MULTIFUNCTIONAL MICROVASCULAR COMPOSITE MATERIALS

S.R. White[1,5*], N.R. Sottos[2,5] J.S. Moore[3,5], A.P. Esser-Kahn[3,5], P. Thakre[5], H. Dong[3,5], J.F. Patrick[4,5]
[1] Aerospace Engineering, [2] Materials Science and Engineering, [3]Chemistry, [4]Civil Engineering, [5]Beckman Institute for Advanced Science and Technology
University of Illinois at Urbana-Champaign, Urbana, IL, USA
*swhite@illinois.edu

Keywords: *Biomimetics, Hybrid Materials, Composites, Fibers, Microfluidics*

Abstract

Living systems rely on pervasive vascular networks to enable a variety of biological function in both soft and hard tissue. The vasculature in composite structures such as osseous tissue in bone and tracheary elements in trees exemplify natural materials that are lightweight, high-strength, and capable of mass and energy transport. In contrast, synthetic composites possess high strength-to-weight ratio, but lack the dynamic functionality of their natural counterparts. Creating microvascular networks using methods that are fully compatible with current composite manufacturing processes is unmet technical challenge. We have recently shown that the introduction of sacrificial fibers into woven preforms enables the seamless fabrication of 3D microvascular composites that are both strong and multifunctional [1]. Underpinning the method is the efficient thermal depolymerization of catalyst-impregnated polylactide (PLA) fibers with simultaneous evaporative removal of the resulting lactide monomer, a process referred to as *Vaporization of Sacrificial Components* (VaSC), see Fig. 1. The hollow channels produced are high-fidelity inverse replicas of the original fiber's diameter and trajectory. The method has yielded microvascular fiber-reinforced composites with channels over one meter in length that can be subsequently filled with a variety of liquids including aqueous solutions, organic solvents, and liquid metals. By circulating fluids with unique physical properties, we demonstrate the ability to create a new generation of biphasic pluripotent composite materials in which the solid phase provides strength and form while the liquid phase provides interchangeable functionality.

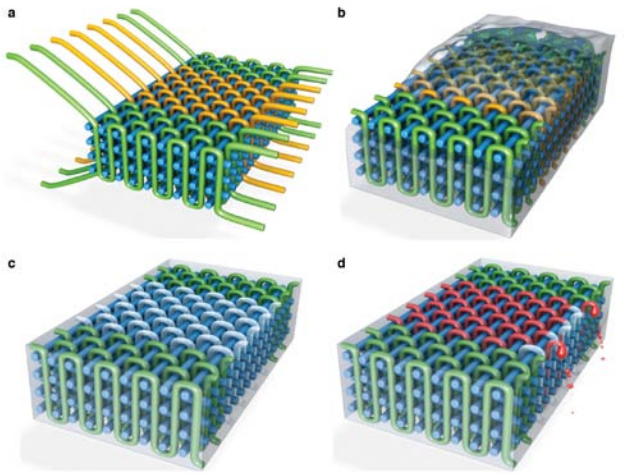

Fig.1. VaSC fabrication procedure. Schematic diagrams of a) Straight warp and weft yarns (light blue) with interwoven Z-fiber tows (dark blue) and sacrificial fibers (red) to form an orthogonal 3D structure; b) Epoxy resin infuses the preform; c) Thermal depolymerization and monomer vaporization results in 3D microvascular network integrated into a structural composite; d) Fluid (yellow) fills the microvascular channels. .

References

[1] A. Esser-Kahn, et al. *Advanced Materials*, in review (2011).