Vat Photopolymerization of All-aromatic Polyimides

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Abstract

Poly(4,4'-oxydiphenylene pyromellitimide) (PMDA-ODA polyimide) is an all-aromatic polyimide and belongs to the class of high performance engineering polymers. It possesses exceptional thermal and thermomechanical properties, chemical resistance, and non-flammability, which makes it the ideal candidate for aerospace and military applications. However, its all-aromatic structure makes it insoluble in any known solvent and causes polymer degradation before flow. These properties complicate manufacturing of PMDA-ODA polyimide and limit its products to mainly films and coatings. The latter are processed through a soluble polyamic acid (PAA) precursor. We present a chemical strategy to enable advanced 3D printing of PMDA-ODA polyimide using vat photopolymerization (VP). VP is a 3D printing technique, which utilizes UV-light to crosslink polymer resins layer-by-layer. To enable UV-curing, we added an amino-functional methacrylate (DMAEMA) to the soluble PAA precursor to generate UV-sensitive PAA DMAEMA salts. Selective UV-curing of the PAA DMAEMA salts yielded an organogel. Photorheology showed short gel times and demonstrated sufficient mechanical integrity of the organogel for VP. Subsequent, drying and heating of the organogel removed the solvent, released the DMAEMA crosslinks and afforded the PMDA-ODA polyimide with an isotropic dimensional shrinkage of 48%. Overall, dynamic mechanical analysis confirmed excellent thermomechanical properties of the additively manufactured PMDA-ODA polyimide and thermogravimetric analysis demonstrated a thermal stability up to 500 °C.

Biography

Jana Herzberger received her PhD in Chemistry at the Johannes Gutenberg University of Mainz in Germany, were she became an expert on the synthesis and characterization of multi-functional polyethylene glycols for biomedical applications. Afterwards, she joined Dr. Timothy Long's research group at Virginia Tech (VT). At VT, she exploited 3D printing of high-performance polymers and investigated the structure-property relationship of polymers to enable Additive Manufacturing. She recently joined the University of Kentucky and Dr. Brad Berron's lab to study the synthesis of biocompatible hydrogels for cell encapsulation and cell isolation.