DISCONTINUOUS LOW-COST CARBON FIBER - BAMBOO FIBER HYBRID INTERMEDIATES FOR LIGHTWEIGHTING VEHICLE APPLICATIONS

Project ID #: MAT171
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2020 DOE Vehicle Technologies Office Annual Merit Review

OVERVIEW

TIMELINE
- Start: 07/01/2019
- End: 6/30/2020
- 75% complete as of 03/31/2020;

Progress delayed due to COVID-19 lab closures

BARRIERS ADDRESSED
- High cost and energy use in processing carbon fiber
- Lack of predictive modeling
- Limited recycling

BUDGET
DOE: $198,697

PARTNERS
- IACMI-The Composites Institute
- The University of Tennessee
- Project lead: Resource Fiber LLC

RELEVANCE

IMPACT
- Reduce energy use in processing materials
- Expand use of lightweight composites by reducing costs and improving moldability
- Improve recyclability and use of sustainable materials

TECHNICAL OBJECTIVES

A. Create a hybrid bamboo/carbon fiber intermediate that is more affordable, more recyclable, and less energy intensive;
B. Improve the interface engineering of constituents within the hybrid bamboo-carbon fiber to realize lighter weight while still being strong, less brittle, and reformable mats; and
C. Pelletize hybrid bamboo/carbon fiber intermediates for injection, extrusion-compression molding and vacuum forming.

MILESTONES

Milestone	Location	Status
Prepare and test bamboo fibers	Resource Fiber/UT	Complete
Create simple blended charge forms, test, and analyze results	UT	Complete
Create compounded blended forms, test, and analyze results	UT	On hold (lab closed for Covid)

APPROACH

The team focused on next generation lightweight multi-scale hybrid intermediates from bamboo and low-cost carbon fiber to create value added intermediates. The team developed innovative multi-scale hybrid preform mats and processes for parts comprising discontinuous fiber forms of low-cost carbon fibers and bamboo fibers in thermoset and thermoplastic polymers.

MATERIALS

(1) Thermoplastic Polymer (MiniFiber) (2) Bamboo Fiber (Resource Fiber) (3) Carbon Fiber (ZolteK). Materials by weight %:

Material Nomenclature	Bamboo Fiber	Carbon Fiber	PP
Bamboo-PP	30%	-	70%
Bamboo-PP	50%	-	50%
20%Bamboo-80%CF-PP	20%	80%	60%
80% Bamboo-20%CF-PP	80%	20%	60%

PROCESSING METHODS

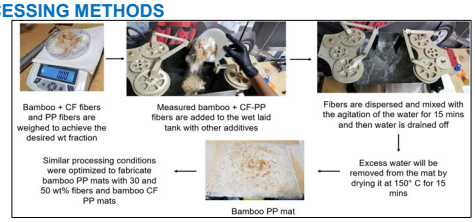


Figure 1. Schematic representation of Wet-laid process

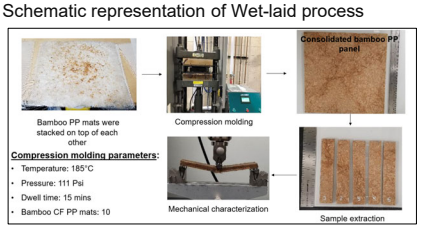


Figure 2. Schematic representation of bamboo-PP composite by compression molding process

POTENTIAL APPLICATIONS

Figure 3. Potential vehicle applications for bamboo/carbon fiber composite

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

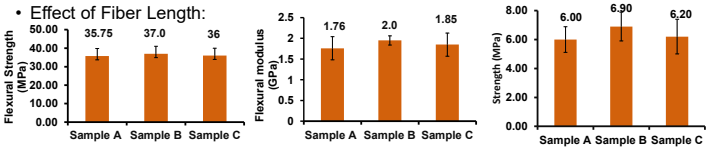
Characterization:

Three-point bend (ASTM D-790),Interlaminar shear strength (ASTM D2344) and impact properties (ASTM D-256) tests were performed using 50N test resources frame on bamboo-PP and CF-bamboo-PP composite panels.

Key Results and Key Findings :

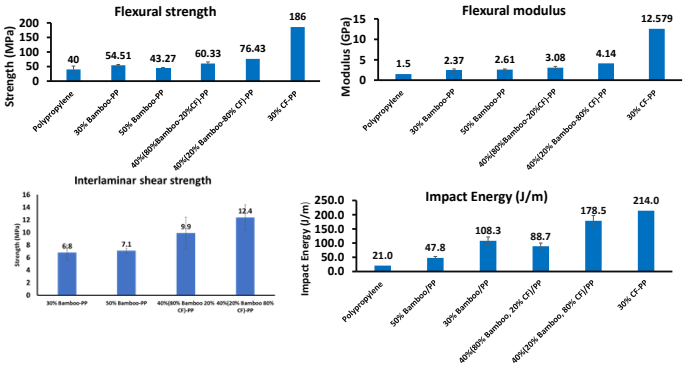
1. Bamboo-PP Composite

- Effect of Fiber Length:

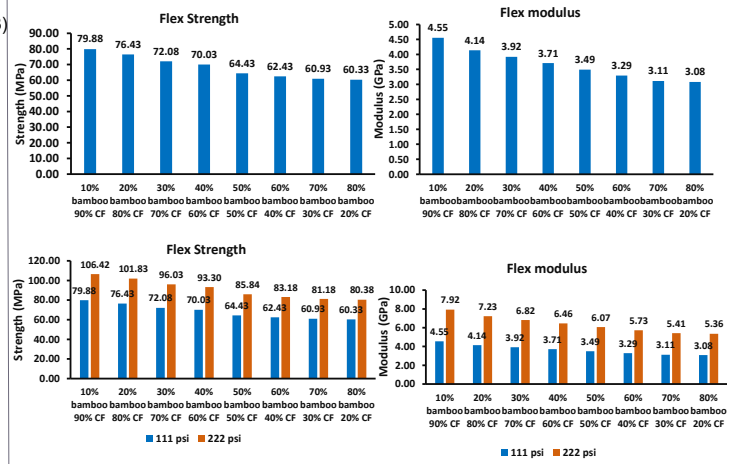


2. Bamboo-CF-PP Composite

- Mechanical Properties:



- Projected Mechanical Properties:



Observations and Future Plans

- From three fiber variants, type B was selected for further trials
  - High mechanical properties compared to type A and type C
  - Fiber length was 11mm similar to long fiber thermoplastic (LFT)
- In bamboo-PP composites, 40% fiber wt. fraction gives higher mechanical properties. Hence, for hybrid formulation 40 wt.% fiber were used
- In hybrid composite, 80% CF and 20% bamboo-PP composite gives higher flexural, interlaminar, impact strength and vibrational damping ratio compared to other formulations
- In future, 80% CF and 20% bamboo-PP composite for various applications
- Pursue Phase II funding and advance to commercialization

Any proposed future work is subject to change based on funding levels

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