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Introduction

The de-cohesion between hydrophilic vegetal fibers and hydrophobic matrix may cause a reduction in the mechanical properties of a typical green wood plastic composite material. The aim of this work is to improve mechanical properties of the final composite by reactive extrusion and characterize these materials by a rigorous mechanical procedure followed by the use of a micromechanical approach. This numerical simulation has the aim to predict and therefore to optimize the tensile properties of the final composite in order to realize materials comparable to the traditional ones reinforced with glass or carbon fibers.

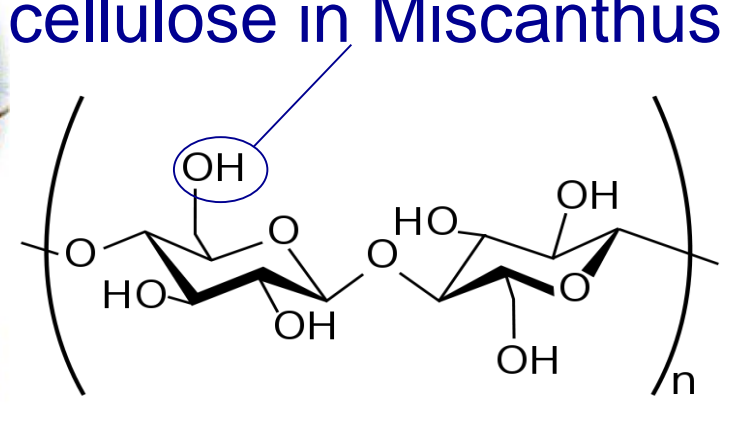
Materials



Miscanthus Giganteus

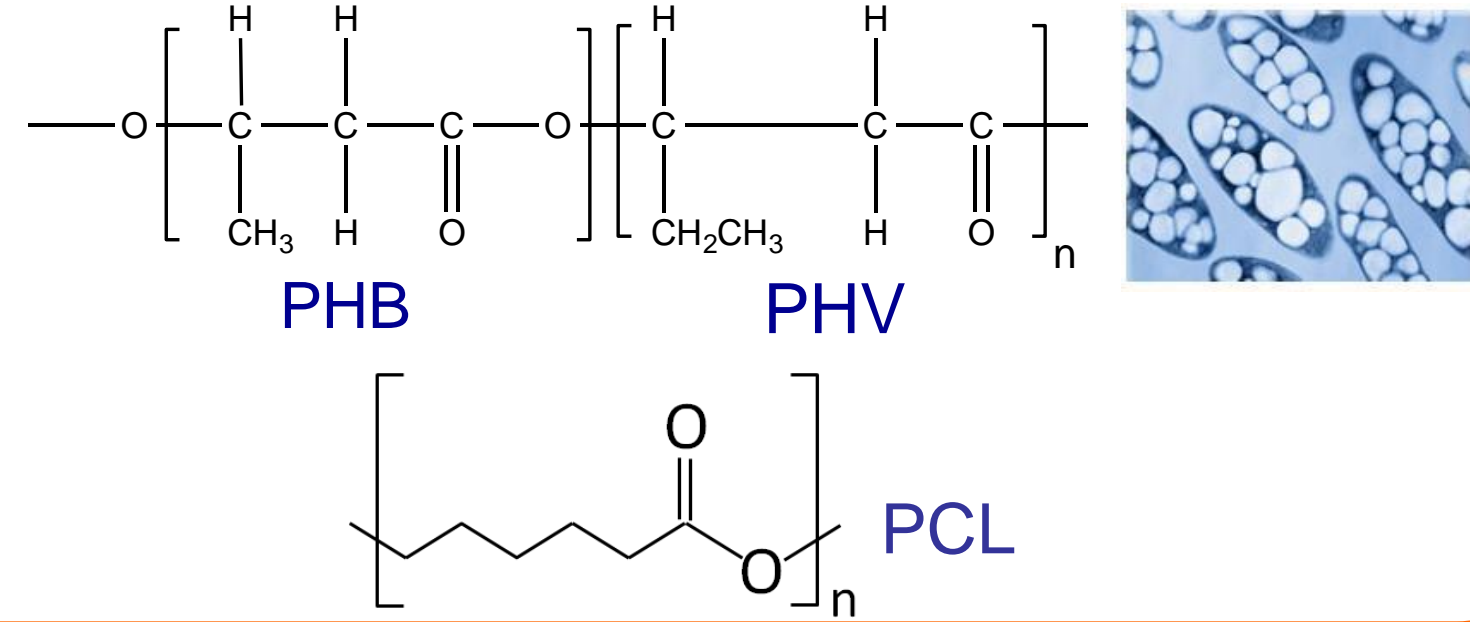
- Very favorable carbon footprint
- Soil protection against erosion

Hydrophilic function of cellulose in Miscanthus

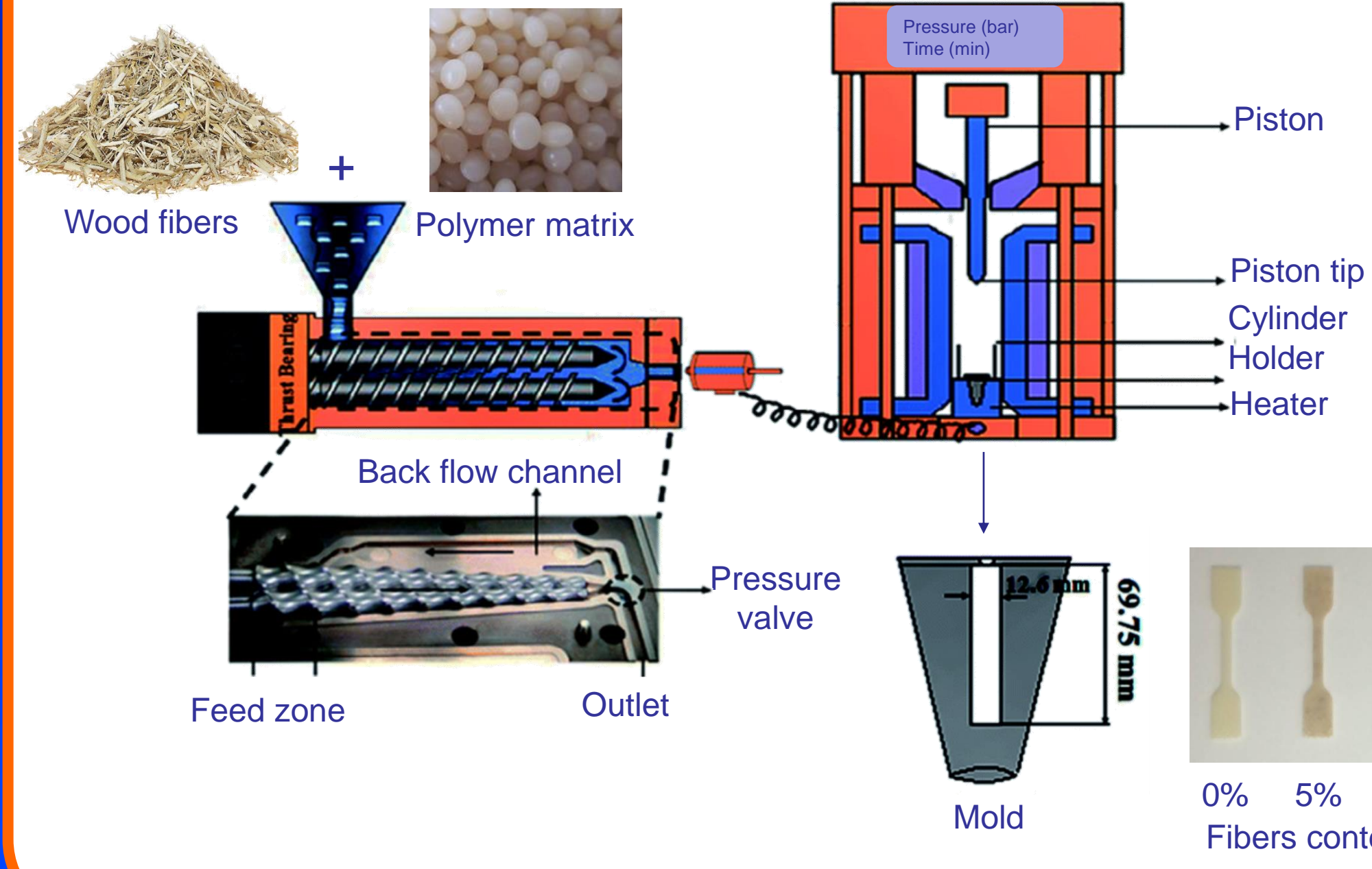


Matrix

- Bio-based/(Bio)degradables
- Biological nature: starch, bacteria



Composites processing



Processing steps

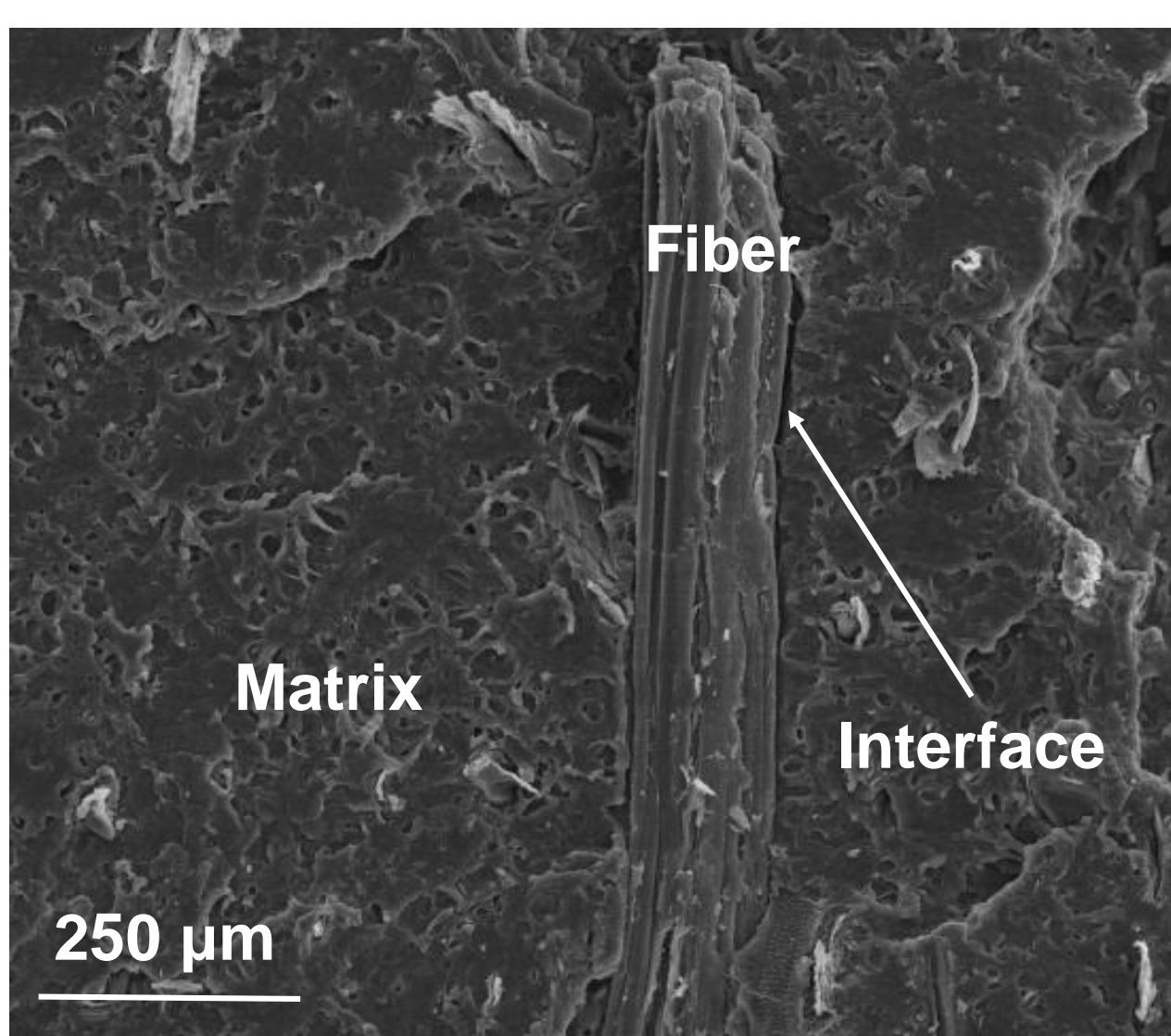
- Milling of fibers
- Compounding of raw materials in the extruder
- Injection molding
- Cooling of specimens and cutting

Objectives of the study:

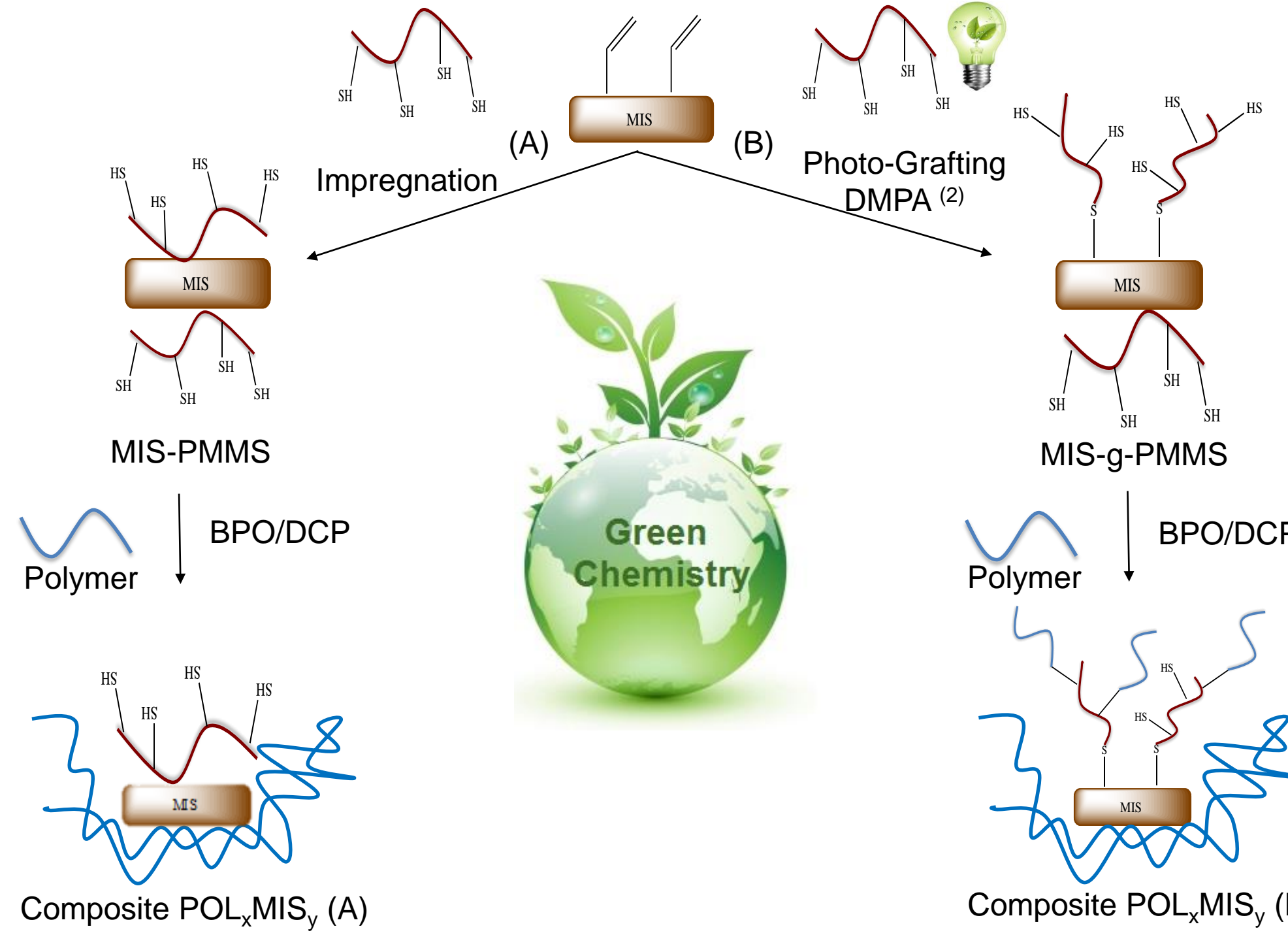
- Effect of fiber content
- Effect of fiber length
- Effect of interface

How to improve interface matrix/reinforcement?

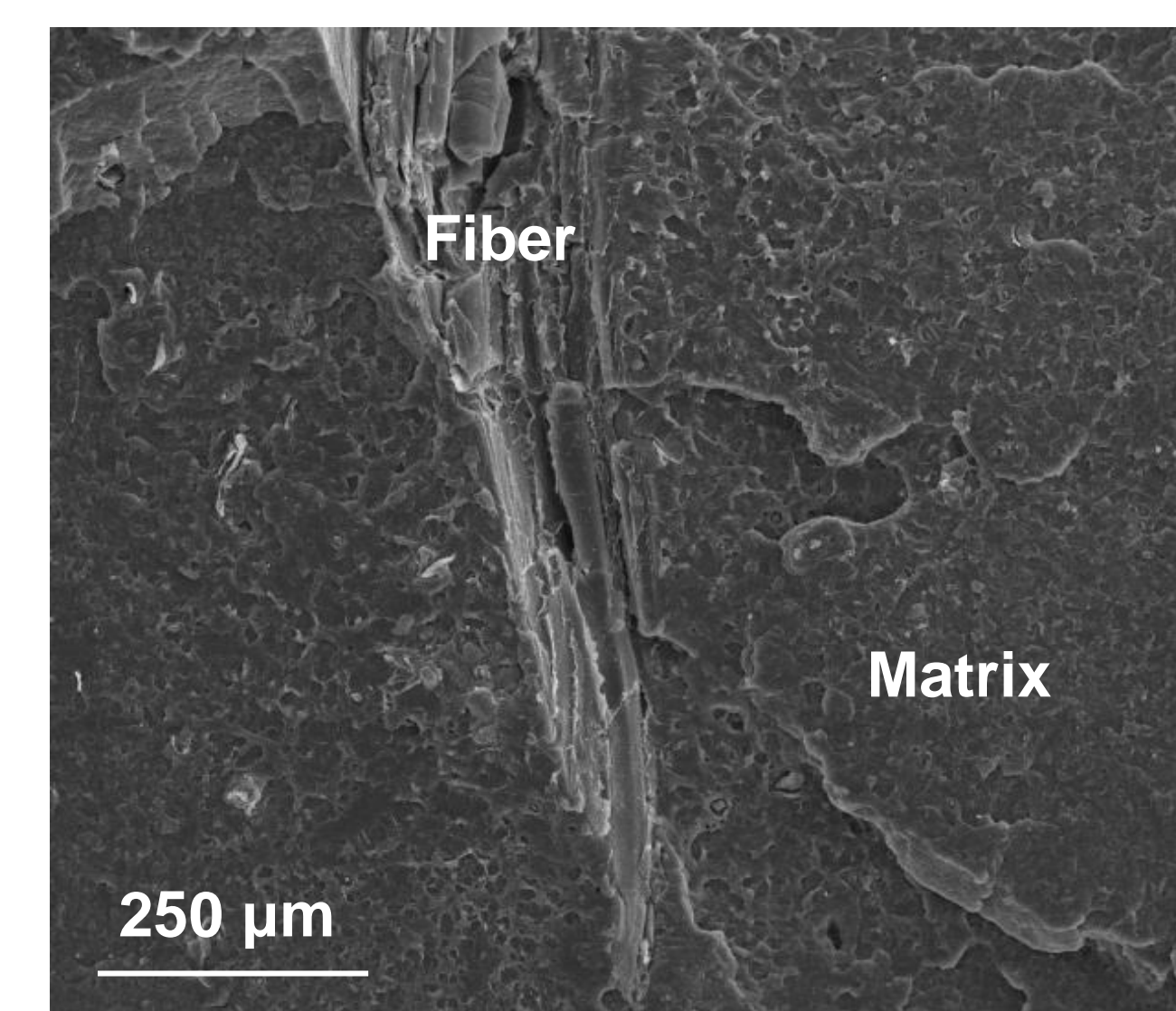
Before chemical interface improvement



MEB micrograph of PHBV95MIS5 composite without improved interface



After chemical interface improvement

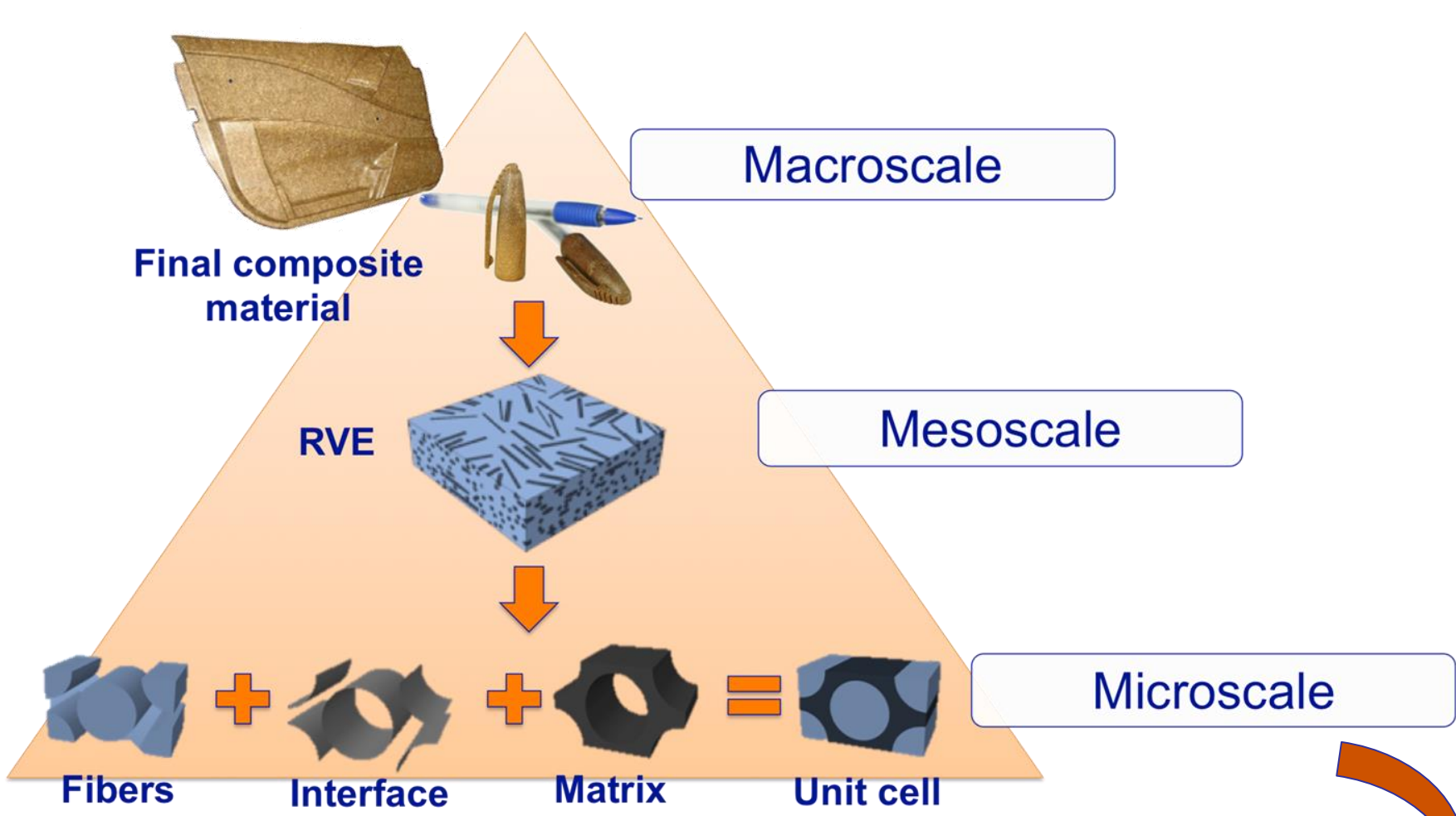


MEB micrograph of PHBV95MIS5 composite with improved interface

Composite with improved interface shows no void at the interface between fibers and matrix and better mechanical properties

Results of Macro/Micro-mechanics and numerical simulation

1. Hierarchy of scales



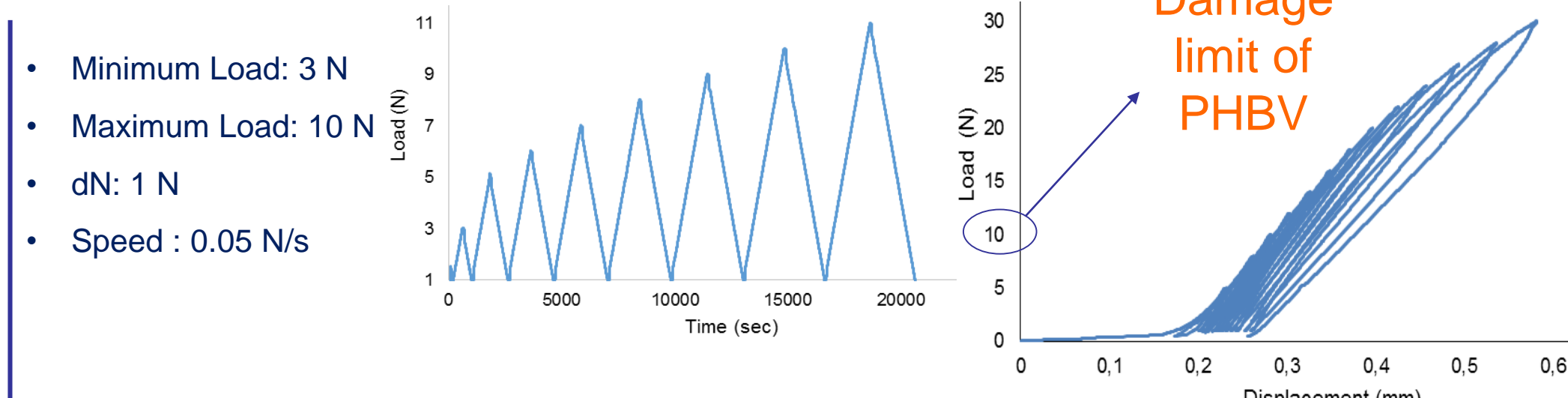
A micromechanical approach relates the mechanical properties and the microstructure of the material in order to obtain the homogenized mechanical properties of the composite⁽¹⁾

Mori-Tanaka Method

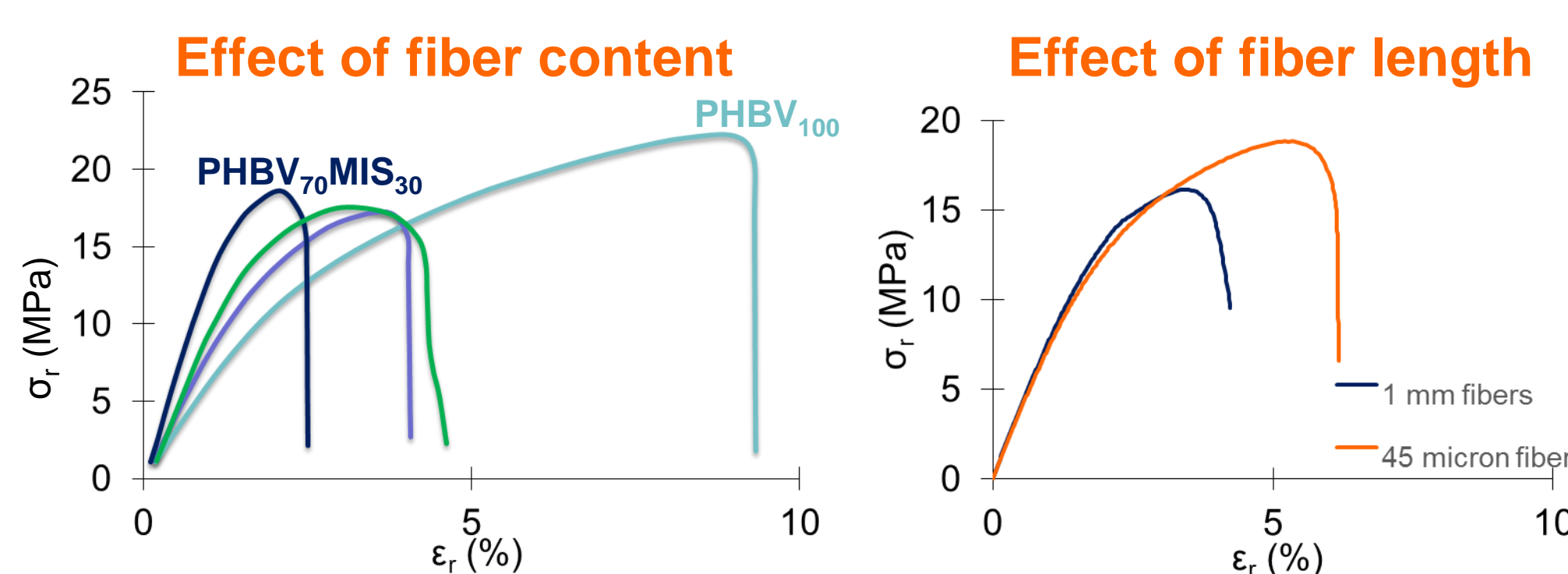
- Volumetric fraction of fibers in the matrix → Determined by solubilization of specimens
- Orientation of fibers in the matrix → Determined by microscopy
- Form of inclusion (cylinder, sphere)

2. Characterization

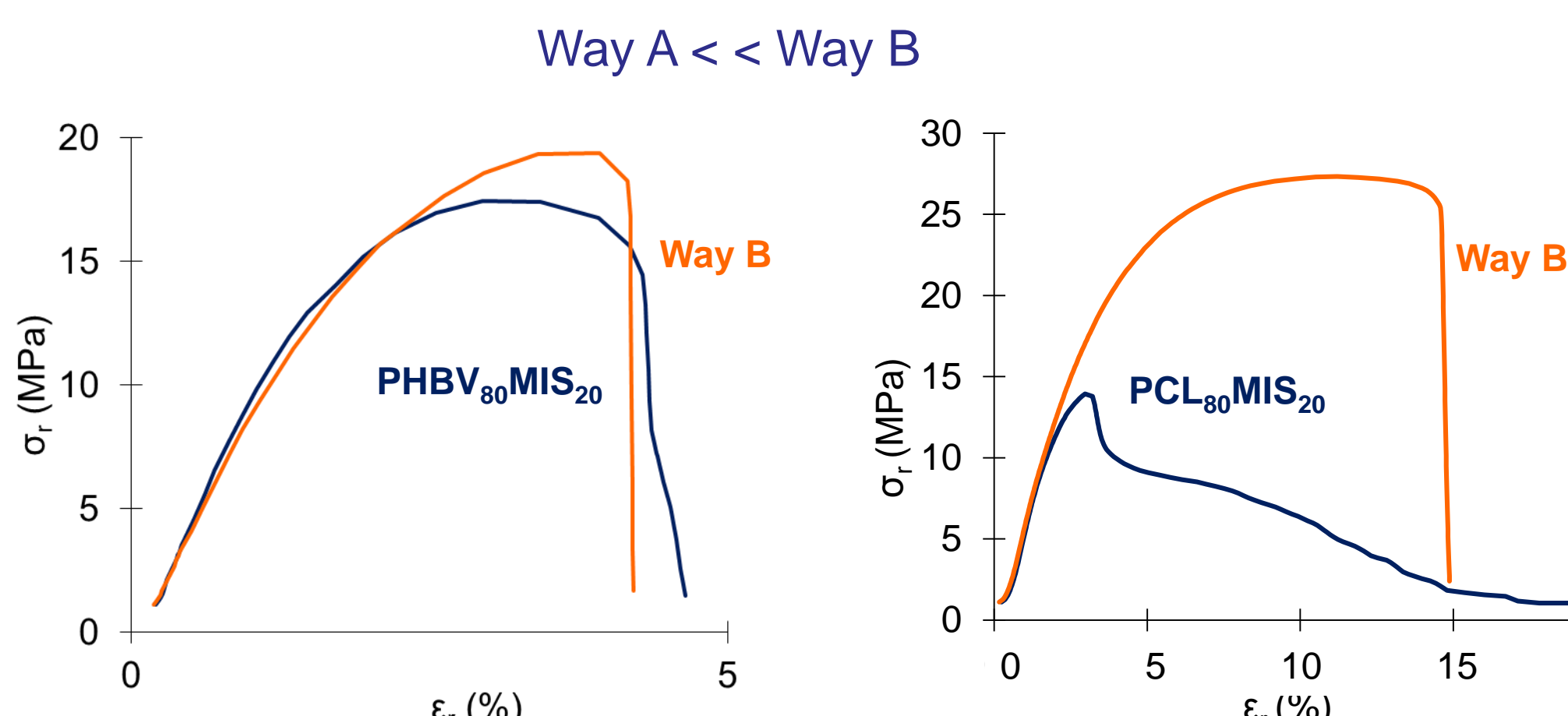
Mechanical procedure



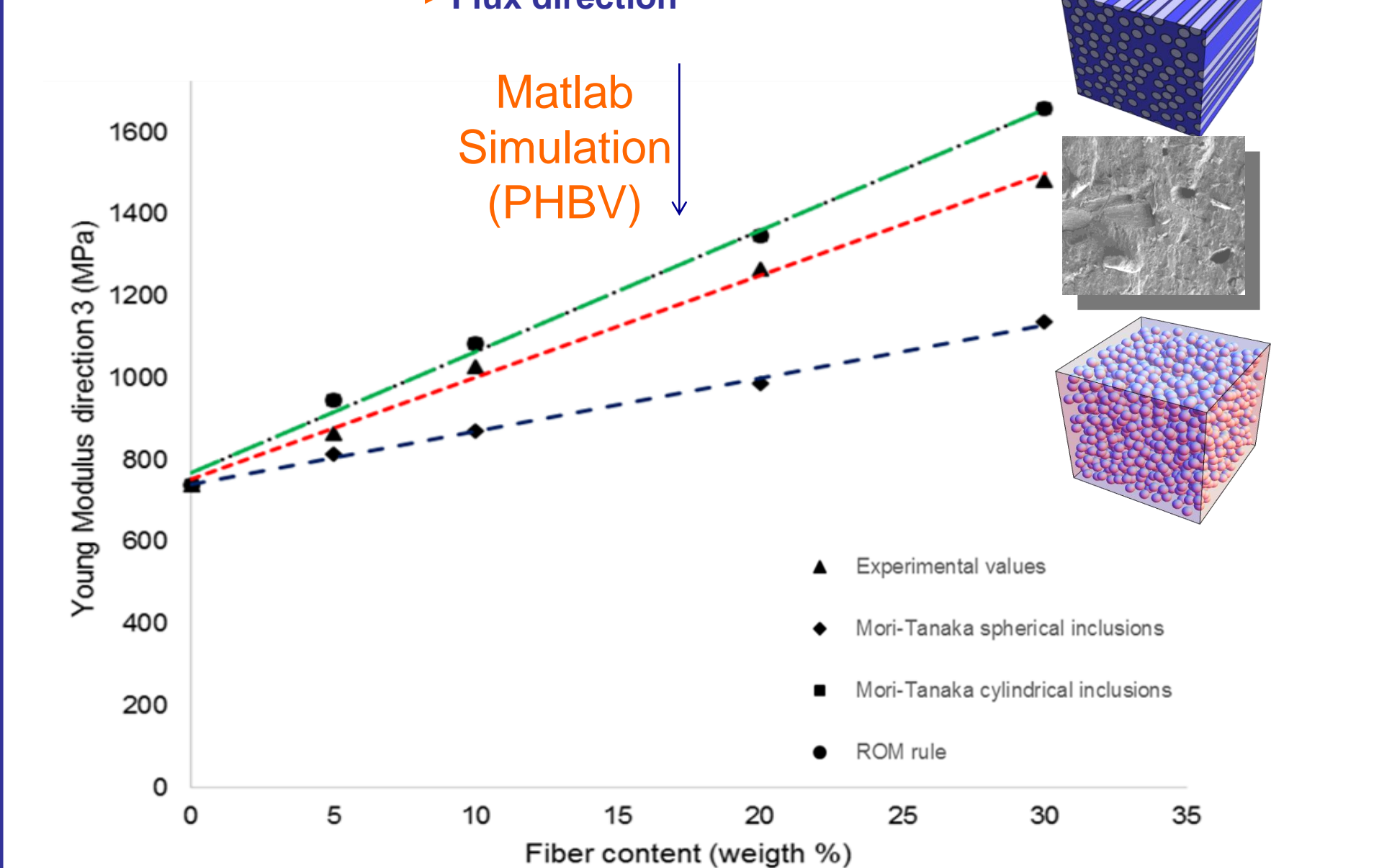
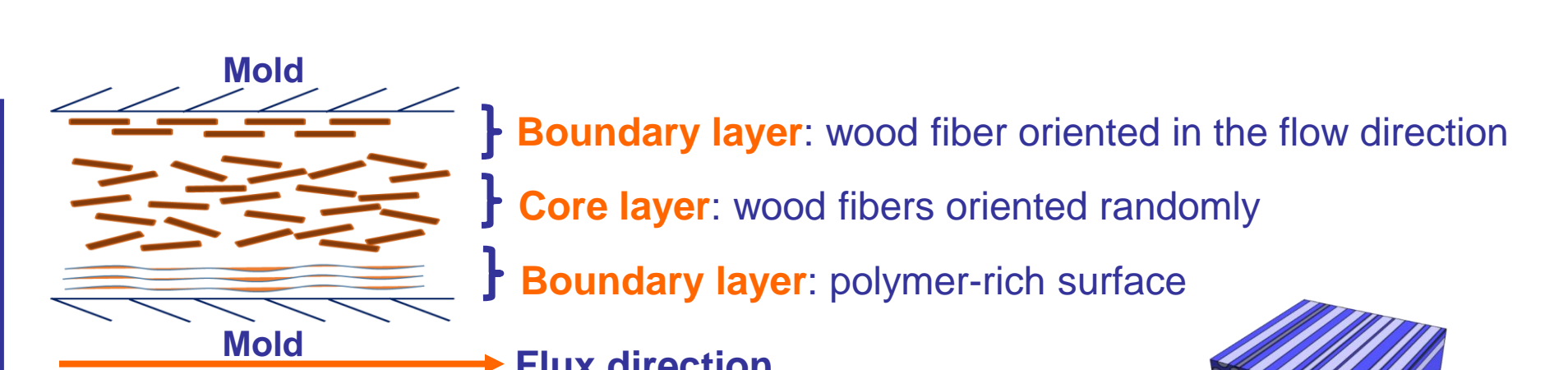
Results of traction tests



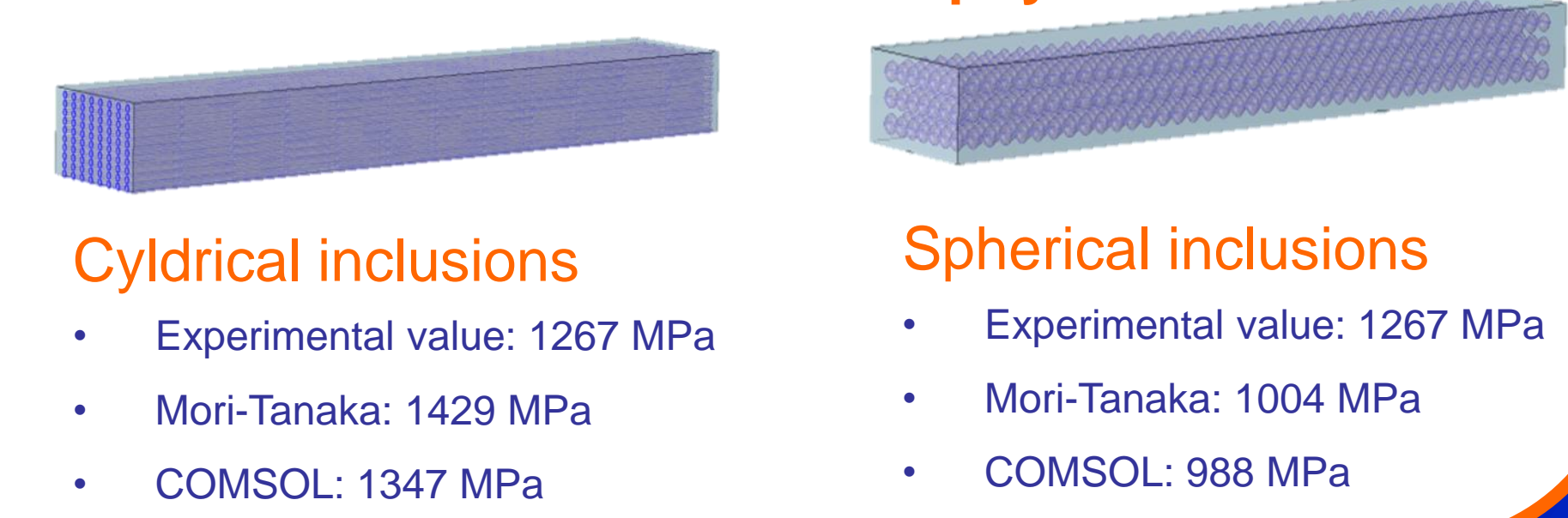
Effect of chemical modification



3. Numerical simulation



3D idealized models with COMSOL Multiphysics



Conclusions

- Polymer is efficiently grafted onto Miscanthus fibers by reactive extrusion in the presence of PMMS
- The chemical modification (way B) improve the interface fiber/matrix
- Mori-Tanaka model with cylindrical inclusions well approximate the mechanical behavior of the PHBV composite
- Processing causes a multilayer structure

Perspectives

New finite element models will be developed using COMSOL Multiphysics software. One of these model will be developed starting from Micro-tomography images.

