



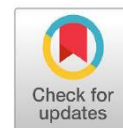
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Studies on Isora Fibers Mixed with 1% Ricinoleic Acid Reinforced with Polypropylene



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ABSTRACT

The aim of this study is to investigate the effectiveness of Isora fiber mixed with 1% ricinoleic acid as a reinforcement for polypropylene (PP) thermoplastic matrix. Isora fibers were subjected to mercerization prior to blending with PP in order to obtain good interfacial adhesion with the matrix. A PP/Isora composite has been prepared by melt blending of PP with 5%, 10%, 15%, 20% alkali treated Isora fiber in co-rotating twin screw extruder. The extruded strands are pelletized and then injection-moulded to obtain specimens. The optimum compositions of the PP/alkali treated Isora composites were mixed with 1% ricinoleic acid. Fiber-matrix adhesion will be analysed by mechanical and thermal properties of the composites which were evaluated.

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Graphical Abstract



Helicteres isora plant

Introduction

In recent years, composites made of natural fibers have received increasing attention in light of the growing environmental awareness [1]. Also, because of their low density, good mechanical performance, unlimited availability and problem free disposal, natural fibers offer a real alternative to the technical reinforcing fibers presently available [2-6]. Natural fiber can compete with glass fiber especially with respect to the specific strength and specific stiffness.

Composites were a need in the evolution of engineering materials because by a combination of materials it is possible to overcome, for instance, brittleness and poor processability of stiff and hard polymers [7-9]. The developments in composite material after meeting the challenges of aerospace sector have cascaded down for catering to domestic and industrial applications. Composites, the wonder material with lightweight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, wood *etc.* The material scientists all over the world focused their attention on natural composites reinforced with jute, sisal, coir, pineapple *etc.* primarily to cut down the cost of raw materials [10]. A composite material is defined as any substance which is made by physically combining two or more materials differing in composition or form to produce a multiphase material which possesses superior properties that are not obtainable with any of the constituent materials acting alone [11]. These constituents remain bonded together but retain their identity and properties. The constituent that is continuous and is often but not always, present in the greater quantity in the composite is termed the matrix. The second constituent is referred to as the reinforcement. It enhances or reinforces the mechanical properties of the matrix. In principle, any isotropic material can be reinforced; the reinforcing material is usually stiffer, stronger or tougher than the matrix and there has to be a good

adhesion between the components. At least one of the dimensions of the reinforcement is small, say less than $500/\mu\text{m}$ and sometimes only of the order of a micron. The geometry of the reinforced phase is one of the major parameters in determining the effectiveness of the reinforcement. In other words, the mechanical properties of composites are function of the shape and dimensions of the reinforcement [12-14]. Isora is a best fiber presented in the bark of *Helicteres isora* plant. The plant occurs as undergrowth especially as a secondary growth in forests. Seed sown during the rainy season easily propagates it. Roots stem and fruits of the plant are used for medicinal applications. The stem bark is exploited for the fiber. The best type of fiber is obtained when the plants are 1-1.5 years old; plants older than 2 years, yield coarse and brittle fiber. Stalks can be harvested annually for fiber extraction from regenerated shoots. It occurs as undergrowth, especially as a secondary growth in forests. It coppices well, shooting up rapidly when cut or burnt back. In some places, the plant forms dense, almost impenetrable thickets covering large areas practically to the exclusion of other growths [12-16]. Polypropylene is one of the most versatile thermoplastic polymers available commercially. Mixtures of propylene and other monomers form a wide range of important co-polymers [12].

Most commercial polypropylene is isotactic and has an intermediate level of crystallinity between that of low-density polyethylene (LDPE) and high-density polyethylene (HDPE). Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as ABS. Polypropylene is reasonably economical, and can be made translucent when uncoloured but is not as readily made transparent as polystyrene, acrylic, or certain other plastics. It is often opaque or coloured using pigments. Polypropylene has good resistance to fatigue. As polypropylene is resistant to fatigue, most plastic living hinges, such as those on flip-top bottles, are made from this material. However, it is important to ensure that chain molecules are oriented across the hinge to maximised strength.

Experimental

Fourier transform infrared spectroscopy

FTIR analysis gives the information of chemical structure through the electromagnetic spectrum using Agilent Cary 630 FTIR. The range of 400 to 4000 cm^{-1} is used to take the IR spectra.

Melt flow index

The rate of extrusion of the material can be determined by using a melt flow index apparatus. The material is loaded into the barrel and a constant load of 2.16 kg is used to pull out the molten material from the die.

The material is melted at a temperature of 230 °C. The extrudate is collected for every 10 minutes. The values are reported as g/10 mins.

Mechanical properties

Tensile and flexural properties were tested using INSTRON 3382 universal testing machine. The samples were cut into dumbbell shapes following ASTM D638 (type V) standard for tensile property a load of 250 KN was applied at constant crosshead speed of 50 mm/min at room temperature. The specimen was equipped as per ASTM D 790 for flexural property. The crosshead speed of 1 mm/min was used to carry out the test. Striking pendulum machine (Tinius Olsen, USA) was used to test the izod notch impact strength. The specimen was prepared as per ASTM D 256.

Results and discussion

Fourier transforms infrared spectroscopy

The Fourier transform infrared spectroscopy (FTIR) can give a quick and qualitative indication about change in chemical structure. The spectra of untreated and alkalization are shown in Figure 1, 2 from wave number 500 -4000 cm^{-1} .

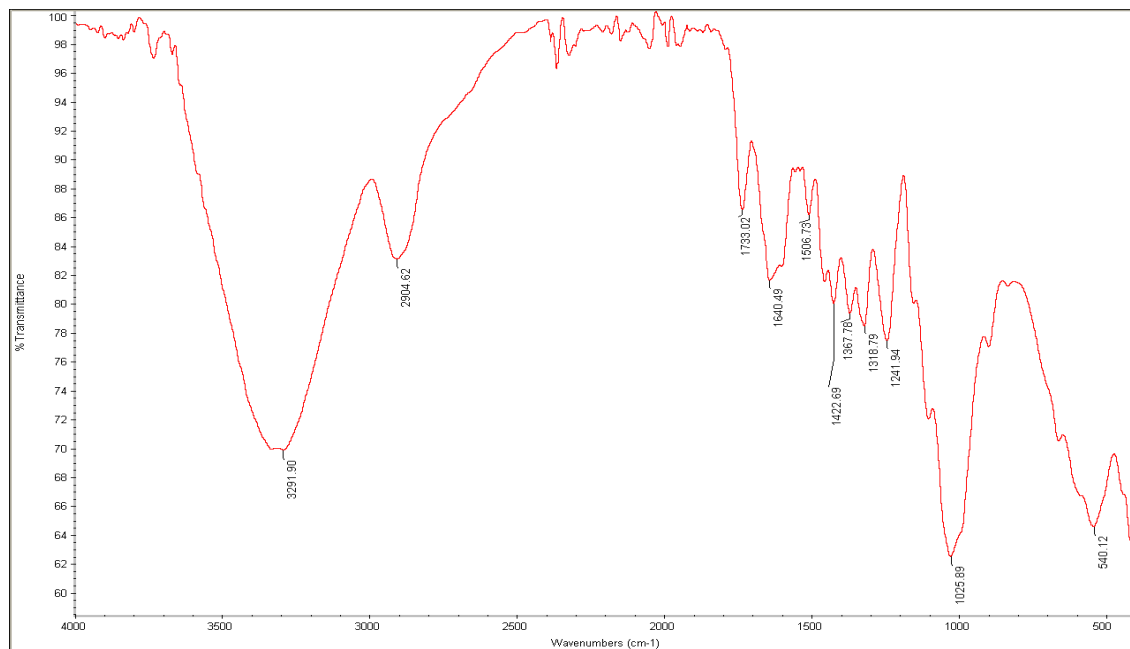


Figure 1. The FTIR spectra of untreated isora fiber

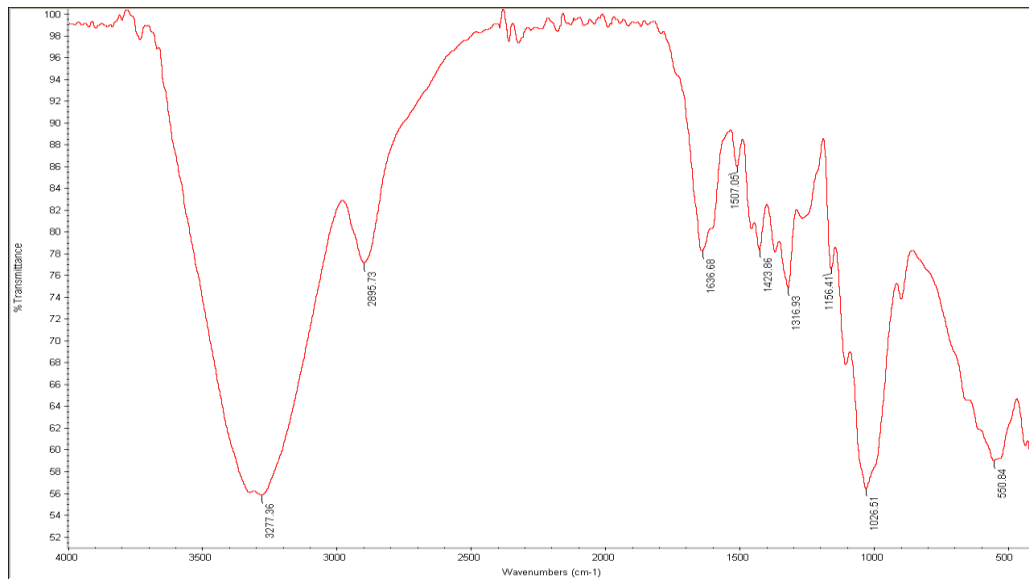


Figure 2. The FTIR spectra of alkali treatment of Isora fibre

Untreated fiber: the IR spectrum of raw Isora fiber shows an absorption peak at 1730 cm^{-1} which is the characteristic band for carbonyl stretching associated with the carbonyl groups present in lignin and other cellulosic components. The strong broad peak at $3300\text{--}3320\text{ cm}^{-1}$ is the characteristic hydrogen-bonded -OH stretching vibration. The peaks at 2910 cm^{-1} and 750 cm^{-1} corresponds to the C-H and C-O stretching vibrations respectively. A band at 1600 cm^{-1} is due to the C-C stretching of the aromatic ring in the lignin components, while a strong peak at 950 cm^{-1} arises from the glycosidic linkages. The bands at 1370 , 1330 , 1310 cm^{-1} are due to the -CH deformation, -OH in plane bending and -CH₂ wagging respectively. The band near 1250 cm^{-1} is due to the -C-O-C bond in the cellulose chain.

Alkali treated fiber: the important change expected as a result of alkali treatment is the removal of the hydrogen bonding in the network which is evident from the increased intensity of the -OH peaks at 3300 cm^{-1} . Also, on mercerization, the peak at 1730 cm^{-1} in the spectrum of the raw fiber is disappeared. This is due to the fact that a substantial amount of uranic acid, a constituent of hemi-Cellulose (xylan) is removed from the fiber, resulting in the disappearance of the peak. The dissolution of waxy materials from the fiber surface due to mercerization may cause increased mechanical interlocking between the fiber and matrix and may result in stronger composite.

Physical properties

The physical properties like density, water absorption and hardness for PP/isora composites mixed with 1% ricinoleic acid at different reinforcement loadings are depicted in Table 1.

The marginal increase in the density may be due to the alkali treatment, the fibre gets denser because of the removal of hemi celluloses and lignin of the fibre, which enables the cellulose micro fibrils to come closer and enhances density. The percentage of water absorption of PP matrix has marginally increased with increase in the Isora fibre content mixed with 1% ricinoleic acid. The surface hardness of PP matrix increased with increase in the fibre content upto 20%.

Table 1. Physical property of PP/Isora (alkali treatment) composites mixed with 1% ricinoleic acid

Composition (by wt%) PP	Composition (by wt%) Isora Fibre	Composition (by wt%) ricinoleic acid	Density (gm/cc)	Hardness (Shore-D)	Water Absorption (%)
100	0	1	0.89	73	0
95	5	1	0.92	77	0.04
90	10	1	0.93	78	0.05
85	15	1	0.94	79	0.06
80	20	1	0.94	80	0.06

Mechanical properties

Tensile strength (ASTM D 638, ISO 527)

The tensile strength and elongation test results of PP/Isora composites mixed with 1% ricinoleic acid (at constant level) at different filler loadings are given in Table 2. Tensile strength increased from 32.80 to 34.5 and elongation increases from 15.74% to 16.8% as the loading of fibre increases from 0.0 to 15%. The reduction in tensile strength, tensile elongation, modulus at 20%. This is because, as the filler loading increased, the interfacial area increased, worsening the interfacial bonding between filler and the matrix polymer, which decreased the tensile strength, the increase in tensile properties is due to the capability of fibers oriented along tensile deformation.

Table 2. Tensile properties of PP–Isora composites

Composition (by wt%) PP	Composition (by wt%) Isora fibre	Composition (by wt%) ricinoleic acid	Tensile strength	Tensile modulus	Elongation (%)
100	0	1	33.0	710.21	15.7
95	5	1	34.3	799.58	15.9
90	10	1	35.3	905.89	16.2
85	15	1	36.5	1000.94	17.8
80	20	1	33.3	988.61	14.4

Flexural properties (ASTM D 790, ISO 178)

The flexural strength test results of PP/Isora composites mixed with 1% ricinoleic acid (constant) at different filler loadings are given in Table 3. which show that the flexural strength increased from 39.92 to 45.6 MPa. The result of flexural strength shows that Isora fibers act as rigid filler responsible for increasing of the stiffness of the polymer matrix. Moreover, the extent of modulus improvement is also correlated to the fibre matrix interfacial adhesion. Whereas the decrease in flexural strength is due to more fibre to fibre interaction than the fibre matrix interaction.

Table 3. Flexural properties of PP/Isora composites

Composition PP	Composition Isora fibre	Composition (by wt%) ricinoleic acid	Flexural Strenghth (MPa)	Flextural modulas (MPa)
100	0	1	39.92	1120.35
95	5	1	44.25	1356.07
90	10	1	45.34	1558.65
85	15	1	46.60	1753.67
80	20	1	44.82	1687.89

Impact Properties (ASTM D256, ISO 180)

The impact strength test results of PP/Isora composites mixed with 1 % ricinoleic acid at different filler loadings are given in Table 4. As per the data, it was found that impact strength of PP/Isora composites mixed with 1% ricinoleic acid increased as the loading of Isora fibre increased upto 15%. When fiber is incorporated into matrix, the energy absorbing capability of fiber improves deformation and ductile mobility of polymer molecules which improve the ability of composites to absorb energy during crack propagation.

Table 4. Impact properties of PP-Isora composites mixed with 1% ricinoleic acid

Composition (by wt%) PP	Compositiion (by wt%) Isora fibre	Composition (by wt%) ricinoleic acid	Impact strength J/m
100	0	1	27.0
95	5	1	28.0
90	10	1	29.0
85	15	1	31.0
80	20	1	28.0

Conclusions

The conclusion reported the results of Isora fiber mixed with 1% Ricinoleic acid as reinforcement for polypropylene (PP) thermoplastic matrix. The tensile strength, Flextural strength and impact properties of PP/Isoro fiber at optimum properties 85/15 with 1% Ricinoleic acid were observed

in order to improve the mechanical properties which are very useful for automobile, electrical and various Engineering Application.

Conflict of Interest

We have no conflicts of interest to disclose.

References

- [1] George J., Pothan L.A., Thomas S. *Composite Interfaces*, 2002, **9**:335
- [2] Bhagavan S.S., Thomas S., Uma Devi L. *J. Appl. Polymer Sci.*, 1997, **64**:1739
- [3] Cao Y., Fukumoto I., Shibata S. *J. Polymer Composite. Part A*, 2006, **37**:423
- [4] Joseph K., Koshy P., Kalaprasad G., Prasannakumari L., Pavithran C., Thomas S., Varghese S. *Eur. Polymer J.*, 1996, **10**:243
- [5] Chhaya R., Gowda T.M., Naidu A.C.B. *Composite. Part A*, 1999, **30**:277
- [6] Herrera-Franco P.J., Gonzalez-chi P.I., Cazaurang-Martinez M.N., Aguilar-Vega M. *J. Appl. Polymer Sci.*, 1991, **43**:749
- [7] Fujii T., Okubo K., Yamamoto Y. *J. Polymer Composite. Part A*, 2004, **35**:377
- [8] Geethamma V.G., Lakshmi-Narayanan R., Mathew K.T., Thomas S. *J. Appl. Polymer Sci.*, 1998, **39**:1483
- [9] Joseph S., Koshy P., Oomzen Z., Sreekala M.S. Thomas S. *Composite Sci. Technol.*, 2002, **62**:1857
- [10] Boudenne A., Candau Y., Ibos L., Idicula M., Thomas S., Umadevi L. *Composite Sci. Technol.*, 2006, **66**:2719
- [11] Van de Weyenberg I., Truong T.C., Vangrimde B., Verpoest I., *Compos. Part A. Appl. Sci. Manuf.*, 2006, **37**:1368
- [12] Arabi H., Hashemi S.A., Mirzaeyan N. *Polymer Composite*, 2007, **28**:713
- [13] Nourbakhsh A., Ashori A. *J. Appl. Polymer Sci.*, 2009, **112**:1386
- [14] Mathew L., Joseph K.U., Joseph R., *Bull. Mater. Sci.*, 2006, **29**:91
- [15] Joseph K., Mathew L., Joseph R. *Composite interfaces*, 2006, **13**:391
- [16] Joshy M.K., Mathew L., Joseph R. *Composite interfaces*, 2006, **13**:377

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