BioLam – Development of Eco-Efficient Bio-Based Carbon Fibre Laminates for Structural Strengthening and Rehabilitation

Summary

The BioLam project aims to develop a bio-based polymer resin system for the replacement of the current petroleum-based resins used in the production of carbon fibre reinforced polymer (CFRP) laminates for structural strengthening in Civil Engineering. The resulting bio-based CFRP laminates should exhibit comparable structural performance to the existing solutions. An initial approach involving the development of a bio-based phenolic resin, obtained directly from raw biomass, was pursued; although being disruptive and innovative (TRL 2), after the initial period of research, this approach was suspended due to the low mechanical properties obtained (Figure 1), and also due to logistical and technical difficulties in obtaining liquefied biomass with sufficiently large volume for application in the pultrusion process.

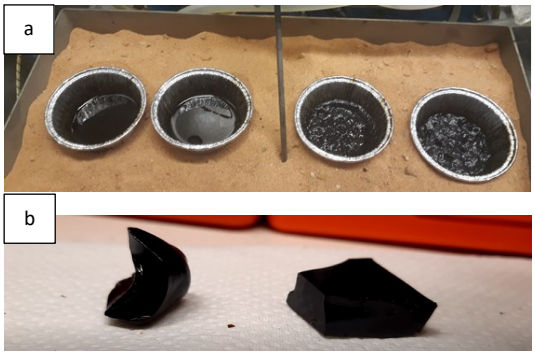

Figure 1. a) Biomass resin synthesis; b) final product obtained.

The development of the bio-resin was then continued by adapting, through modifications in its main polymeric chain, an unsaturated bio-based polyester resin (BUPE1), previously developed at IST (TRL 7). Currently, efforts are being made to improve various aspects of that bio-based resin and to obtain a modified bio-based polyester resin (BUPEM) through a polycondensation reaction (Figure 2), which will be more suitable for the pultrusion process. These modifications are intended at adjusting its viscosity, increasing its shelf life and its resistance to hydrolysis and/or plasticization.

For this purpose, several experimental productions have already been carried out in an iterative process, accounting for a total of 14 formulations following a two-step synthesis procedure and 11 formulations with a one-step synthesis.

A first pilot production by pultrusion of bio-laminates was already carried out using the BUPE1 resin (Figure 3). A new production will be carried out at a later stage, after the successful development and characterization of the BUPEM resin.

Figure 2. Reaction system to synthesize the BUPEM resin.

Figure 3. Pilot production of pultruded CFRP bio laminates using the BUPE1 resin.

The durability of the CFRP laminates produced with the BUPE1 resin is being assessed through hygrothermal ageing followed by mechanical tests at predetermined periods (up to 12 months); as a reference, similar testing using conventional laminates is being performed. In these experiments, the specimens are immersed in tap water at temperatures of 20, 35 and 50 °C. Moreover, to evaluate the photo-degradation of the CFRP laminates, they will be placed in a QUV chamber and mechanically tested after 750 h, 1500 h and 3000 h of exposure. The results already obtained (1 and 3 months) seem to indicate that the hygrothermal degradation of the BUPE1 resin is more severe than that experienced by the conventional epoxy- and vinyl ester-based resin. Results of future tests will allow confirming these initial trends.

The performance of the bio-laminates in structural strengthening applications will be experimentally assessed in the laboratory as a proof-of-concept evaluation. These tests aim at assessing and demonstrating the structural efficiency of the CFRP bio-laminates through: (i) CFRP-concrete bond tests (double lap and pull-out); (ii) durability assessment of this bond; and (iii) flexural tests of CFRP-strengthened reinforced concrete beams. The results will be compared to those using conventional CFRP laminates.

The project is led by the company S&P – Clever Reinforcement Ibérica Lda., market leader in structural strengthening with CFRP laminates and their production by pultrusion, in consortium with Instituto Superior Técnico, through its research units CERIS and CERENA.

CERIS : Civil Engineering Research and Innovation for Sustainability

BIOLAM

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Leading Institution

S&P – Clever Reinforcement Ibérica Materiais de Construção Lda (Portugal)

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Project Website

coregroup.tecnico.ulisboa.pt/research-projects/on-going/biolam