Introduction

A liquid crystal is state of matter that simultaneously displays properties of both a liquid and a solid. Liquid crystals have applications in liquid crystal displays (LCD's) and optical imaging technology. Liquid crystals or “mesogens” are created when molecules have both core (ex. aromatic) and chain (ex. alkyl group) structures. This allows the molecule to form a semi-ordered phase in between a solid and a liquid. In this experiment, liquid crystallinity was induced thermally to form rod-like semi-ordered phases.

Two different bisacid donors, tetraethyleneglycoxy-bis-4-benzoic acid (4EOBBA) and tetraethyleneglycoxy-bis-4-naphthoic acid (4EOBNA) were used as primary hydrogen bonding donors. 4,4-bipyridyl (BIPY) and 1,2-di(4-pyridyloxy)ethane (2RP) were used as primary hydrogen bonding acceptors. Inducing liquid crystallinity creates mesogenic properties that can display network properties. When heated and cooled, molecules melt and are free to align based on the hydrogen bonds that are formed. This system allows us to tune liquid crystallinity with both temperature and amount of hydrogen bonding present.

Disruption of the balance between core and chain components in a liquid crystal can lead to loss of liquid crystallinity. This project investigates the ramifications of varying the mole percent of hydrogen bond acceptors (2RP and bipy) to flexible hydrogen bond donors (4EOBBA and 4EOBNA) by using differential scanning calorimetry and polarizing light microscopy. This study uses means of “controlled contamination” with the given inhibitors: 2,2'-bipyridyl (BIPY) and 1,1,1-tris(4-pyridyloxymethylene) (3PD), and tetrakis(4-pyridyloxymethane) (4PD) to show how the mole percentages of these inhibitors affect the mesogenic properties of the complex. Additionally, studying the mesogenic properties of these complexes will give us a better understanding of liquid crystal design for potential application use.

Materials Used

Bisacid Donors:

Tetraethyleneglycoxy-bis-(4-benzoic acid) (4EOBBA)
Tetraethyleneglycoxy-bis-(4-naphthoic acid) (4EOBNA)

Hydrogen Bonding Acceptors:

1,2-Di(4-pyridyloxy)ethane (2RP)
4,4 Bipyridyl (BIPY)

Inhibitors:

2,2-Dimethyl-1,3-di(4-pyridyloxoy)propane (2PD)
1,1,1-Tris(4-pyridyloxymethylene) (3PD)
Tetrakis(4-pyridyloxymethane) (4PD)

Thermal Analysis

We studied our complexes using two different methods of thermal analysis. The first was differential scanning calorimetry (DSC) which was used to study thermal energy change in our complexes as a way of determining the temperatures where phase changes were occurring. The second method was through the use of polarizing light microscopy to which allowed for visual corroboration of the phase changes proposed by DSC.

Differential Scanning Calorimetry (DSC)

These curves show the peaks which indicate liquid crystal transitions and the general effect of which the inhibitor has on the liquid crystal phases.

Polarizing Light Microscopy

On the left is a smectic phase, and on the right is a nematic phase of a 4EOBNA, 85% 2RP, and 15% 2PD complex. Both pictures were taken during the cooling of the complex on the same slide.

Observations/Conclusions

- Multiple series of liquid crystalline supramolecular polymers were successfully assembled through hydrogen bonding.
- Smectic phases appear to be limited to low percentages of inhibitor inclusion for most series of complexes.
- Most of these polymers exhibit liquid crystalline characteristics up to 30% inhibitor addition into the network.
- The existence of an additional ring in 4EOBNA appears to increase the temperature where liquid crystalline properties exist compared to those prepared with 4EOBBA.

Acknowledgements

This work was funded by the National Science Foundation (Award Number 1105256), The Camille and Henry Dreyfus Foundation, and UWEC Office of Research and Sponsored Programs.