Development of Liquid Crystal Thin Films for Application in Photovoltaics

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Introduction

As the world progresses, there is rapid increasing energy demand and urgency to cut down on greenhouse gases; renewable and clean energy technology, such as solar, are in demand for a solution. Silicon derivatives of solar cells are currently the most commercially viable option, but other types, such as organic, perovskite, and multijunction [1], are currently being researched and steadily growing in efficiency. Organic photovoltaics (OPVs) are cost-effective in manufacturing [1 and 2], more durable than other materials [1 and 2], and less difficult to develop films of [2]. One form of organic molecule of particular interest in photovoltaics are organic liquid crystals (OLCs), which present a high amount of order and range of customizability, not only in their macroscopic ordering but also microscopic ordering [2]. Some of the downfalls is their current low efficiencies [2] and are sensitivity to impurities in LC phases.

Prior Work

- UV-Vis spectra shows optical band gaps of LC thin films with undoped and doped solutions with tetrabutylinammonium halides(TBAX, X=F, Br, I), having a tunable range of 1.3-2.1 eV.
- Polymer solution doped with TBA Br drop casted on Octadecyl trichlorosilane (OTS) coated substrate (b and c) observe to have best ordering and uniformity.

Overall Experimental Design

- Synthesis and Purification: Structural, Optical, Morphological, and Electrical.
- Characterization: Structural, Optical, Morphological, and Electrical.
- Dr. Cohn laboratory adapted procedure from Ros-Liu et al. [3] in synthesis of polymeric LC product seen in scheme 1. Several purification techniques used.

Thin Film Development

- (b) Solution Development
  - High boiling Point Co-Solvent (0.4:0:6 molar Diphenyl Ether:THF)
  - Tuning with different equivalents of TBA Br
- (c) Cleaning Substrates
  - Alconox, Acids and Bases [4], Organic Solvents [5]
- (d) Increasing surface attraction with surfactant coating
- (e & f) Thin film Fabrication
  - Drop casting or Spin Coating
- Characterization
  - UV/Vis Spec, AFM, Conductivity, XRD, Optical Microscope

Results

Synthesis and Purification of LC Polymer

- Synthesis did not scale up to produce a significant product yield
- 1-dodecylicxoycante was impure
- Several impurities in the crude reaction mixture
- Pyridine/Pyridinium salts, DMS, and carbamic acid byproduct
- Several purification techniques with differing purity obtained, never 100% purity
- Flash column and heating gently to evaporate solvents had the best purity

LC Thin Film Development

- All OTS dip coated films produced from all methods of cleaning were clear visually, but only substrates cleaned with boiling isopropanol were able to be become wet by THF or the polymer solution

Future Plans

- Optimize thin film fabrication methods (explore dip coating)
- Characterize uniform and ordered films with AFM, UV/Vis Spectroscopy, XRD, and Conductivity

Conclusions

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References