Fast Switching Polymer-Stabilized Bend Nematic Devices

Sang Hwa Kim and Liang-Chy Chien
Chemical physics Interdisciplinary Program and Liquid Crystal Institute
Kent State University, Kent, OH 44242, USA

Abstract

We report a fast-switching polymer-stabilized bend nematic (PSBN) device. The morphology study reveal a templated polymer networks captures the orientation of the field deformed nematic host.

1. Objectives and Background

Among the most promising liquid crystal display configurations featuring high switching speeds is the device with variable retardation. Optically compensated bend (OCB) nematic cells, in which the liquid crystal is disposed between alignment layers which create parallel alignment, is known to exhibit a fast response time and wide viewing angle with compensated films. For the display to operate in the OCB mode, the liquid crystal has to be transformed from initial splay to the bend state. Uchida et al.[1] introduced an approach the OCB mode in which they used polymer to stabilize the twisted state of the nematic liquid crystal. In this paper, we present a method of fabricating liquid crystal displays with templated bent polymer fibrils suitable for display applications requiring a video rate operation. In this paper we report a new approach in stabilizing the bend nematic using bulk polymer network, templated from the nematic host and the results of electro-optical studies.

2. Results

We report here a technique of using liquid crystal templated polymer networks to stabilize an optical meta-stable state of a nematic. In order to observe the stabilized bend state of a field deformed nematic, we use a mixture of a nematic liquid crystal, a photomonomer to fill an electro-optical cell. Exposing the cell to a collimated UV light allows the formation of orientationally-ordered polymer network. The photomicrographs (Fig. 1a) taken from the crossed polarizers clearly show that the polymer network was formed by capturing an image of liquid crystal orientation. The images draw a sharp distinction in optical contrast between the liquid crystal with a bend orientation (low birefringence at the electrode area) and a planar alignment (higher birefringence at the no electrode area).

Morphological study of polymer leads to reveal a very interesting bend-shaped network structure formed at the field deformed bend state of a nematic host. After removal of liquid crystal, the photomicrograph (fig. 1b) of polymer network at the non-ITO region shows long fibrils. On contrary, the photo shows a sandy-like texture at the ITO region, indicating a bulk alignment by the polymer network.

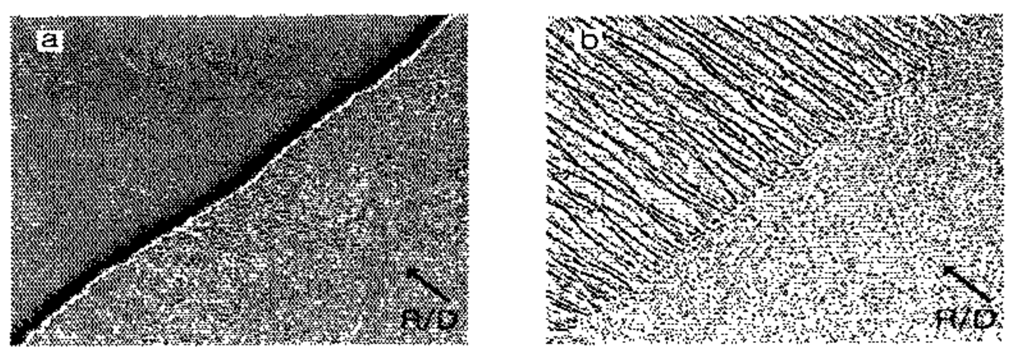

Figure 1: (a) photomicrograph of a stabilized bend nematic state at electrode region with sharp contrast with that of the planar state at no electrode area. (b)

To further confirm this observation, we study the morphology of the polymer network using a SEM. The morphology of polymer network corroborates microscopy observations of bulk polymer stabilization effect. As one can see from the SEM images were taken at a 45^{o} angle to the substrate normal. The bottom surface of the image in

Fig. 2c reveals highly-ordered submicron-scaled fibers parallel to the rubbing direction. The top surface of the image shows leaf-like fibrils and fibril bundles (aggregated fibrils) curved toward the direction opposite the host alignment direction. It is supposed that this fragment comes from the mid layer of the cell and formed during sample preparation. Long curvatures of this fragment have about 7~8 μm lengths, representing a somewhat bended polymer network. Figure 2d shows a close up polymer morphological image of a "far" substrate from UV incident of a 3% polymer sample. The bottom part (nearest to reader) of the image is the non-ITO region in which polymer fibrils run horizontally and parallel to the host alignment direction. The ITO region shows polymer fibrils tilted up with respect to the liquid crystal orientation and mimic the bend structure of the host.

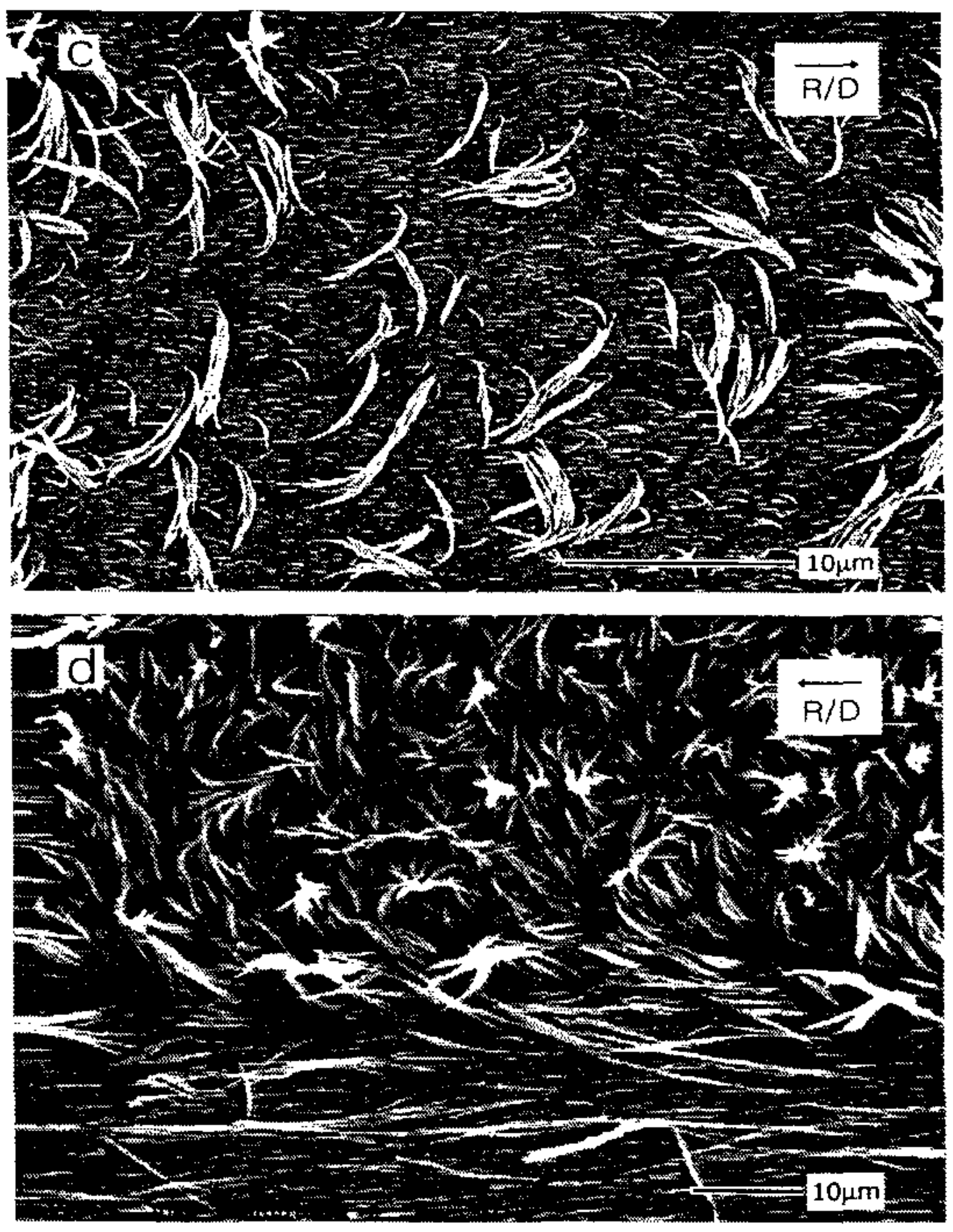

Figure 2: Bend polymer fibrils locate at the electrical field deformed nematic region whereas long straight polymer fibrils remains at no field region following the rubbing direction.

Electro-optical properties as transmittance vs. applied voltage and transmittance vs. time were performed for a sample containing 3% of polymer. The switching voltage and response time of the PSBN sample compared with those of the host LC the difference between them are relative small to draw a significant distinction. Yet, these results serve as a basis for further improvements in cell design and electro-optics. The transmittance vs. time of the PSBN sample is shown in Fig. 3.

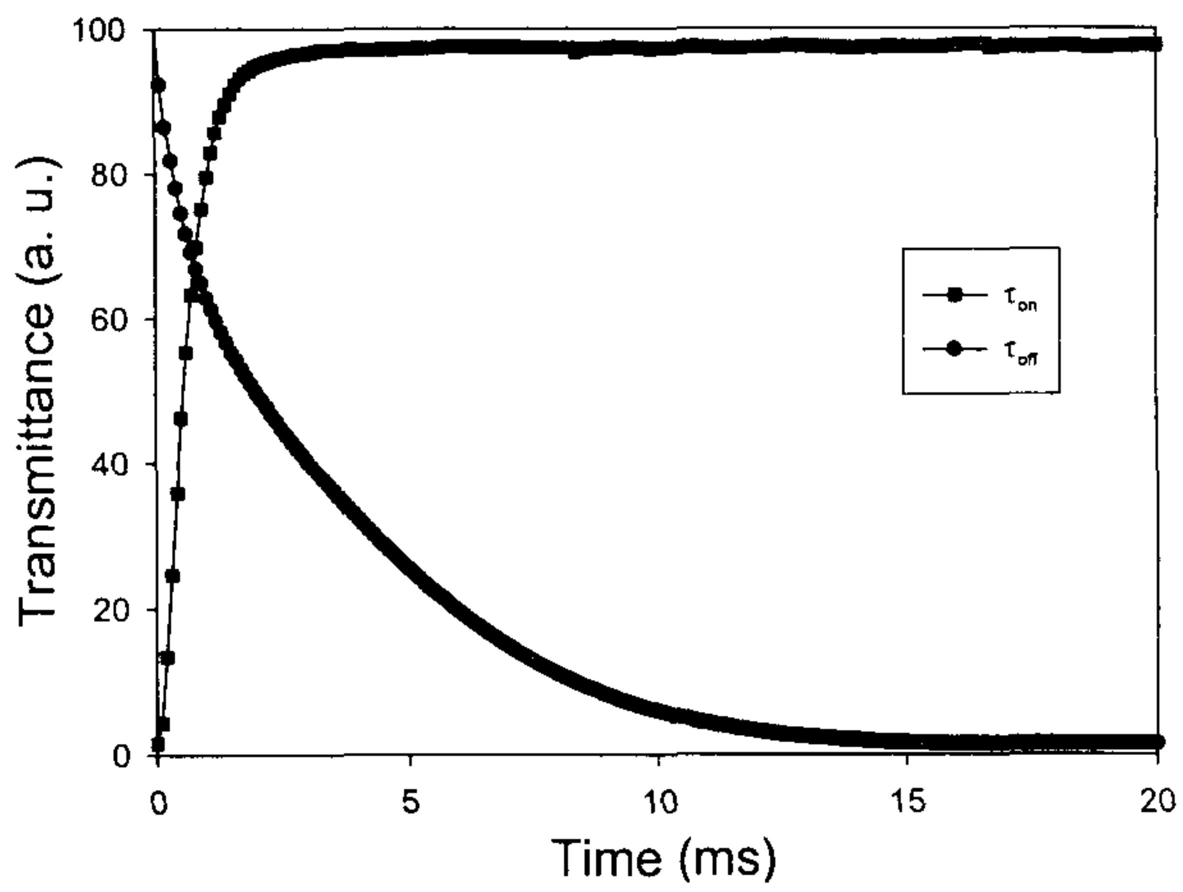

Figure 3: The rise and decay time of a PSBN with 3% polymer under the applied field of 0 to 10 V or 10 to 0 V at 1KHz, square wave.

3. Impact

The results serve as a basis how bulk polymer networks can stabilize optical pattern-forming states of liquid crystals and enhance electro-optical performance of a liquid crystal device. The polymer stabilization can lead to the development of a milisecon response time LC device suitable for video display applications.

4. Acknowledgements

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5. References

1. T. Kono, T. Miyashita, T. Uchida, *Asia Display* 581 (1995).