Nano-sized Polymer-dispersed Liquid Crystal with Strong Scattering Intensity Made by Emulsification Process

***Yan Jin*[1], *Burm-Young Lee*[2], *Soon-Bum Kwon*[1], *and Ji-Hoon Lee*[2*]**
[1]Dept. of Display Engineering, Hoseo University, Chungnam 336-795, Korea
[2]Next Display Laboratory, NDIS Corporation, Chungnam 336-795, Korea
TEL:82-41-549-9440, E-mail: jhlee@ndis.co.kr

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Abstract

Here we report a nano-sized polymer-dispersed liquid crystal (NPDLC) with an excellent scattering effect due to the maximized Mie scattering. We used a modified emulsification method combined with a limited coalescence mechanism. The fabrication process is simpler to obtain uniform nano-sized droplets rather than the conventional polymerization-induced phase separation method.

1. Introduction

Polymer-dispersed liquid crystal (PDLC) has drawn much attention for last two decades [1, 2]. First, the refractive index of polymer should be similar with one of the principal refractive index of the host liquid crystal (LC). Second, the size of the LC droplet in the polymer matrix should be similar with the wavelength of visible light called as Mie scattering.

Polymerization-induced phase separation (PIPS) method is complicated and difficult to optimize the UV curing conditions like curing intensity, curing time, curing temperature to obtain a uniformly distributed droplet size of the visible wavelength scale.

In this report, we used a modified emulsification method to form nano-sized LC droplets instead of conventional PIPS method. In addition to the conventional emulsification, we applied limited coalescence method [3] to obtain a uniform distribution of domain size, wherein LC droplets are stabilized by colloidal particles. This modified emulsification method makes it easy to fabricate a uniform-sized nano LC droplets and showed an excellent scattering property. The size of LC droplet once emulsified was very stable and never changed.

2. Experimentals

A nematic liquid crystal E7 (Merck Ltd.) was mixed with a water soluble polymer poly vinyl alcohol (PVA) in the distilled water. Because the LC is hydrophobic and the PVA is hydrophilic, these two constituents are hardly mixed uniformly. To emulsify liquid crystal droplets into the water soluble polymer, the mixture was ultrasonicated with a high power homogenizer (50W) for 6 minutes. During the ultrasonication, small size LC droplets are emulsified into the PVA solution [see the inset of Figure 1(a)]. To obtain a uniform size of LC domain, small amount of charged amphiphilic colloidal silica was mixed with LC. The doped silica forms an outer shell of LC droplet and prevents a formation of huge domain by limited coalescence mechanism. The size of LC droplet once emulsified was never increased.

3. Results and Discussion

Figure 1(a) shows the SEM image of the polymer matrix structure made by emulsification. It is clearly confirmed that the LC droplet has 400nm ~ 800nm diameter. Figure 1(b0) shows a comparing image of conventional PDLC cell made by PIPS method (upper) and the nano-sized PDLC cell made by emulsification (lower). It is definitely shown the nano-sized PDLC cell shows scattering effect.

Figure 2(a) shows the transmittance of the PDLC cell as a function of applied voltage. The sample was located between crossed polarizes. It shows good grayscale level enough to be driven by active matrix. Figure 2(b) shows the response time of PDLC cell. We need to note that the nano-sized PDLC cell shows a fast response both in the rising and decaying process. This fast dynamics seem to be due to the increased anchoring effect from the boundary polymer surface of LC droplet and the increased elastic torque due to the large second derivative value of the LC director orientation in the small polymer shell.

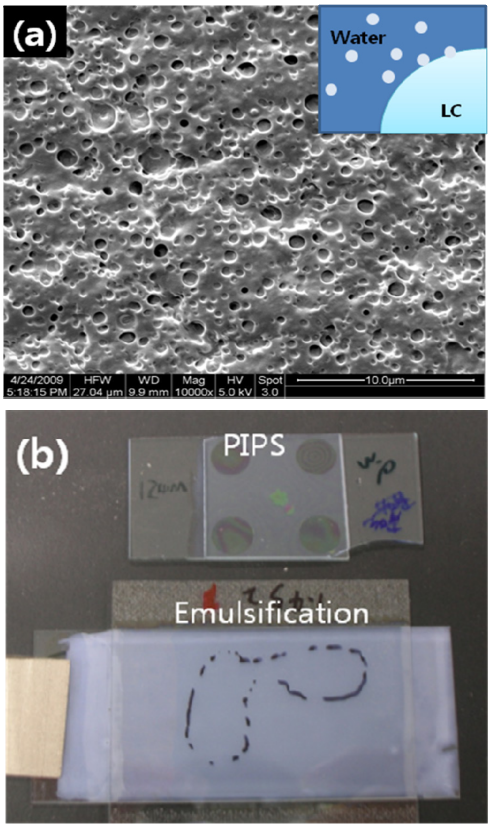
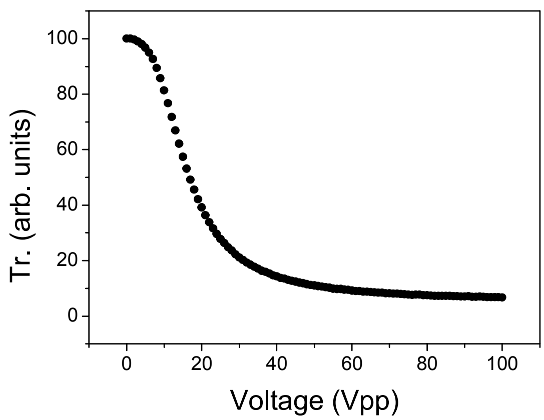


Fig. 1. SEM image of the nano-sized PDLC polymer (a). Compared image of the conventional PDLC cell made by PIPS method and the PDLC cell made by emulsification (b).



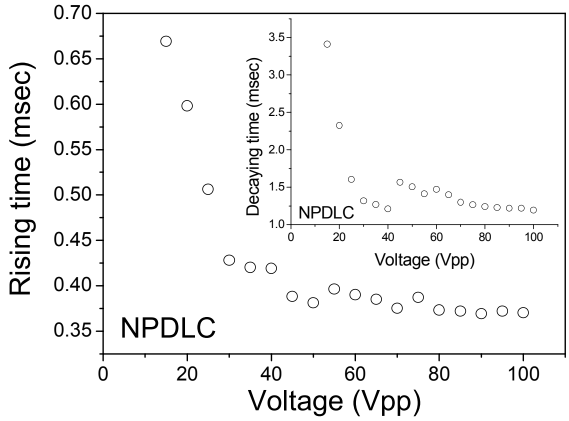


Fig. 2. Transmittance of the PDLC cell vs. voltage (a). Rising time and Decaying time of the PDLC cell(b).

3. Summary

We suggested a method to make a nano-sized PDLC cell using an emulsification combined with limited coalescence. This method is very easy to control and guarantees strong scattering effect than the previous conventional PIPS method. The droplet size was never changed once it was emulsified. We think this result enables a cost-effect and reliable process to fabricate a PDLC cell.

Acknowledgement

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