

MICROVASCULAR BASED SELF-HEALING POLYMERIC FOAMS

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ABSTRACT

The low density and high-energy absorption characteristics of closed-cell polymeric foams make them ideal candidates for core materials in structural sandwich panel applications. Energy absorption under fatigue and impact loading often occurs through macro-scale cellular damage, which can lead to core to face-sheet debonding and a reduction of in-plane compressive strength [1, 2]. Additionally, a prominent failure mode of core shear fracture (characterized by large diagonal fissures) can trigger core to face-sheet debonding under quasi-static loading conditions [3]. These failure mechanisms result in an overall reduction in structural integrity of the panel.

Here we present a microvascular based healing strategy to improve the resilience of rigid foam core materials. Specifically, we have investigated healing of brittle polyisocyanurate (PIR) foam after Mode I crack separation in a 3-point single edge notch bend (SENB) specimen [4]. A two-part healing chemistry based on a commercially available polyurethane (PUR) formulation is employed to rebond the interface. One healing component, consists of polymeric methylene diphenyl diisocyanate (pMDI). The second component consists of a proprietary chemical blend of polyols, catalysts, surfactants, flame-retardants, and blowing agents. Both components are initially sequestered in separate channels in a vascularized edge notch bend specimen. Upon loading and subsequent crack propagation through the network, the healing agents are released and polymerize on contact to create new foam material in the crack plane.



Figure 1: Photograph of healed PIR foam fracture specimen with regenerated polymeric foam material expelled from the crack plane (pMDI contained in top channel).

An attractive feature of this system is the expansive healing chemistry, leading to the potential for repair of macro-scale damage. Furthermore, the reaction occurs on the order of minutes at room temperature, enabling rapid in-situ healing. Through repeated mechanical testing of the healed SENB specimens, we have demonstrated a significant recovery of the virgin fracture toughness and stiffness (**Fig 2**) for this new class of cellular self-healing microvascular materials.

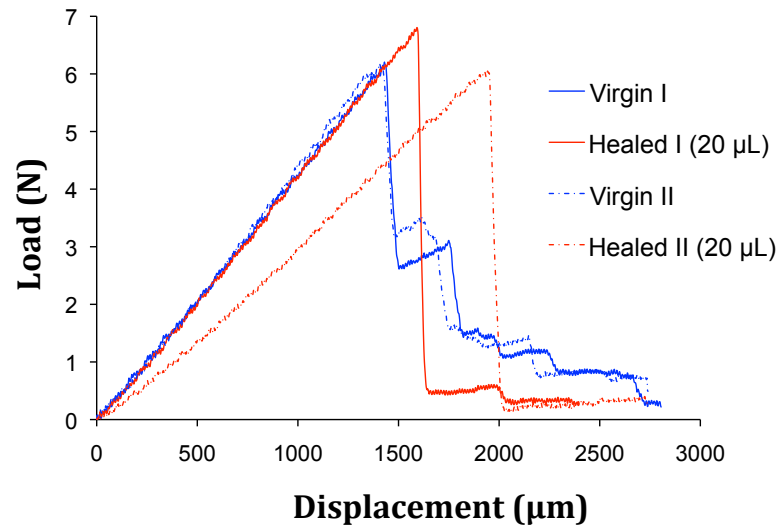


Figure 2: Representative load-displacement data for virgin fracture (blue) and healed (red) response, where 20 μ L of each component was delivered and tested after 24 hrs at room temperature.

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