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Future Composites
Manufacturing Research Hub

Acceleration of Monomer Transfer Moulding using microwaves

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Aims/Objectives

The project will develop a manufacturing process that will facilitate and accelerate the production of thermoplastic composites through the use of microwave (volumetric) heating. Thermoplastic composites are a significantly growing market because they offer a combination of high processing speeds, good toughness and attractive thermal/chemical resistance. However, because they typically exhibit high melt viscosity, successful infusion of thermoplastic resin into fibre forms can be challenging. Monomer transfer moulding (MTM) is an effective, low pressure method of producing fibre-reinforced thermoplastic composites from dry fibre that exhibit good fibre/ matrix interface quality, while avoiding issues with viscosity, fibre crushing and matrix degradation.

This project will:

- Demonstrate microwave heating can successfully produce a MTM part for at least one thermoplastic system
- Determine processing parameters through multiple scales
- Produce a significant flat panel demonstrator in a large, multimode microwave oven
- Identify process benefits and assess process limitations to inform follow on studies

Methodology

The experiments will progress through three scales:

1) Laboratory glassware
Small scale experiments using a laboratory microwave system (see fig.1) to test the polymerisation reaction in the presence of glass fibres

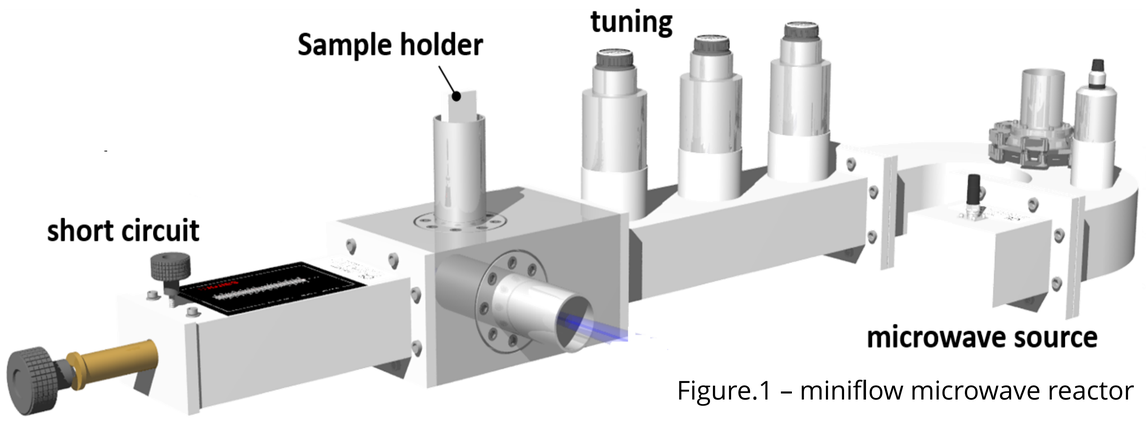

Figure.1 – miniflow microwave reactor

2) Small instrumented microwave
Establish manufacturing parameters for a small composite panel, ensuring even heating

3) Large multimode microwave oven
Utilise the large Votsch multimode oven at Sheffield AMRC (see fig.2) to produce a large flat panel

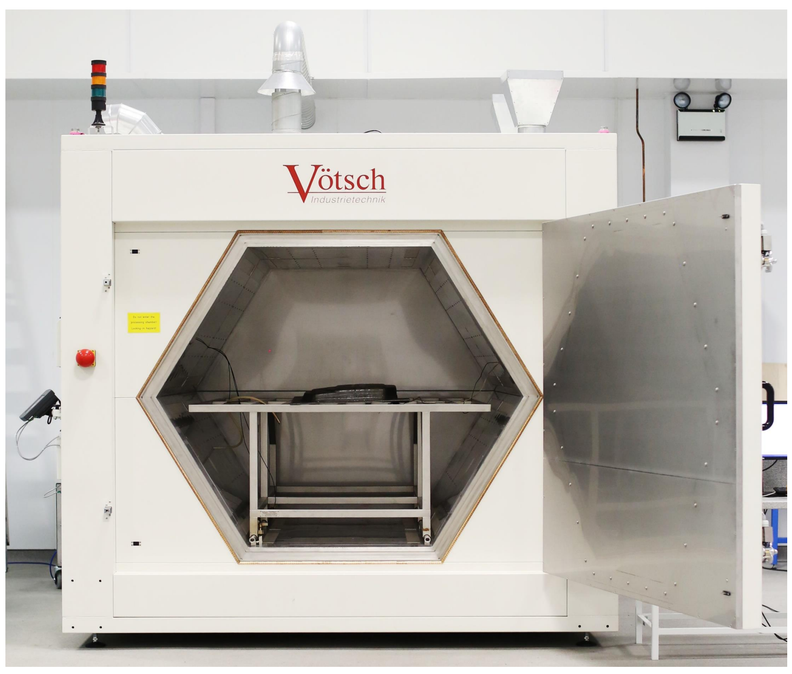

Figure.2 – Votsch multimode microwave oven at Sheffield AMRC

Progress to date

The majority of lab scale experiments have been completed with the first polymer (polycaprolactone), assessing reaction kinetics with and without microwaves and determining dielectric behaviour. Experiments on the small instrumented microwave are planned for June.

Key Findings

It has been determined that the presence of glass fibres has a significant effect on the polymerisation reactions. This has been attributed to (a) small amounts of water on the fibre/in the monomer and (b) the sizing treatment.

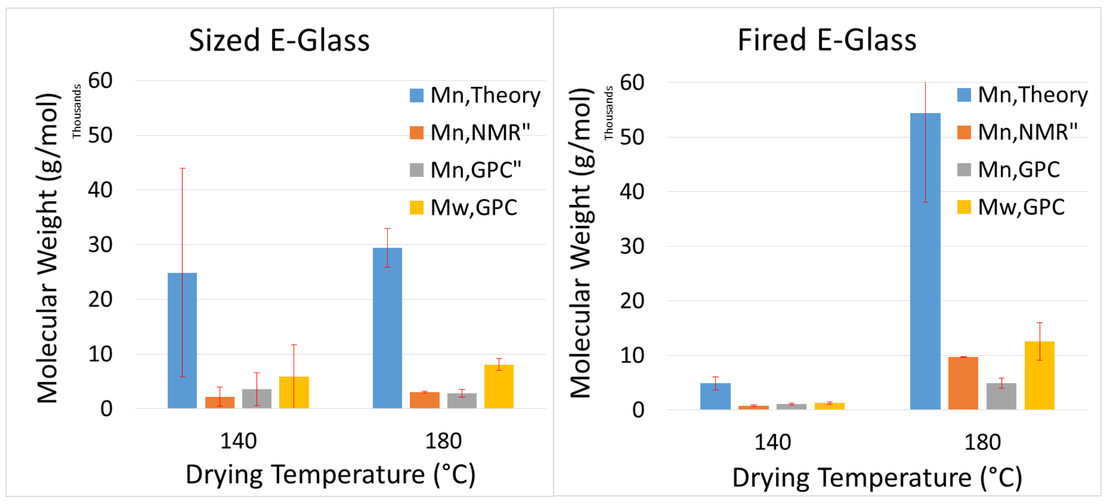

Figure.3 – Effect of fibres on the final composite molecular weight

A drying protocol has been established to successfully remove the remaining water, with microwave assisted drying being very effective. This can be incorporated with the moulding process quite simply.
The interaction with the sizing could mean that the reaction can proceed without the need for an initiator. This is serendipitous, as the reaction would then proceed from the fibre surface and provide improved fibre matrix adhesion.

Collaboration

Our thanks to the Sheffield AMRC for their advice and use of facilities, and to the University of Edinburgh for their specialist materials and input on Nylon polymerisation.

This work was supported by the EPSRC through the Future Composites Manufacturing Research Hub [EP/P006701/1]

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