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LARGE THERMOPLASTIC MATRIX MARINE COMPOSITES BY LIQUID COMPOSITE MOULDING PROCESSES

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ABSTRACT

A significant majority of large fibre composite structures in the marine environment currently use a thermoset resin matrix. These materials have excellent durability in the sea, but are difficult to dispose of at end-of-life. After a rigorous selection process [1], methyl methacrylate and lactide monomers have been identified as potential thermoplastic matrix systems which can be manufactured using in situ polymerisation (ISP) during composite manufacture by liquid composite moulding (LCM) processes. LCM includes resin transfer moulding (RTM) for components up to about 3 m square, then Infusion under Flexible Tooling (RIFT for resins, or MIFT for monomers). The presentation will address manufacturing issues (acrylic is a "drop in" for polyester resin, but lactide requires elevated temperature processes), and end of life (acrylic is lower in the recycling hierarchy).

INTRODUCTION

With the increasing concerns over environmental issues, natural fibres and thermoplastic matrices attract increasing interest by composite engineers. As a method of Liquid Composite Moulding (LCM), Resin/Monomer Infusion under Flexible Tooling (RIFT/MIFT) has been widely used for the production of large and complex composite structures with high mechanical properties [2, 3]. Acrylic methyl methacrylate (MMA) and lactide monomers were reported to be suitable to produce thermoplastic matrix marine composites using in situ polymerisation (ISP) by LCM [1]. In this study, flax fibre reinforced thermoplastic composites were made (by MIFT via ISP) and flexural tested to guide the future production and application of large marine composite structures.

MATERIALS, SAMPLE PRODUCTION AND TESTING

The acrylic MMA resin used in this work is Elium® 188 XO catalysed with benzoyl peroxide. The L-lactide was catalysed with Tin(II) 2-ethylhexanoate. The natural fibre reinforcement was a 2x2 twill weave flax fabric with areal weight of 200 g/m2. The schematic of the MIFT for production was shown in Fig. 1. As elevated temperature is required for the process of MIFT of L-lactide monomer, polylactic acid (PLA)-flax composites were produced in the oven at 170ºC for 3 hours. The flax fibre volume fractions were ~31% for both PLA-flax and Elium®-flax composites. The mechanical properties of the sample were investigated by three-point flexural testing. The sample geometry for flexural tests is 80 x 10 x 3 mm3 (cut from the composite plate). The test span and speed in the flexural testing were 48 mm and 1.28 mm/min respectively according to ASTM D790 standard [4].

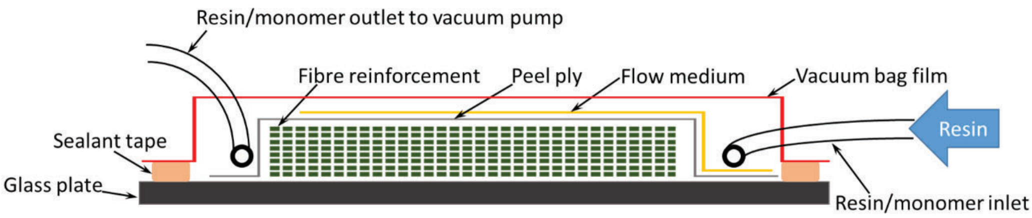

Figure 1. Schematic of the MIFT.

RESULTS AND CONCLUSIONS

The experimental results from the flexural tests and theoretical prediction (by rule-of-mixture equations [5, 6]) are shown in Table 1. Although acrylic resin (Elium®) is lower in the recycling hierarchy at end-of-life, it can be seen Elium®-flax shows better flexural properties than PLA-flax composites. In addition, except for the flexural strength of Elium®-flax, all experimental results are significantly lower than the theoretical prediction values.

Table 1 Flexural properties for PLA-flax and Elium®-flax composites.

Composite	Flexural strength			Flexural modulus		
	Experimental Mean ± SD (MPa)	Prediction (MPa)	E/P* (%)	Experimental Mean ± SD (GPa)	Prediction (GPa)	E/P* (%)
PLA-flax	56.98±9.58 (16.8%)	91.7	62.1	3.66±0.31 (8.5%)	9.86	37.1
Elium®-flax	123.73±4.96 (4.0%)	119.3	103.7	4.98±0.42 (8.4%)	9.45	52.7

*E/P represents the ratio between experimental value and prediction.

This study successfully produced flax fibre reinforced thermoplastic composites by MIFT via ISP. Further study may focus on the optimisation of ISP processes and fibre-matrix interfaces to improve the composite mechanical properties.

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