OAK RIDGE NATIONAL LABORATORY
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3D Printable Liquid Crystalline Elastomers with Tunable Shape Memory Behaviors and Bio-derived Renditions

Disclosure Number

201503489

Technology Summary

The invention describes a method to prepare a smectic main-chain liquid crystalline epoxy elastomer. Microstructures of the material including liquid crystallinity and crosslinking network were modified by adjusting the stoichiometric ratio of the reactants to tailor thermomechanical properties and shape memory behaviors. This invention includes a new class of materials based on epoxy and elastomer composites and processing solutions that will enable additive manufacturing of materials with enhanced cross-layer bonding and functionality such as shape shifting structures. Additive manufacturing of mechanically robust polymer composites requires localized heating and large thermal gradients that cause many conventional materials designed for polymer additive manufacturing to fail due to large macroscopic distortions. This problem is compounded by low adhesion between deposition layers. Our invention provides a specific solution that is centered on controlling the evolution of crystalline domains using directional electromagnetic fields and strong covalent bonding across layers. Materials with low coefficient of thermal expansion (CTE) can be obtained from liquid crystalline precursors. The a zero-CTE epoxy composite and a shape shifting liquid crystalline elastomeric composite disclosed here is compatible with additive manufacturing. The economic viability can be maintained by making use of low cost biopolymers (lignin) both as integral component and/or cross-linking agent. We will pursue a two-phase approach: 1. Conversion of a commercial epoxy into stable pellets for room temperature extrusion. Electromagnetic processing will provide the targeted deposition of power and thermal energy to control polymer morphology resulting in a benchmark zero-CTE epoxy resin. 2. Incorporation of lignin as a rigid crosslinker and compounding with other reinforcing agents such as glass fibers, to lower cost and to improve the strength and durability of the material.

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