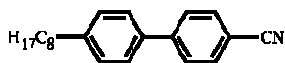


Abstract

The photomechanical properties of the liquid crystal 8CB doped with the organic molecule 7AB were examined with atomic force microscopy by using different cantilevers of varying stiffnesses with different AFM techniques. Such research of light-activated materials is expected to play an important role in industry in the near future. Unexpected adhesion between tip and sample, and viscoelastic properties of 8CB were observed. The work done on the sample was calculated to be 7×10^{-13} J.

What is a liquid crystal?

Liquid crystals are materials that exhibit properties between those of a liquid and a solid. A liquid crystal flows like a liquid but displays some ordering similar to conventional solids. This project focuses on the smectic-A phase of the liquid crystal 8CB.



Structure of the liquid crystal molecule 8CB. Approximate shape: rigid rod.



In the smectic-A liquid crystal phase, the molecules display orientational and positional order. As a result, distinct layers are formed.

Liquid crystals respond to light

To study photomechanical properties of liquid crystals, the liquid crystal 8CB was used as the host for the photoactive dye molecule 7AB.

Before UV irradiation



At room temperature the dye molecule is in its elongated trans-isomer form and fits into the smectic layers of the host 8CB (left).

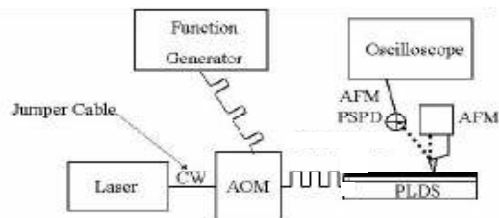
When irradiated with UV light, 7AB undergoes a conformational change to its bent cis-isomer. The cis-isomer does not fit into the smectic layers. As a result, the 7AB molecules are expelled to positions in between the layers. This phenomenon is known as nanophase segregation (right).

After UV irradiation



Experimental setup and measurement techniques

As described above, nanophase segregation takes place as a result of irradiating the doped liquid crystal sample with a UV light source. The resultant increase in layer spacing of the host 8CB should have been observed and detected with the Atomic Force Microscope (AFM). The pulsed light delivery system (PLDS) would then have been used to irradiate the sample with visible light. This should have induced a rapid back relaxation of 7AB to the stable trans form and returned the layer spacing to its initial state.



- A cantilever is brought into contact with the sample surface.
- The tip is then held stationary with respect to the sample surface, which is illuminated from below by the PLDS.
- The visible light from the PLDS is alternated with light from the UV lamp in order to observe the effects of each on the sample.
- As the layer spacing of the host molecule 8CB changes, the cantilever's position changes. These changes in height correspond to a change in the V_{A-B} voltage signal.
- The V_{A-B} is recorded by an oscilloscope in order to plot voltage as a function of time.

Problems encountered

Many obstacles were encountered, many of which were overcome. Due to time limitations some were not resolved; therefore, experimentation was altered, and the original question was modified.

Source	Power Output (mW)
Laser	4.5
1" Jumper Cable	0.0038
PLDS	0.00012

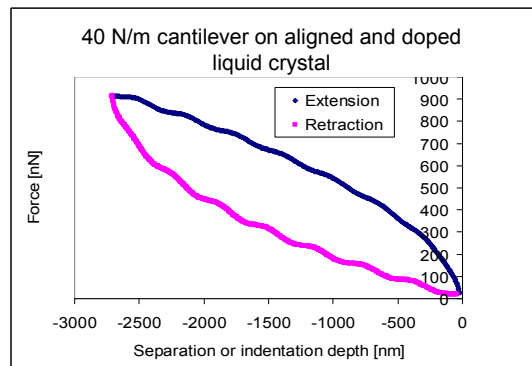


Deterioration of cables: the PLDS had a lower than expected power output. Unfortunately, as equipment ages, and components deteriorate, it can become difficult to find the source of such attenuation. As seen in the table above, the power loss in the PLDS was significant.

An unforeseen problem: the host, 8CB, exhibited unexpected forces of adhesion and viscoelasticity. Consequently, the cantilever was absorbed into the sample, as seen above in the picture of the video monitor. As a result, it was impossible to approach the sample surface with conventional methods.

Results and conclusions

The liquid crystal sample proved to be quite unusual in its interaction with the AFM probes. Under the given conditions, the initial goal of detecting height changes due to illumination was not achievable. Therefore, it was decided to explore the unusual properties of our samples by taking and analyzing force curves.



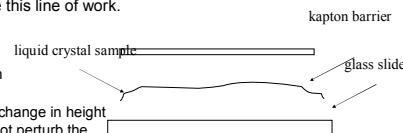
The figure above shows a force curve where the tip and sample were in contact throughout the measurement. Also, the tip was completely immersed in the liquid crystal (refer to the figure at the left). Qualitatively, one can see that the viscoelastic properties of the liquid crystal resulted in an unusually large amount of work done on the cantilever as depicted by the huge area between curves of extension and retraction. Quantitatively the work done was calculated to be approximately 7×10^{-13} J. J.

Recommendations for future work

Though many obstacles were met, potential solutions were hypothesized. Due to time constraints it was not possible to implement all of these ideas. The following, are two important recommendations for future researchers that continue this line of work.

Kapton barrier

- Provides a layer on top of the sample that acts as a barrier, which can be contacted by the AFM tip
- Changes in layer spacing lead to change in height of the barrier, which hopefully will not perturb the smectic layers.



Force curves

- The force curve to the left demonstrates that the tip is doing work on the sample. This physical interaction can be explored further by varying conditions under which the curves are taken.
- Taking force curves before and after illumination may yield different values for viscoelasticity and/or elastic modulus of the liquid crystal solution, which would be a good argument for the presence of photoactive properties.

References

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