Improvement of Luminescent Solar Concentrators using Liquid Crystal Polymer

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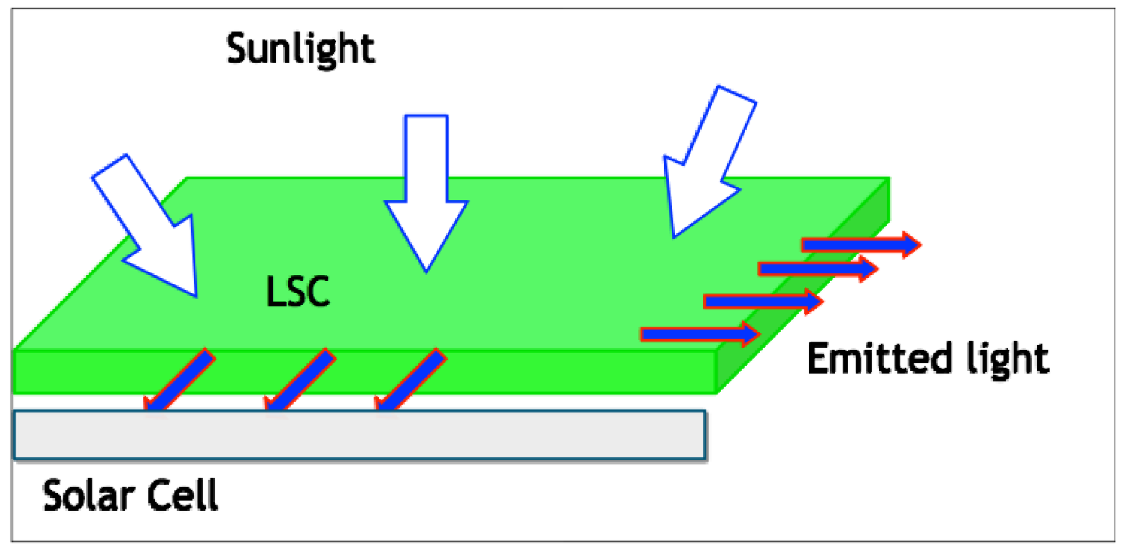
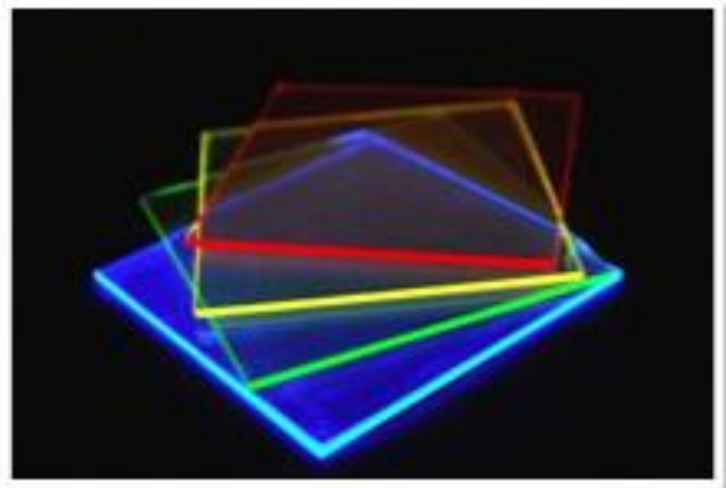
Abstract:

Luminescent solar concentrators (LSCs) incorporating a dye doped thin film coating can be used as a wave-guide to absorb and redirect light to coupled solar cells. Coatings including dyes dispersed in a liquid crystalline host can be used to redirect absorbed light preferentially to the edges of a concentrator for collection by solar cells. The goal of this project is to demonstrate that a liquid crystalline host (UCL--018) can improve the gain of a solar concentrator, and to design an LSC based on this technology. To do this, various liquid crystal alignments are tested, as well as different designs that incorporate liquid crystalline thin films.

Luminescent Solar Concentrators

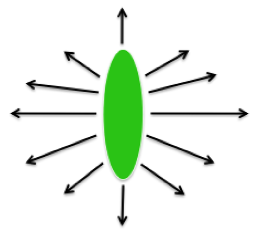
A Luminescent Solar Concentrator is a device used to **increase the current output** of a solar cell by **absorbing** and **re-emitting** light to the sides of the concentrator substrate where it can be collected with solar cells.

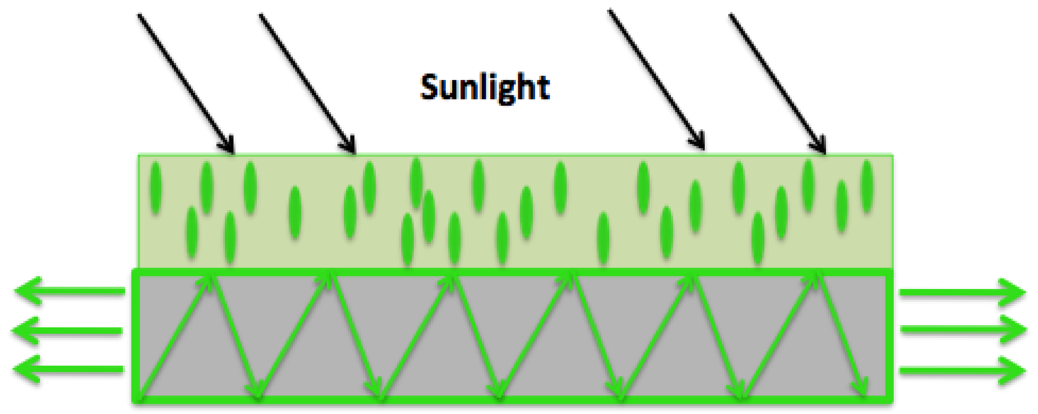




Luminescent Solar Concentrators (LSCs) use a sheet of transparent material (glass or plastic), doped with fluorophores: **organic dyes**, **quantum dots**, or **rare-earth complexes**.

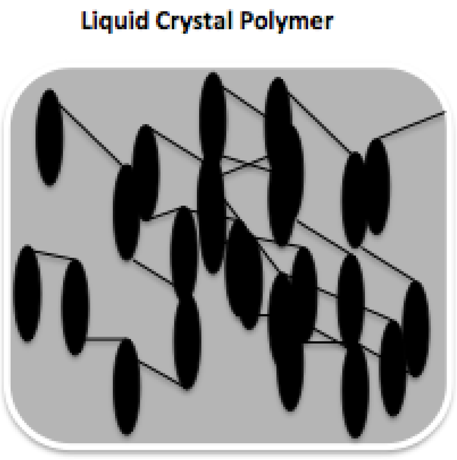
A **Luminescent dye** is a type of **fluorophore** that can absorb photons a specific band of wavelengths and re-emit them at a larger band of wavelengths.





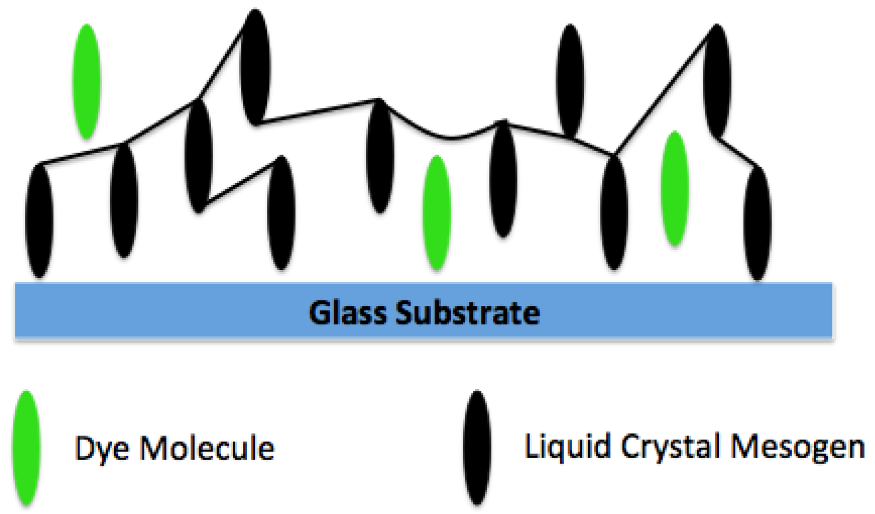
How do we control dye alignment??

Incorporate liquid crystal (UCL-018) into a thin film mixture as a "scaffold" to align dyes.The unique rod shape is ideal for this alignment.

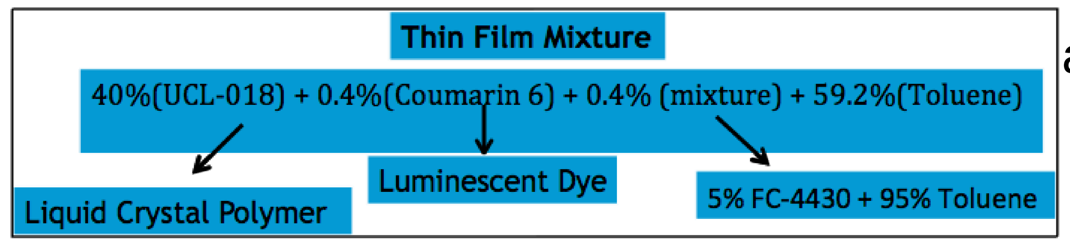


When we introduce the Liquid Crystal into the dye doped mixture it creates an alignment of both the molecules

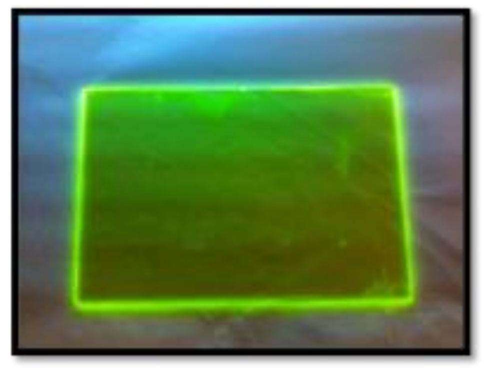
-Thermotropic
-Cross linking



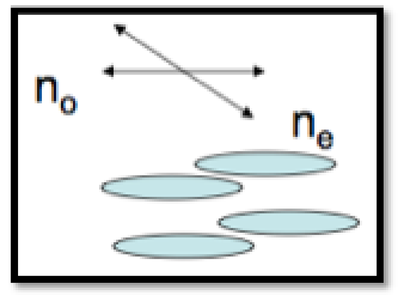
LSC Fabrication Process



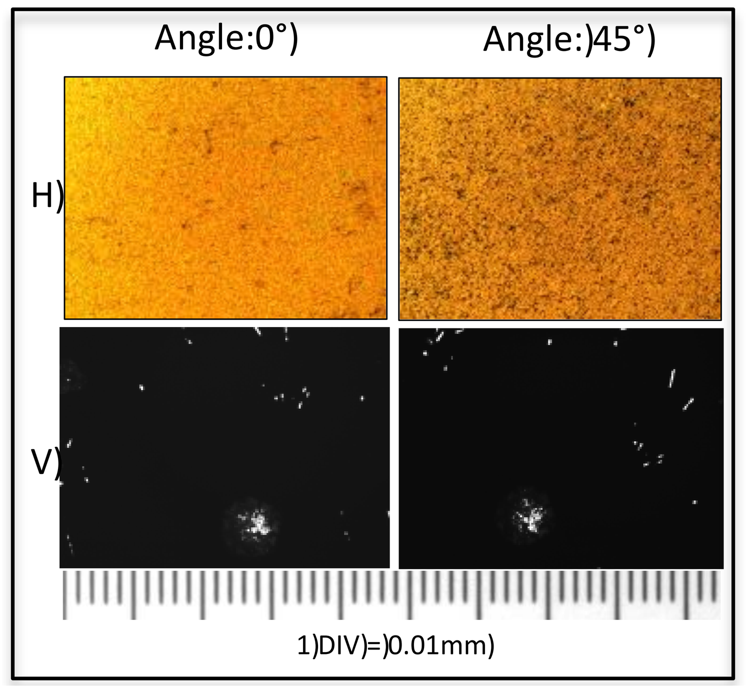
The thin film mixture is applied using a spin-coater, it is then placed under a UV lamp (see image to the right) where the cross-linking of polymer strands takes place



Liquid Crystal Birefringence

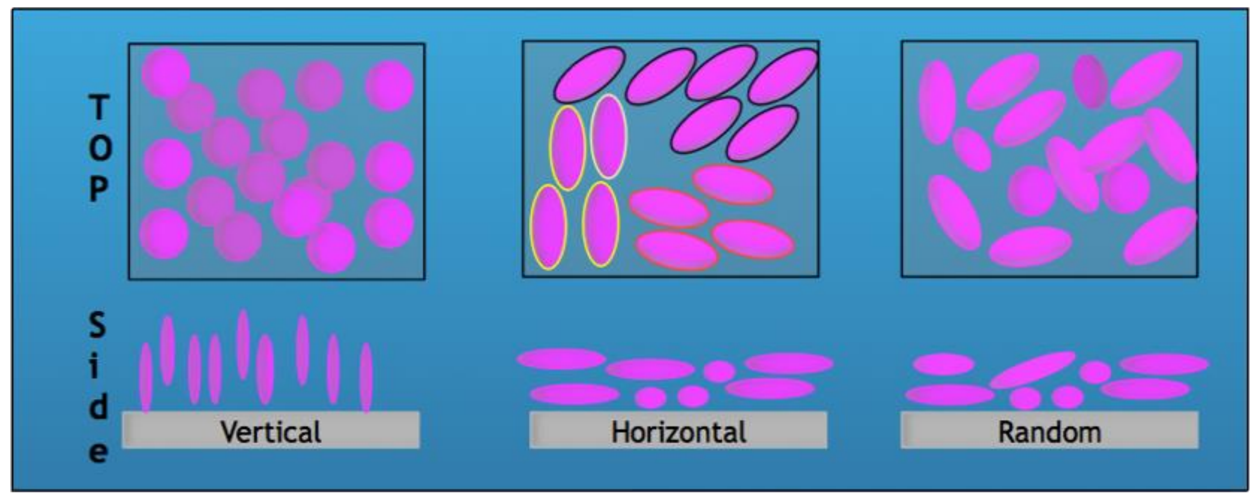


Using birefringence, we can place the samples under a cross-polarizing microscope to check the alignment of the polymer. The horizontally aligned sample will alternate between light and dark with each 45 degree rotation due to the anisotropy of the molecules.

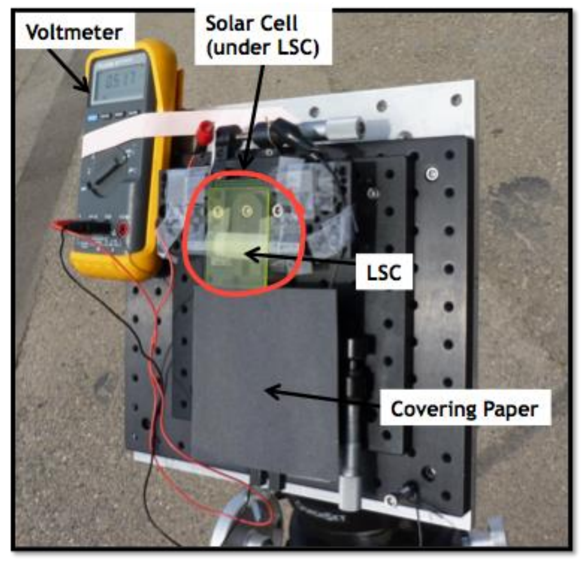


Project Goals

Show the benefits of liquid crystal polymer for dye alignment by achieving **a larger current gain(electrical current increase)** using a vertically aligned concentrator. We will test various orientations to show this.



Sample Testing



The LSCs are tested using natural sunlight and a voltmeter that takes current readings from the solar cell. These current readings are used to calculate the **gain** of the sample. **Gain** is the amount of current increase given by adding the LSC to the solar cell.

$$\% \text{ Gain} = \frac{I_{LSC} - I_0}{I_0} = \frac{\Delta I}{I_0}$$

Results:

Current / Gain Readings	Covered Reading: I_o (mA)	Uncovered Reading: I_{LSC} (mA)	Gain %: (I_{LSC}/I_o)-1
Randomly Aligned LSC	98.66	105.27	6.6%
Horizontally Aligned LSC	96.30	103.40	7.3%
Vertically Aligned LSC	97.05	104.63	7.8%

Acknowledgments

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