SELF-HEALING IN WOVEN COMPOSITE LAMINATES VIA BIOINSPIRED MICROVASCULAR NETWORKS


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ABSTRACT

The introduction of microvascular features to a structural material imparts multifunctional capabilities in otherwise quiescent, mechanical support by means of simple fluid circulation. Biomimetic microvascular networks have been created in fiber-reinforced composites via thermal depolymerization of interwoven sacrificial fibers providing added functionality. Thermal regulation, chemical reaction, magnetic field modulation, and conductivity accession have already been demonstrated. Here we develop a microvascular-based self-healing strategy for improvement in the damage resilience of fiber reinforced composite materials. Specifically, we have investigated healing a woven E-glass composite laminate after Mode-I interply delamination in a Double Cantilever Beam (DCB) geometry. A two-part healing chemistry based on a commercially available thermoset epoxy formulation is employed to rebond the fractured interface. Both components are initially sequestered in separate channels of a vascularized DCB specimen. Upon loading and subsequent crack propagation through the network, the healing agents are released and polymerize on contact to create new polymer material in the crack plane.

An attractive feature of this system is the renewable supply of healing agents leading to the repair of macro-scale delaminations over three consecutive heal cycles. Furthermore, the polymerization reaction occurs at room temperature under non-stoichiometric conditions, enabling practical in-situ healing. Through repeated mechanical testing of the healed DCB specimens, we have demonstrated a significant recovery (>100%) of the virgin mode-I fracture resistance for this latest class of self-healing polymer composite materials.