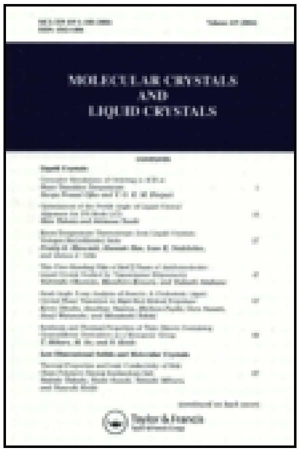

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Influence of Phase Transition of Langmuir Monolayers on Liquid Crystal Alignment

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Influence of Phase Transition of Langmuir Monolayers on Liquid Crystal Alignment

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Abstract The alignment of a nematic liquid crystal MBBA on dipalmitorylphosphatidylcholine(DPPC) monolayers has been investigated. The monolayers are prepared using Langmuir-Blodgett techniique. In the liquid-expended state, the monolayers induce homeotropic alignment of liquid crystal molecules. While in the liquid-condensed and the solid-condensed states, the homeotropic alignment disappears. The experimental result is useful to select a suitable aligning layer for fabricating liquid crystal devices.

1. INTRODUCTION

Liquid crystals have been widely used in display devices and optoelectronic devices because of the features of their physical characteristics. In these applications, one of the most improtant problems is initial alignment of liquid crystal molecules. It is well known that the alignment of liquid crystal molecules depends on the surface boundary conditions[1]. Surfactant coated substrate is a routinely used technique for producing the boundary surfaces that have alignment action to liquid crystal molecules. However, it is difficult to produce a controllable aligning layer using common dipping and spin coating techniques.

Recently,the alignment of liquid crystal molecules on Langmuir-Blodgett films has been investigated[2-4]. It is possible to deposit organic monolayers with known structures using Langmuir-Blodgett technique. Which will offer the opportunity to investigate the alignment mechanism of liquid crystal molecules. Lecithin is a surfactant that can induce the homeotropic alignment. While Langmuir monolayers of lecithin show various physical states and phase transitions[5]. In this paper, we have investigated the influence of phase transition of lecithin monolayers on nematic liquid crystal MBBA.

2. EXPERIMENTAL

A relatively simple lecithin, namely dipalmitorylphosphatidylcholine(DPPC), was used in our experiments. DPPC was dissolved in chloroform solution at the concentration of o.034mg/ml. DPPC monolayers were prepared in a Langmuir trough. The monolayers were compressed until the reguired physical states were attained. The glass plates were immersed in the water subphase before spreeding of the monolayers. The deposition spreed of the monolayers was 5mm/min, as shown in Fig.1.

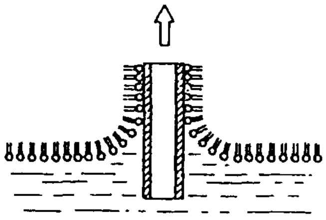

Fig.1 Deposition of DPPC monolayer by LB technique

The liquid crystal cell were assembled using two glass plates with 25um Mylar spacer. The inner surfaces of glass plates were covered with DPPC monolayers. The samples were placed in a hot stage and observed under a Leitz polarizing microscopy(ORTHOPLAN-POL). The nematic liquid crystal MBBA was filled in the cells by capillary in the isotropic phase, then the samples were cooled down to the nematic phase of MBBA to obtain uniform alignment in liquid crystal layers.

3.RESULTS AND DISCUSSION

Fig.2 shows the surface pressure-area isotherms of DPPC monolayers. Various monolayer states can be obtained for aligning liquid crystal molecules by varying either temperature at constant surface pressure or surface pressure at constant temperature. The sharp kink in the middle of each isotherm signs the onset of the transition between the liquid-expanded(LE) phase and the liquid-condensed(LC) phase. As can be seen in the figures the transition point is strongly temperature dependent.

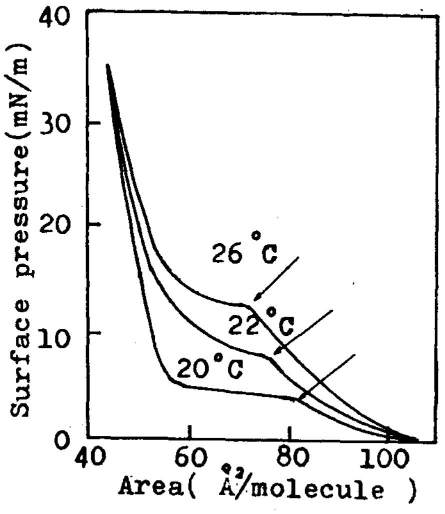

Fig.2 Surface pressure-area isotherms of DPPC monolayers

In this study, the later approach is employed. The LE/LC transition occures at the surface pressure of 9 mN/m, when the temperature is maintained at 22 °C. The plateau in the isotherm indicates a coexistence between LE phase LC phase. At the surface pressures of 5, 25 and 35 mN/m, DPPC monolayers were transferred onto glass plates, these surface pressures are representative of DPPC monolayers in the LE,LC and solid-condensed(SC) phases,respectively.

Fig.3 shows the photography of liquid crystal cells using DPPC monolayer deposited at the surface pressure of 5mN/m. The liquid crystal layer has a distinct interface between DPPC monolayer coated substrate and bare substrate. On bare substrate, the field of view is not uniform, many small domains are visible. This indicates

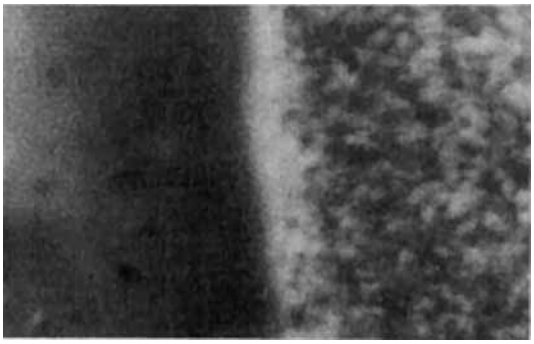

Fig.3 Photograph of liquid crystal cell. Crossed polarizers.Left:uniform texture;Right:mosaic texture.

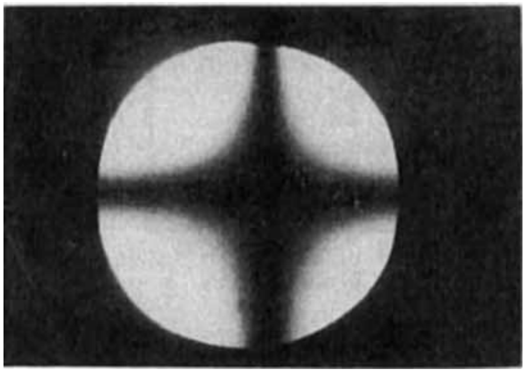

Fig.4 Conoscopic image of homeotropic texture in nematic phase of MBBA

that the director of liquid crystal molecules varies randomly in the region. On DPPC monolayer coated substrate, the field of view is uniform. The conoscopic examination indicates that liquid crystal molecules are aligned perpendicular to the monolayer surface, as shown in Fig.4. When DPPC monolayers were deposited at the surface pressures of 25 and 35 mN/m, the conoscopic examinations show that the homeotropic alignment of liquid crystal molecules disappears.

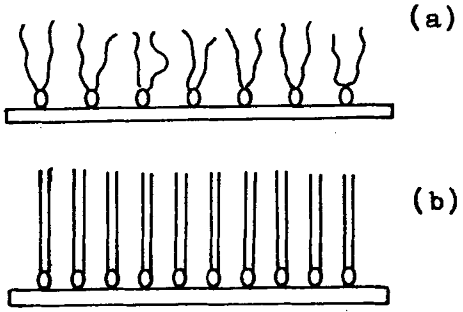

Fig.5 Schematic representation of DPPC packing in monolayers.(a) LE phase; (b)LC phase

If the aligning forec is hydrocarbon chain interaction between liquid crystal molecules and DPPC molecules, the aligning force of DPPC monolayers can not decrease with increasing surface pressure. Kahn [6] demonstrated that hydrocarbon chain interaction was great so that rubbing was not sufficient to disrupt it. So we suggest that the aligning force of DPPC monolayers come from the dipole-dipole interactions, because liquid crystal molecules and DPPC molecules have polar groups. In the surface pressure of 5mN/m, average area per molecule is about 80 $Å^2$. This indicates that DPPC molecules are loosely packed in monolayers, as shown in Fig.5a. Liquid crystal molecules can inset among long hydrocarbon chains of DPPC molecules. The assumption was propoesd by Hiltrop et al [7]. In this case, the non-polar spacing between dipole of liquid crystal molecule and dipole of DPPC molecule is smaller. With increasing surface pressure, the interaction of hydrocarbon chains of DPPC becomes more important and lead to the phase transition to the LC and SC phases. The no-polar long chains are gradually oriented homeotropicly, as shown in Fig.5b. The increace of non-polar spacing leads to the decrease of the attractive force between dipoles. Which makes the homeotropic alignment of liquid crystal molecules to disappear. It is also noted that a given DPPC monolayer has not the same aligning action for all liquid crystals. For the DPPC monolayers deposited at the surface pressure of 25mN/m, 8CB liquid crystal molecules show tilt homeotropic alignment, while MBBA liquid crystal molecules do not show uniform alignment. It is well known that the dipole of 8CB is larger than that of MBBA. The result also implies that the dipole-dipole interaction is main alignment mechanism.

4. CONCLUSION

We have found that DPPC monolayers can induce the homeotropic alignment of nematic liquid crystal MBBA. However, the alignment properties depend on DPPC molecular packing density in monolayers. We suggest that the phenomenon is attributed to rearrangement of DPPC during the phase transition of monolayers.

REFERENCES

1.J.Cognard, Mol.Cryst.Liq.Cryst.suppl.1,(1982)
2.F.C.Saunders,J.Otcromlynska,G.W.Smith and M.F.Daniel, Mol.Cryst.Liq.Cryst.122,297 (1985)
3.Y.Nishikata,A.Morikawa,Y.Takiguchi,A.Kanemoto,M.Kakimot and Y.Imai, Jpn.J.Appl.Phys.27, L1163 (1988)

4.J.Y.Fang,Y.Wei,Z.M.Sun and .Stroeve,Phys.Lett A.154,396 (1991)

5.R.D.Neuman and S.Fereshtehkhou,J.Colloid and Interface Sci.125,34 (1988)

6.F.J.Kahn,Appl.Phys.Lett. 22,368 (1973)

7.K.Hiltrop and H.Stagemeyer,Mol.Cryst.Liq.Cryst. 49,61(1978)