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The Design of Vacuum Bag Resin Transfer Moulding (VBRTM) For Fabrication Bio-Based Natural Fiber Composites

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Introduction

The development of new bio-based composites for automotive becomes new trend in the automotive industries. There are 4 big reasons why it is important to develop : (1) there are uptake of environment friendly production and processing technologies; (2) encouraging the growth of sustainable agriculture; (3) fostering economic development; and (4) strengthening the participation smallholders in the value chain. Natural fibres such as bamboo and banana leaf interesting to be investigated mechanically, thermally and chemically. However, these natural fibres

are often filled by resins. Green-poxy as matrix becomes new trend on bio-based filler matrix. Most of all plant fibres are hydrophilic in nature with a moisture content of 81,3% due to the presence of cellulose in cell structure.

Objectives

1. Investigating the thermos-physical behaviour of natural fibre emphasized on banana leaf and bamboo for automotive applications.
2. Describing future works and the role thermal degradation on the kinetics studies

Materials

First, banana leaf and bamboo natural fibres have been selected (Figure 1) to reinforce Green-poxy as resin matrix. Natural fibres have been selected by emphasizing on the research novelty based on the amount of new papers, mechanical, chemical, and thermal properties.



Figure 1 : Raw Materials (a) Banana leaf (b) Bamboo

Second, the raw materials have been ordered from UK and France for Bamboo and banana leaves respectively. Mechanical, thermal and chemical properties of the selected natural fibers are recapitulated in Table 1, 2 and 3.

Table 1. Mechanical properties.

Natural fibre	Tensile strength (MPa)	Young Modulus (GPa)	Density (g/cm ³)	Elongation (%)
Banana leaf	529 – 914	20 – 24	0,74	4,37
Bamboo	500 – 575	27 – 40	1,2 – 1,5	1,9 – 3,2

Due to low density, high tensile strength, high tensile modulus, and low elongation at break of banana fibers and bamboo have very good potential use in the various sectors like construction, automotive, machinery, etc.

Table 2. Chemical components.

Natural fibre	cellulose (wt %)	Holocellulose (wt %)	Alpha-cellulose (wt %)	Hemi-cellulose (wt %)	Lignin (wt %)	Extractives (wt %)
Banana leaf	48,31	49,5	31,7	17,8	39,1	15,5
Bamboo	41	-	46,87	26,5	25,3	-

Table 3. Thermal properties.

Natural fibre	initial thermal degradation (° C)	maximum thermal degradation n (° C)	devolasatio n process complete (° C)	Tdecomp. (° C)	residue of char (%)	Thermal conductivity (w/m/k)	Thermal diffusivity (m ² /s) × 10 ⁻⁴
Banana leaf	170	300 - 350	570	170	25	0,11 ± 0,03	0,157
Bamboo	212	350,66	700	100	20 - 23	0,55 – 0,59	0,34

Methods

1. Fabrication

In this project, bio-based composites material will be manufactured by Vacuum Bag Resin Transfer Moulding (VBRTM). This process not only reduces worker contact with the liquid resin but also reduces volatile content. In addition, standard wet lay-up tools can be modified from this process and cored structures could be produced in one operation. The VBRTM test bench will be developed in PRISME laboratory at INSA CVL.

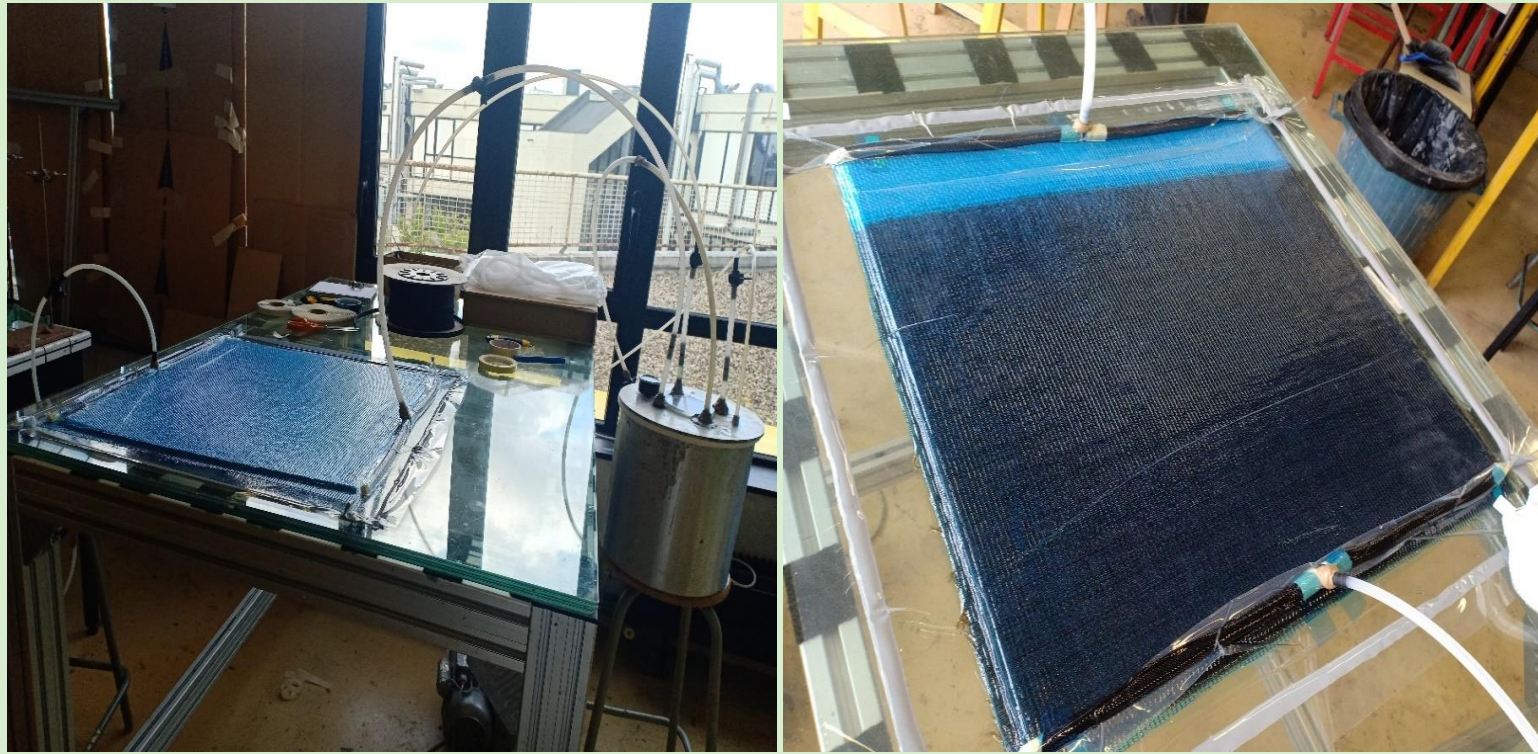


Figure 2 : Example on the VBRTM process design (UTC univ.)

2. Thermal characterization

The manufactured bio-based composites will be investigated at different scales (matter, product, and large)ale and big scale thermal test using TGA, Cone Calorimetre and Vesta fire test.



Figure 3 : Experimental setups (a) TGA (b) Cone Calorimeter (c) Vesta fire tests

Future Works

- Comparation result of thermal degradation in different scales (TGA, Cone Calorimeter and Vesta fire test).
- During TGA and cone calorimeter characterization, in parallel the kinetics polymerisation studies will be carried out.
- Making simulation kinetics data polymerization of banana leaf and bamboo natural fibres reinforced by green – poxy matrix
- the thermal degradation kinetic will be evaluated on the single and multi-step reaction based on numerical methods respectively with ICTAC recommendations.
- Mechanical characterization pre/post fire will be investigated on this bio – based composites materials.
- Comparation studies on the natural fibres: bamboo and flax on the thermal properties will be investigated.

Conclusion

From the literature, it found that very few works were carried out on banana and bamboo fabrication composite using bio matrix (green-poxy) especially on the thermos-physical behaviour, so it is very challenging to be investigated.

Banana leaf and bamboo as natural fibres if strengthen by Green-poxy resin have good potential use in the automotive application which is cheaper, bio-degradable and have no health hazard. Furthermore, natural fibre reinforced fibres are seen to have good potential in the future as substitute.