BIOLOGICALLY INSPIRED, STIMULI TRIGGERED SELF-HEALING IN ADVANCED COMPOSITES

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ABSTRACT

In the genre of self-healing fibre reinforced composite materials, autonomous healing has been achieved by the active (human intervention required) or passive release of a healing medium through the damage site. This approach requires the 'engineering' control of the storage medium's toughness for release and the development of bespoke resin chemistries to be compatible with the manufacturing route, to remain active whilst latent with the ability to recover full mechanical performance once a damage event occurs.

Numerous authors have investigated different self-healing methodologies for the repair of composite materials; a microencapsulated monomer and dispersed catalyst approach [1-5], and hollow glass fibres which break under impact damage [6-8], have been shown to be effective methods to 'heal' the damage site. These approaches require the damage to cleave open the storage vessel, whether capsules or fibres, which has been shown to yield healing potentials, when loaded in the compression after impact configuration, of 66%, for 125 μm DCPD-filled microcapsules with catalyst-containing wax microspheres of 135 μm average diameter [5], and, 95%, for 60 μm diameter fibres with a premixed 2-part epoxy [8].

In an effort to mitigate against the necessity to 'design' and 'tune' the storage medium such that it is triggered by the damage event, Trask *et al* [9-12], have investigated the concept of employing the host matrix as the containment structure for the healing medium. The premise behind this methodology is based upon the assumption that the global and local fracture toughness of the composite material remains unchanged, i.e. the vascule does not impart a material toughening effect but in terms of toughness can be 'viewed' as 'neutral' and not as a crack deflector or attractor. The success of this methodology has already been demonstrated within the open literature, see for example [11, 12], where the control of the vascule diameter, both for optimised delivery performance and for the controlled release of the healing medium can now be optimised for healing release.

The development of healing chemistries to remain active whilst latent, and then operate within the engineering domain, where they must survive the manufacturing stage, typically 180°C, and the operational life, minimum of 25 years, and still deploy and heal on demand, is an active research area with at present no viable system available. An alternative solution to the development of new resin chemistries is to develop a control system such that the healing medium is deployed from a controlled environment, i.e. a storage reservoir, to the area of interest at the moment of damage initiation. This approach offers a number of benefits namely the ability to change the healing resin throughout the life of the structure, to eliminate the associated parasitic mass of the healing medium within the structure, and to provide a feedback loop to the design authority indicating when healing has taken place. However, it should be recognized that this approach requires the inclusion of a sensor network (in this study the empty vascular network performs this function), the development of signal processing software and the inclusion of a remote delivery system (e.g. peristaltic pumps).

Ongoing research at Bristol University has successfully designed and integrated a vascular sensor and healing network within commercial closed-cell PVC foam composite sandwich panels and aerospace

grade composite laminates (IM7/8852) whereby the healing medium is deployed to the damage site once the sensor had been triggered. In this study, impact damage was used as the event stimuli to trigger the deployment of a healing medium held remotely in a storage reservoir. The success of this approach is currently being determined through the restoration of the mechanical performance using a compression-after impact testing methodology.

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