373b Structure Property Relationships for Nanostructured Biopolymeric Networks

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The network structure of a synthetic biopolymer is an important factor in the physical behavior of the material in both tissue engineering and drug delivery applications. Specifically, the network structure in a crosslinked polymer will influence nutrient or drug diffusion through the matrix, mechanical strength, swell potential, cell attachment, cell growth, and the degradation rate of the material. This work proposes to use a novel polymer structuring technique to fabricate biocompatible / biodegradable polymeric materials with controllable network architecture for tissue engineering applications. The particular target medical application for these materials involves the fabrication of a microvascular shunting device for the direct treatment of a common ocular disorder, central retinal vein occlusion. The technique for creating highly ordered polymer networks involves the generation of a number of lyotropic liquid crystalline (LLC) mesophases, each possessing ordered structures on the nanometer size scale, through the self assembly of amphiphilic surfactants in aqueous solution. It has been shown in previous work that by dispersing liquid monomer within these crystalline structures, LLCs can essentially be used as monomer templates forming highly ordered, nanostructured polymer networks upon photopolymerization.(1)

A number of LLC morphologies were investigated as monomer templates for UV-crosslinked networks of biocompatible poly(ethylene glycol) diacrylate (PEGDA). Results indicate that the material properties of structured PEGDA hydrogels are heavily influenced by the type of network structure with which the matrix is templated. For example, by transitioning from a disordered network or micellar template to a hexagonal or lamellar orientated network, a 100% increase in the volumetric swell potential of the hydrogel is obtained. Furthermore, a three fold increase in the compressive modulus of the material is also observed and can be attributed to the structural transition from disordered matrix architecture to a hexagonal type network structure. Finally, in addition to swelling and modulus behavior, it has been observed that the network architecture of templated PEGDA polymers has a direct influence over the transport behavior of this material. The hexagonal packed induced network structure results in a three fold increase in the release rate of small solutes when compared with the micellar templated sample, and yields an eight fold increase in release rate over a random oriented bulk polymer network. These results demonstrate the influence of specific ordered network structure on the physical properties of PEGDA hydrogels, and show promise towards the engineering of biodegradable materials using similar network structuring techniques.

1. Lester, C.L., Smith, S.M., Colson, C.D., Guymon, C.A., “Physical Properties of Hydrogels Synthesized from Lyotropic Liquid Crystalline Templates”, Chemistry of Materials, 2003, v.15, p. 3376-3384