FiBreMoD Conference
L. Gorbatikh, S.V. Lomov, Y. Swolfs (Editors)
Leuven, 11-12 December 2019

RELATIONSHIPS BETWEEN PROCESSING PARAMETERS, MECHANICAL AND CHEMICAL PROPERTIES OF THICK GLASS FIBRE REINFORCED THERMOPLASTIC METHACRYLIC COMPOSITES

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Keywords: Polymer composites, Mechanical properties, Physico-chemical properties, Porosity
Session topics: Constituent properties, Thin ply composites, Micromechanics, Computed tomography, Structural applications

ABSTRACT

As the energy transition unfolds, the recycling targets applied to composite materials are on the rise, thus getting more and more challenging to meet. In this context, continuous fibre reinforced thermoplastic composites and their recyclable matrix have gained increasing interest over the past twenty years – especially for the design of lightweight and high-performance structural parts. In order to produce such materials, specific monomers are usually vacuum-infused through glass or carbon fabric before undergoing in-situ polymerization. While most parts obtained this way are only a few millimetres thick, some industrially important applications require the manufacturing of much thicker components – up to several centimetres.

The present work focuses on the links between the infusion parameters, physico-chemical state of the matrix and mechanical properties of 6-cm-thick glass fibre reinforced thermoplastic methacrylic composite plates, at both the micro- and macroscopic scales. More precisely, different composite plates were infused with Elium® resin and left to polymerize at different temperatures, while recording the temperature profiles at several locations. The evolution of the microstructure was then studied along the thickness of each sample, and emphasis was placed on the characterization of the porosity distribution and morphology by optical microscopy and computed microtomography.

Heating up the bottom part of the plates after infusion - in order to trigger the polymerization reaction - can in turn lead to monomer boiling and thus favour the formation of porosity inside the matrix, with more and larger pores observed near the surface. While it seems obvious that such cavities affect the overall mechanical response of composite parts, the decrease of modulus and strength as a function of the volume fraction of pores proved much more significant than first expected, at least under uniaxial compression.

In order to get a better understanding of the phenomena, the local mechanical response of the matrix was then measured further to various infusion conditions by carrying out nano-indentation tests inside the matrix pockets, while chromatographic analyses gave access to the molecular weight distributions and monomer conversions achieved in the Elium® matrix. The results revealed small but mutually consistent differences in matrix properties across the thickness of the plates. Though the latter were slight enough to have a limited influence on the chemical and micromechanical properties of the matrix, they give important insights into the complexity of the thermal and chemical phenomena occurring in the system during polymerization and cooling.

In a nutshell, this work suggests that changing the infusion temperature strongly impacts the amount and distribution of porosity in Elium® composites. This governs in turn the macroscopic mechanical properties of the final part, and implies significant variations in the course of the polymerization reaction along the thickness of the plate.

The authors would like to thank Arkema for funding this research, the Elium® team at Groupement de Recherche de Lacq for their guidance and support, and Dr Jeroen Soete at KULeuven for his help with CT measurements.