OPS networks while employing class-based model, resulting in improved QoS.

It is seen from the simulation results that the Poisson arrival model, which is assumed in the analysis, approximates a more practical model wherein all input wavelengths are modelled as independent ON–OFF processes. It is deduced that in OPS, RB reduces delay and thereby QoS is improved. At the same time, non-uniform traffic pattern results in better quality of service compared to ON–OFF and Poisson traffic patterns. Also, ON–OFF traffic pattern has better QoS when compared to Poisson traffic pattern, if OFF periods of one service class are more efficiently utilized by other service classes.

1. Øverby, H. and Stol, N., Evaluating and comparing two different service differentiation methods for OPS: the wavelength allocation algorithm and the preemptive drop policy. In Proceedings of 3rd International Conference on Networking, 2004, vol. 1, pp. 8–15.
2. Bjornstad, S., Stol, N. and Hjelme, D. R., A highly efficient optical packet switching node design supporting guaranteed service. *Proc. SPIE*, 2002, **4910**, 63–74.
3. Øverby, H., Packet loss rate differentiation in slotted optical packet switched networks. *IEEE Photon. Technol. Lett.*, 2005, **17**(11), 2469–2471.
4. Odom, W. and Cavanaugh, M. J., *IP Telephony Self-Study-Cisco QOS Exam Certification Guide*, CISCO Press, USA, 2005, 2nd edn.
5. Sun, X., Li, Y., Lambadaris, I. and Zhao, Y. Q., Performance analysis of first-fit wavelength assignment algorithm in optical networks. In IEEE Proceedings of the 7th International Conference on Telecommunications (ConTEL2003), 2003, vol. 2, pp. 403–409.
6. Yue, W., Takahashi, Y. and Tagaki, H., *Advances in Queueing Theory and Network Application*, 2009, Springer, ISBN: 978-0-387-09702-2, e-ISBN: 978-0-387-09703-9.
7. Kulikos, M. and Petersons, E., Remarks regarding queueing model and packet loss probability for the traffic with self-similar characteristics, networks. *Int. J. Electrical Comput. Engg.*, 2008, **3**(2), pp. 85–90.
8. Wong, E. W. M. and Zukerman, M., Bandwidth and buffer trade-offs in optical packet switching. *J. Lightwave Technol.*, 2006, **24**(12), 4790–4798.
9. Wen, B., Shenai, R. and Sivalingam, K., Routing, wavelength and time-slot-assignment algorithms for wavelength-routed optical WDM/TDM networks. *J. Lightwave Technol.*, 2005, **23**(9), 2598–2609.
10. Vadakital, V. K. M., Hannuksela, M. M., Razaei, M. and Gabbouj, M., Optimal IP packet size for efficient data transmission in DVB-H. In Proceedings of the 7th Nordic IEEE Signal Processing Symposium, 2006, pp. 82–85.
11. Jance, J. and Thomopoulos, N., Min and max uniform extreme interval values and statistics. *J. Bus. Econ. Res.*, 2009, **7**(1).
12. Ramaswamy, R., Weng, N. and Wolf, T., Characterizing network processing delay. IEEE Proceedings of Global Telecommunications Conference (GLOBECOM'04), 2004, vol. 3, pp. 1629–1634.
13. Kavitha, A., Rajamani, V. and Anandhakumar, P., Performance analysis of slotted optical packet switching scheme in non-uniform traffic pattern using reservation bit technique. *INFOCOMP J. Comput. Sci.*, 2009, **8**(4), 71–78.

Received 3 August 2010; revised accepted 3 November 2011

A study on the factors affecting the morphology and electro-optical properties of polymer dispersed liquid crystal display

Farzana Ahmad[1], Jin Woo Lee[1], Y. J. Jeon[1,]* and M. Jamil[2]

[1]Liquid Crystal Research Center, Department of Chemistry, and
[2]Division of International Studies, University College, and
High Energy Physics Lab, Department of Physics, Konkuk University, Seoul 143-701, Korea

This communication deals with the study of polymer dispersed liquid crystal (PDLC) display fabricated by polymer-induced phase separation method. The effect of change in curing conditions (e.g. composition, UV power and temperature) on morphology and electro-optical properties of PDLCs was studied. In the studied PDLC film, liquid crystal (LC) dispersed in polymer matrix made droplet morphology. From our experimental findings, an increase in droplet size with increase in LC content (curing at low temperature and low UV power) has been observed. Further electro-optical properties developed by these morphologies are studied in detail.

Keywords: Droplet morphology, electro-optical properties, phase separation, polymer dispersed liquid crystal.

IN the last few decades polymer-dispersed liquid crystals (PDLCs), composed of micron-sized liquid crystal (LC) droplets (diameter from 10^{-8} up to 10^{-4} μm) embedded in a solid polymer matrix[1] have been the subject of intensive studies[2–13], because of both fundamental interest and potential applications in the field of smart windows, light shutter and active display devices[14–17]. These are subjects of interest due to the unique electro-optical properties of LC and ease of the fabrication process.

A PDLC film exhibits transparent and light-scattering states in electric field-on and field-off states respectively. In the field off-state, the PDLC film scatters light due to mismatch between the effective refractive index (n_{eff}) of the LC and the refractive index of the polymer (n_p). In the field-on state, LCs of positive anisotropy tend to align themselves with the directors parallel to the field direction. In such a state, the refractive index for incident light is equal to the ordinary refractive index (n_0), and if n_0 is matched with n_p, the films become transparent[18].

There are four distinct phase-separation methods for the preparations of PDLC films: polymerization-induced phase separation (PIPS), thermally induced phase separation (TIPS), reaction-induced phase separation (RIPS) and solvent evaporation-induced phase separation (SIPS)[19,20]. Morphologies, i.e. concentration, size and shape of LC

*For correspondence. (e-mail: yjjeon@konkuk.ac.kr)

droplets, the director direction inside them, and electro-optical properties of PDLC films depend on both the properties of components (pre-polymer and LC mixtures) and preparation methods. The number and mean size of LC droplets, driving voltage, switching time and optical contrast of the PDLC depend mainly on LC types, their weight fraction, n_{eff} and the droplet nucleation (polymer solidification) ratio[21]. Many experimental studies have already been performed considering such factors of LCs[22–24].

In the present work, the effects of preparation methods on morphology and electro-optical properties of PDLC films are studied. The aim of this work is to understand the effect of preparation methods on morphologies and electro-optical properties of PDLCs.

The PDLC films were prepared by the PIPS method. Polymerization was performed by UV light with wavelength (λ) 365 nm. In order to obtain PDLC polymer matrix, we purchased one bi-functional monomer ethoxylated-bisphenol-A-diacrylate (EOBPhDA; Sigma-Aldrich) (EO/phenol, 1.5), two mono-functional monomers 2-ethylhexyl acrylate (2-EHA; Sigma-Aldrich) and *n*-hexyl methacrylate (HMA, Sigma-Aldrich) with refractive indices of 1.534, 1.436 and 1.432 respectively. The chemical structures of the monomers are shown in Figure 1. Irgacure 651 (2 wt%) was used as photo-initiator. A commercial nematic liquid crystal MLC-12100-100 (Merck) was used in this work. The monomers EOBPhDA, EHA and HMA were used with the following composition – 3 : 3 : 4 w/w% ratio respectively. The homogeneous mixtures of monomers and LC were prepared with constant stirring by varying LC weight fractions from 70 to 82 wt% at room temperature. The cell gap between two indium tin oxide-coated glass plates (ITO) was fixed using the 20 μm mylar-type spacers. The cells were filled by capillary force action and then UV cured on a temperature-controlled plate at 20–40°C temperature. The UV lamp power (*I*) for polymer curing was varied from 72 to 22 $\mu W/cm^2$.

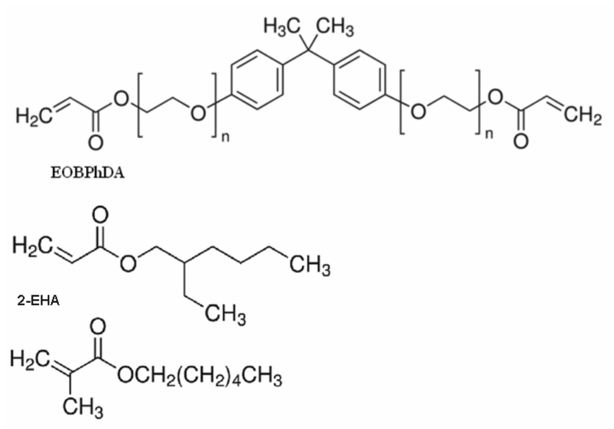

Figure 1. The chemical structure of monomers.

The LC droplet morphologies formed by curing the above-mentioned mixtures at different fabrication conditions were viewed under polarizing optical microscope (POM; Olympus Model BX-60) at a magnification of 20× and fitted with a charge-coupled device (CCD) digital camera interfaced with a computer. A UV–visible spectrophotometer (Minolta CM-3500d) was used to measure the electro-optical properties of the PDLC film. Before measuring the sample cell the spectrophotometer was calibrated with the reference cell containing two ITO-coated blank glasses. An external AC (~) electric power source was connected to the ITO glasses to study the PDLC cell at the desired voltage. The transmittance of the PDLC film was recorded at a frequency of 60 Hz and the applied voltage was slowly increased.

Figure 2 shows the morphology of PDLC films formed by varying the LC composition from 70 to 82 wt%, cured at 22°C temperature and at 72 $\mu W/cm^2$ UV light intensity. These results showed initially at low LC contents formation of sponge or foam-like morphology of PDLC film, where the LCs formed closely packed spherical that have small domains within the polymer matrix. The number of LC domains is high and they have small size from 0.6 to 1.6 μm. The polymer network is strongly associated to the substrate of the sample.

The PDLC film morphology exhibited an increase in LC domain size (Figure 2) with the increase in LC contents (data is shown in Figure 3*b*). It showed that the PDLC having low LC content (70 and 77 wt%) exhibited small domain size (≈ 0.6 μm) and showed higher scattering at zero volts, whereas the film containing high LC

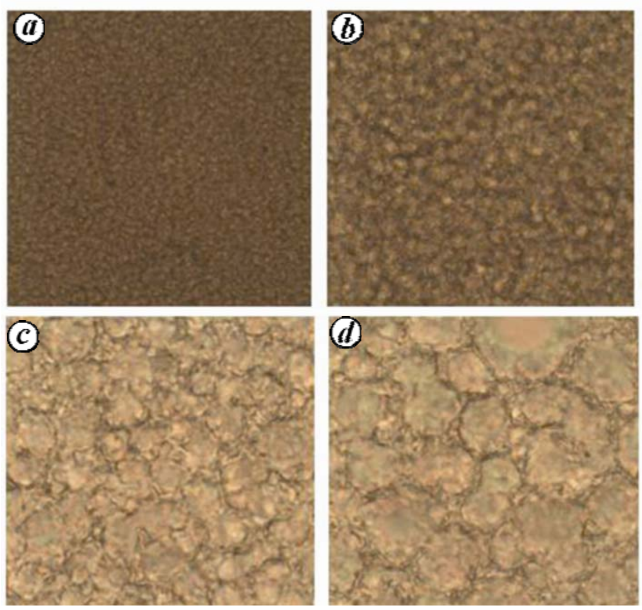

Figure 2 Dependence of the polymer dispersed liquid crystal (PDLC) morphologies on liquid crystal (LC) composition at curing conditions of 22°C and 72 $\mu W/cm^2$. LC compositions are: (***a***) 70 wt%, (***b***) 77 wt%, (***c***) 80 wt% and (***d***) 82 wt%.

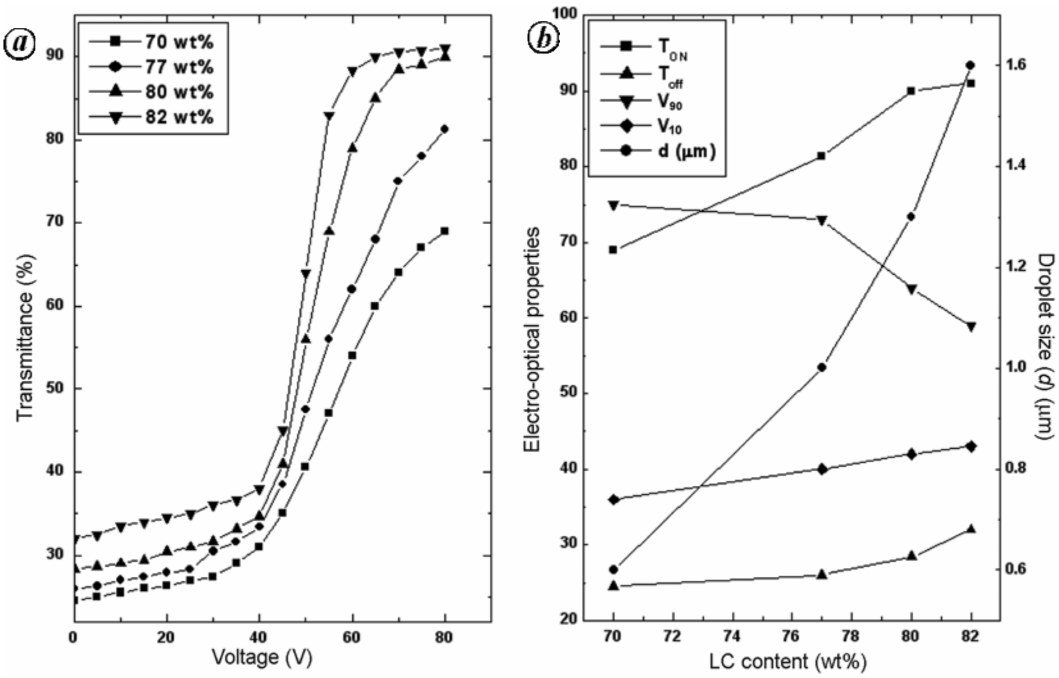

Figure 3. ***a***, Dependence of per cent transmittance of 70, 77, 80 and 82 wt% LC contents on different applied voltages. ***b***, Dependence of electro-optical properties and droplet size on LC content.

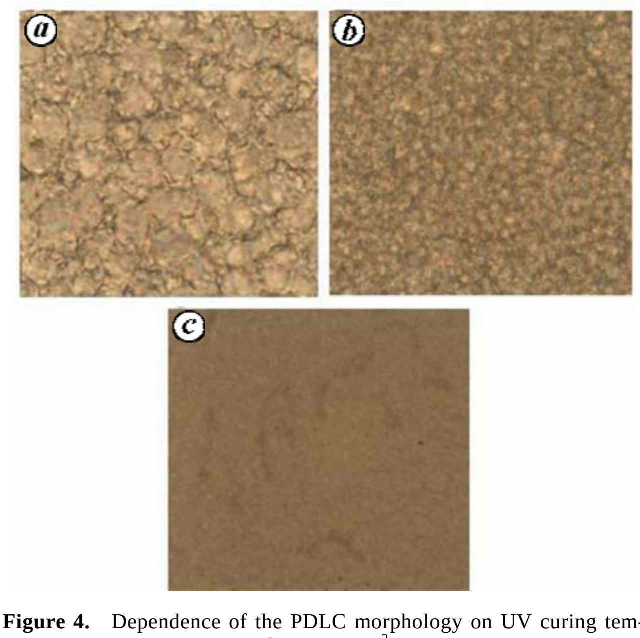

Figure 4. Dependence of the PDLC morphology on UV curing temperature at 80 wt% LC and 72 μW/cm^2. Curing temperatures are: (***a***) 22°C, (***b***) 30°C and (***c***) 40°C.

content (80 and 82 wt%) showed comparatively bigger domain size (1.6 μm) and showed small scattering at zero voltage. The increase in droplet size with increasing LC fraction has also been observed previously[25–27]. This behaviour can be explained by the extent of changes occurring during polymerization at the onset of phase separation. It could be explained as follows: the increase in LC fraction moved the PDLC mixture closer to the phase boundary; a less developed polymer matrix appeared during phase separation and consequentially it gave more time for the LCs to form large domains.

Figure 3 *a* shows the general behaviour of light transmittance of PDLC against applied voltage as measured for different LC contents. In accordance with the theory[28], the per cent transmittance at voltage off-state and on-state depends on curing conditions, incident light intensity and thickness of the PDLC film. A PDLC film exhibits transparent and light-scattering states in electric field-on and field-off states due to the mismatch between n_{eff} and n_{p}. Generally at the field-on state, LCs of positive anisotropy tend to align themselves with the directors parallel to the field direction. This in turn results in the refractive index of the incident light being equal to n_0, and if n_0 is matched with n_{p}, the films become transparent[18]. Figure 3 *b* shows the measured droplet size (*d*) and other electro-optical properties of PDLC. These findings exhibited an increase in LC droplet size, and an increase in off-state transmittance (T_{off}) and on-state transmittance (T_{on}) with LC content. Further, in Figure 3 *b*, the saturation voltages (V_{sat}) or V_{90} (voltage needed to get 90% of transmittance) and V_{10} of these morphologies are measured and plotted against the LC content. There was a decrease in V_{90} and an increase in V_{10} (10% transmittance at voltage on-state) with the increase in LC content and ultimately with the increase in droplet size. Accordingly[28,29] saturation voltage is correlated to anchoring energy. The smaller the droplet size stronger is the anchoring energy, which results in higher saturation voltage, as it needs high electric field to reach the transparent state; whereas the formation

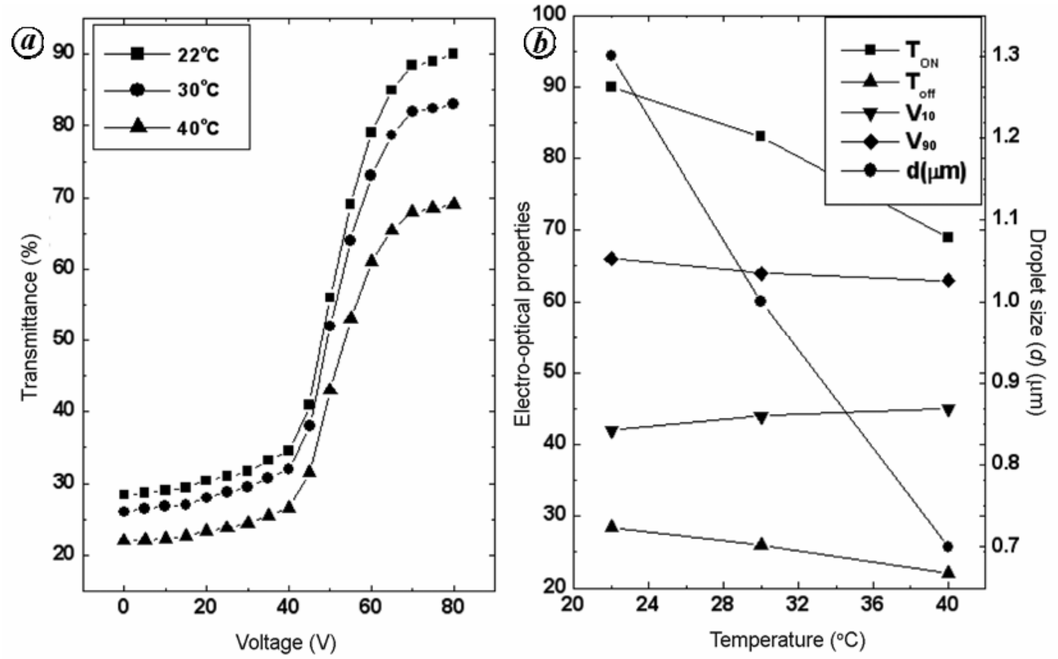

Figure 5. ***a***, Dependence of *T* (%) of 80 wt% LC content at different applied voltages cured at 72 μW/cm^2 UV light intensity while varying the temperature. ***b***, Dependence of electro-optical properties and droplet size on different curing temperatures.

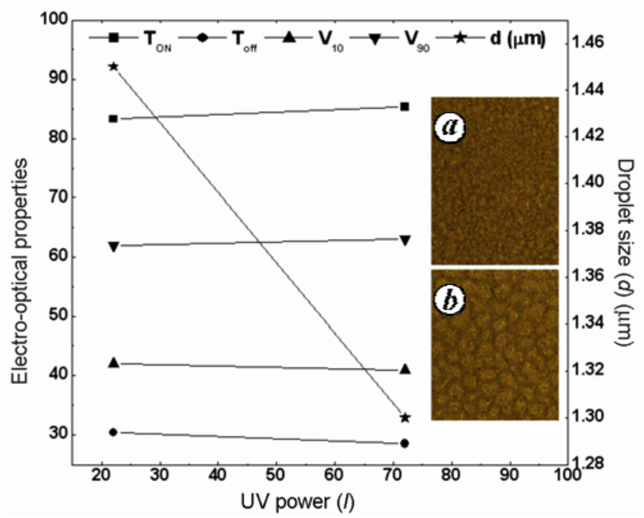

Figure 6. Dependence of PDLC electro-optical properties, droplet size and morphology on UV curing power. The decrease in droplet size with decrease in UV cure power for 80 wt% is shown in the right most corner for (***a***) 72 μW/cm^2 and (***b***) 22 μW/cm^2.

of small droplet size is related to viscosity of polymer matrix[30].

In order to further understand the effect of temperature on PDLC morphologies and electro-optical properties, we cured pre-polymer at different temperatures while keeping the composition and UV power constant (72 μW/cm^2). Figure 4 shows the PDLC morphologies at different curing temperatures. The PDLC mixtures under study, with 80 wt% LC content were cured at three selected temperatures, i.e. 22°C, 30°C and 40°C. The observed morphology shows a decrease in droplet size with increase in temperature.

Figure 5 shows the morphology and change in electro-optical properties, i.e. the average droplet size (*d*, μm), the per cent transmittance (T_{off} %) and (T_{on} %), and V_{10} and V_{90} with change in temperature. Figure 5 *a* shows the general behaviour of PDLC film against the temperature for 80 wt% LC content. Figure 5 *b* demonstrates a decrease in T_{off} and T_{on} and an increase in V_{10} and V_{90} with increase in temperature. Additionally, the Figure 5 *b* also exhibits a decrease in droplet size with increase in curing temperature. It is known that the degree of polymerization at the onset of phase separation and viscosity of the PDLC mixtures accounts for the morphology changes. Increase in temperature generally leads to decrease in the viscosity of the polymers and increases the rate of polymerization which in turn produces smaller droplet size and improves the electro-optical properties of the PDLC[31]. The reason behind the increase in saturation voltage with the increase in temperature may be the increase in anchoring energies due to decrease in droplet size, as observed in Figure 4. The decrease in transmittance of the PDLC film with temperature corresponds to a decrease in droplet size. This is due to the increase in scattering of light and anchoring energy of the system that associated with small-sized domains and randomly dispersed LC directors.

Finally, we measured the morphology and electro-optical properties of PDLC by varying the UV power at fixed temperature and composition. The resultant morphologies and electro-optical properties for 80 wt% LC content, cured at 22°C and at two UV powers (72 and 22 μW/cm^2) are shown in Figure 6. The morphologies are shown in the right most corner in the figure. It indicated an increase in the LC droplet size with decrease in UV power intensity. Moreover, Figure 6 shows the electro-optical properties and droplet size measurement for the developed morphologies. It also shows an increase in transmittance at the on-state (T_{on}) with the increase in UV power and a decrease in T_{off}, V_{10} and droplet size with increase in UV power. It is also observed that the average time for curing increased at low UV power.

The increase in droplet size for the 80 wt% LC content with decrease in UV curing power intensity is also shown in Figure 6. The increase in LC droplet size with decrease in UV power correlated with polymerization rate and gel formation of the polymer. This behaviour implies that the polymerization rate of PDLC slows down with the decrease in UV power and hence the droplets grow in size. The slow curing during phase separation gave enough time for the LC droplets to grow in size. A small change in the electro-optical properties, i.e. in T_{on} and V_{90}, and decrease in T_{off} and V_{10} is also recognized. This correlated with the change that occurred in the droplet size and could be due to slow phase separation.

In this communication we have studied PDLC films fabricated by the PIPS method. The main aim of this work was to study the dependence of various factors, e.g. LC content, curing temperature and UV power on morphology, which in turn affects the electro-optical properties of the PDLC films.

It has been observed that the LC droplet size decreases, with a decrease in LC contents, increase in temperature and increase in UV power. Droplet size in PDLC films is related with the viscosity and polymerization rate of polymers. Indeed low LC content, low temperature and high UV power increased the viscosity of the polymers and increased the polymerization rate, thus giving enough time for the LC droplets to grow in size.

The electro-optical properties observed for these morphologies show an increase in T_{off} at low LC content, low temperature and low UV curing power. These morphologies also show a decrease in V_{90} at high LC content, low temperature and low UV curing power; this is attributed to bigger droplet size formation. Moreover, an increase in T_{on}, with increase in LC content at low curing temperatures and at low UV curing power is also noticed. The ultimate results are enlargement in droplet size which leads to low scattering at zero voltage and small V_{90} values, and good transmittance at saturation voltage.

It can be concluded that proper selection of material, its composition, temperature and UV curing power conditions are the key factors to get a PDLC with good morphologies and electro-optical properties.

1. Mirantsev, L. V. and Romano, S., Molecular dynamics simulation of polymer dispersed liquid crystal droplets under competing boundary conditions. *Liq. Cryst.*, 2006, **33**, 187.
2. Wang, M., Li, W., Zou, Y. and Pan, C., A study on the effects of the UV curing process on phase separation and electro-optical properties of a polymer-network-dispersed liquid crystal. *J. Phys. D*, 1997, **30**, 1815.
3. Doane, J. W., Golemme, A., West, J. L., Whithead Jr, J. B. and Wu, B-G., Polymer dispersed liquid crystals for display application. *Mol. Cryst. Liq. Cryst.*, 1988, **165**, 511.
4. Pirs, J., Zumer, S., Blinc, R., Doane, J. W. and West, J. L., *Soc. Inf. Display Digest Tech. Pap.*, 1988, **XIX**, 277.
5. Drzaic, P. S., Polymer dispersed nematic liquid crystal for large area displays and light valves. *J. Appl. Phys.*, 1986, **60**, 2142.
6. Han, J.-W., Effect of the nematic-isotropic phase transition on the electro-optical characteristics of polymer-dispersed liquid crystal films. *J. Korean Phys. Soc.*, 2002, **40**, 849–855.
7. Fujisawa, T., Ogawa, H. and Maruyama, K., In Proceedings of 9th International Display Research Conference, Tokyo, SID Japan, 1989, p. 690.
8. Doane, J. W., West, J. L., Pirs, Y., Zumer, S. and Blinc, R., The International Society for Optical Engineering: Liquid Crystal Displays and Applications. *SPIE Proc.*, 1988, **958**, 94.
9. Yamagishi, F. G., Miller, L. J. and Van Ast, C. Z., *Proc. SPIE*, 1989, **24**, 1080.
10. Jinwoo Han, Memory and depolarization effects of polymer-dispersed liquid crystal films based on E7/NOA61. *J. Korean Phys. Soc.*, 2003, **43**, 45–50.
11. Farzana, A. *et al.*, Comparative study on the electro optical properties of polymer-dispersed liquid crystal films with different mixtures of monomers and liquid crystals. *J. Appl. Polym. Sci.*, 2011, **121**, 1424.
12. Kato, K., Tanaka, K., Tsuru, S. and Sakai, S., Multipage display using stacked polymer-dispersed liquid crystal films. *Jpn. J. Appl. Phys.*, 1993, **32**, 4594.
13. Wang, J., Directly formed polymer dispersed liquid crystal light shutter displays. USA, Patent 5270843, 1993.
14. Fergason, J. L., Polymer encapsulated nematic liquid crystals for display and light control applications. *Soc. Inf. Display Digest Tech. Pap.*, 1985, **16**, 68.
15. Doane, J. W., Vaz, N. A. and Wu, B. G., Field controlled light scattering from nematic micro droplets. *Appl. Phys. Lett.*, 1986, **48**, 269.
16. Sutherland, R. L., Tondiglia, V. P., Natarajan, L. V., Bunning, T. J. and Adams, W.-W., Electrically switchable volume gratings in polymer? dispersed liquid crystals. *Appl. Phys. Lett.*, 1994, **64**, 1074.
17. Ding, X., Cao, M., Liu, H., Cao, H., Wenbo, Li and Yang, H., A study of electro-optical properties of PDLC films prepared by dual UV and heat curing. *Liq. Cryst.*, 2008, **35**, 587.
18. Jeon, Y. J., Bingzhu, Y., Rhee, J. T., Cheung, D. L. and Jamil, M., Application and new developments in polymer dispersed liquid crystals simulation studies. *Macromol. Theor. Simul.*, 2007, **16**, 643.
19. Jeon, Y. J., Jamil, M., Lee, H.-D. and Rhee, J. T., A comparative simulation studies on three lattice systems for the phase separation of polymer dispersed liquid crystals. *Pramana J. Phys.*, 2008, **71**, 559.
20. Keosowicz, S. J. and Aleksander, M., Effect of polymer-dispersed liquid crystal morphology on its optical performance. *Opto-Electron. Rev.*, 2004, **12**, 305.
21. Yu, H., Hou, R., Yin, B., Jamil, M. and Jeon, Y. J., Synthesis and properties of dimesogenic compounds containing cholesterol and 4-(trans-4-*n*-alkylcyclohexyl)-benzoic acid moieties. *Chin. J. Chem.*, 2009, **27**, 1401.
22. Zhang, C., Jin, L., Yin, B., Jamil, M. and Jeon, Y. J., Synthesis and properties of non-symmetric liquid crystal dimmers containing a cholesteryl moiety. *Liq. Cryst.*, 2008, **35**, 39.
23. Yu, H., Huang, Z., Yin, B., Jamil, M. and Jeon, Y. J., Chiral dimesogenic compounds having cholesterol and trans-*n*-hexylcyclohexylbenzoic acid moieties. *Mater. Lett.*, 2008, **62**, 3284.

24. Amundson, K. R., Blaaderen, A. Van. and Wiltzius, P., Morphology and electro-optic properties of polymer-dispersed liquid-crystal films. *Phys. Rev. E*, 1997, **55**, 1646.
25. Lovinger, A. J., Amundson, K. R. and Davis, D. D., Morphological investigation of UV-curable polymer-dispersed liquid-crystal (PDLC) materials. *Chem. Mater.*, 1994, **6**, 1726.
26. Carter, S. A., Legrange, J. D., White, W., Boo, J. and Wiltzius, P., The dependence of the electro-optical properties of polymer dispersed liquid crystals on the photo polymerization process. *J. Appl. Phys.*, 1997, **81**, 1.
27. Pankaj, K. and Raina, K. K., Morphological and electro-optical responses of dichroic polymer dispersed liquid crystal films. *Curr. Appl. Phys.*, 2007, **7**, 636.
28. Kashima, M., Cao, H., Meng, Q., Liu, H., Wang, D., Li, F. and Yang, H., The influence of crosslinking agents on the morphology and electro-optical performances of PDLC films. *J. Appl. Polym. Sci.*, 2010, **117**, 3434.
29. Sugimura, A. and Ishino, D., Nematic director deformation induced by a periodic surface anchoring strength. *Thin Solid Films*, 2003, **438**, 433.
30. Andy, Y. G. F., Huang, K. L., Lin, C. H., Lin, I.-I. C. and Jiang, I. M., Studies of the dependence of the electro-optical characteristics of polymer dispersed liquid crystal films on curing temperature. *Chin. J. Phys.*, 1990, **28**, 551.
31. Bosc, D., Guilbert, M., Trubert, C. and Vinouze, B., Improvements in fabrication conditions of liquid crystal–polymer composite cells. *Mol. Cryst. Liq. Cryst.*, 1996, **287**, 83.

Received 8 April 2011; revised accepted 3 November 2011

A comparison of endophyte assemblages in transgenic and non-transgenic cotton plant tissues

T. S. Suryanarayanan*, A. Venkatachalam and M. B. Govinda Rajulu

Vivekananda Institute of Tropical Mycology, RKM Vidyapith, Chennai 600 004, India

Seed, root, stem, petiole and leaf tissues of *Bt* and non-*Bt* cotton (Krishidhan variety) were screened for the presence of symptomless endosymbiotic fungi (endophytes). All the tissue types of both *Bt* and non-*Bt* plants harboured endophytes. Although the number of endophyte species isolated from the two types of plant did not vary much, the number of isolates of endophytes was higher in all non-*Bt* tissues when compared with the respective *Bt* tissues. The lower infection frequency observed for the *Bt* cotton tissues may not be due to a direct effect of *Bt* gene insertion, but possibly due to the *Bt* plant warding off insect pests.

Keywords: *Bt* cotton, fungal endophytes, infection frequency, plant tissues.

THE efficiency of the insecticidal protein (Cry1Ab protein) produced by *Bacillus thuringiensis* (*Bt*) in killing several lepidopteran herbivorous pests has led to the development of transgenic crop plants carrying the *Bt* gene, such that they are insect-resistant *ab initio* in the field. Among such genetically modified crops, *Bt* cotton is most popular and is being cultivated all over the world[1]. In India, about 7.6 million hectares (m ha) was under *Bt* cotton cultivation during 2009, accounting for nearly 80% of the total area under cotton cultivation[2]. To evaluate the effects of transgenic plants on agroecosystems, several studies have been conducted on the influence of *Bt* cotton on target and non-target insects[3–5]. Relatively fewer studies address the effect of *Bt* gene integration on microorganisms associated with cotton plants. Sarkar *et al.*[6] and Chen *et al.*[7] studied the impact of *Bt* cotton on the soil enzymes and rhizosphere bacteria respectively. Wang *et al.*[8] looked at the changes in the diversity of leaf surface microorganisms of *Bt* cotton. However, except for the recent work of Vieira *et al.*[9], there are no studies on the effect of *Bt* gene integration on the endophyte status (viz. diversity, tissue preference and density of infection) of cotton plants. Here we compare the endophyte assemblage of different tissues of *Bt* cotton plant with those of non-*Bt* cotton plant to assess the influence of the genetic modification of host on endophyte colonization and to provide baseline data for further detailed studies.

Endophytes are an ecological group of fungi, mainly belonging to the Ascomycotina, which reside inside living tissues of plants without producing any visible disease symptoms[10]. They are ubiquitous[11], and may enhance the fitness of their hosts by protecting them against insect pests[12] and pathogens[13]. Plants infected with endophytes tolerate abiotic stress better than those that are endophyte-free[14]. The interactions between host plants, herbivorous insects and the endophytes colonizing these plants are complex and little understood[12,15].

Seedlings of Krishidhan variety of *Bt* and non-*Bt* cotton raised from seeds of *Gossypium hirsutum* (Central Institute of Cotton Research, Nagpur, India) were sampled. Mature, green and symptomless leaves, petioles, main stems (5 cm above soil level) and roots (5 cm below soil level) were collected from 60-day-old plants grown in open garden, and screened for endophytes. We did not study older plants since Cry protein levels are reported to be low in older seedlings[16]. Healthy tissues were collected from 10 *Bt* or non-*Bt* plants, washed in tap water, cut into 0.5 sq. cm segments, and surface sterilized using ethanol and bleach[17]. Surface-sterilized *Bt* and non-*Bt* seeds were also cut into 0.5 cm^2 segments and screened for endophytes. The different tissue segments (100 segments for each tissue type) were plated on antibiotic (chloramphenicol 150 mg l^{-1}) amended potato dextrose agar medium and incubated in a light chamber at 26°C for 1 month to isolate the endophytes[17]. To test the efficacy of surface-sterilization, the surface-sterilized tissue segments were gently pressed onto the agar medium and removed. Such petri dishes were incubated and observed

*For correspondence. (e-mail: t_sury2002@yahoo.com)