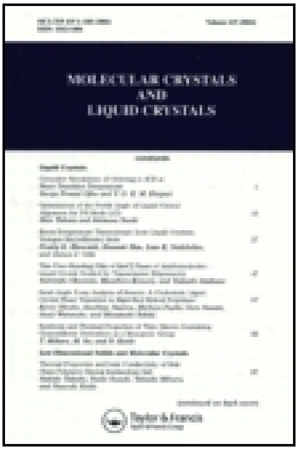

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Fabrication of the Alignment Layer with Cavities by using Two Dimensional Template of Polystyrene Latex Array

Mu-Hyun Kim [a], Won-Seok Kang [a] & Jong-Duk Kim [a]

[a] Dept. of Chemical Engineering, Korea Advanced Institute of Science and Technology, 373-1 Kusung-dong Yusong-ku, Taejon, 305-701, Korea

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MU-HYUN KIM, WON-SEOK KANG and JONG-DUK KIM

Dept. of Chemical Engineering, Korea Advanced Institute of Science and Technology, 373-1 Kusung-dong Yusong-ku, Taejon, 305-701, Korea

Two-dimensional and three-dimensional arrays of small latex particles have been concentrated because of their possibilities of various applications in the optical storage medium, electronics, and optical photonic crystal in templates. The two-dimensional polystyrene latex particles are easily packed in highly oriented layers over a wide surface area due to water evaporation and lateral capillary forces. The latex array could be dissolved out by solvents after making a regular structure of polymer matrix. Nematic liquid crystal between the polymer structure with regular cavities showed a random orientation. Each cavity could act as a liquid crystal cell with random alignment of liquid crystals. The highly ordered arrays with polystyrene latex and its application to liquid crystal alignments have been studied.

Keywords: polystyrene; template; liquid crystal; alignment layer

INTRODUCTION

Regular structures of small latex particles have been concentrated because of their possibilities of various applications. Three-dimensional macroporous membranes with assemblies of microspheres as templates have potential applications in catalysis, separations, coatings, microelectronics and electrooptics. An tantalizing uses of the crystalline macroporous materials is the field of photonic crystals that create photonic band gaps[1-4].

The two-dimensional arrays of small particles have been discussed in many reports from the viewpoint of high-density optical storage media[5, 6] optical imaging[7], nano-fabrication with a lithography[8], and templates of structured porous surfaces[9]. The latex particles were deposited onto substrates by dipping method[10], casting[5], dynamic thin laminar flow[11], and movement of x-y stage[9]. The two-dimensional PS latex particles are easily packed in highly oriented layers over a wide surface area due to water evaporation and lateral capillary forces[10, 12]. Our group studied the surface modified liquid crystal alignment with the LB method and domain-dispersed film[13, 14].

In this paper, highly ordered arrays of PS latex have been studied for possible applications as a template of the homogeneous alignment layers in the liquid crystal display because of their ordered structure.

EXPERIMENTAL

PS latex particles were synthesized by emulsifier-free emulsion polymerization[15]. Some of experiments were carried out with a latex suspension containing 2 wt.% of PS particles(Aldrich Co.). The diameter of the latex particles was 1μm. The diameter of the synthesized latex particles were measured by a scanning electron microscope(XL30SFEG, Philips). The zeta-potential of the particles was measured by a zeta-potential analyzer(Zetaplus, Brookhaven). A cationic surfactant, cetyltrimethyl-ammonium bromide (CTAB) (Aldrich Co.)was added to change the charge of the particles.

The latex particles were deposited onto substrates by casting, dip coating, water drifting, and moving stage. The arrays were used as a template to fabricate an alignment layers with cavities. Figure 1 illustrates the experimental detail to fabricate the structured alignment layer. UV curable epoxy resin was coated on glass substrates. Solvent was evaporated in a oven and the coated resin was precured by a UV lamp. The synthesized emulsion particles were packed onto another substrate. The two-dimensional arrays of the PS particle were attached to a conventional 3M tape. Then, the attached arrays were deposited onto the upper surface of the precured epoxy resin.

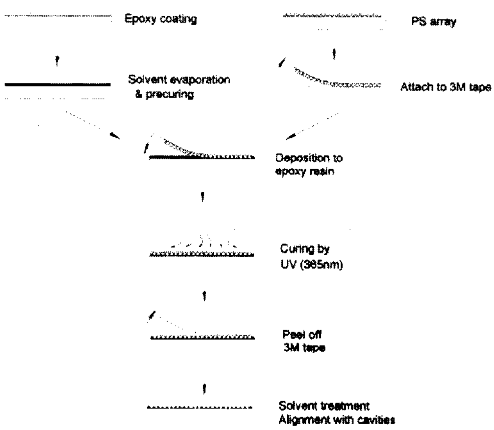


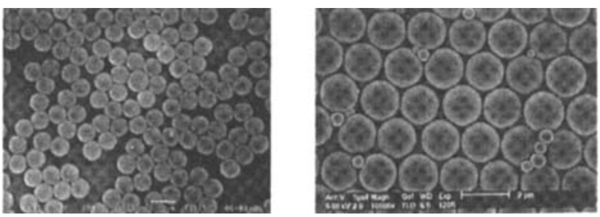
Figure 1. Experimental detail to fabricate the structured layer.

After curing the epoxy resin with irradiation of the UV lamp at the wavelength of 365nm, the 3M tape was peeled off from the surface. Subsequent solvent treatment was carried out. The polystyrene particles were dissolved in toluene for 1 hr. The ordered arrays of the particles and the surface of the alignment layers were monitored by a microscope(CSB-HP5, Samwon Co.) and the scanning electron microscope(XL30SFEG, Philips). After assembling cell with two substrates coated with the films, nematic liquid crystal (E7, Merck Co.) was filled by the capillary force. The gap between two ITO substrates was hold by inserting 6μm polyethyleneterephthalate (PET) film. Textures of the liquid crystal were observed by a polarized microscope(CSB-HP5, Samwon Co.).

RESULTS AND DISCUSSION

Synthesized polystyrene latex particles were negatively charged due to the initiator[15]. The diameter of the synthesized polystyrene particles was 1.7μm. In order to increase hydrophobic attraction between the particles, the cationic surfactant was utilized for the coupling of the negative charges on the surface of the beads[10]. Measured zeta-potentials were -30.59 mV for cationic surfactant-free particles, -29.33 mV for 10^{-6} M of CTAB added, -15.9mV for 10^{-4} M, 39.9mV for 10^{-3} M, and 58.31mV for 10^{-2} M, respectively.

The 2D PS latex particles were easily packed on the hydrophilic substrate in highly oriented layers over a wide surface area due to water evaporation and lateral capillary forces[10, 12]. Microscopic images of the latex particles on the hydrophilic slide glasses show two-dimensional hexagonal array despite some defects because of the size distribution of the particles in the case of synthesized polystyrene particles. Figure 2 shows the SEM images of latex particles on the glasses. The wettability of the substrate is important to form the 2D arrays of the latex particles. As shown in figure 2, the smaller particles were inserted between the particles of two-dimensional array in the synthesized sample. We could solve this problem by perfect separation of the smaller particles by filtration after emulsion polymerization. Figure 3 shows the SEM images of 2D structured polymer surfaces after dissolving the latex particles with toluene. The surface showed a regular structure having cavities with the same size of the synthesized polystyrene particles.



(a) (b)

Figure 2. SEM image of latex particles on the glass; (a) 1μm, on the silanized glass, (b) 1.7μm, on the slide glass.

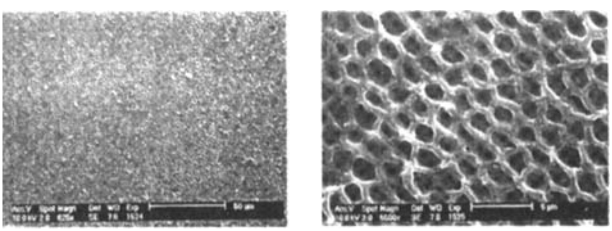
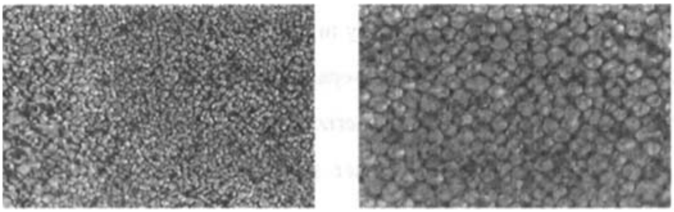


Figure 3. SEM images of 2D structured polymer surfaces.

After assembling the glass substrates coated with the alignment layers, E7 liquid crystal was filled into a liquid crystal cell. Textures of the liquid crystal were observed by polarized microscope. Figure 4 illustrates the textures of the LC cell.



(a) (b)

Figure 4. Polarized microscopic images of the textures of the nematic liquid crystals; (a) ×5, (b) ×10 objective lens.

Because the cured epoxy film can align the liquid crystals with homogeneous orientation without rubbing, nematic liquid crystals subjected to the surface of the cavity can have various directors. Each domain of the random orientation was the same order of the size of the polystyrene latex. A similar structure of multi-domain alignment was reported by using amorphous TN[16], 90μm size of conic-cylindrical-cavities[17], axially symmetric microcell[18], and random domain[19]. If we adapt the homeotropic alignment, the template process can be applied to the multi-domain vertical alignment[20, 21].

CONCLUSIONS

PS latex particles were synthesized by emulsifier-free emulsion polymerization and the diameter of the synthesized polystyrene particles was 1.7μm. The attraction between the particles was changed by incorporating CTAB because of the coupling of the negative charges on the surface of the beads. The 2D PS latex particles were easily packed on the hydrophilic substrate in highly oriented layers over a wide surface area due to water evaporation and lateral capillary forces. The wettability of the substrate is most important factor to form the 2D arrays of the latex particles. After dissolving the latex particles with toluene, 2D structured polymer surfaces were obtained. The surface showed a regular structure having cavities with the same size of the synthesized polystyrene particles. Nematic liquid crystals subjected to the surface of the cavity have various directors. The liquid crystal cell showed the random orientation, which was the same order of the size of the particles. As a conclusion, multi-domain structure was obtained by using the template method.

References

[1] Wijnhoven, J.E.G.J. and Vos, W.L., Science, **281**, 802 (1998).
[2] Zakhidov, A.A., Baughman, R.H., Iqbal, Z., Cui, C., Khayrullin, I., Dantas, S.O., Marti, J., and Ralchenko, V.G., Science, 282, 897 (1998).
[3] Yamasaki, T. and Tsutsui, T., Applied Physics Letters, **72**, 16 (1998).
[4] Park, S.H. and Xia, Y, Chem. Mater., **10**, 1745 (1998).
[5] Micheletto, R., Fukuda, H., and Ohtsu, M., Langmuir, **11**, 333 (1995).
[6] He, K.X., Curley, M., Williams, A., and Wang, J.C., Optics Communications, **139**, 39 (1997).
[7] Hayashi, S., Kumamoto, Y., Suzuki, T., and Hirai, T., Journal of Colloid and Interface Science, **144**(2), 538 (1991).
[8] Haginoya, C., Ishibashi, M., and Koike, K., Appl. Phys. Lett., **71**(20), 2934 (1997).
[9] Matsushita, S.I., Miwa, T., Tyrk. D.A., Fujishima, A., Langmuir, **14**, 6441 (1998).
[10] Nagayama, K., Colloids and Surfaces, **109**, 363 (1996).
[11] Picard, G., Langmuir, **13**, 3226 (1997).
[12] Dushkin, C.D., Kralchevsky, P.A., Paunov, V.N., Yoshimura, H., Nagayama, K., Langmuir, **12**, 641 (1996).
[13] Kim, M.H., Lee, H.S., Koo, Y.M., Kim, S.M., Lee, M.S., and Kim, J.D., Mol. Cryst. Liq. Cryst., **316**, 241 (1998).
[14] Kim, M.H., Kim, H.W., and Kim, J.D., Mol. Cryst. Liq. Cryst., **331**, 297 (1999).
[15] Goodwin, J.W., Hearn, J., Ho, C.C., Ottewill, R.H., Br. Polym. J., **5**, 347 (1973).
[16] Toko, Y., Sugiyama, T., Katoh, K., Iimura, Y., Kobayashi, S., J. Appl. Phys., **74**(3), 2071 (1993).
[17] Liang, B.J., Chen, S.H.. Wang, Y.F., Appl. Phys. Lett., **72**, 1290 (1998).
[18] Yamada, N., Kohzaki, S., Funada, F., and Awane, K., J.of the SID, **3**, 155 (1995).
[19] Murai, H., Suzuki, M.. Suzuki, T., Konno, T., Kaneko, S., Liquid Crystals, **25**, 131 (1998).

[20] Yoshida, H., Seino, T., Koike, Y., Jpn. J. Appl. Phys., **36**, L1449 (1997).
[21] Taketa, A., Kataoka, S., Sasaki, T., Chida, H., Tsuda, H., Ohmuro, K., Koike, Y., SID' 98 Digest, 1077 (1998).