Composites
Innovation Centre

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PROJECT FINAL REPORT

ASSESSMENT OF THERMOSET RESIN COMPATIBILITY WITH FLAX FIBRES FOR COMPOSITE PANELS

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EXECUTIVE SUMMARY

It was identified in the report entitled Flax Fibre Mat Assessment[1] issued by the Composites Innovation Centre that investigation into the resin-to-natural fibre compatibility was required to improve the impact, tensile and flexural properties necessary for composite part manufacture applications. The natural fibres used in the testing were short to medium length (2-10cm) oil seed flax fibres and were donated to the project by Schweitzer-Mauduit Canada, Inc. Five readily available commercial thermoset resins were selected based on favourable mechanical and physical properties for the vacuum assisted resin infusion process used in the bus industry and, for four of the five materials, there being precedent for affinity with natural fibres. The five resins ultimately selected for testing were Hetron 922 INF epoxy vinyl ester resin donated by Ashland, Hydropel R037-YDF-40 vinyl ester resin donated by AOC, Stypol 040-8086 unsaturated polyester resin produced by Cook Composites and Polymers (CCP) and donated by Progress Plastics, R736-APD-30 unsaturated polyester resin donated by AOC, and Polylite 33234 unsaturated polyester resin donated by Reichhold. Due to Stypol 040-8086's use in the Flax Fibre Mat Assessment program it was included in this study to form a baseline. The test program undertaken to evaluate the fibre-matrix bonding and compatibility included the following tests:

- Mechanical Testing: single fibre pull-out, short beam shear combined with scanning electron microscopy (SEM) and tensile strength/modulus
- Chemical Assessment: inverse gas chromatography verified by attenuated total reflectance - fourier transform infrared spectroscopy (ATR-FTIR)
- Visual Assessment: confocal microscopy imaging (CMI)

Table 1: Mechanical Properties of Flax-Resin Specimens

Description	Single Fibre Pull Out Strength (MPa)	Short Beam Shear (MPa)	Tensile Strength (MPa)	Young's Modulus of Elasticity (GPa)
STYPOL 040-8086	18.5	11.59	24.73	5.84
POLYLITE 33234	16.5	11.27	26.93	5.24
HYDROPEL R037-YDF-40	65.0	13.25	31.00	5.62
R736-APD-30	34.0	12.12	34.80	5.65
HETRON 922 INF	40.0	13.20	35.15	5.19

Table 1 displays the average results for the single fibre pull-out, short beam shear, and tensile strength tests. Hydropel R037-YDF-40, R736-APD-30, and Hetron 922 INF all performed similarly with the Hydropel exhibiting better results in the single fibre pull-out and short beam shear tests. The Polylite 33234 and Stypol 040-8086 results were generally worse than the other three resins. SEM imaging of the resin-fibre specimens following the short beam shear testing showed very little resin remained bonded to the individual fibres indicating the mode of failure to be from fibre pull-out and not from fibre breakage.

The Lewis acid and base constants were measured using Inverse Gas Chromatography for each of the five resins and one flax fibre sample. The values obtained indicated the surfaces of all the resins to be amphoteric, with Hydropel, Hetron and R736 showing Lewis basicity. It was found that the flax fibres used in this study were not amorphoteric and showed Lewis basicity.

From a CMI visual analysis of comparable fibre bundles, all five resin samples appeared to have very few voids or cracks along the resin-fibre interface indicating good fibre wet-out.

The mechanical, chemical, and visual testing of the five commercial resins embedded with flax fibre reinforcement confirmed that the significantly lower mechanical properties compared to glass fibre

reinforced composites is primarily due to poor matrix-fibre bonding and not due to a weakness in the flax fibres themselves. It is concluded that research is required into the development of treatments to the flax fibres to further improve resin-fibre compatibility and bonding.

The report is one of the deliverables in the Composites Innovation Centre's Biofibre Initiative sponsored by the Agricultural Policy Framework (APF), Science and Innovation Broker Program coordinated through the Department of Agriculture and Agri-Food Canada. Funding was also provided by the Composites Innovation Centre through their Economic Partnership Agreement with Western Economic Diversification Canada and the Province of Manitoba.