First Bent-Core Nematic Liquid Crystal Elastomer: Characterization and Giant Flexoelectric Response

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Purpose

• Synthesis and Production of Bent-Core Nematic Liquid Crystalline Elastomers (BCLCE) see Raphael Verduzco et al. talk from Thursday Bent-Core LC Elastomers and Side-Group LC Polymers Using Reactive Bent-Core Mesogens

• Study the Properties of a BCLCE Including Giant Flexoelectricity ($e_3 \sim 30 \text{nC/m}$)

• Create a simple demonstration of a Giant Flexoelectric Generator
\[ \vec{P}_f = e_1 \vec{n} \text{ div } \vec{n} + e_3 \text{ curl } \vec{n} \times \vec{n} \]

Macroscopic Demonstration of Alignment to a Curved Surface

Photo by James Maxwell
Discovery of Giant Flexoelectricity in Bent-Core Nematic Liquid Crystals

1000 Times Bigger Than Rod Like Molecules

100 Times Bigger Than Predicted for Bent-Core

Our answer

Clusters are in 87 phase (polarization* and layer modulated**) structures

Note: this has both in layer and out of layer parts, due to SmCG structure with out of layer polarization.

Length scale:
\(~50\text{nm}\)

Clusters oriented in polarization direction according to the bend direction, but this orientation strongly depend on bend/electric field.

A. Jákli, J. Harden, J. Gleeson, S. Sprunt, 12th International Conference on Ferroelectric Liquid Crystals 2009
Why make a BCLCE?

- Solves the Leaking Problem (Material eventually pumps out of cell if it is fluid.)
- Solves the Shorting Out problem
- Lower and Wider Temperature Range
- We Love Bent Core Molecules!!!
Components of the BCLCE

See R. Verduzco talk for ILCEC 2009
Below $T_{NI}$

113°C

Polarizer at 0°

Above $T_{NI}$

130°C

Polarizer at 45°

$T_{NI} = 120°C$
Measuring Change of Length vs Temperature in Crossed Polarizers
Relative Length $\lambda = L/L_0$ vs Temperature ($^\circ$C)

- $a = 0.0800$
- $b = 109$

Equation:

\[ y = 1 + a \times (b - x)^{1/3} \]
Measurement of the Flexoelectric Coefficient
Measurement of the Flexoelectric Coefficient
Video of Giant Flexoelectric Effect

http://www.lci.kent.edu/PI/Jakli/gallery.html
Oscilloscope with Flexing by Hand

![Oscilloscope Graph]

- Voltage (V)
- Time (seconds)

http://www.e-lc.org/presentations/docs/2009_10_02_11_26_51
Summary

Giant Flexoelectric Polarization exists for BCLCE ~30nC/m
- Control Groups and Isotropic Phase show no such effect

~4mm x 4mm x 0.3mm can produce 20mV

Currently plan to work on converse effect where a field
will provide a cylindrical curvature


http://www.e-lc.org/presentations/docs/2009_10_02_11_26_51
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New Liquid Materials Facility, Kent State University