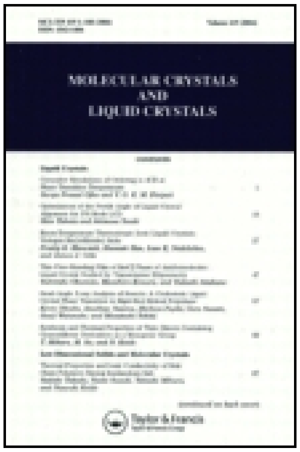

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The Relationship Between Contact Angles and Characteristics of Ch-Liquid Crystal/Polymer Composite Films

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THE RELATIONSHIP BETWEEN CONTACT ANGLES AND CHARACTERISTICS OF Ch-LIQUID CRYSTAL/POLYMER COMPOSITE FILMS

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Abstract The relations between contact angles of Ch liquid crystal / polymer interface and contrast ratios of the composite films are investigated. It is found that there is a correlation between contact angles and contrast ratios. But the correlation depends on materials of composite films.

INTRODUCTION

Recently, several types of backlightless and reflective display devices for high resolution and large size LCDs using cholesteric liquid crystals(ChLC) have been reported.[1~9] Bistable reflective paper-white display devices,however, had not been achieved before we reported one using ChLC and polymer materials.[10] ChLC possessing IR selective reflection wavelength have a very uniform transparent planar state and a scattering focal conic state in the visual region.These states can be stabilized by using polymer materials. We confirmed that ChLC / polymer composite films using monoacrylate monomer and tolan series nematic liquid crystals had bistable properties and showed that the characteristics of composite films depended on the materials such as liquid crystals and monomers. We believe this is due to interactions between ChLC and polymers. But there has been few discussion about this interactions. In this paper we notice contact angles of ChLC / polymer interface as a parameter having influence on contrast ratios. We investigate,therefore, relations between contact angles and contrast ratios.

EXPERIMENT

In our experiments we measured contact angles of ChLC/polymer interface and contrast ratios of composite films. FIGURE 1 illustrates the drop method used to measure the contact angles. We measured contact angles of dropped liquid crystal droplets on polymer films, using contact angle meter (Kyowa kaimen kagaku CA-A). Polymer films were prepared on glass substrates(0.24mm thickness).

Monomers were coated on the glass substrate and exposed UV light to cure them. ChLC controlled to reflect light in the infrared region(1.1 μm) were mixtures of a nematic liquid crystal and a chiral dopant S-811.As we reported before, monoacrylate monomers had good performances on the contrast ratios[10]. We used monoacrylate monomers(M1~M5) shown in TABLE Ⅱ and two species of ChLC (Ch-A,Ch-B) shown in TABLE Ⅰ.

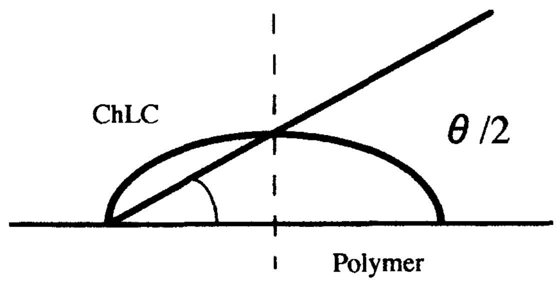


FIGURE 1. Drop method.

TABLE Ⅰ Characteristics of ChLC

ChLC	Nematic	Δ ε	Δn	Chiral dopant
Ch-A	Tolan series(Chisso)	8.08	0.219	S-811(Merck)
Ch-B	E7(Merck)	13.8	0.2246	S-811(Merck)

TABLE Ⅱ Characteristics of monomers

Monomer	Numbers of functional groups	ε
M1~5	1	3.5~4.0

We measured the contrast ratios as follows. At first, ChLC / polymer composite films were prepared by a photopolymerization induced phase separation method. Materials used are also shown in TABLE Ⅰ, Ⅱ. We mixed a ChLC mixture and a monomer and a photoinitiator by a weight ratio of 86:12.6:1.4. The solution was sandwiched between ITO coated glass substrates with no alignment layers and exposed by UV light of about 13mW/cm^2 for polymerization. The thickness of films were controlled in 20 μm. We measured the luminous reflectance(Y stimulus value) of composite films using spectrophotometer CM1000(Minolta Co.,Ltd) after applying high voltage pulse(150V-5ms) and after applying low voltage pulse(80V-5ms). When high voltage pulse was applied, ChLC transformed into transparent state and when low voltage pulse was applied, ChLC transformed into scattering state and the contrast ratio was defined as the ratio of Y stimulus values of scattering state to Y stimulus values of transparent state.

RESULTS AND DISCUSSION

FIGURE 2 shows contact angles of ChLC / polymer interface versus contrast ratios of composite films for both Ch-A and Ch-B. It is found that when the contact angle of Ch-A/polymer interface is small, the contrast ratio is large. And for Ch-B, there is a slight correlation between contact angles and contrast ratios.

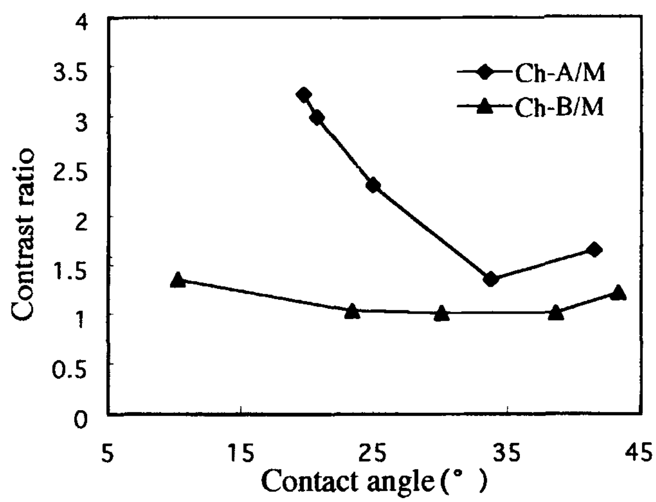


FIGURE 2. Relations between contact angles of ChLC (Ch-A,B)/polymer (M1-M5) interface and contrast ratios of composite films.

We think that when the interaction between Ch-A and polymers is large, the contact angle is small.Then small contact angle makes the ChLC forms a planar texture easily and because of that the transparency and the contrast ratio of films are improved. When contact angle is large,the interaction between liquid crystal molecules and polymers is weak and the weak interaction makes ChLC forms several textures(almost focal conic,planar...) .Then the transparency of films decreases and the contrast ratio also decrease. In Ch-B case, the correlation between the contact angle and the contrast ratio become weak since the diameter of the polymer matrix is small and the numbers of anchored ChLC molecules increase.Therefore by measuring dielectric constants of composite films it is possible to estimate how easy ChLC molecules moved. Dielectric constants of composite films were measured by using Impedance analyser(HP 4192A). TABLE II shows the results. In Ch-A case it is found that the value of εt of the composite film having good contrast ratio is small and the difference between εs and εt is large. We think this result indicates that ChLC in the composite film having good contrast ratio forms uniform planar texture.

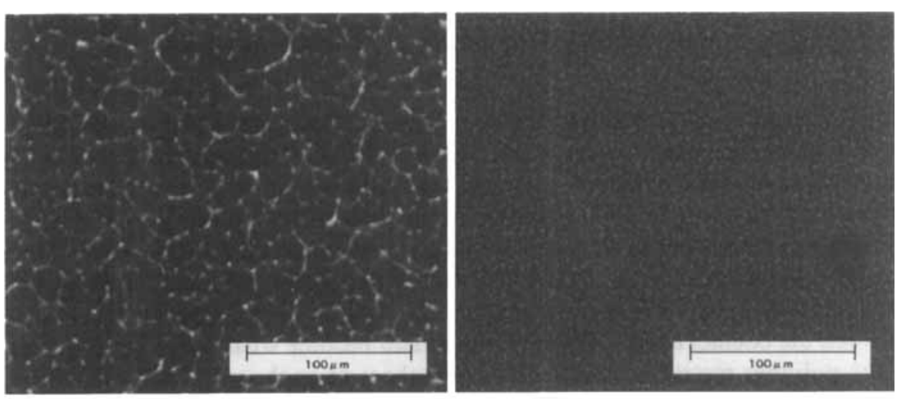
TABLE II Dielectric constants of composite films

ChLC	Monomer	Contrast ratio	ε t	ε s	ε s- ε t
Ch-A	M1	3.23	5.29	7.25	1.94
	M2	3.01	5.47	7.39	1.92
	M3	2.31	5.57	7.46	1.89
	M4	1.37	6.06	7.23	1.17
	M5	1.65	5.62	7.12	1.50
Ch-B	M1	1.37	7.10	8.34	1.24
	M2	1.05	7.34	8.22	0.88
	M3	1.02	7.64	7.70	0.06
	M4	1.03	7.63	7.67	0.04
	M5	1.22	7.16	9.15	1.99

ε t: dielectric constants of transparent state

ε s: dielectric constants of scattering state

In Ch-B case, it is found that the values of both ε t and ε s are large and there is little correlation between ε t and the contrast ratio. Then we observed morphologies of polymer matrix, shown in FIGURE 3 (a)(b).



(a) Ch-A / M1 (b) Ch-B / M1

FIGURE 3. Morphologies of polymer matrix.

In these photographs it can be seen that diameters of polymer matrix in the case of Ch-A/M1~5 are larger than those of Ch-B / M1~5. The diameters of polymer matrix of Ch-B are so small that ChLC are hard to respond with applied voltages.

Therefore we believe that there is no correlation between the value of ε t and contrast ratios in Ch-B case.

CONCLUSION

We investigated relations between the contact angles and contrast ratios of composite films. We found that when the contact angle of ChLC/polymer interface is small, contrast ratio is large.We think that interactions between ChLC and polymers are strong and small contact angle make a ChLC forms a planar texture easily and because of that the transparency and the contrast ratio of composite films are improved.

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