Confinement of 5CB Between Lyotropic Bilayers

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We have attempted to confine a hydrophobic liquid crystal (5CB) within bilayers of lipid-resembling liquid crystal (DDAB).

After creating this system, we wish to gather optical data for this mixture.
Why?

- Bilayers in the body.
- Drug delivery and Transport.
Rod-like

Disc-Shaped

Example of a Nematic: P-Azoxylanisole (PAA)

$\text{CH}_3 - \text{CH} = N = N - \text{CH}_3$

Terminal Group  Core  Terminal Group

Nematic

Columnar
Phases

- Smectic A
- Nematic
- Isotropic

Temperature
Liquid Crystals Used

5CB - (4cyano- 4’-pentylbiphenyl)
  ◦ Thermotropic liquid crystal.
    − Phase change $f(T, P)$

 DDAB - Dimethyldioctadecylammonium bromide
  ◦ Lyotropic liquid crystal.
    − Phase change $f(T, \text{Concentration})$
Microemulsion

\[
\text{OIL} + \text{H}_2\text{O} + \text{Surfactant} = \text{Microemulsion}
\]

5CB + H\text{H}_2\text{O} + \text{DDAB} = \text{Microemulsion}
Micelle

Reverse Micelle of Water in Oil

• Hydrophobic tails face outward.
• Hydrophilic heads face inward.
• Water is trapped inside.

Micelle of Oil in Water

• Hydrophilic heads face outward.
• Hydrophobic tails face inward.
• Oil (5CB) is trapped inside.
Goal

- Change concentration ($\Phi =$% {75% DDAB and 25% $H_2O$}) of Microemulsion.
  - $\Phi=0\%$ to $90\%$.

- Observe how Orientational Ordering changes as a function of $T$ and Concentration.

- Map a phase diagram for our system.
Birefringence

- Refraction of light waves.
- Propagation of light changed by medium.
Goal–Revised

- Birefringence as $f(T, \Phi)$.
  - Vary $\Phi$ from 0 to 90%

- Use Birefringence data to understand orientational ordering.
Birefringence Vs. Temperature (°C)

Birefringence vs. Temperature (100% 5CB)

Temperature °C

Birefringence
In liquid crystal systems, alignment is very important.
  ◦ Polarization

Without surface treatment.
  ◦ Homeotropic.
  ◦ Isotropic.
In Liquid crystal systems, alignment is very important.
- Polarization

With Surface Treatment
- Parallel alignment.

![Diagram of liquid crystal alignment](attachment:liquid_crystal_alignment.png)
Originally, sample cells were prepared using a mixture of 1% Polyvinyl Alcohol (PVA), and 99% Distilled Water, as a surface treatment.

- PVA in our system suspected to result in a homeotropic alignment
- Surface anchoring energies were not strong enough for parallel alignment.

MEOH solution (N-OctadecylDimethyl[3-(Trimethoxysilyl) Propyl) surface treatment produces the desired Parallel Alignment.

- Treatment is 95% {95% ethyl alcohol and 5% distilled water} and 5% MEOH Solution
Observations

- Seemingly Isotropic at all $T$ for samples when $\Phi < 0.6$.
  - Observed Transparent Nematic Phase (TN)
  - Thin samples succumb to homeotropic anchoring.
    - Unable to detect Nematic phase under cross polarization (Yamamoto & Tanaka 2001)

- Appearance of “Maltese Cross” structure
  - Reversible phase separation
  - Phase separations occur with low anchoring energies within the Nematic phase (Matsuyama 2012)
Rubbed 10 times with .01 PVA solution .65 (.75ddab+.25WATER) / .35 (5CB)
17:54:12 1-22-2013
Temperature: 30.9 C
Rubbed 15 times with .01 PVA solution .80 (.75ddab+.25WATER) / .20 (5CB)
16:22:03 1-22-2013
Temperature: 31.9 C

100µm
MeOH .05 solution rubbed 40 times. .85 (.75ddab+.25WATER) / .15 (5CB) [20x mag]
13:09:58 3-5-2013
Temperature: 46.9 C
MeOH .05 solution rubbed 40 times. .9 (.75ddab+.25WATER) / .1 (5CB) [10x mag]
12:56:25 3-15-2013
Temperature: 35.5 C
Phase Diagram

- I-TN (theory)
- Phase separation
- Static light scattering
- Microscope observation
- DSC
- Dynamic light scattering
- Dynamic light scattering

**Graph 1: Phase Diagram**
- Isotropic
- TN+N 2 phase
- TN phase

**Graph 2: Temperature vs. Concentration**
- Isotropic
- Lamellar
- $\Phi$(DDAB + 25% Water)
Continuing Research

- Thick Sample (~1mm)
- Pinpoint $\Phi$ for the onset of Lamellar phase.
  - Between $\Phi = 0.65$ and 0.75.
- Complete phase diagram.
- Birefringence Measurements.
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Professor Noel A. Clark of University of Boulder, CO, has drawn our attention to this problem.
Thank You
Cross Polarizers, 20X Magnification, Thin Film, MEOH Surface Treatment, .15- 5CB + .6375- DDBA + .2125- H2O, Slide DRH-005
Temperature: 51.7°C