LIQUID CRYSTALS

Investigating the effects of terminal alkyl chain alterations on oxadiazole based liquid crystals

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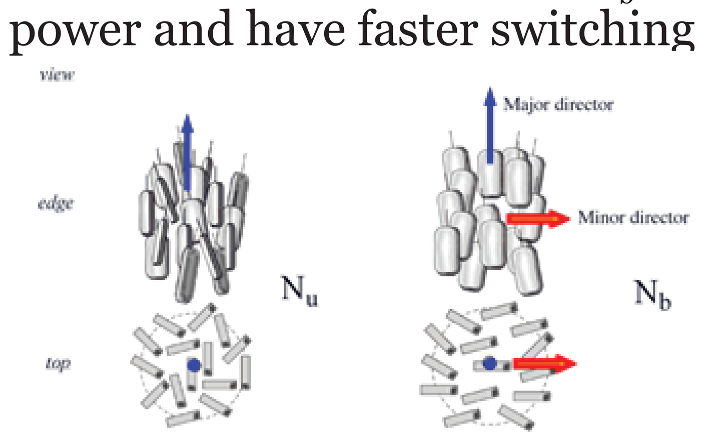
Introduction

- Liquid crystals are compounds that exhibit an intermediate phase between solid and liquid. Utilized in liquid crystal dispays (LCD).
- There are multiple different kinds of liquid crystal phases.
  --Nematic is best for LCD's due to fluidity and disorganization.
- In 1970, M.J. Freiser theorized certain nematic phase liquid crystals could have a major and minor axis, perpendicular to each other (see below).[1] The biaxial nematic phase (N_b) was hypothesized to consume less power and have faster switching times.



- 2004 the Samulski group discovered compounds with this N_b phase, but only accessible at very high temperatures.[2]

Previous Research

Professor Eric Scharrer and the Samulski group have been working together to synthesize molecules that exhibit the N_b phase at lower temperatures, with the goal of achieving room temperature.

The initial unsubstituted butoxy oxadiazole bisphenol (ODBP) liquid crystal molecule (Figure 1) had very high nematic phase temperatures. Upon the addition of lateral methyl groups not only does the nematic onset temperature become lowered, but when cooled it can stay in this phase until room temperature (Figure 2).[3]

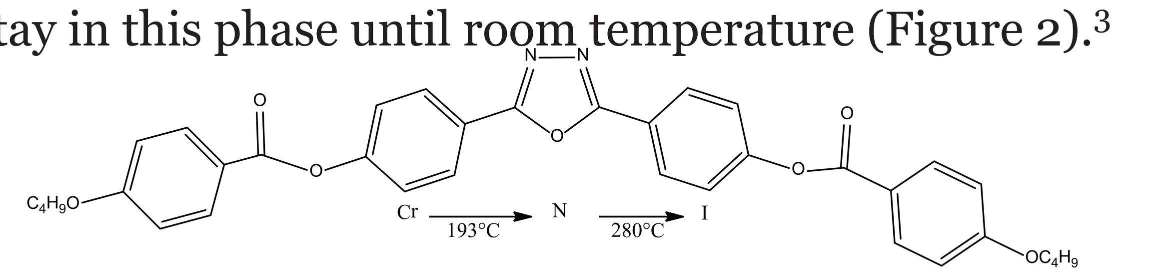


Figure 1. Phase behavior of OC4 unsubstituted ODBP

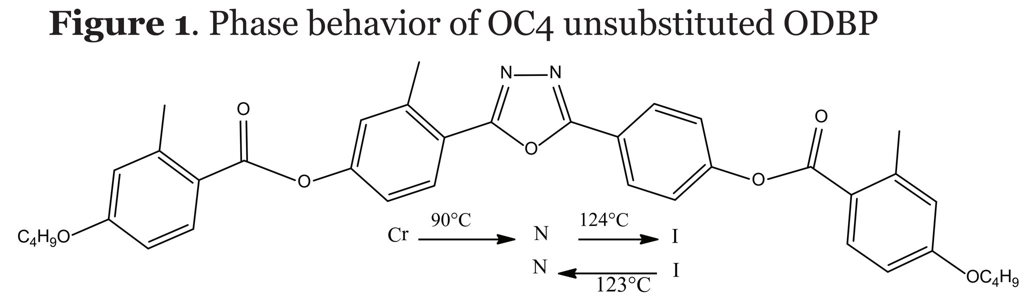


Figure 2. Phase behavior of OC4 dimethylated ODBP

An issue with these forms of the ODBP molecule is that although they remain in the nematic phase, they are no longer fluid enough to be practical for industrial use. Previous research has found that the incorporation of lateral halogens has shown promise in allowing access to a lower temperature nematic phase.[3]

Currently students have been working with fluorinated, chlorinated, or brominated versions of the ODBP molecule which have proven to be very promising (Figure 3).

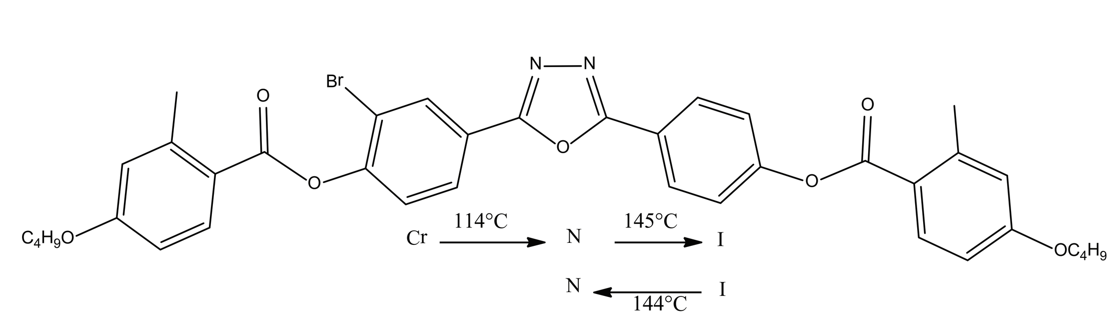
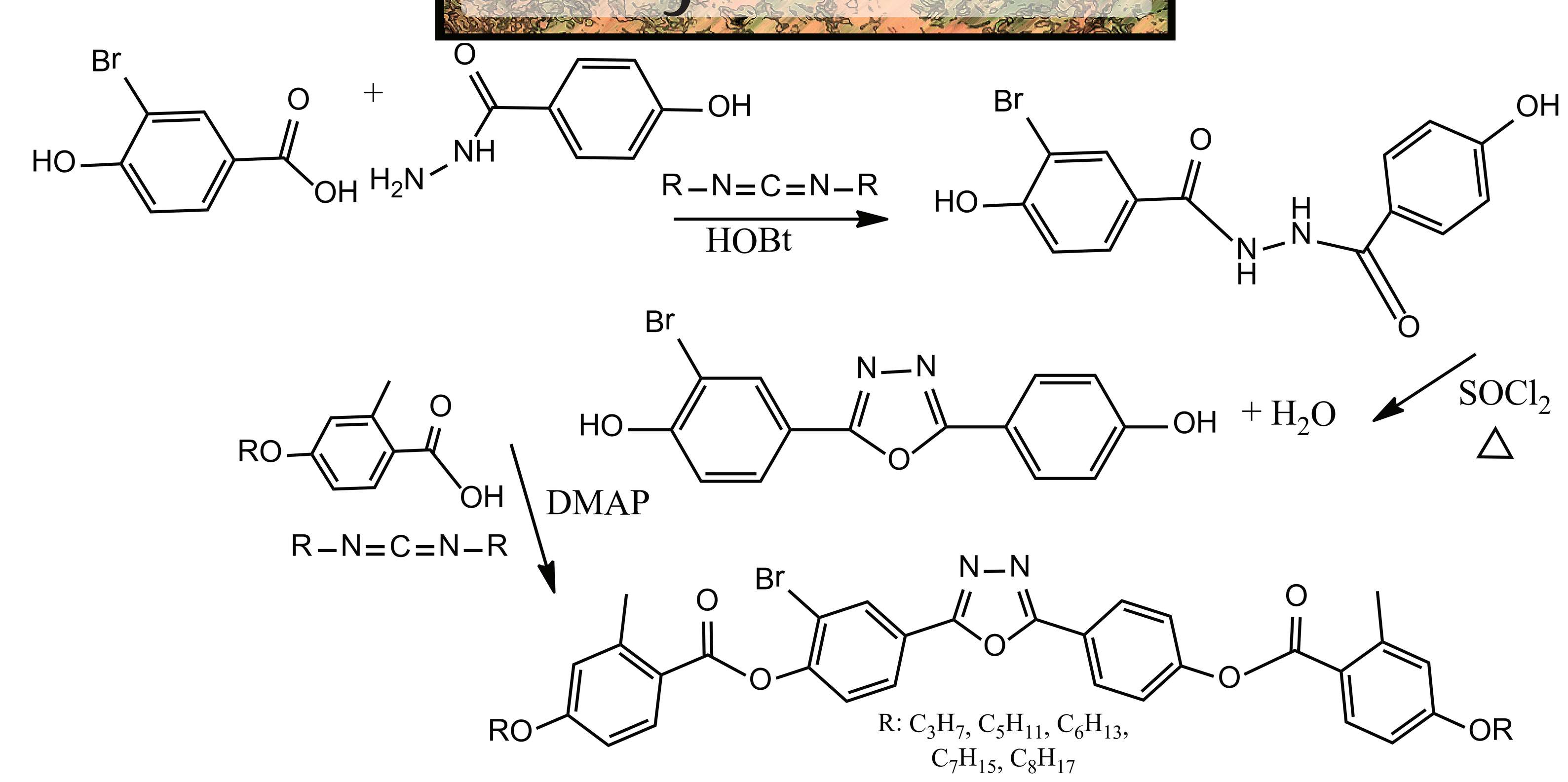


Figure 3. Phase behavior of OC4 bromine ODBP derivative

Goals

The goal of this research is to alter the length of the carbon chains on the ends of the molecule and see if the molecule can stay in a fluid nematic phase at room temperature. Previous research has experimented with 4-carbon and 12-carbon length molecules. I have synthesized derivatives with alkyl chains ranging from C_5H_{11} to C_9H_{19}.

Synthesis



*Characterized by H-NMR and purified by flash chromatography

Phase Behavior & Analysis

In order to be analyzed the compound is viewed under a polarizing microscope with a heating apparatus as phase transitions are noted. During cooling, the cover slip is pressed upon to check for fluidity.

To more accurately find phase transition temperatures, the compounds are also put through a differential scanning calorimeter (DSC) which will heat and cool the molecules and produce a peak where each phase transition occurs (Figure 4).

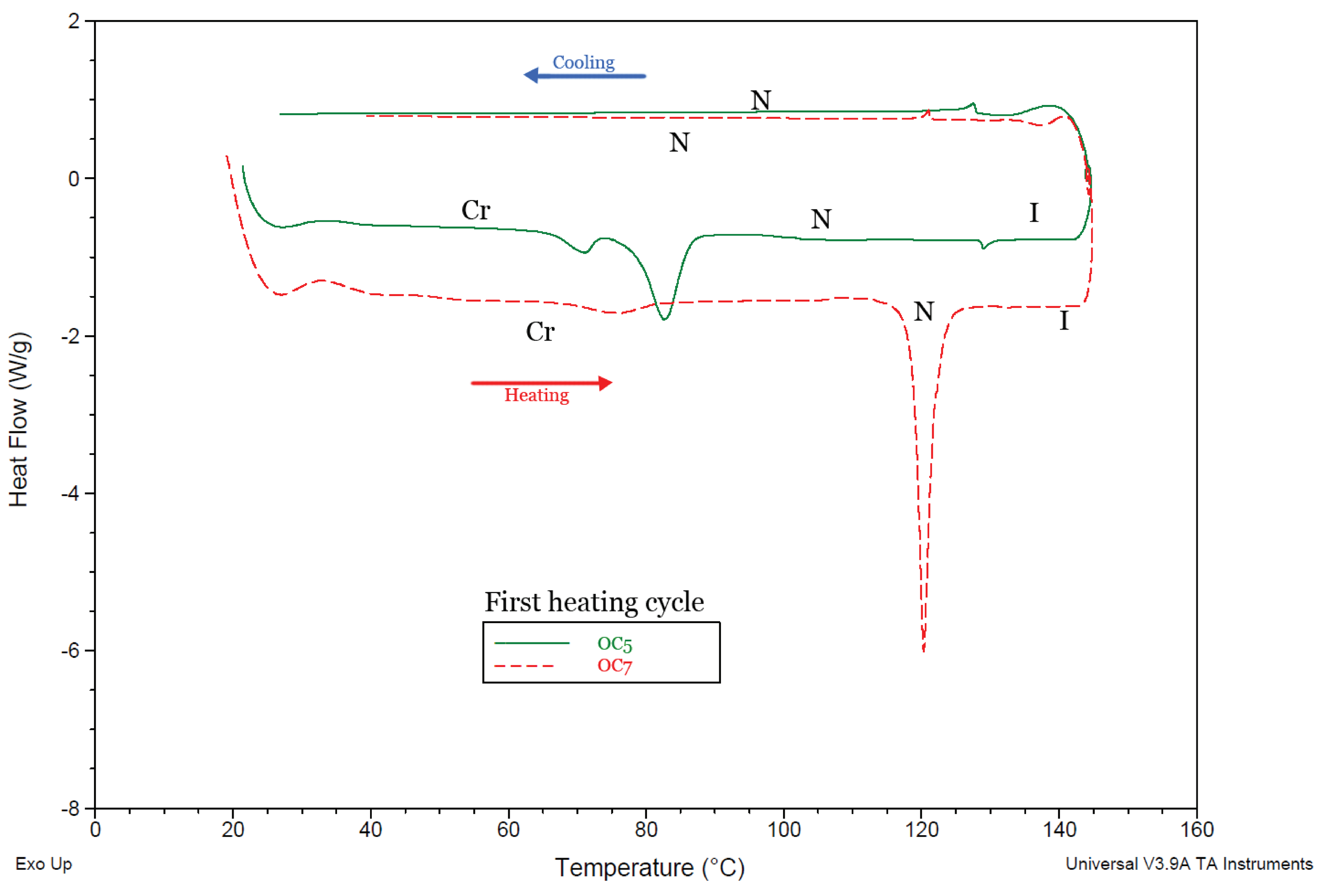
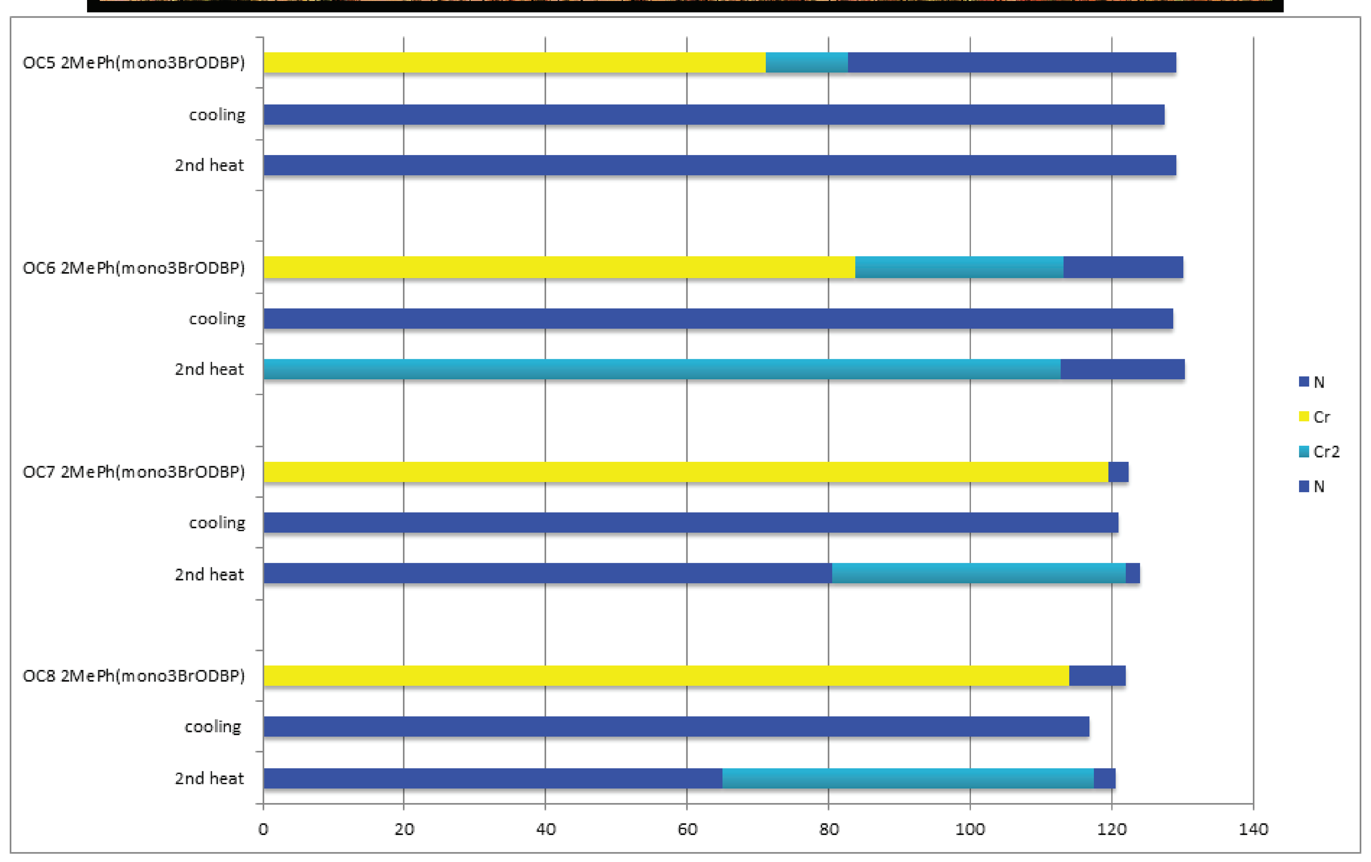


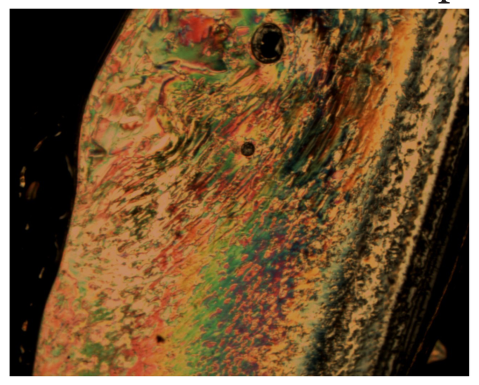
Figure 4. DSC thermogram of two molecules in their first heating and cooling.

Phase Summary



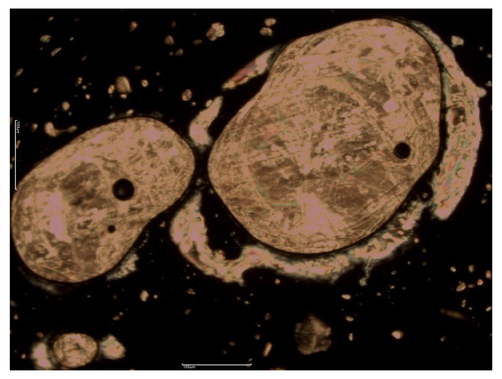
As shown in the graph above, the OC5 derivative displayed the lowest nematic onset temperature followed by OC6, OC8, and then OC7. All of these compounds remained in the nematic phase until room temperature upon cooling. However OC7 and OC8 did show more fluidity in the cooler temperatures, 25-30°C, than the other two compounds.

Pictures taken with the polarizing microscope:



OC5 nematic phase, 32°C; Cooling

OC7 nematic phase, 26°C; Cooling



OC8 nematic phase, 50°C; Cooling

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References:

[1]Freiser, M.J.; *phys. Rev. Lett.*; **1970,** 24, 1041.
[2]Dingemans, T.J.; Madsen, L.A.; Nakata, M.; Samulski, E.T.; *Phys. Rev. Lett.* **2004,** 92,12.
[3]Scharrer, E.; Speetjens, F.; Lindborg, J.; Tauscher, T.; LaFemina, N.; Nguyen, J.; Samulski, E.; Vita, F.; Francescangeli, O; *J. Mater. Chem.*, **2012**, 22, 22558