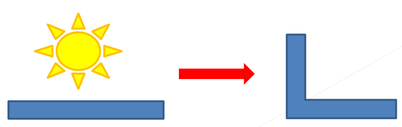
Building a Photoactive Material That Generates Mechanical Work When Exposed To Light

Vivian Ross – UCSB – Chemical Engineering
Geoffrey Hanson – Ventura College – Chemical Engineering
Advisor: Javier Read De Alaniz – Department of Chemistry, UCSB
Mentor: Kyle Clark
Funded by the United States Army's Institute for Collaborative Biotechnology

Introduction

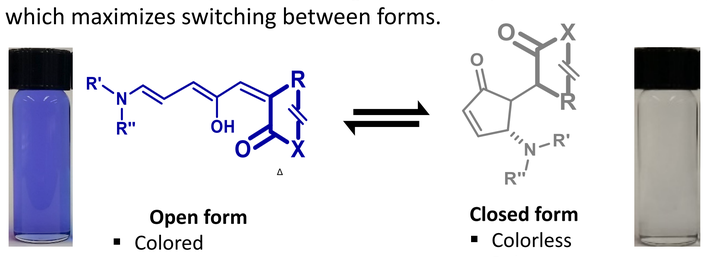
Current methods of extracting work from light energy are complex and slow. This project aims to generate work from light energy using photo-switches, molecules that change their structure when exposed to specific wavelengths of light. Specifically, the goal of this project is to incorporate photo-switches into elastomers in order to produce a materials system capable of generating mechanical work. This material could be used to create devices such as actuators, which convert signals into mechanical motion.



Simple actuator: the light causes the piece of plastic (blue) to bend

DASA

The photo-switches used in this project are donor-acceptor Stenhouse adducts (DASAs). DASAs offer several advantages to azobenzenes, the only other photo-switch successfully incorporated into a polymer. DASAs switch at wavelengths of visible light, not UV radiation, eliminating UV degradation. DASAs are also negative photochromes and have different absorption wavelengths in their open and closed forms, which maximizes switching between forms.

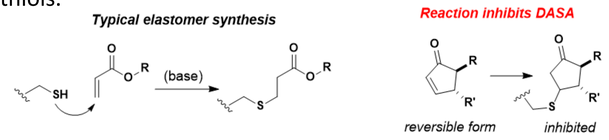


Open form
- Colored
- Non-polar

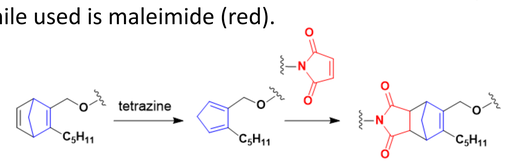
Closed form
- Colorless
- Polar

Compatibility

Many polymers are acrylate-thiol systems. However, DASAs are incompatible with these systems because they will not survive exposure to thiols.



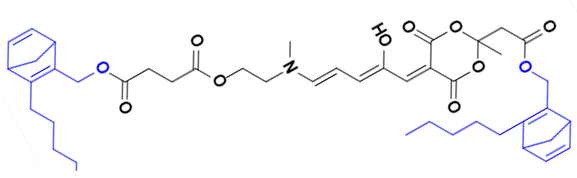
As a result, this project uses the Diels-Alder reaction, in which a diene reacts with a dienophile. The diene used is norbornadiene (blue), and the dienophile used is maleimide (red).



Does not react with DASA

Photo-Switch

A – Photo-Switch - A



- The photo-switch allows the polymer to generate work

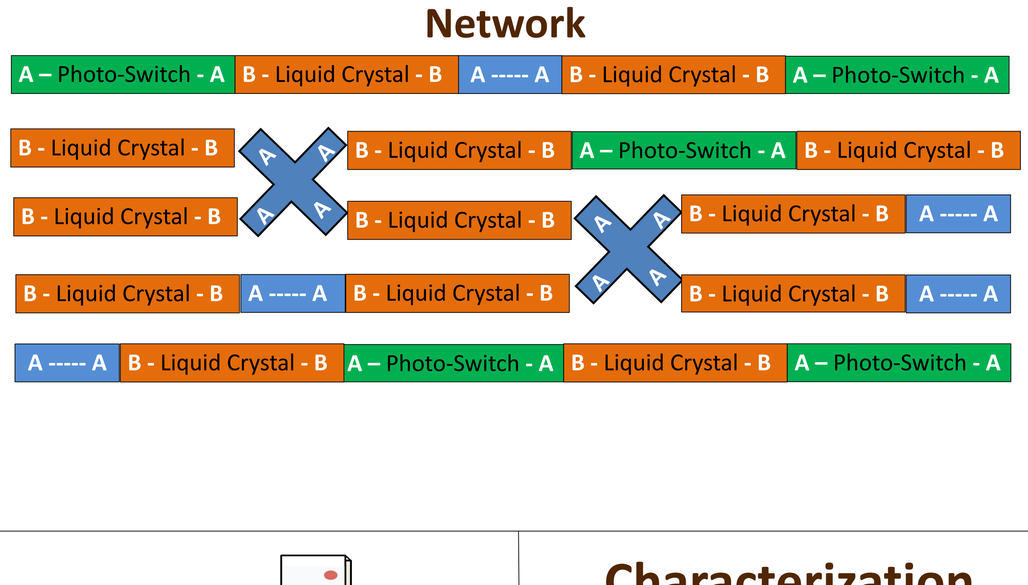
Liquid Crystal

B - Liquid Crystal - B

- The liquid crystal structure provides a method of alignment

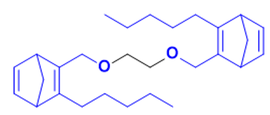
Strategy

Network



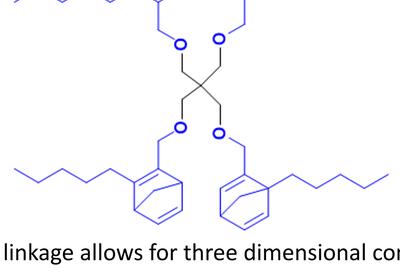
A ----- A

Simple Linkage



- The simple linkage provides a spacer between liquid crystals

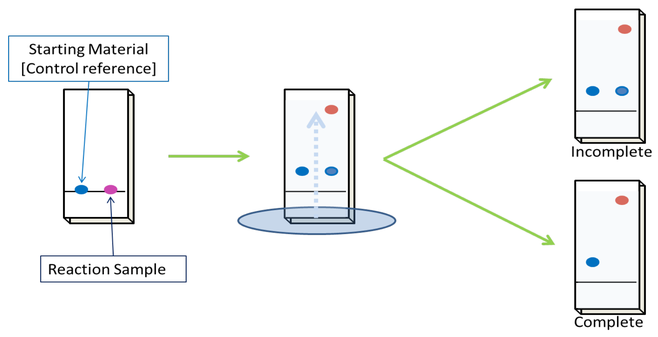
Cross-Linkage



- The cross linkage allows for three dimensional connectivity

Methods

Silica coated glass plates are spotted with two or more reference materials for comparison and exposed to a less polar mobile phase. The reference materials will travel at different rates based on their unique polarity (affinity for mobile phase) and can be examined under UV light or stain to determine the status of the reaction of interest.



Characterization

A prepared sample is suspended in a deuterated solvent and is placed inside of a magnetic field . In this field each unique hydrogen environment will require different amounts of energy to reach an excited state, As the resonant energy of the electron relaxation is measured the NMR imaging software generates a wave form for characterization analysis.

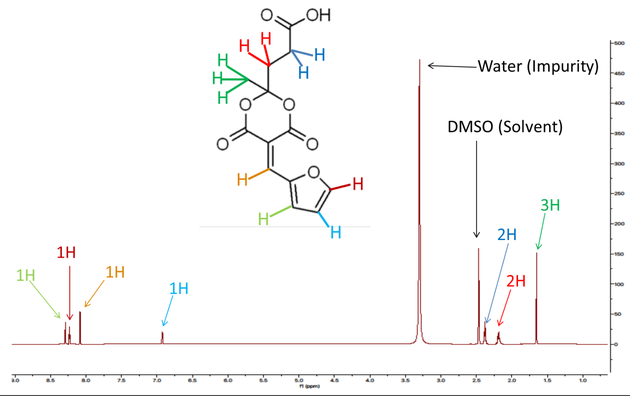


Photo-Switch Synthesis

- Synthesis of multiple photo-switches allows for systematic comparison

Future Plans

- Finish photo-switch synthesis
- Test and compare photo-switch switching responses
- Create polymer using Diels-Alder reactions

Institute for Collaborative Biotechnologies
Maria Teresa Napoli
Elliot Hong

US ARMY (AEOP HSAP/URAP)
Jennifer Ardouin

UCSB Chemistry Dept.
Javier Read de Alaniz
Kyle Clark
Friedrich Stricker

Funding and Support