Research Article

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# Environmentally sustainability of short Areca-nut leaf sheath fiber reinforced polypropylene composites

**Abstract**

Polypropylene (PP) and short areca nut leaf sheath (ALS) fiber (2-3mm) composites were prepared by compression molding technique where as fiber used as reinforcing material. Hot compression molding and cold compression techniques were used. Different fiber content in the composites were used and optimized with the extent of tensile strength properties and simulating weathering test. Comparatively 10% areca nut leaf sheath fiber prepared composites showed best result.

**Keywords:** polypropylene, areca nut leaf sheath fiber, composites, simulating weathering test

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Pinku Poddar,[1] Shahin Sultana,[2] Md Ali Akbar,[3] Husna Parvin Nur,[2] Sarwaruddin Chowdhury AM[1]

[1]Department of Applied Chemistry and Chemical Engineering, University of Dhaka, Bangladesh

[2]Bangladesh Council of Scientific and Industrial Research, Bangladesh

[3]Department of Chemistry, Wright State University, USA

**Correspondence:** Sarwaruddin Chowdhury AM, Department of Applied Chemistry and Chemical Engineering, Faculty of Engineering and Technology, University of Dhaka, Dhaka-1000, Bangladesh, Email sarwar@du.ac.bd

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## Introduction

Using of natural fibers as a reinforcement of polymer-based composites is growing mainly because of its renewable origin.[1] Again all over the world, uses of natural fibers increases because its biodegradability, bioresorbility, availability, etc.[2] Among all of the natural fibers, areca nut fiber materializes as a promising reinforcing material because of its easy availability, nontoxicity, biodegradability, cheap cost and environment friendly manner. The areca nut fiber contains α–cellulose, hemicellulose, lignin, pectic matters.[3] The fiber mainly contains 66.08% of α–cellulose, 19.59% of lignin, and 7.40% of hemicellulose. Areca nut leaf sheath fiber is composed of small units of cellulose surrounded and cemented together by lignin and hemicelluloses.[1]

*Areca catechu* trees are available in the coastal area of our country which produces huge leaf-sheath. The unusable items of the tree can be used to produce composite materials.[4] Polypropylene offers a combination of outstanding chemical, physical, thermal, mechanical and electrical properties not found in any other thermoplastic materials.[5] Again it is an economical material. Comparing with low or high density polyethylene, it has a lower impact strength, but superior working temperature and tensile strength.[6] Chemical interactions between matrix and filler interface yield an interphase, or a region in the filler surroundings that may change the physical properties of the composite.[7,8]

Prepared composites would be particularly beneficial; both in terms of the biodegradability features[9–12] and also in socio-economic terms, if a significant amount of the fillers were obtained from a renewable agricultural source. Ideally, of course, an agro–/bio-based renewable polymer reinforced with agro-based fibers[13–16] would make the most environmental sense.

The aim of this work is to study the composite potentiality of agro-fiber towards diversified application within environmental legal framework. These areca nut / pp based composites may be used in the interior design, construction industries,[17] packaging, furniture, housing, decking, window, door frames,[18–21] and automobiles sectors.

## Materials and methods

### Materials

Polypropylene (PP) was purchased from Polyolefin Company, Private Ltd., Singapore. Areca nut leaf sheath fibers were prepared from areca nut leaf sheath. At first, areca nut leaf sheath soaked into water for 15 days. The water loosed the fiber from the resin and waxy materials and then the fibers peeled from the resinous materials, washed with clean water and air dried properly.

### Methods

Polypropylene granules were grinded to get small particle (50–60µm) with the help of grinder for proper and homogeneous adhesion between fibers and matrix. The areca nut leaf sheath fibers were chopped into small pieces (2–3mm) with the help of hand scissors and cleaned with mesh and all dirt's are removed from the chopped fiber. Then the chopped fibers were cleaned with distilled water and exposed thoroughly to sunlight for about 24 hours. The fibers were dried at 100°C in a vacuum oven for 5 hours prior to the preparation of the composites. According to Table 1 different ratio (in wt) pp powder and chopped fibers were mixed properly and poured into the mould (12cmx15cm). The processing temperature was maintained at 190°C for 5min under 5 bar consolidation pressure in the heat press (Carver, INC, USA Model 3856). The molds were then cooled for 1 min in a separate press under 5 bar pressure at room temperature.

### Tensile strength test

The tensile strength tests of the different composites ($S_1$–$S_5$) were determined using a UTM (universal testing machine, model H50 KS-0404, Hounsfield Series S, UK). The capacity of load was 5000N;

efficiency was within ±1%. The crosshead speed was 10 mm/min and the gauge length was 20mm. The Tensile strength properties were carried out according to DIN 53455 standards methods (Figure 1).

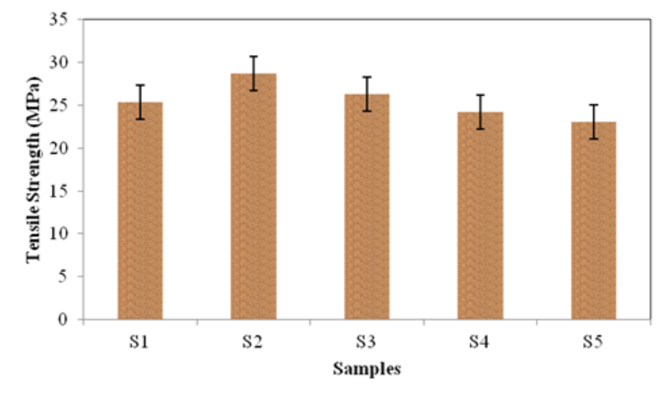


**Figure 1** Tensile strength (MPa) of different composites.

**Table 1** Shows the different samples of Polypropylene & fiber

| Samples | % of Polypropylene (wt) | % of Fiber (wt) |
|---|---|---|
| $S_1$ | 95 | 5 |
| $S_2$ | 90 | 10 |
| $S_3$ | 85 | 15 |
| $S_4$ | 80 | 20 |
| $S_5$ | 75 | 25 |

### Simulating weathering testing

Simulating weathering test of the composites was determined by Accelerated Weathering Tester (model Q-UV, the Q–Panel Company, USA). The temperature during the treatment varied between 65±2°C (sunlight) and 45±2°C (condensation) through alternating cycles of 4 h sunlight and 2 h condensation for a period of about 100 h. After weathering treatment, tensile strength of the composites was carried out.

## Results and discussion

### Tensile strength property

The composite samples were cut into desired size. Mechanical property such as tensile strength was measured. According to Table 2 and Figure 1, the highest tensile strength value observed for $S_2$ samples and the value is 28.7 MPa. For the samples of $S_3$, $S_4$, $S_5$ tensile strength values are gradually abated.[1]

### Simulated weathering testing of the composites

Tensile strength of the different formulations of composites was degraded with the passing of time using simulating weather testing machine and it was shown in Figure 2. But it was found that after 100 h, the degradation rate of $S_2$ formulation was lowest (8.71%) whereas it was 18.11%, 14.83%, 19.42% and 22.08% for $S_1$, $S_3$, $S_4$ and $S_5$ formulation respectively. So, $S_2$ formulated composite is more sustainable than other formulated composites due to highly adhesion between fibers and matrix.

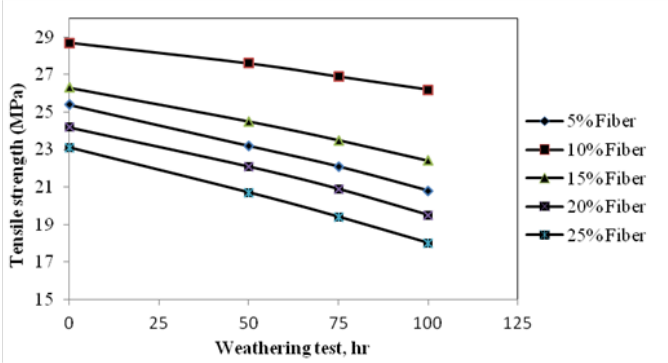


**Figure 2** Tensile Strength of the composites after weathering treatment in simulated weathering testing machine for different formulations against time (up to 100h).

**Table 2** Shows the samples of Tensile Strength

| Samples | Tensile strength (MPa) |
|---|---|
| $S_1$ | 25.4 |
| $S_2$ | 28.7 |
| $S_3$ | 26.3 |
| $S_4$ | 24.2 |
| $S_5$ | 23.1 |

## Conclusion

Polypropylene and areca nut leaf sheath short fibers reinforced composites were prepared by compression molding. Fibers content in the composites were optimized. $S_2$ formulated (10% fiber content) composite showed higher tensile strength. Simulated weathering testing supported the TS result that lower and higher than 10% of fiber content in the composites: degradation rate was comparatively higher due to poor fiber–matrix adhesion. Enduring capacity of optimized composite ($S_2$) was higher. Using this optimized composite finished product will be able to sustain long time in the environment.

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## Conflicts of interest

The author declares no conflicts.

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