Dissolution and diffusion of nanofilled thermoplastic yarns in epoxy resins

Dumont David, Daoust Daniel, Sclavons Michel, Devaux Jacques

The performances of fiber-reinforced polymer composites based on highly crosslinked epoxy networks justify their outstanding use for aerospace applications and structures requiring high mechanical, thermal and chemical resistances. However, properties like fracture toughness or thermal and electrical conductivities remain important drawbacks of such thermoset matrices. Therefore, improvements have already been proposed by incorporating thermoplastics (TPs) or carbon nanotubes in epoxy resins with benefits demonstrated. This work proposes a method to disperse simultaneously a soluble amorphous TP and nanofillers in the epoxy matrix during the composite manufacturing using modern liquid moulding technologies like Resin Transfer Moulding (RTM). The concept consists in a nanofilled TP added to the dry preform in the form of yarns, veils or films. The dissolution of the TP in the resin is completed during the temperature increase following the RTM injection stage. After TP and nanofiller diffusions, reaction induced phase separation generates the final microstructure. Unfunctionalized multiwall carbon nanotubes (MWNTs) were initially dispersed in poly(ether sulfone) (PES) and poly(hydroxyether of bisphenol A) (phenoxy) using an extrusion process. The resulting nanocomposites were subsequently drawn to manufacture monofilaments. Dissolution of a TP yarn was measured in the HexFlow RTM6 resin widely used in the aeronautical industry and in alternative epoxy resin compositions. Moreover, TP and MWNT concentration profiles were assessed using Raman spectroscopy after diffusion in the resin and the induced morphology gradients were observed by electron microscopy. Results evidence a faster dissolution for the phenoxy yarns compared to the PES ones and a better TP diffusion for the proposed resin compositions compared to RTM6. The extent of MWNT diffusion and the generated microstructures demonstrate that soluble TPs are adapted for the MWNT delivery in epoxy resins.