UV-curable liquid crystal for a retarder

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Keywords: Liquid crystal, Patterned retarder

Abstract

A liquid crystalline monomer is applicable to fabricate a retarder in which various types of alignment are fixed. We have developed the monomer, UV-curable liquid crystal optimized for coating processes. Applications and materials for the retarder are reviewed.

1. Fabrication of retarder using UV-curable liquid crystal

Figure 1 presents processes to make the retarder. First, the UV-curable liquid crystal is coated on a glass substrate with an alignment layer. Then, the UV-curable LC is irradiated with UV light at room temperature to polymerize.

2. Applications of retarder

The retarder with homogeneous alignment applicable to compensate color[1)] or widen viewing angle of polarizer[2)]. That with homeotropic alignment is also applicable to widen viewing angle of polarizer[2)]. That with hybrid alignment is effective to improve viewing characteristics of TN displays[3,4)]. That with twisted alignment can be used to compensate color of STN displays[5,6)].

3. Materials for various types of alignment

Clearing point, birefringence and viscosity of UV-curable liquid crystals are summarized in TABLE 1. Various types of alignment can be obtained by only coating on a substrate with an alignment layer.

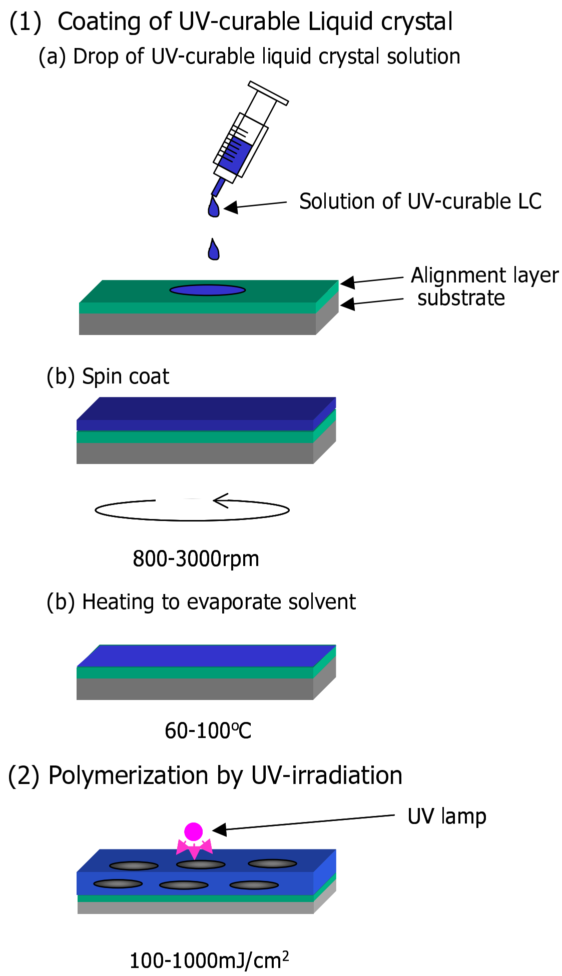


Fig. 1. Fabrication process of retarder.

TABLE 1. Properties of UV-curable liquid crystals

Alignment	Product. No.	Clearing point (°C)	Birefringence (Δn)
Homogeneous (positive-A)	UCL-017	70	0.17
	UCL-017A	96	0.16
Hybrid	UCL-008	70	0.17
Homeotropic (positive-C)	UCL-018	70	0.17
Cholesteric (negative-C)	UCL-Ch002	65	0.16

3.1 Homogeneous type material: UCL-017

Fig. 2 shows thermal stability of retardation with homogeneous alignment using UCL-017A at 240°C. Decrease of retardation after 2hours is less than 10%. This means that this type of the retarder is applicable to "In-cell retarder".

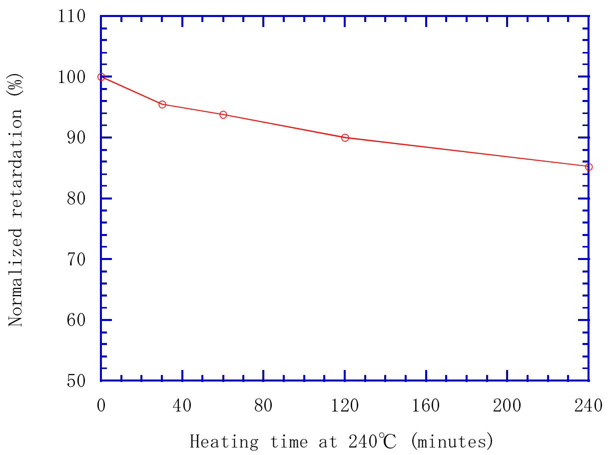


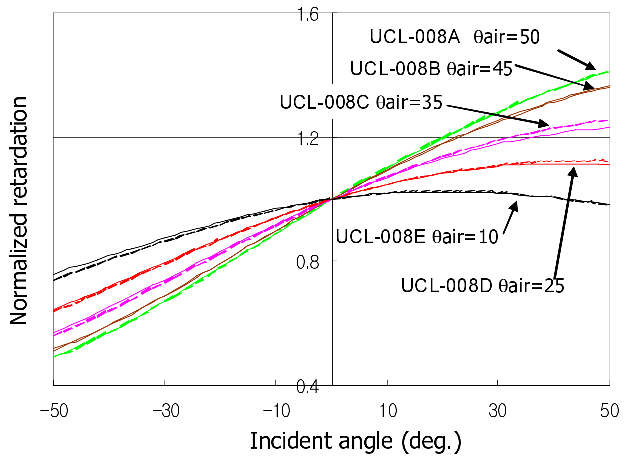
Fig.2. Thermal stability of retardar with homogeneous alignment made of UCL-017A

3.1 Hybrid type material: UCL-008

Fig. 3 shows Incident angular dependences of retardation for film made of UCL-008 series. Tilt angle at air surface (θair) can be controlled in the range of 20-50 degrees.

3.2 Homeotropic type material: UCL-018

UCL-018 is free from homeotropic type alignment layer to align. Homeotropic alignment can be obtained by coating the material on glass substrate or non-rubbed homogeneous type alignment layer.



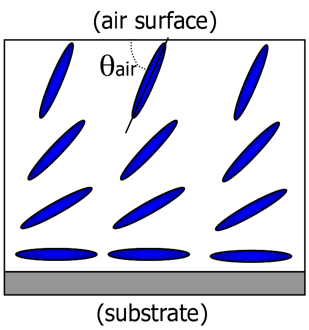


Fig. 3. Incident angular dependence of retardation for film made of UCL-008 series.

3.3 Typical fabrication conditions of films

Typical fabrication conditions in case of spin coating are summarized in TABLE 2. No defects are observed in these films.

TABLE 2. Typical fabrication conditions of film

Alignment	Sample No.	Solid content (%)	Spin	Drying	UV curing	Retardation (nm)
Homogeneous (positive-A)	UCL-017	20	1200rpm ×15sec.	80°C× 1min.	20mW/cm^2× 20sec.	Re=126
	UCL-017A	20	1200rpm ×15sec.	90°C× 2min.	30mW/cm^2× 30sec.	Re=126
Hybrid	UCL-008	20	1200rpm ×15sec.	80°C× 1min.	20mW/cm^2× 20sec.	Re=99
Homeotropic (positive-C)	UCL-018	20	1200rpm ×15sec.	80°C× 1min.	20mW/cm^2× 20sec.	Rth=110
Cholesteric (negative-C)	UCL-Ch002	40	1000rpm ×30sec.	60 °C× 3min.	10mW/cm^2× 50sec.	Rth=243

Re=(nx-ny)d, Rth=((nx+ny)/2-nz)d,

4. Material for patterned retarder

An in-cell patterned retarder makes it possible to improve brightness and contrast ratio of transflective LCDs[7-9]. The retarder can be obtained by in-situ photo polymerization of a liquid crystalline monomer through a mask then flushing away of non-polymerized region as shown in Fig. 4.

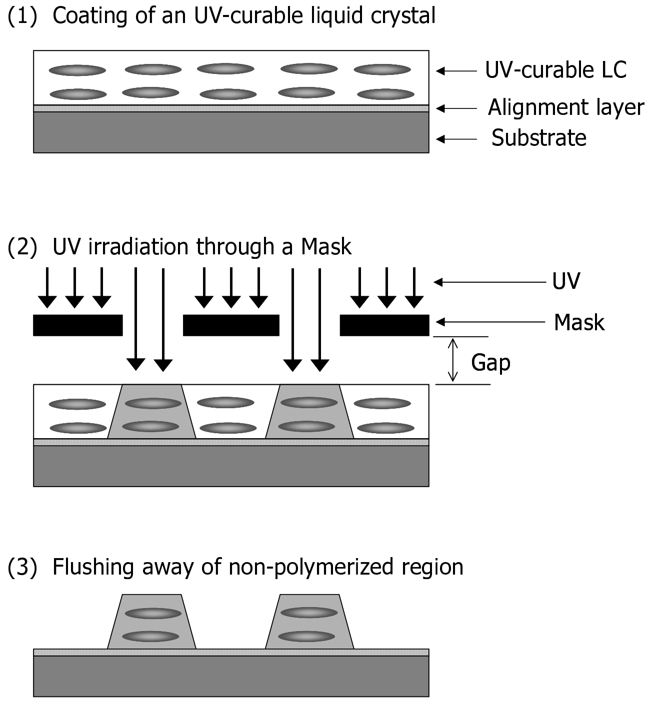


Fig. 4. Fabrication process of patterned retarder.

Figure 5 presents definition of cross sectional shape of the pattern. Critical Dimension (CD) is the smallest dimension of pattern correctly resolved. Our target is to achieve Critical Dimension<15μm and Projection Length (PL) <5μm when retardation value is half wave, to use the retarder for mobile LCDs.

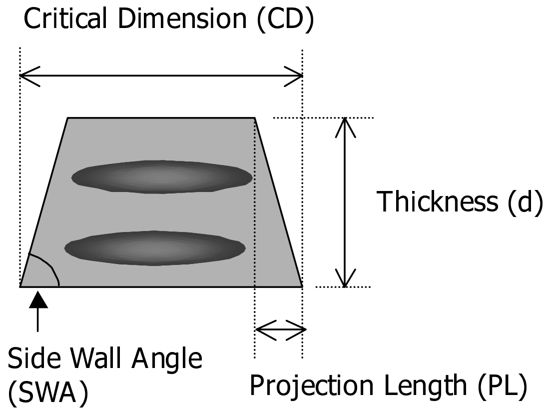


Fig. 5. Definition of cross sectional shape of pattern.

We have optimized UV-curable LC material to achieve the target on the condition that thickness of retarder (d)=1.6μm, UV energy=100mJ/cm^2. Patterning characteristics of conventional material (LC-2) and optimized materials (LC-3 and LC-4) are summarized in Table 3. The target, CD <15μm and PL <5μm are achieved by using LC-4 material.

Figure 6 shows an example of polarizing photomicrograph of patterned retarder with various width of pattern (Line/Space=1/1), which is made of LC-4. It is clear that CD< 15μm is achieved.

TABLE 3. Patterning characteristics of optimized material.

UV-curable LC	CD (m)	SWA (degree)	PL (m)
LC-2(Ref.) n=0.17	31.3	15.7	5.7
LC-3 n=0.17	22.1	19.2	4.6
LC-4 n=0.17	11.0	20.0	4.4

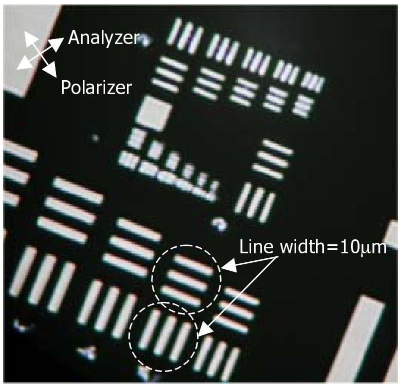


Fig. 6. Polarizing photomicrograph of patterned retarder.

5. Summary

UV-curable liquid crystals for various alignments have been developed. Good thermal stability of film made of the liquid crystals opens application field for in-cell retarder. It is possible to make patterned retarder using photo lithograph technique. Resolution of the pattern is 11μm.

6. References

1) T.Hanami, M.Hara, H.Odai, K.Iwasa, Proc. of 14th Liquid crystal conference in Japan, 64(1988).
2) J.Chen, K.-H. Kim, J.-J. Jyu, J.H. Souk, J.R. Kelly and P.J. Bos, SID'98, 315(1998).
3) P.van de Witte, S.Stallinga and J.A.M.M. van Haaren, SID'97, 687(1997).
4) T.Toyooka, E.Yoda, Y.Kobori, T.Yamanashi and H.Itoh, SID'98, 698(1998).
5) J.Mukai, T.Kurita, T.Kaminade, H.Hara, T.Toyooka and H.Ito, SID'94, 241(1994).
6) M.Bosma, SID'98, 850(1998).
7) C.Doornkamp, B.M.I. van der Zande, S.J. Roosendaal, L.W.G. Sofmeel, J.J. van Glabbeek, J.T.M. Osenga, J.A.M. Steenbakkers,, IDW'03, 685(2003).
8) S.J.Roosendaal, B.M.I. van der Zande, A.C.Nieuwkerk, C.A. Renders, J.T.M. Osenga, C. Doornkamp, E.Peeters, J. Bruinink, J.A.M.M. van Haaren and S.Takahashi, SID'03, 78(2003).
9) C.Doornkamp, S.J.Roosendaal, B.M.I. van der Zande, L.W.G. Stofmeel, J.J. van Glabbeek, J.T.M. Osenga, SID'04, 670(2004).