Apr 05, 2018

Achieving Flexibility and Programmable Shape Changes in Polymeric Networks and Devices

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ABSTRACT:

Conjugated polymers combine the solution processibility of polymers with the electronic properties of conductors or semiconductors, enabling a variety of low-cost devices, including photovoltaics, transistors, and batteries. However, conjugated polymers have poor mechanical properties, limiting their viability for flexible devices. Molecular engineering of the semiconductive material can enhance mechanical properties but oftentimes is detrimental to electronic properties and overall device performance. In the first part of the talk, I will present a general approach to fabricating flexible bulk heterojunction organic photovoltaics (OPVs) through the incorporation of an elastic and mechanically robust interpenetrating network. Reactive small molecule thiol-enes are incorporated in the active layer through solution blending, casting, and post-deposition crosslinking. A thiol-ene network is formed through short, one-minute exposure to UV light or with an amine catalyst. This results in fully functional devices with significantly increased crack-to-onset strain and flexibility. The approach is compatible with a variety of donors and acceptors and results in significant enhancement of mechanical properties and device flexibility. In the second part of the talk, I will present work with thiol-ene liquid crystal polymer networks capable of complex and programmable shape changes. These liquid crystal networks respond to a variety of external stimuli and exhibit a large-amplitude and fully-reversible shape response. While prior work has used surface patterning to achieve complex, non-planar shapes, we demonstrate a straightforward mechanical imprinting technique along with tailoring of the network structure to achieve reversible, complex shape changes in liquid crystal elastomers. These materials are of interest for soft artificial robots and as shape-redponsive biomaterials.

We acknowledge the National Science Foundation (DMR- 1352099) and the Welch Foundation for Chemical Research C-1888.

BIOGRAPHY:

Rafael Verduzco is an Associate Professor in Chemical and Biomolecular Engineering and Materials Sciences and NanoEngineering at Rice University. Verduzco received his Ph. D. in Chemical Engineering from the California Institute of Technology in 2007 and his BS in Chemical Engineering from Rice University in 2001. The Verduzco laboratory uses a combination of materials synthesis and multi-scale characterization tools to develop new materials for organic photovoltaics, energy storage, antifouling coatings, water purification, and shape-programmable systems. Verduzco received an NSF CAREER award in 2015 for the study and development of all-conjugated block copolymers. He has led successful interdisciplinary projects supported by the National Science Foundation, the Welch Foundation, and the Department of Energy, and he organized the 2017 International Liquid Crystal Elastomers Conference. Verduzco is the Chair for the 2018 De Lange Conference on Bioelectronics and the first Gordon Research Conference on Bioelectronics, to be held in 2019.