzyl ($\text{O}-\text{CH}_2-$) fragments arising from BPO curing. However, untraceable peaks in the BPO-cured methylacrylate-transesterified coir dictates a very low degree of transesterification with the latter monomer. The medium band at 895.6 cm^{-1} due to β -glucosidic linkage in the parent coir has undergone shifting to low extent in both directions in the wavelength axis in the modified fibers. This shift relates to the rotation of glucose residue around the glucosidic bond³³ and indicates transition from the parent fiber to chemically modified fiber. A new weak peak at 698.6 cm^{-1} [Fig. 2(f)] and 700 cm^{-1} [Fig. 2(g)] appear in the FTIR spectra of coir-BA(Py-acetone)-C-BPO and Coir-BA(4% NaOH)-C-BPO, respectively, and may be due to five adjacent H atoms of the aromatic nucleus, indicating introduction of a monosubstituted benzene onto coir arising from curing with BPO. The remaining bands at and beyond 667.2 cm^{-1} (Fig. 2) corroborate clearly with the findings of Blackwell et al.³⁴

PH Determination

The pH of all the samples in distilled water was measured by a pH meter standardized with buffer

BA-Coir/0.4%NaOH		MA-Coir/Py		Transesterified Coir Curing with Benzoylperoxide (BPO)		
Time of Transesterification in Hours	% of Moisture Regain	Time of Transesterification in Hours	% of Moisture Regain	Time of Curing in Hours	Curing of the Transesterified Coir	% of Moisture Regain
0	17.70	0	16.87	2	Coir-BA(Py)-C-BPO	11.59
1/2	16.25	1/2	15.66			
1	15.35	1	15.02	h	Coir-BA(Py-Acetone)-C-BPO	9.48
2	14.17	2	14.49	o		
3	13.19	3	13.88	u	Coir-BA(0.4%NaOH)-C-BPO	14.29
		4	13.16	r		
		6	11.63		Coir-BA(4%NaOH)-C-BPO	12.42
					Coir-MA(Py)-C-BPO	10.88

of pH 4 and 9. For this, the samples were immersed separately in distilled water using the sample to liquor ratio of 1 : 100. The pH value of all the samples except the alkali-treated fiber were ~ 6.5; for coir-ONa, it was ~ 7.5. The latter value entails low-degree involvement of the coir-hydroxyl group in the alkali treatment and may be the surface —OH group only.

Physicochemical Behavior

Percent of Moisture Regain (Extent of Hydrophobicity)

About 0.2 g of parent coir and each of the modified coir were placed separately in jarred bottles. The bottles were kept in an oven at 50–60°C until a constant weight was obtained. The oven dry samples were kept in an artificial humidity chamber (RH = 80%) for a week. The bottles were weighed at intervals until a constant weight were obtained.

% moisture regain

$$= \frac{\text{equilibrium wt of fiber} - \text{oven dry wt}}{\text{oven dry wt}} \times 100$$

The percentage of moisture regain of parent coir, alkali-treated coir, transesterified coir, and BPO-cured vinylog coir for various time intervals are shown in Table II. For BA-coir/Py, BA-coir/Py-acetone, and MA-coir/Py samples, the moisture regain is 12.76, 10.29, and 11.63%, respectively; but after curing, these fibers with BPO, the moisture regain decreases from 12.76 to 11.59,

10.29 to 9.48, and 11.63 to 10.88%. Similarly, for BA-coir/0.4% NaOH, BA-coir/4% NaOH, coir-BA(0.4% NaOH)-C-BPO, and coir-BA(4% NaOH)-C-BPO, the moisture regain is 15.65, 13.19, 14.29, and 12.42%, respectively; so all the samples show less percentage of moisture regain in comparison to parent coir, which has 16.87% moisture content. The extent of hydrophobicity follows this order: Coir-BA(Py-acetone)-C-BPO > BA-Coir/Py-acetone > Coir-MA(Py)-C-BPO > Coir-BA(Py)-C-BPO > MA-Coir/Py > Coir-BA(4% NaOH)-C-BPO > BA-Coir/Py > BA-Coir/4% NaOH > Coir-BA(0.4% NaOH)-C-BPO > BA-Coir/0.4% NaOH > coir. This order show

Table III Tensile Strength of Parent and Chemically Modified Coir

Sample	Tensile Strength (Kg/Cm ²)
Parent coir	130
Coir-ONa (2%)	161
Coir-ONa (8%)	155
Coir-ONa (10%)	152
BA-coir/Py	167
BA-coir/Py-acetone	178
BA-coir/0.4% NaOH	142
BA-coir/4% NaOH	160
MA-coir/Py	170
Coir-BA(Py)-C-BPO	169
Coir-BA(Py-acetone)-C-BPO	181
Coir-BA(0.4% NaOH)-C-BPO	148
Coir-BA(4% NaOH)-C-BPO	166
Coir-MA(Py)-C-BPO	174

Table IV Effect of Chemical Behavior of Parent and Chemically Modified Coir Towards Different Reagents

Sample	Percentage Solubility					
	H ₂ SO ₄	HCl	NaOH	NH ₄ OH	NaCl	H ₂ O ₂
Coir	9.97	10.07	11.73	9.47	4.57	14.22
Coir-ONa	14.02	13.97	9.52	2.34	8.20	11.25
BA-coir/Py-Acetone	6.02	4.76	5.02	5.47	3.83	10.67
BA-coir/4% NaOH	5.18	2.97	2.96	4.32	2.02	11.02
MA-coir/Py	4.82	6.32	4.93	5.07	3.28	9.65
Coir-BA (Py-Acetone)-C-BPO	5.98	4.27	7.42	2.5	3.88	11.09
Coir-BA (4% NaOH)-C-BPO	4.98	4.21	5.57	3.95	2.35	10.54
Coir-MA/(Py)-C-BPO	5.90	4.63	7.02	3.82	2.98	8.69

that, except for coir-BA(0.4% NaOH)-C-BPO and BA-coir/0.4% NaOH, the others are good samples for use as reinforcement.

Tensile Strength

The tensile strength of the parent and chemically modified fibers were determined using a KMI tensile tester. The speed of the testing machine is set at 12.7 mm. The load scale range was adjusted to be adequate for the estimated breaking load of the specimen under test. The jaws were set at effective gauge length of approximately 254 ± 1 mm. The specimen axis was placed on the grip with an imaginary line joining the points of attachment of the grips to the machine. Then the machine was set at zero. The deflection measuring device was set up, and the recorder was started. The ultimate breaking loads were recorded.³⁵ The results of the tensile strength (Kg/Cm²) are presented in Table III. The results of the tensile data show that treatment of coir with 2% NaOH under the condition mentioned earlier significantly increases its tensile strength but follows depletion with increase in concentration of alkali. This is similar to that reported by Kulkarni et al.³⁶ For other chemically modified samples, there is increase in tensile strength compared to the parent coir. The enhancement may be attributed to chain stiffening of the component polymer in coir as a net consequence of the increase hydrogen bonding between the OH and ester groups in the neighboring chain.

Chemical Behavior (Solubility)

The behavior of parent, transesterified, and cured coir towards H₂SO₄, HCl, NaOH, NaCl, NH₄OH,

and H₂O₂ was tested by determining the percent of solubility. For this purpose, the samples were immersed separately in aqueous solution (0.1M) of the reagents for 2 h at 60°C by using fiber to liquor into 1 : 100. The method adopted was similar to that of Leaveau et al.³⁷ The results of solubility are recorded in Table IV. The data on the Table IV indicate that among the transesterified samples, the BA-coir/4% NaOH has most resistance to chemical damage, except that for H₂O₂. Similarly, among the BPO-cured coir, coir-BA(4% NaOH)-C-BPO has most resistance to chemical damage, except that for H₂O₂ and NH₄OH. All the transesterified and BPO-cured samples are less affected by saline solution in comparison to other chemical reagents.

CONCLUSION

The results of these studies established that good hydrophobicity, improved mechanical strength, and resistance to common chemical reagents may be imparted to coir through a simple chemical route involving transesterification and/or curing with the use of cheap chemical reagents. The merit of the method may be adopted on a large scale for developing suitable reinforcing candidates for Fiber Reinforced Plastic (FRP) for low strength applications.

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