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Studies on the Mechanical and Degradation Properties of Composites Using Acacia Catechu, Jute and Polypropylene

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Abstract: Catechu is a natural and biodegradable polymer. It is made up of catechin, tannic acid etc. The composites by using Acacia catechu, jute and polypropylene were fabricated by compression molding process. Jute fabrics (hessian cloth) reinforced polypropylene (1:1) composites as well as the jute fabrics soaked with different types catechu reinforced polypropylene composites were fabricated by compression molding. The mechanical properties like tensile strength (TS), tensile modulus (TM), percentage of elongation at break (%Eb), impact strength (IS) and hardness of fabrics, polypropylene, and composites were measured. The TS, TM, %Eb, and IS of jute fabrics reinforced polypropylene composites were found 51.4MPa, 1416.75MPa, 14.29%, and 18Kj/m^2. After adding different types of catechu, the mechanical properties ware decreased with increasing soaking time. The degradation of different types of composites in soil medium was measured. Soaked with soft resin for 5 min jute fabrics reinforced polypropylene composites showed lowest mechanical properties and highest degradation. The TS, TM, %Eb, IS and hardness of jute fabrics (soaked with soft catechu resin for 5 min) reinforced polypropylene composites were found 32.26MPa, 380MPa, 17.14%, 28Kj/m^2 and 95 shores A. The TS of this composite decreased 53.57% after 6 weeks degradation. For the fiber and matrix adhesion analysis, the scanning electron microscopic images were taken.

Keywords: Jute, Polypropylene, Catechu, Composite, Mechanical Properties, Soil Degradation

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1. Introduction

Recently natural fiber based composites replace the inorganic fiber based polymer composites. Natural fibers are environmental friendly as well as low cost. The primary component of natural fiber is cellulose which is the polymer of β -D- glucose monomer unit joined together by β-1,4 glycoside bonds [1]. Major part of this cellulose is micro-crystalline with high order of crystalline region. Other compounds of jute are lignin, pectin, hemicelluloses, and water soluble materials etc. For this structural features, the high moisture absorption and poor wet ability of the natural fiber polymer results in insufficient adhesion between fiber and polymer matrices leading to deboning during use and aging [2, 3]. Various modification of natural fiber were done such as alkali treatment [4-8], silane treatment [9-13], combination of alkali and silane treatment [14], use of maleic anhydride copolymer [15]. All these modification improve the mechanical properties as well as the degradation time is also increase. As we know hydrophobic polypropylene is not biodegradable, but for environmental concern the composite should biodegradable after several years. To concern to this phenomenon in this research we tried to make a surface modified (by catechu) jute reinforced polypropylene composites which were biodegradable.

2. Experimental

2.1. Materials

The raw materials were jute fabrics (hessian cloth), polypropylene collected from local market near savar, Dhaka, Bangladesh. Catechu was collected from local market named Ananda Bazar, Dhaka, Bangladesh. Methanol, ethanol and benzene were collected from Nikkon Scientific and Chemical Shop, Dhaka, Bangladesh.

2.2. Extraction of Pure Catechu

Raw catechu was taken in a beaker and stirred with 60% ethanol+ 40% benzene mixture for an hour. Then the mixture was kept standing for 2 hours. This process was repeated for two times and then the brownish resin was found. This solid was kept under ethanol-benzene mixture for a whole night. After the evaporation of the solvent (ethanol and benzene), solid resin was found. Finally, the dried resin was washed with methanol to remove trace amount of ethanol and benzene.

2.3. Formulation

Percentage of hard resin and soft resin in catechu

Hard resin= 36.4% (approximately)

Soft resin= 60.97% (approximately)

Weight loss and impurities= 2.79% (approximately)

Impurities are varied for the different kinds of catechu in the market. In Bangladesh catechu processed domestically. That's why the impurities are available too much.

2.4. Preparation of Composite

Granules of polypropylene (PP) were made into thin sheets at temperature, pressure and time of 200°C, 3 tons and 5 minutes respectively inside two steel plates wrapping with silicon papers using heat press (Carver, INC, USA Model 3856). The formed sheets were kept in polyethylene bag until composite fabrication. The jute fabrics were cut into small pieces and Polypropylene sheets which were also cut into the same dimensions. The jute fabrics were soaked with raw catechu (1min), hard resin and soft resin (1min and 5 min). The composites were fabricated by sandwiching four pieces of jute fabrics (both soaked and not soaked) and five pieces of polypropylene at the same operating conditions and same machine. The prepared composites were rapidly cooled using the water bath and then cut into the desired size.

2.5. Mechanical Properties

2.5.1. Tensile Properties

TS, TM, and %Eb of jute, Polypropylene and composites were evaluated according to ASTM D638 having efficiency of 1% in a universal testing machine (model: H50KS, Hounsfield, UK) with a crosshead speed of 20 mm/min.

Composite samples were sliced into the machine having gauge length and applied a load of 20mm and 500N respectively. The results represent the average value of 5 samples at room temperature and around 60% of relative humidity.

2.5.2. Impact Strength

The IS of the samples was determined according to ASTM D-256 on a Hung Ta TMI zod Impact tester, model HT8041B IZOD.

2.6. Soil Degradation

Composite samples were buried in soil (having at least 25% moisture) for different periods of time in a depth of 12 cm from the surface of the earth. The sample composites were cut into desired size (60mm × 20 mm× 2mm) and then buried. After a certain period, samples were withdrawn carefully, washed with distilled water and dried at 105°C for 6 h and kept at room temperature for 24 h and then measured for their mechanical properties.

2.7. Scanning Electron Microscopy (SEM) Analysis

Surface morphologies of the carbon-coated fracture surfaces of the samples were analyzed on a scanning electron microscope (JEOL JSM-840 SEM) using secondary electron beams with an accelerating voltage of 15KV.

3. Results and Discussions

3.1. Comparative Study of Mechanical Properties

The TS of jute, polypropylene, the non-soaked composite, soaked composites with raw catechu (1min), hard and soft resin both for 1min and 5min were 24MPa, 18MPa, 51.4MPa, 35MPa, 50.83MPa, 33.6Mpa, 37.31MPa, and 32.26MPa respectively.

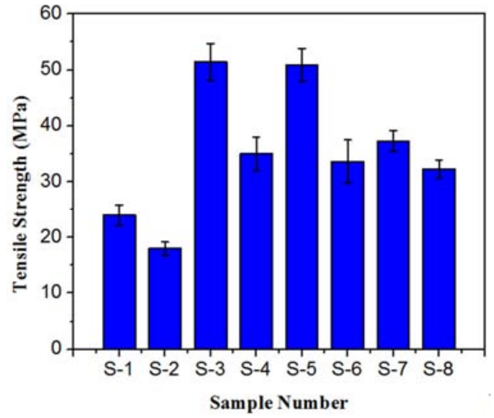
The TM of jute, polypropylene, the non-soaked composite, composites of soaked with raw catechu (1min), hard and soft resin both for 1 min and 5 min were 450MPa, 120MPa, 416.75MPa, 383MPa, 413.75MPa, 396Mpa, 326MPa and 380MPa respectively.

The %Eb of jute, polypropylene, the non-soaked composite, composites of soaked with raw catechu (1min), hard and soft resin both for 1 min and 5 min were 15.33 %, 7%, 14.29%, 11.655, 13.82%, 12.67%, 15.05% and 17.15% respectively. The change of tensile properties of the composites was, due to the effect of catechu and soaking time. Raw catechu contained hard resin, soft resin and some impurities. Hard resin made the composite much brittle than soft resin. High concentration of hard resin improved the tensile properties of the composites. On the other hand high concentration of soft resin decreased the tensile properties of the composites.

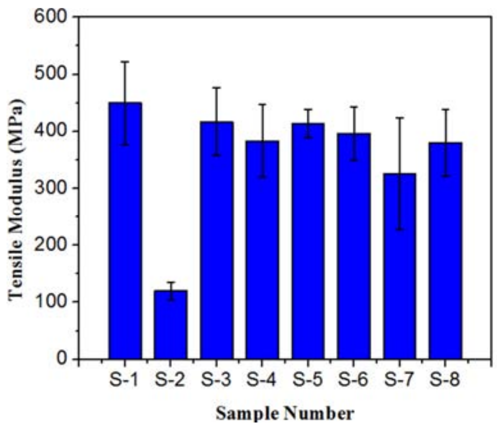
The IS of the composites of jute +PP, Jute +PP +Hard resin, and Jute +PP +Soft resin was found 18Kj/m^2, 28Kj/m^2, and 26Kj/m^2 respectively.

Table 1. *Different types of samples used to determine tensile properties.*

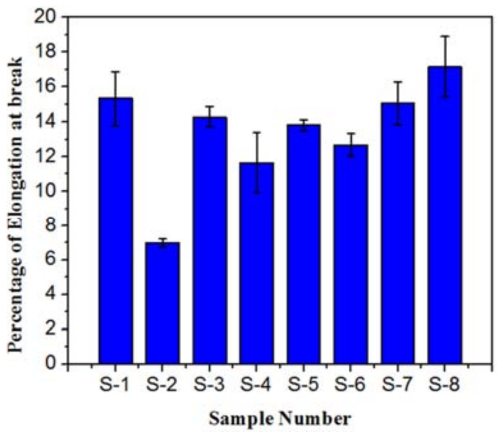
Sample no.	Composition
S-1	Jute
S-2	Polypropylene (PP)
S-3	Composite of Jute + PP
S-4	Composite of Jute + PP+ Raw catechu
S-5	Composite of Jute + PP +Soft resin (1min)
S-6	Composite of Jute + PP +Hard resin (1min)
S-7	Composite of Jute + PP +Soft resin (5min)
S-8	Composite of Jute + PP +Hard resin (5min)



(A)



(B)



(C)

Figure 1. *Tensile properties of the samples (A) Tensile Strength, (B) Tensile Modulus and (C) Percentage of Elongation at break of the different composites.*

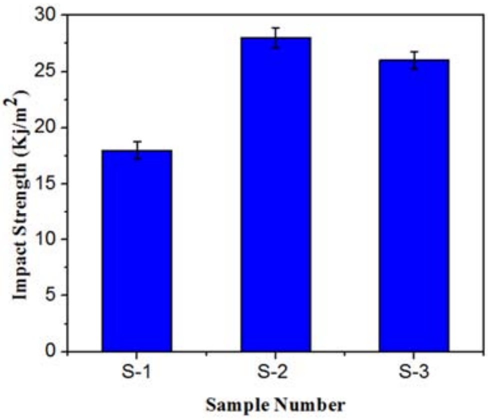


Figure 2. *Impact Strength of different composites.*

Table 2. *Different types of composites used to determine impact strength.*

Sample No.	Name
S-1	Composite of Jute + PP
S-2	Composite of Jute + PP +Hard resin
S-3	Composite of Jute + PP +Soft resin

3.2. The Effect of Soil Degradation

The degradation of the composites (both soaked and non-soaked) was performed in soil at ambient condition up to six weeks. The non-soaked composite showed the lowest TS loss during degradation and after 6 weeks this composite lost it 23.03% of its TS. On the other side the composite which was soaked with hard resin for 5 min showed highest TS loss during degradation and after 6 weeks the composite lost about 53.57% of its TS.

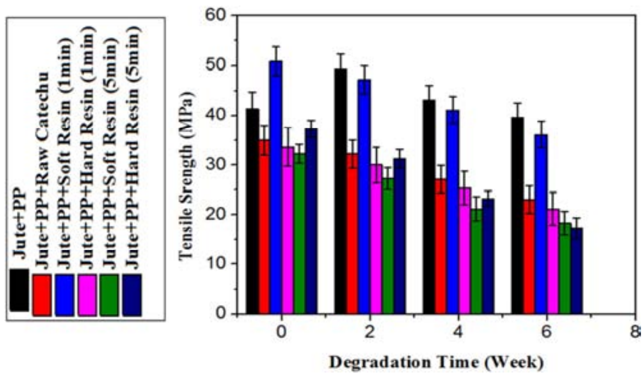


Figure 3. *Tensile Strength of different composites during degradation time.*

3.3. The Scanning Electron Microscopy (SEM) Analysis

To find out the fiber matrix adhesion inside composites, SEM studies were carried out. SEM images of jute fibers (figure 4A) which is the clean surface. From the SEM image (figure 4B) of the jute soaked with catechu showed no gap and they bonded strongly. The fracture side of the non-soaked fiber/polypropylene composite was presented in the figure 4C. This was clearly indicated that the jute fiber pull-out was quite higher and the bonding between the jute and PP was not so good. Small gaps were evident in the matrix near to the jute fibers. This phenomenon was applicable to the soaked jute/PP based composites (Figure 4D).

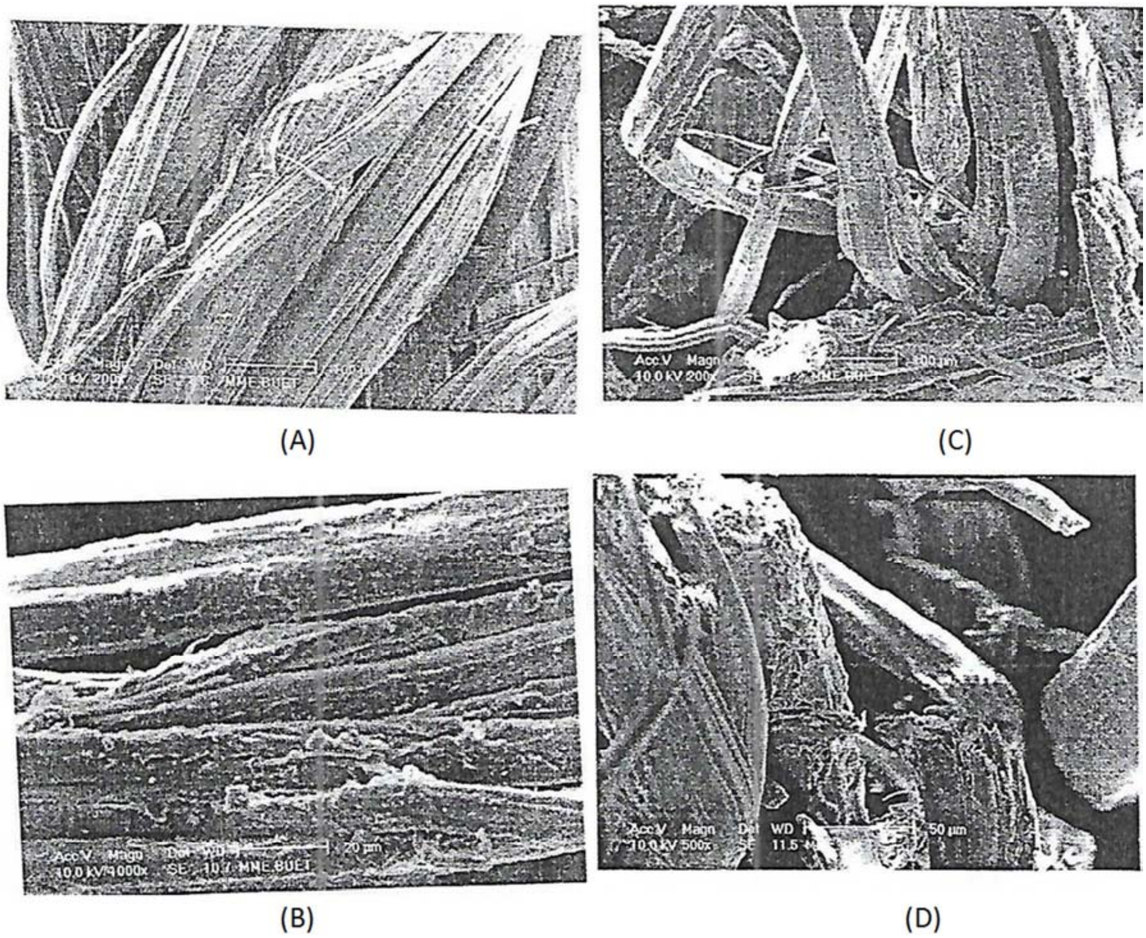


Figure 4. *SEM images of (A) Jute, (B) Jute +Catechu, (C) Jute +PP, and (D) Jute +PP +Catechu.*

4. Conclusion

The soaked fabrics with soft resin based PP composite showed highest tensile strength, impact strength and elongation at break. At the same time this composite showed moderate degradation rate while composite making by jute fabrics soaked with hard resin and polypropylene showed high degradation rate.

The SEM image of jute with catechu showed no gaps and they bonded strongly but the SEM images of jute fabrics reinforced PP composite showed that there were small gap between the fiber and PP and bonding between fiber and PP were not so good. Thus soaked fabrics with soft resin based PP composite is more environment friendly because this composite has moderate degradation rate, high mechanical properties and less impurities in the resin. But when require low degradation rate and high tensile strength, Jute based PP composite can use.

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