Confinement of 5CB Between Lyotropic Bilayers

Cory Dolbashian
Dr. Rizwan Mahmood
Physics Dept.
Slippery Rock University
We have confined 5CB, a calamatic thermotropic liquid crystal, between lamellar bilayers formed by the lyotropic lipid DDAB, a double tailed ionic surfactant.

Bilayers were swollen by the addition of an anisotropic liquid crystal 5CB.

We have attempted to gather birefringence data on this mixture to understand how orientational ordering is affected by a change in temperature (T) and concentration of the DDAB and H₂O mixture (Φ).
Disc-Shaped

Rod-like

Example of a Nematic: P-Azoxylanisole (PAA)

\[
\begin{align*}
\text{CH}_3 &- 0 - \text{\(\bigcirc\)} - N = N - \text{\(\bigcirc\)} - 0 - \text{CH}_3 \\
\text{Terminal Group} & & \text{Core} & & \text{Terminal Group}
\end{align*}
\]
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 + \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 is trapped inside.
Goal

- Change concentration ($\Phi = \% \{75\% \text{ DDAB and } 25\% \text{ H}_2\text{O}\}$) 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
Sample Preparation

- 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 (.75 ddab + .25 WATER) / .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
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
Continuing Research

- Thick Sample (~1mm)
- Pinpoint $\Phi$ for the onset of Lamellar phase
  - Between 0.65–0.75
- Complete phase diagram
- Birefringence Measurements
Acknowledgements

- We would like to thank the Dean’s office for providing funding and support for the project.
- Professor Noel A. Clark of University of Boulder, CO, has drawn our attention to this problem.
Cross Polarizers, 20X Magnification, Thin Film, MEOH Surface Treatment, .09-5CB + .6825- DDBA + .2275- H2O, Slide DRH-012
Temperature: 88.4°C

10% 5CB 88.4C
Cross Polarizers, 10X Magnification, Thin Film, MEOH Surface Treatment, .10- 5CB + .6750- DDBA + .2250- H2O, Slide DRH-013
Temperature: 79.1 C

10% 5CB 79.1C