RE-PROGRAMMABLE SHAPES IN LIQUID CRYSTAL ELASTOMER MICRO-ACTUATORS

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Liquid crystal elastomers (LCEs) have garnered much attention for their use in soft robotics and optics. Here we demonstrate micron-sized actuators designed as LCE microparticles capable of covalent bond exchange also known as having a covalent adaptable network or CAN to program a variety of shapes that can be reprogrammed. LCE microparticles (LCEMPs) were generated using a thiol-Michael dispersion reaction to yield particles with an average diameter of 7 ± 2 mm. The particles were designed with the latent ability to perform addition-fragmentation chain-transfer (AFT), by incorporating allyl sulfide functionality into the network. To program a new particle shape, the particles were cast on a substrate and compressed with a superstrate. By varying the programming conditions such as temperature, pressure, light exposure, and compressive superstrate, a variety of geometries were accessed. Upon irradiation with light, radicals generated from a pre-doped photoinitiator, generate a cascading bond exchange reaction of the allyl sulfides to reorganize the network to relieve the stress from the deformation event, ultimately programming and preserving a new shape. Utilizing the thermotropic nature of the LCs, once heated past the LC phase transition from nematic to isotropic (T_{NI}), the programmed prolate particle shape was recovered to its original spherical shape and was thermally cycled to switch between a high temperature spherical and low temperature prolate shape. Furthermore, the shape programming was erased by irradiating the particles at high temperature while they were in their temporary spherical shape. This enables the AFT mechanism to erase prior programming when the reaction is activated at the isotropic phase temperature. A permanent oblate shape and a switchable complex surface grating pattern was achieved by varying the programming conditions. These materials have applications for rheological control, optics, drug delivery, and micro-soft robotics.

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