CERIS : Civil Engineering Research and Innovation for Sustainability

Sustainable bio-based resins and fibre-polymer composites for civil engineering structural applications

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Summary

Given the growing societal demand for more sustainable products with lower environmental impacts, the search for solutions that minimise our dependence on fossil resources is becoming increasingly relevant. In the context of the fibre-polymer composites industry, the development of thermoset polymer matrices based on raw materials derived from renewable resources (bio-based) is key to increase its sustainability and to reduce its current dependence on oil.

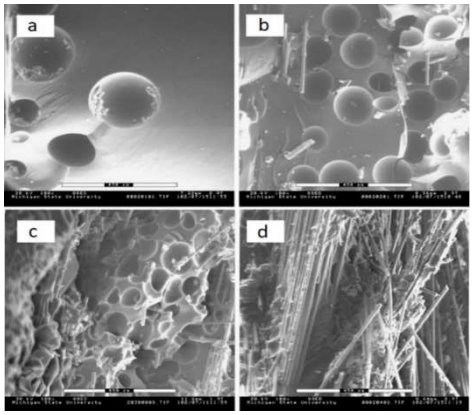
In a first stage of this thesis, a set of innovative unsaturated polyester (UP) thermoset resins with high bio-content were developed. The formulation that presented the highest potential to replace its petroleum-derived counterparts was used as impregnation matrix of reinforcing fibres in the production of more sustainable high-performance fibre-polymer composites, specifically targeting applications in civil engineering structures.

In this respect, in a second stage, the thesis presents the successful production, by vacuum infusion, of glass fibre reinforced polymer (GFRP) composites using the abovementioned bio-based UP resin, and their respective characterisation. In addition, a prototype of a carbon fibre reinforced polymer (CFRP) strip was produced by pultrusion, also using the selected bio-based UP resin; this production was carried out in an industrial pultrusion facility used to manufacture high-performance CFRP strips for strengthening civil engineering structures.

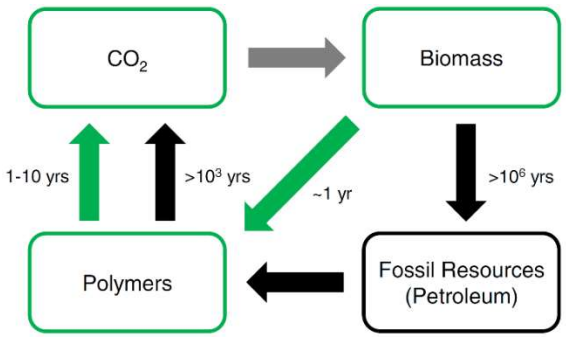
Based on the processing properties of the resins and the mechanical and thermomechanical properties of the composites obtained in the extensive experimental campaign carried out in this thesis, it was possible to conclude that the bio-based fibre-polymer composites developed herein present equivalent or, in some cases, better performance than their petroleum-derived counterparts assessed under the same conditions. Thus, it was possible to confirm that there is a very relevant opportunity to increase the sustainability and competitiveness of the fibre-polymer composites industry, which should be further explored, addressing a very important challenge presently faced by this sector.

Keywords

Sustainable composites, bio-based polyester resins, bio-based thermosets, bio-based fibre-polymer composites, renewable raw materials.



ESEM micrographs of glass reinforced biobased polyurethanes: (a) no fiber, (b) 15 wt%, (c) 30 wt% and (d) 50 wt%, Dwan'Isa et. al. (2004).



Carbon cycle of fossil-based polymers and bio-based polymers. Renewable resource pathway (green arrows); fossil resource pathway (black arrows); and pathway for both renewable and fossil resources (grey arrow), Castro-Aguirre et. al. (2016).