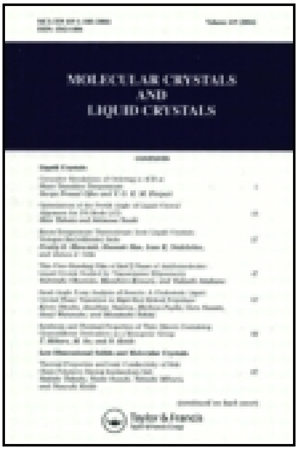

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STRUCTURAL PROPERTIES OF HETERO LAYER THIN FILM COMPOSED OF FREELY SUSPENDED AND SPIN-COATED LIQUID CRYSTAL FILMS

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Structural Properties of Hetero Layer Thin Film Composed of Freely Suspended and Spin-Coated Liquid Crystal Films

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Hybrid liquid crystal film (HF) composed of two kinds of smectic liquid crystals has been fabricated stacking a freely suspended smectic film on another kind of smectic thin film which is spin-coated on a substrate. The layer structure of the hybrid film has been investigated by a X-ray diffraction measurement. It is confirmed that the stacked layer structures are stably maintained for a long time.

Keywords: smectic; freely suspended film; spin-coated film; hybrid film

INTRODUCTION

Freely suspended film (FSF) of a smectic liquid crystal has attracted much interest from fundamental viewpoint, because its thickness can be varied from only two smectic layers to several thousands layers [1-3]. FSF has free surfaces exposed to the air and is very fragile for an external stress. However, a transferred film of the smectic liquid crystal (TF), which is made by putting FSF on a solid substrate, has an interface with solid, so that it is stable to the external force [4].

On the other hand, we have proposed a spin-coated film (SCF) of a polymer smectic liquid crystal which can be easily fabricated by a conventional spin-coating technique [5-7]. This thin film is one of candidates for a thin liquid crystalline film on the substrate and has a good homeotropic alignment and layered structure as like FSF and TF.

So far, liquid crystal cell or thin films such as FSF, TF and SCF, have been composed of single liquid crystalline materials. In general, if the liquid crystal compound contacts with another kind liquid crystal, they should molecularly mixed each other, resulting in the liquid crystalline mixture showing different features from original ones.

In this paper, we propose a hybrid film (HF) containing two kinds of smectic liquid crystalline materials. The HF is fabricated by stacking FSF on SCF (Fig.1). In order to investigate a layer structure, X-ray diffraction analysis of the HF and its original components has been performed as a function of temperature.

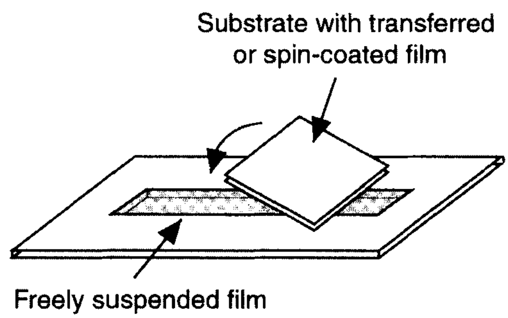
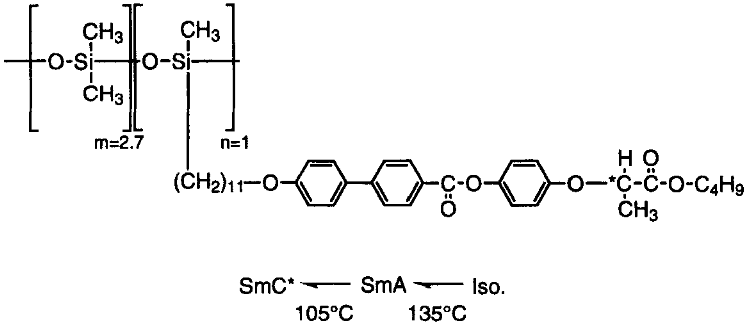


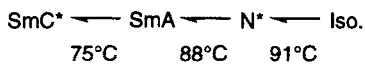
FIGURE 1. Schematic explanation of the fabrication of the hybrid liquid crystal film.

EXPERIMENTAL

Figure 2 shows molecular structure and phase sequences of polymeric ferroelectric liquid crystal (PFLC), PSi-1MC1EPOPB, and low molecular weight ferroelectric liquid crystal (LFLC), CS-1029 (Chisso), used in this study. Below 88°C, both of them show the smectic phases.



(a) PFLC (PSi-1MC1EPOPB)



(b) LFLC (CS-1029)

FIGURE 2. Molecular structure and phase sequences of PFLC and LFLC used in this study.

SCF of PFLC was prepared as follows. A glass substrate (12mm×12mm), whose surface was treated with a silane coupler (AY43-021, Toray Dow Corning Silicone), was set on a turntable of a spin-coater. The solution of PFLC (20 mg dissolved in 1 cm^3 of chloroform) was dropped over the substrate, and subsequently, the substrate was revolved at 250 rpm for 1second and then 1500rpm for 15 seconds to remove excess solution. The film thickness can be controlled by the concentration of PFLC in a solution. In order to realize a well-aligned homeotropic alignment, SCF was heated up to the isotropic phase (145°C).

FSF was prepared as follows. A glass substrate (30mm×30mm) with a rectangular hole (2mm×10mm) was heated up to the smectic A (SmA) phase (80°C). FLC compound was put on the substrate beside the hole, and was spread onto the hole using a polyethylene terephthalate (PET) sheet.

HF was prepared by following procedure. First of all, we prepared the SCF of PSi-1MC1EPOPB on a substrate and the FSF of CS-1029 in the manner mentioned above. FSF was stacked on the SCF whose temperature was kept as same as that of FSF. The number of layers was determined by measuring a reflection spectrum.

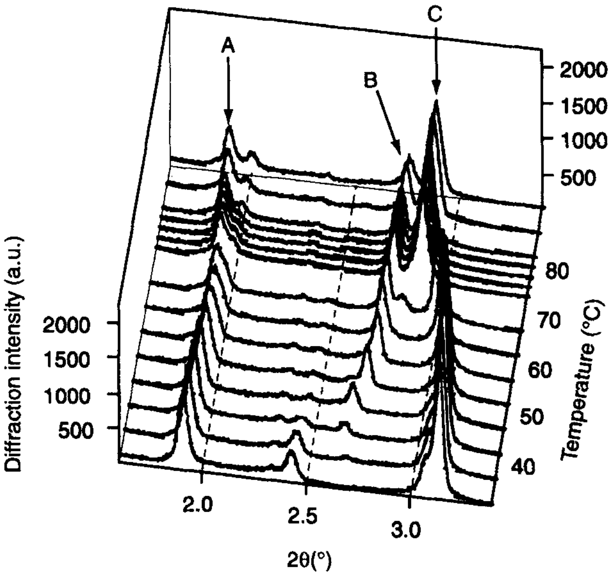


FIGURE 3. The temperature dependence of X-ray diffraction profile of thicker HF composed of PFLC thick SCF (about 150 layers) and LFLC thick TF (about 300 layers).

RESULTS AND DISCUSSION

Figure 3 shows the temperature dependence of the X-ray diffraction profiles of HF composed of PFLC thick SCF (about 150 layers) and LFLC thick TF (about 300 layers). As evident from this figure, clear three diffraction peaks are observed in the entire temperature range, which are denoted by A, B and C as shown in Fig. 3. The diffraction peaks, A and C, shift to larger diffraction angles with decreasing temperature, whereas peak B shifts to smaller angle.

Figure 4 (a) and (b) show temperature dependence of lattice spacing estimated from the diffraction angles of peaks A and C, respectively. The smectic layer spacing of PSi-1MC1EPOPB SCF and CS-1029 TF evaluated from the X-ray diffraction analysis are also shown in Fig. 4 (a) and (b) as open circles, respectively. As is evident from this figure, temperature dependence of spacing corresponding to peaks A and B in HF coincide with those of individual thin films, that is SCF of PFLC and TF of LFLC, respectively. Therefore diffraction peaks A and C in HF correspond to those from PSi-1MC1EPOPB and CS-1029 layers in HF, respectively. In other words, PFLC SCF and LFLC TF exist separately and hetero structure is independently composed of LFLC and PFLC layers.

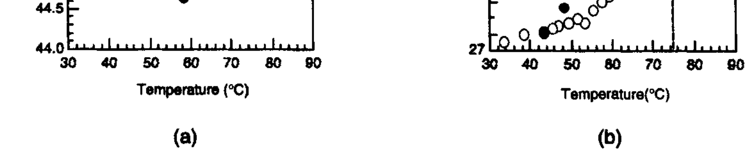


FIGURE 4. The temperature dependence of the layer spacing of PFLC in SCF and HF (a), and LFLC in TF and HF (b).

Figure 5 shows the temperature dependence of the X-ray diffraction profile of HF composed of PFLC thin SCF (about 40 layers) and LFLC thin TF (about 70 layers). In a thinner HF, two diffraction peaks are mainly observed. The temperature dependence of spacing corresponding to peak D coincides with that of peak A as shown in Fig. 6 (a). This indicates that peak D in a thinner HF is associated with the peak of SCF PFLC, as the same manner as that in a thicker HF. However, peak E in a thinner HF does not correspond to any peaks in a thicker one. With decreasing temperature, peak E is divided into two peaks, F and G, around 90°C, and peak G disappears around 70°C.

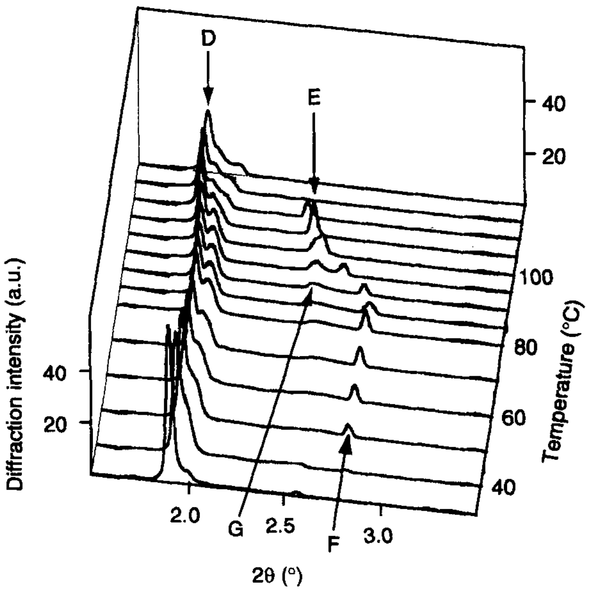


FIGURE 5. The temperature dependence of X-ray diffraction profile of thinner HF composed of PFLC thin SCF (about 40 layers) and LFLC thin TF (about 70 layers).

Figure 6 (b) shows the temperature dependence of the layer spacings corresponding to peak F in the thinner HF and peak C in the thicker HF. As evident from this figure that the peak F in thinner HF is not associated with any original components in HF. This result may indicate that LFLC thin layer almost diffuses into PFLC layer at the interface of thinner HF.

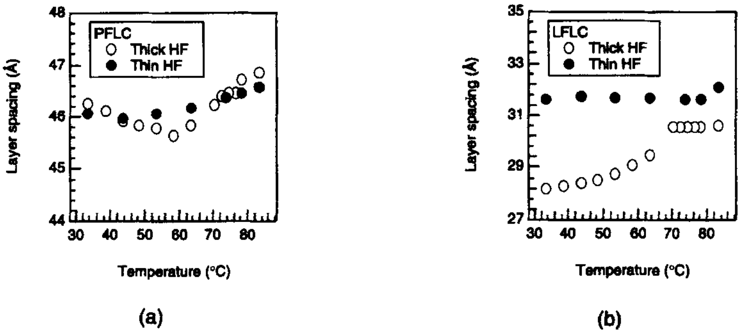


FIGURE 6. The temperature dependence of the layer spacing of PFLC (a) and LFLC (b) in thicker and thinner HFs.

Also in the thicker HF, a small diffraction peak B is observed at an intermediate position between peaks A and C. This additional peak belongs to neither PFLC nor LFLC, and may originate from the mixed layer of LFLC and PFLC at the interface of HF.

Figure 7 shows the temperature dependence of the layer spacings of the bulk LFLC/PFLC mixture and that corresponding to peak B in HF. The layer spacing of LFLC/PFLC mixture coincides with that corresponding to peak B. Therefore, the additional peak in HF might be associated with the mixed layer at the interface of PFLC with LFLC in HF.

The height of the additional peak in HF is almost independent of time. This implies that the thickness of the mixed layer at the interface does not change. Therefore, the mixed layer at the interface between PFLC and LFLC might be caused at the instance of stacking the FSF on the SCF, and original PFLC and LFLC layers in the HF may be stably maintained for a long time.

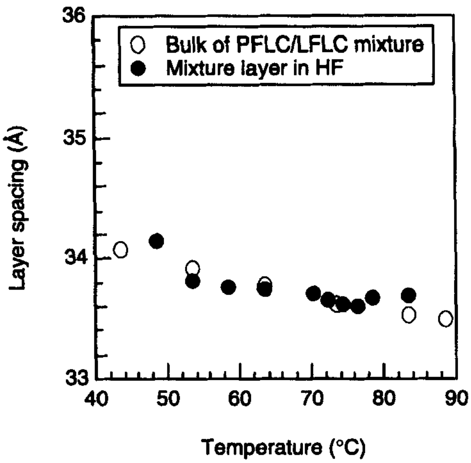


FIGURE 7. The temperature dependence of the layer spacing of the bulk LFLC/PFLC mixture and that corresponding to diffraction peak B in HF.

CONCLUSIONS

We successfully realized a hetero structure film containing SCF and FSF for the first time. From the X-ray measurement in HF, it was confirmed that the layer structures of the individual films were stably maintained. From these results, we can expect various novel characteristics in HF because HF consists of different kinds of liquid crystalline materials. For example, if two liquid crystal layers having different refractive index can be piled up alternately with a periodicity of the optical wavelength, optical stop band should be observed. If the liquid crystals having opposite polarities of spontaneous polarization are piled up, it might have the possibility that antiferroelectric-like characteristics are expected.

References

[1] P. Pieranski, L. Beliars, J.-Ph. Tournellec, X. Leoncini, C. Furtlehner, H. Dumoulin, E. Piou, B. Jouvin, J.-P. Fenerol, Ph. Palaric, J. Heuving, B. Cartier and I. Kraus, *Physica A* **194**, 364 (1993).
[2] Y. Demikov and V.K. Dolganov, *Mol. Cryst. Liq. Cryst.* **303**, 193 (1997).
[3] S. Uto, E. Tazoh, M. Ozaki and K. Yoshino, *Jpn. J. Appl. Phys.* **36**, 1198 (1997).
[4] J. Maclennan, G. Decher and U. Sohling, *Appl. Phys. Lett.* **59**, 917 (1991).
[5] K. Skarp, S. Uto, K. Myojin, H. Moritake, M. Ozaki and K. Yoshino, *Jpn. J. Appl. Phys.* **34**, 5433 (1995).
[6] S. Uto, H. Moritake, K. Myojin, K. Skarp and B. Helgee, *Ferroelectrics* **181**, 297 (1996).
[7] S. Uto, H. Moritake, M. Ozaki, K. Yoshino, K. Skarp and B. Helgee, *J. Appl. Phys.* **79**, 4444 (1996).