"Characterization of Coir Pith/Jute Fiber/Bisgma Hybrid Composites"

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ABSTRACT -In the present work coir pith/jute fiber/ BisGMA (bisphenol-A glycidyldimethacrylate) hybrid composites are fabricated using simple hand layup technique. Here, BisGMA is the polymer matrix, jute fiber acts as the reinforcing fiber and coir pith acts as filler. Various composites have been prepared by incorporating 2-hydroxy ethylacrylate (HEA) treated jute fiber and alkali treated & untreated coir pith. In this work, detailed characterization of the fabricated composite panels has been carried out such as Fourier transform infrared (FTIR) spectroscopy and Scanning electron microscopy (SEM). This work quantitatively demonstrates that whole fabric treatment and filler addition can be used effectively to obtain low cost natural fiber composites that can be successfully used as a low cost structural material in housing, automobile and marine applications.

Keywords: Natural fiber, Filler, Composites, FTIR spectroscopy, Scanning electron microscopy

I. INTRODUCTION

Coir pith is one of the major agro wastes found in the southern coastal regions of India which is generated in the separation process of the fiber from the coconut husk and is generally dumped as an agro waste. Due to its low degradability, coir pith poses severe environmental pollution problems and occupies fertile useful land. Therefore developing engineering end use such as building materials and structural parts out of these materials has become a requirement. These agro-wastes are used as particle boards, thermal insulators, building material composites/bricks, cementitious/binder and aggregates etc.

All natural fillers are hydrophilic in nature which causes poor adhesion to hydrophobic matrix resulting in poor mechanical properties. To overcome this issue, alkali treatment of natural fillers, which is one of the most commonly adopted methods has been carried out in this work. Similarly, natural fibers like jute are also hydrophilic in nature with moisture content about 3-13% which leads to a very poor interface between jute fiber and the hydrophobic matrix resulting in poor moisture absorption resistance. Though alkali treatments have been mostly suggested to enhance natural fiber/matrix interactions, here HEA has been used as an exception. This work addresses the effectiveness of HEA treatment on jute fabric and alkali treatment on coir pith as a whole and their effect on the fabricated composites.

II. EXPERIMENTAL

- Raw Materials

BisGMA prepolymer was synthesised from methacrylic acid and DGEBA by using a reported method in our laboratory [1]. Jute fibers in the form of Hessian cloths were collected from Southern Jute Industries, India (207GSM). Coir pith was collected from Lida Export, Tamil Nadu. Dicumyl Peroxide (DCP), Cobalt naphthenate (J&K Scientific Ltd.) and N, N-dimethyl-aniline (DMA) (Industrial solvents & chemical Pvt. Ltd.) were used as catalyst, accelerator and promoter respectively. HEA (Ankush Enterprise), NaOH and solvents were used without any modifications.

- Methods

  - Synthesis of BisGMA

BisGMA was synthesized by the esterification of DGEBA with methacrylic acid (1:2) using hardener, butylated hydroxytoluene (0.03 wt %) (BHT) as stabilizer and triphenylphosphine (1 wt %) (TPP) as catalyst. The temperature was raised to 90-95^{0}C and the reaction took 6 hrs for completion.

  - Alkali treatment of coir pith and HEA treatment of jute fiber

Coir pith was soaked in 5% concentration of NaOH solution for 1 hour at room temperature followed by washing with distilled water. Afterwards, the samples

were oven dried at 70 ^{0}C for 2 hours. The bleached jute (Hessian cloths) was cut into square sizes (18 cm × 12 cm) and temporarily fixed in a long square size plate (50 cm × 50 cm). Then the samples were subjected to soak a solution of 10 % (w/w) HEA and 1.2% (w/w) DCP in methanol for 30 minutes. Finally they were dried at ambient temperature for 24 hours and then heated for 20 minutes at 60 °C.

- Fabrication of composites

A formulation of BisGMA (60 gram), treated coir pith (20%), 2% (w/w) DCP and 0.5% (w/w) DMA and 0.5 % (w/w) Cobalt naphthenate on the basis of HEA treated jute weight were prepared using simple Hand-layup technique. At the beginning of fabrication, gelcoat with 2% (w/w) DCP is uniformly brushed in to the finished side of male and female parts of the mould. After one hour when curing of gelcoat is completed, each layer of fiber is pre-impregnated with matrix material and placed one over another as sandwich making system. Then the mold was subjected to hot-press. The temperature was 110 °C for 1 hour and pressure was 5 tons. Details of the composite specification are given in Table I.

Sl. No.	Materials code	Materials abbreviation
1	Blank	BisGMA resin
2	BUJC	BisGMA/Untreated Jute Composite
3	BTJC	BisGMA/Treated Jute Composite
4	BTJUCPC	BisGMA/Treated Jute/ Untreated Coir Pith Composite
5	BTJTCPC	BisGMA/Treated Jute/Treated Coir Pith Composite

Table I: Materials code and its abbreviation

III. CHARACTERIZATION

➢ FTIR spectroscopy and Scanning electron microscopy

FTIR spectra were collected using Thermo-Nicolate Model 400 instrument equipped with a controlled temperature cell (Model HT-32 heated demountable cell used with an Omega 9000-A temperature controller). SEM was utilized to qualitatively examine the morphology of coir pith and the fabricated composites. The samples were gold coated and examined using a Philips 420T scanning transmission electron microscope with a secondary electron detector, operating at 60 KV in the SEM mode.

IV. RESULTS AND DISCUSSION

➢ Synthesis of BisGMA

The synthesis of BisGMA was confirmed from its FTIR spectroscopy as shown in Figure 1. The FTIR spectrum of BisGMA shows a wide band at 3443cm^{-1}, which is due to the presence of hydroxyl group. The peak at 2963cm^{-1} is due to the C–H stretching of the aromatic ring. The peaks at 2933 and 2872cm^{-1} are attributed to the asymmetrical and symmetrical C–H stretching of methylene and methyl groups. The ester carbonyl stretching is observed at 1727cm^{-1} where as the carbon carbon double bond (C=C) stretching is at 1627 cm^{-1}. The ring stretching vibrations of the aromatic nuclei are seen at 1606, 1580 and 1506cm^{-1} respectively. The symmetrical and asymmetrical bending vibrations of the methyl groups are seen at 1407 and 1463cm^{-1}. The peaks at 1295, 1247 and 1113cm^{-1} are due to the C–O stretching. The C–H out of plane bending vibrations are observed at 828, 811 and 560cm^{-1}. All the peaks supported the formation of BisGMA.

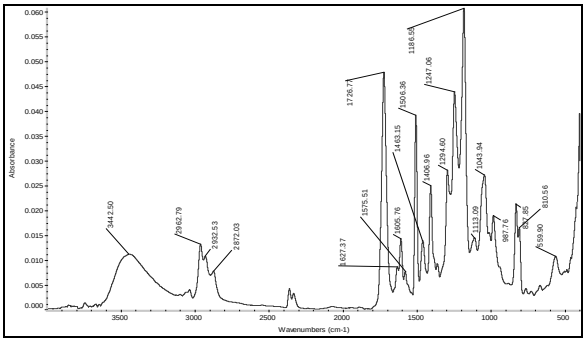


Figure 1: FTIR of BisGMA

➢ Alkali treatment of coir pith

In this work, alkali treatment of raw coir pith has been carried out to improve the surface qwality of coir pith thereby facilitating efficient adhesion with matrix. Figure 2(a) and 2(b) shows the SEM images of both untreated and alkali treated coir pith. The surface of untreated coir pith consists of pectin, lignin and other impurities. But alkali treatment results in the removal of impurities making the surface of coir pith rougher. The rough surface is also due to the breaking of hydrogen bonding in the network structure. This reduces the hydrophilicity and void content of coir pith and enhances mechanical bonding between matrix and filler. Thus NaOH treatment increases surface roughness, resulting in better mechanical interlocking and also promotes the activation of hydroxyl groups of cellulose unit, thereby increasing the number of possible reaction sites [2].

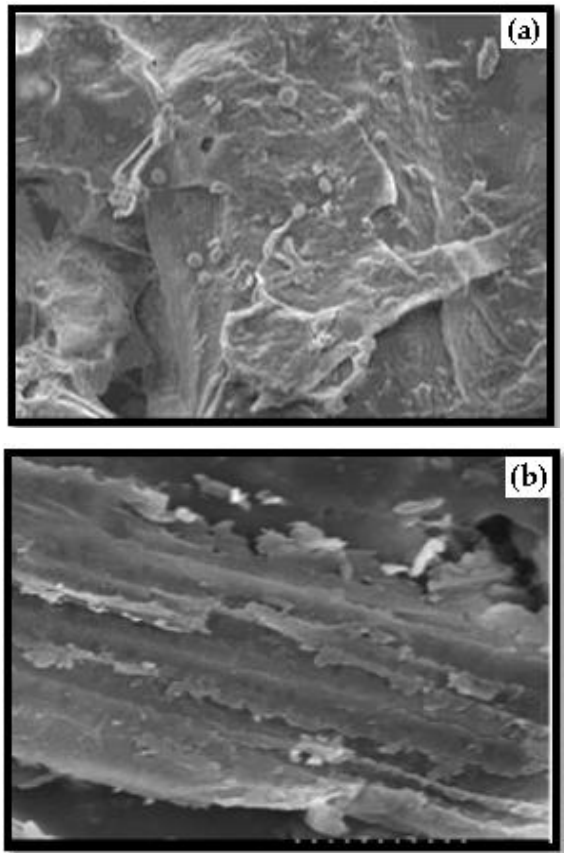


Figure 2: (a) SEM of untreated coir pith (b) SEM of alkali treated coir pith

- Surface treatment of jute fabric with HEA

The treatment of jute fiber with HEA improves the fiber surface drastically by making it rougher so that it can bond properly with the matrix. As shown in Figure 3, HEA treatment results in the development of carbonyl groups which is evident from a peak at 1737 cm^{-1} and a C-O_{str} band is observed at 1371 cm^{-1}. The O-H band which should be observed above 3000 cm^{-1} is shifted to lower frequency side i.e. at 2926 cm^{-1} and 2855 cm^{-1} due to the presence of hydrogen bonding between cellulose and HEA.

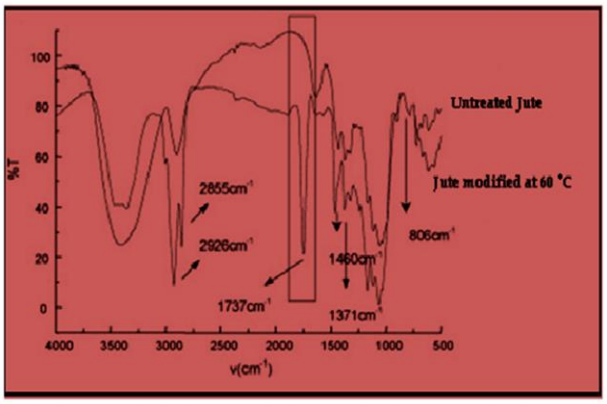


Figure 3: FTIR of treated and untreated jute

- SEM of fabricated composites

SEM images of BisGMA, BUJC, BTJC, BTJUCPC and BTJTCPC are shown in Figure 4(a), (b), (c), (d), (e) respectively. It is clear that HEA treatment improves the fiber surface adhesive characteristics by removing natural and artificial impurities and thereby producing a rough topography. The HEA treated composite thus shows better surface characteristics than the untreated composite. The BTJUCPC shows the presence of voids due to the untreated coir pith present in it. But in BTJTCPC, these voids are absent because alkali treatment of coir pith reduces the void content of coir pith by reducing its hydrophility. Alkali treatment of coir pith is also responsible for the physical binding of coir pith with jute fiber. In BTJTCPC, both the matrix and treated coir pith are responsible for filling up the voids. This makes the surface of BTJTCPC much smoother than BTJUCPC. Thus the treated coir pith acts as better filler then the untreated one. Moreover, due to the improved surface topography, the BTJTCPC also tend to exhibit better mechanical, corrosive and water absorption properties than BTJUCPC.

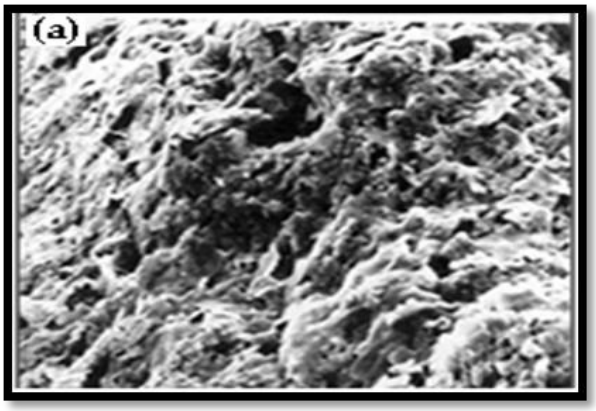
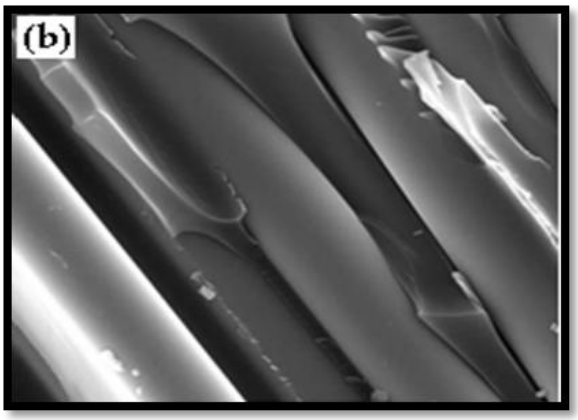
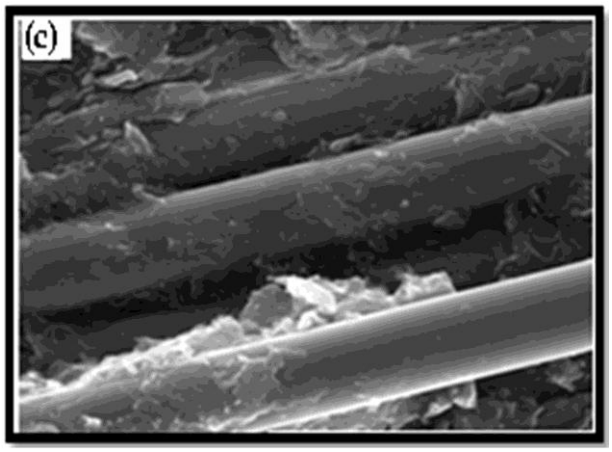


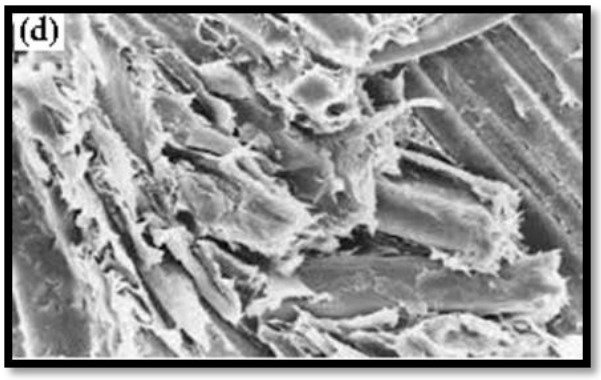
Figure 4: (a) SEM of BisGMA



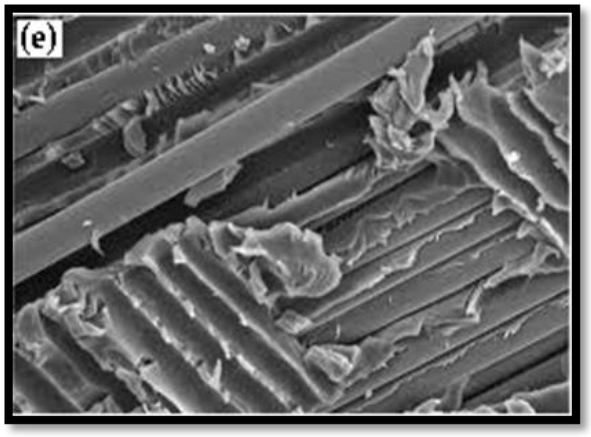
(b) SEM of BUJC



(c) SEM of BTJC



(d) SEM of BTJUCPC



(e) SEM of BTJTCP

V. CONCLUSION

In this work, we have investigated the effect of both treated and untreated jute fiber & coir pith on the surface characteristics of BisGMA composites. HEA treatment was carried out on whole fabric basis alongwith the alkali treatment of coir pith which led to improved surface quality of composites. The amount of BisGMA and filler content was kept constant whereas the untreated and treated coir pith was used with treated jute fiber. The BTJC shows better surface properties which gets improved with filler addition. FTIR study confirms the successful synthesis of BisGMA and HEA treatment of jute fiber. SEM study confirms the alkali treatment of coir pith and the fabrication of various composites. The BTJC is better than the BUJC due to HEA treatment. The BTJUCPC shows poor results compared to BTJTCPC which shows improved suface due to the alkali treated coir pith. Among all the composites, BTJTCPC is recommended for its use in structural purposes specifically for low cost housing projects and members in marine application in saline environment.

VI. REFERENCES

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