

# Synthesis of Schiff Base-type Liquid Crystalline Crown Ethers Containing Dibenzo-18-Crown-6 Unit

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The synthesis and characterization of novel Schiff base liquid crystalline crown ethers prepared from the intermediates 4-(4'-alkoxybiphenyl-4-carbonyl)benzaldehyde, *cis*- and *trans*-4,4'-diaminodibenzo-18-crown-6 are described. The structure of these compounds have been well characterized by elemental analysis, IR, <sup>1</sup>H NMR and MS spectroscopy. The liquid-crystalline behavior of these compounds was also investigated by differential scanning calorimetry (DSC), polarizing optical microscopy (POM) with a heating stage and polarimetric analysis.

**Keywords** Schiff base, liquid crystalline crown ether, thermotropic liquid crystal, phase transition

## Introduction

Recently, much interest has been attracted to the new liquid crystalline materials in the field of chiral recognition, ion transportation, function membranes, transferring signal and information at the molecular level.<sup>1-3</sup> Nematic, smectic, discotic and columnar mesomorphic crown ethers<sup>5-8</sup> have been reported since cholesterol mesomorphic crown ethers were first reported by Bogatskaya *et al.*<sup>4</sup> in 1982.

It is well known that liquid crystalline crown ether possesses the properties of both liquid crystal and crown ether. For example, by connecting crown ether ring to mesogenic units with the base bond, the recognizing part for the difference of coexisting metal ion can be formed. These can make them widely used because of their fine-order structure and functional group. To date, there is few reports on the study of Schiff base type liquid crystalline crown ethers.<sup>9,10</sup> In this work, a series of novel Schiff base liquid crystalline crown ethers was designed and synthesized in order to investigate the relationship between the structure and their liquid crystalline properties.

## Experimental

### General

Melting points were measured on a WRS-1 melting point apparatus and the thermometer was uncorrected. Elemental analysis were performed with a Carlo Erba 1160 elemental analyzer. IR spectra were recorded on a Perking-Elmer 1750 FT-IR spectrophotometer with KBr pellets. <sup>1</sup>H NMR spectra were recorded on a Bruker

DPX 400 spectrometer using DMSO-*d*<sub>6</sub> or CDCl<sub>3</sub> or CF<sub>3</sub>COOD as an internal standard. Mass spectra were recorded on a VG-ZAB-HS spectrometer in FAB and a Bruker inc. BiflexIII apparatus with MALDI-TOF technique, using CCA as matrix. This instrument was equipped with a nitrogen laser (337 nm, pulse length 3 ns). It was operated at an accelerating potential of 20 kV. Specific rotations were measured on a WZZ-1 automatic Polarimeter. Differential Scanning Calorimetry (DSC) was recorded on a NETZCH DSC-204 Calorimeter with a data system at a heating rate of 10 °C/min. The phase transition temperatures shown in this paper are values of peaks in the transition temperatures on DSC traces. A Nikon Eclipse E600 polarizing microscope equipped with a hot stage was used to observe various mesophases. Dichloromethane, petroleum ether, pyridine, triethylamine and thionyl chloride were got commercially, and purified according to a reported procedure.<sup>11</sup> Chemical reagents used were of A.R. grade or chemical grade without further purification.

The target compounds were synthesized according to the procedures as shown in Scheme 1.

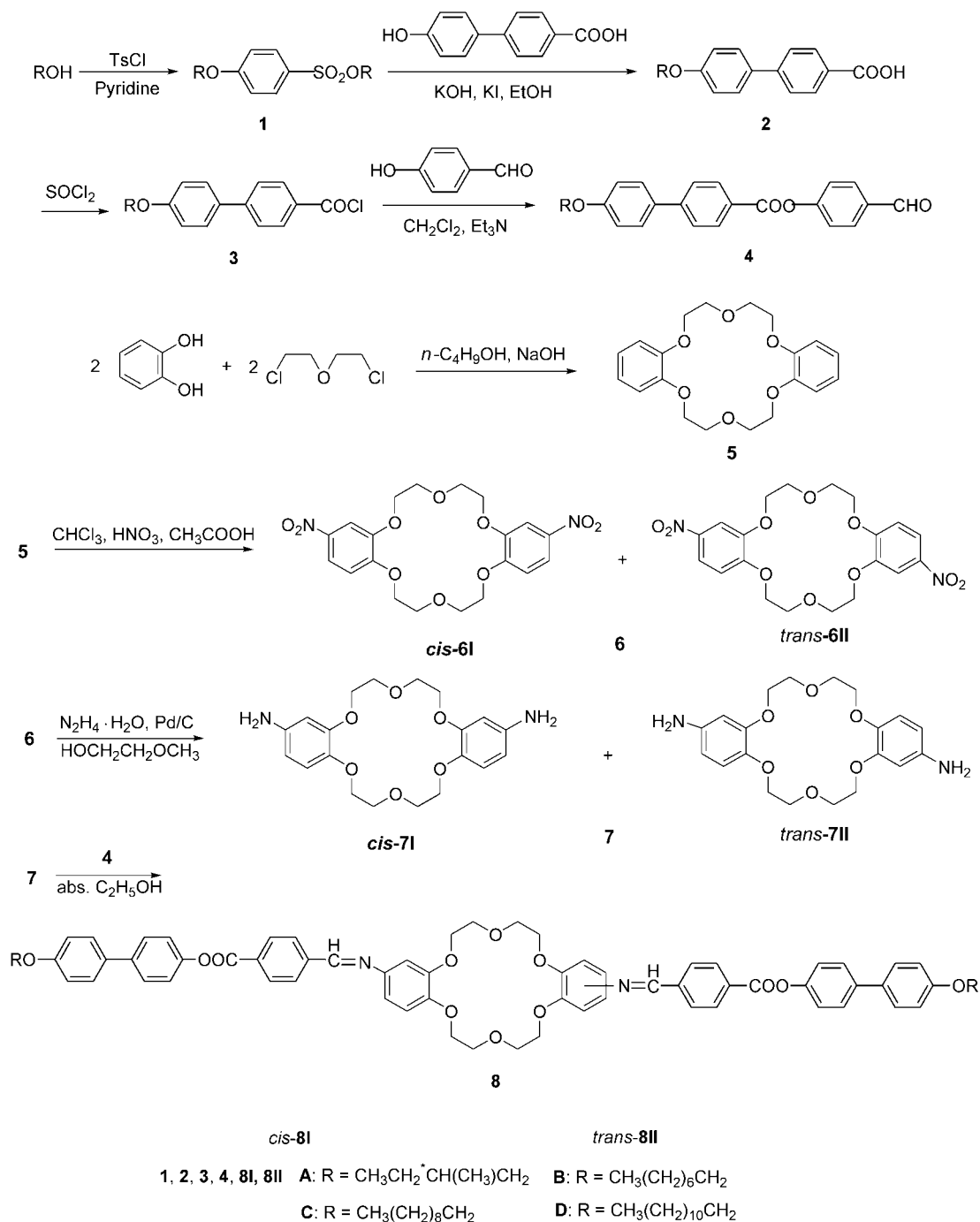
4-Alkoxytosylate (**1**), 4-alkoxybiphenyl-4'-carboxylic acid (**2**), 4-alkoxy biphenyl-4'-carbonyl-chloride (**3**), 4-(4'-alkoxybiphenyl-4-carboxy)-benzaldehyde (**4**), dibenzo-18-crown-6 (**5**), dinitrodibenzo-18-crown-6 (**6I**, **6II**), and diaminodibenzo-18-crown-6 (**7I**, **7II**) were prepared as described.<sup>12,13</sup> The condensation of compounds **7I** or **7II** with compounds **4** gave the target compounds **8I** and **8II**, respectively. Then these target compounds were purified by recrystallization in a mixed solvent of CHCl<sub>3</sub>/ethanol.

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Scheme 1 Synthetic procedure of the target compounds



#### 4,4'-Bis[(4'-alkoxybiphenyl-4-carboxyl)benzylideneamino]dibenzo-18-crown-6 (8)

Taking **8IA** as an example: **4A** (1.800 g, 4.636 mmol) and ethanol (250 mL) were mixed at refluxing under N<sub>2</sub> and **7I** (0.9052 g, 2.3184 mmol) was added. The solution allowed refluxing for 6 h. Then, the solution was cooled, filtrated to give the product. The product was recrystallized in a mixed solvent of CHCl<sub>3</sub>/ethanol (volume ratio: 2/1) and dried in vacuum to give **8IA** as light yellow crystals (2.4980 g). The compounds **8IB**, **8IC**, **8ID** and **8II** were synthesized with similar procedure to that of the compound **8IA**. The data for com-

pounds **8I—8II** were shown as follows:

**8IA**: Yield, 95.2%;  $[\alpha]_D^{20} + 8.65$  (c 0.25, CHCl<sub>3</sub>); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz)  $\delta$ : 8.48 (s, 2H, 2 × CH=N), 8.24 (d, *J* = 8.4 Hz, 4H, ArH), 7.97 (d, *J* = 8.8 Hz, 4H, ArH), 7.70 (d, *J* = 8.8 Hz, 4H, ArH), 7.60 (d, *J* = 8.8 Hz, 4H, ArH), 7.35 (d, *J* = 8.4 Hz, 4H, ArH), 7.01 (d, *J* = 8.8 Hz, 4H, ArH), 6.90—6.88 (m, 6H, 2 × ArH<sub>3</sub>), 4.24 (t, *J* = 5.6 Hz, 12H, 6 × ArOCH<sub>2</sub>), 4.08—4.06 (m, 8H, 2 × CH<sub>2</sub>OCH<sub>2</sub>), 1.62—1.57 (m, 2H, 2 × C\*H), 1.24—1.16 (m, 4H, 2 × CH<sub>2</sub>), 1.05 (d, *J* = 6.4 Hz, 6H, 2 × C\*HCH<sub>3</sub>), 0.97 (t, *J* = 7.2 Hz, 6H, 2 × CH<sub>3</sub>); IR (KBr)  $\nu$ : 1729, 1602, 1580, 1508, 1262, 1129, 875, 823 cm<sup>-1</sup>;

MALDI-TOF MS  $m/z$ : 1131 ( $M^+$ ), 1154 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{70}H_{70}N_2O_{12}$ : C 74.32, H 6.24, N 2.48; found C 74.37, H 6.20, N 2.41.

**8IB**: Yield, 92.3%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.48 (s, 2H,  $2 \times CH=N$ ), 8.24 (d,  $J=8.0$  Hz, 4H, ArH), 7.97 (d,  $J=8.4$  Hz, 4H, ArH), 7.70 (d,  $J=8.4$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.35 (d,  $J=8.0$  Hz, 4H, ArH), 7.01 (d,  $J=8.8$  Hz, 4H, ArH), 6.91—6.88 (m, 6H,  $2 \times ArH_3$ ), 4.24 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.07—4.00 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.30 [m, 24H,  $2 \times (CH_2)_6$ ], 0.90 (t,  $J=5.6$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1732, 1602, 1580, 1510, 1265, 1130, 878, 825  $cm^{-1}$ ; MALDI-TOFMS  $m/z$ : 1216 [ $M+1$ ] $^+$ , 1238 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{76}H_{82}N_2O_{12}$ : C 75.10, H 6.80, N 2.30; found C 75.03, H 6.85, N 2.21.

**8IC**: Yield, 90.2%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.49 (s, 2H,  $2 \times CH=N$ ), 8.24 (d,  $J=7.6$  Hz, 4H, ArH), 7.99 (d,  $J=8.4$  Hz, 4H, ArH), 7.71 (d,  $J=7.6$  Hz, 4H, ArH), 7.60 (d,  $J=8.0$  Hz, 4H, ArH), 7.44 (d,  $J=8.0$  Hz, 4H, ArH), 7.35 (d,  $J=8.4$  Hz, 4H, ArH), 7.01—6.82 (m, 6H,  $2 \times ArH_3$ ), 4.23 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.07—4.00 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.29 [m, 32H,  $2 \times (CH_2)_8$ ], 0.89 (t,  $J=5.6$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1730, 1602, 1580, 1510, 1264, 1130, 872, 821  $cm^{-1}$ ; MALDI-TOFMS  $m/z$ : 1271 ( $M^+$ ), 1294 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{80}H_{90}N_2O_{12}$ : C 75.56, H 7.13, N 2.20; found C 75.61, H 7.10, N 2.09.

**8ID**: Yield, 90.2%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.48 (s, 2H,  $2 \times CH=N$ ), 8.24 (d,  $J=8.4$  Hz, 4H, ArH), 7.97 (d,  $J=8.8$  Hz, 4H, ArH), 7.70 (d,  $J=8.4$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.43 (d,  $J=8.4$  Hz, 4H, ArH), 7.35 (d,  $J=8.8$  Hz, 4H, ArH), 7.01—6.88 (m, 6H,  $2 \times ArH_3$ ), 4.23 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.08—4.00 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.27 [m, 40H,  $2 \times (CH_2)_{10}$ ], 0.89 (t,  $J=6.4$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1731, 1602, 1580, 1509, 1265, 1130, 878, 821  $cm^{-1}$ ; MALDI-TOFMS  $m/z$ : 1328 [ $M+1$ ] $^+$ , 1350 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{84}H_{98}N_2O_{12}$ : C 75.99, H 7.44, N 2.11; found C 75.92, H 7.47, N 2.01.

**8IIA**: Yield, 94.2%;  $[\alpha]_D^{20} +8.60$  (c 0.25,  $CHCl_3$ );  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.49 (s, 2H,  $2 \times CH=N$ ), 8.25 (d,  $J=8.4$  Hz, 4H, ArH), 7.97 (d,  $J=8.8$  Hz, 4H, ArH), 7.71 (d,  $J=8.8$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.36 (d,  $J=8.8$  Hz, 4H, ArH), 7.01 (d,  $J=8.8$  Hz, 4H, ArH), 6.90—6.88 (m, 6H,  $2 \times ArH_3$ ), 4.24 (t,  $J=5.6$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.08—4.06 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.62—1.55 (m, 2H,  $2 \times C^*H$ ), 1.24—1.16 (m, 4H,  $2 \times CH_2$ ), 1.05 (d,  $J=6.8$  Hz, 6H,  $2 \times C^*HCH_3$ ), 0.97 (t,  $J=7.2$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1730, 1604, 1580, 1510, 1260, 1136, 875, 824  $cm^{-1}$ ; MALDI-TOFMS  $m/z$ : 1131 ( $M^+$ ), 1154 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{70}H_{70}N_2O_{12}$ : C 74.32, H 6.24, N 2.48; found C 74.36, H 6.29, N 2.57.

**8IIB**: Yield, 93.4%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.49 (s, 2H,  $2 \times CH=N$ ), 8.25 (d,  $J=8.4$  Hz, 4H, ArH), 7.97 (d,  $J=8.4$  Hz, 4H, ArH), 7.71 (d,  $J=8.8$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.36 (d,  $J=8.8$  Hz, 4H, ArH), 7.01 (d,  $J=8.4$  Hz, 4H, ArH), 6.90—6.883

(m, 6H,  $2 \times ArH_3$ ), 4.24 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.08—4.01 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.30 [m, 24H,  $2 \times (CH_2)_6$ ], 0.90 (t,  $J=6.4$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1730, 1602, 1580, 1510, 1260, 1132, 875, 824  $cm^{-1}$ ; MALDI-TOFMS  $m/z$ : 1216 [ $M+1$ ] $^+$ , 1238 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{76}H_{82}N_2O_{12}$ : C 75.10, H 6.80, N 2.30; found C 75.05, H 6.76, N 2.39.

**8IIC**: Yield, 93.3%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.49 (s, 2H,  $2 \times CH=N$ ), 8.25 (d,  $J=8.0$  Hz, 4H, ArH), 7.97 (d,  $J=8.4$  Hz, 4H, ArH), 7.70 (d,  $J=8.8$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.36 (d,  $J=8.0$  Hz, 4H, ArH), 7.01 (d,  $J=8.4$  Hz, 4H, ArH), 6.90—6.82 (m, 6H,  $2 \times ArH_3$ ), 4.25 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.07—4.00 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.27 [m, 32H,  $2 \times (CH_2)_8$ ], 0.90 (t,  $J=6.4$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1730, 1602, 1580, 1509, 1260, 1135, 877, 824  $cm^{-1}$ ; MALDI-TOF MS  $m/z$ : 1271 ( $M^+$ ), 1294 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{80}H_{90}N_2O_{12}$ : C 75.56, H 7.13, N 2.20; found C 75.50, H 7.17, N 2.10.

**8IID**: Yield, 92.7%;  $^1H$  NMR ( $CDCl_3$ , 400 MHz)  $\delta$ : 8.49 (s, 2H,  $2 \times CH=N$ ), 8.25 (d,  $J=8.4$  Hz, 4H, ArH), 7.97 (d,  $J=8.4$  Hz, 4H, ArH), 7.71 (d,  $J=8.8$  Hz, 4H, ArH), 7.60 (d,  $J=8.8$  Hz, 4H, ArH), 7.35 (d,  $J=8.8$  Hz, 4H, ArH), 7.01 (d,  $J=8.4$  Hz, 4H, ArH), 6.90—6.88 (m, 6H,  $2 \times ArH_3$ ), 4.24 (t,  $J=4.8$  Hz, 12H,  $6 \times ArOCH_2$ ), 4.06—4.01 (m, 8H,  $2 \times CH_2OCH_2$ ), 1.84—1.28 [m, 40H,  $2 \times (CH_2)_{10}$ ], 0.89 (t,  $J=6.4$  Hz, 6H,  $2 \times CH_3$ ); IR (KBr)  $\nu$ : 1730, 1602, 1580, 1509, 1260, 1130, 878, 824  $cm^{-1}$ ; MALDI-TOF MS  $m/z$ : 1328 [ $M+1$ ] $^+$ , 1350 [ $M+Na$ ] $^+$ . Anal. calcd for  $C_{84}H_{98}N_2O_{12}$ : C 75.99, H 7.44, N 2.11; found C 75.95, H 7.41, N 2.19.

## Results and discussion

### Optical activity of the chiral compounds

The optical activity was measured with a dilute solution (*ca.*  $10^{-2}$  g/mL) of sample on a WZZ-1 automatic polarimeter at 20 °C with a beam of 589.44 nm. The length of the sample cell used was 200 nm. As shown in the Table 1, all the chiral materials prepared from (*S*)-(-)-2-methyl-1-butanol which has a specific optical rotation of  $-6.3^\circ$  are optically active. Care must be taken to protect the chiral center by first activating the alcohol into its tosylate and by using mild reaction conditions during measuring. The result obtained for 4-[(*S*)-2-methylbutoxy]biphehyl-4'-carboxylic acid showed a specific optical rotation of  $12.87^\circ$  ( $deg \cdot dm^{-1} \cdot g^{-1} \cdot cm^3$ ). Although these chiral compounds showed significant optical activities, no optical purity was determined for them.<sup>14</sup>

### Study and characterization of the chemical structure and liquid crystalline phase

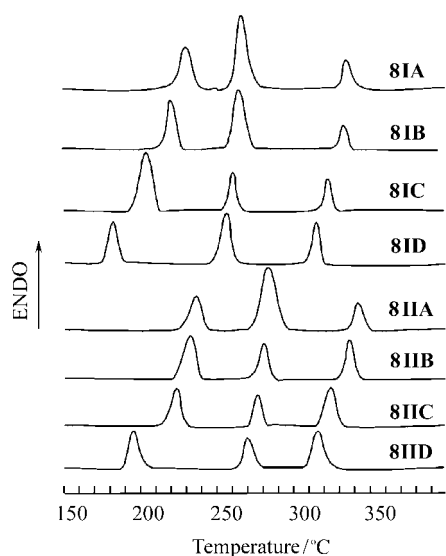
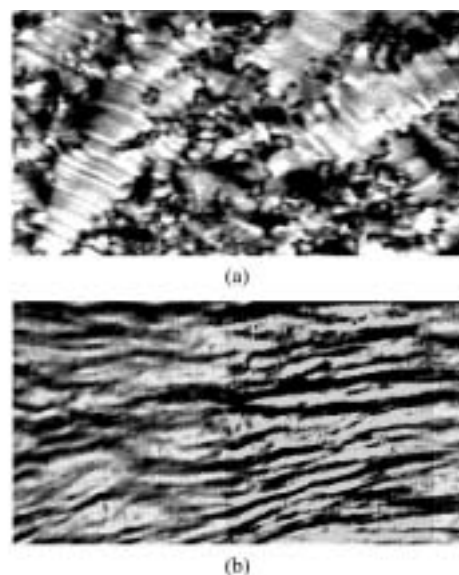
The chemical structures of **2**, **4**, **5**, **6**, **7** and **8** were determined by elemental analysis, IR,  $^1H$  NMR and MS spectroscopy. The phase transition temperatures of **8I** and **8II** were measured by DSC and POM and the type of mesophase was determined by observing the meso-

**Table 1** Phase transition temperatures, enthalpy changes, phase length of mesomorphic, and molecular length to diameter ratio ( $L/D$ ) for the compounds **8**<sup>a</sup>

Compd	Phase transition temperature/°C (corresponding enthalpy changes, J · g <sup>-1</sup> )	Phase length of mesomorphic			$L/D$
		S/°C	Ch/°C	N/°C	
<b>8IA</b>	C220.7(6.72)Sc*257.1(13.52)Ch327.5(4.95)I	36.4	70.4	—	5.79
<b>8IB</b>	C210.8(8.83)S255.9(9.54)N324.6(4.50)I	44.5	—	69.7	6.32
<b>8IC</b>	C194.3(10.5)S250.2(6.91)N313.5(5.70)I	55.9	—	62.9	6.83
<b>8ID</b>	C171.4(6.75)S247.0(8.75)N304.8(6.91)I	75.6	—	57.8	7.34
<b>8IIA</b>	C227.4(5.45)Sc*273.8(12.7)Ch331.9(4.20)I	46.4	58.1	—	5.77
<b>8IIB</b>	C221.0(8.41)S270.7(6.60)N328.1(7.54)I	49.7	—	57.4	6.24
<b>8IIC</b>	C213.6(7.30)S267.8(5.41)N315.5(7.45)I	54.2	—	47.7	6.92
<b>8IID</b>	C187.7(6.50)S261.2(4.56)N307.3(6.84)I	73.5	—	46.1	7.30

<sup>a</sup> C: crystal; Sc\*: chiral smectic C; S: smectic; Ch: cholesteric; N: nematic; I: isotropic.

morphic texture on the POM. The phase transition temperature and their enthalpy changes, phase length of liquid crystal phase and  $L/D$  of **8** are presented in Table 1. It can be observed that there are three endothermic peaks on the DSC curve of **8IA** shown in Figure 1, in which the maximum of the first peak is 220.7 °C, the second is 257.1 °C and the third is 315.5 °C. For POM investigation it was found that the sample began melting near 215 °C in the POM experiment and showed typical lined texture of the chiral smectic phase after melting. The smectic phase transferred to cholesteric phase with the temperature increasing to 265 °C and looked as oily streak texture. Moreover, when the temperature was increased to 320 °C, birefringence disappeared and became isotropic. On the other hand, birefringence appeared again, the transition temperature of liquid crystalline phase and its corresponding texture could be observed during the slow process of decreasing temperature. The photographs are shown in Figure 2. In the case

**Figure 1** The DSC cure of compounds **8** (the first heating rate: 10 °C/min).**Figure 2** Polarizing optical micro-graphs of **8IA**. (a) lined texture of chiral smectic C phase at 235 °C (×20); (b) oily streak texture of cholesteric phase at 271 °C (×20).

of **8IB**, focal-conics of smectic phase and Schlieren texture of nematic phase were observed from POM images. The POM pictures of **8IC** and **8ID** are similar to those of **8IB**.

All the liquid crystalline textures of **8IIA**, **8IIB**, **8IIC** and **8IID** obtained from POM are similar to those of **8IA**, **8IB**, **8IC** and **8ID**.

#### The relationship between the chemical structures and the liquid crystalline properties

The molecular length to diameter ratio ( $L/D$ ) of the small molecular compound is important to the form of liquid crystal. Usually it is considered that the  $L/D$  ratio must be larger than 4 for the rigid rod molecules. According to Corey-Pauling-Koltun (CPK) molecular modeling, the  $L/D$  ratios of the compounds **8** in this work are in the range of 5.79—7.30.

From the results shown in Table 1, it is clear that the melting points and clearing points of **8IA** to **8ID**,

**8IIA** to **8IID** decreased gradually with the increasing of carbon number in the end alkoxy group. However, the smectic phase length and smectic-nematic phase transition temperature increased gradually, the nematic phase length decreased. The melting point and clearing point of *trans*-conformation compounds **8II** are higher than those of *cis*-conformation compounds **8I** due to its higher symmetry.

## References

- 1 Lehn, J. M. *Angew. Chem., Int. Ed. Engl.* **1988**, 27, 89.
- 2 Shinkai, S.; Nishi T.; Mastsude T. *Chem. Lett.* **1991**, 437.
- 3 Zhu, Y. M.; Wei, Y.; Hu, Z. L. *Phys. Lett. A* **1994**, 188, 287.
- 4 Bogatskaya, L. G.; Lukyanenko, N. G.; Kulygine, E. Y.; Nesterenko, N. L. *The Ninth International Conference on Liquid Crystals, Programme and Abstracts*, Bangalore, **1982**, p.15.
- 5 He, G. X.; Wada, F.; Kikukawa, K.; Shinkai, S.; Matsuda, T. *J. Org. Chem.* **1990**, 55, 541.
- 6 Liebmann, A.; Mertesdorf, C.; Plesnivy, T.; Ringsdorf, H.; Wendorff, J. H. *Angew. Chem., Int. Ed.* **1991**, 30, 1375.
- 7 Idziak, S. H. J.; Maliszewsky, N. C.; Heiney, P. A.; Mccauly, J. P.; Sprengeler, J. P. A.; Smith, A. B. *J. Am. Chem. Soc.* **1991**, 113, 7666
- 8 Li, L. Z.; Zhu, J. L.; Zhao, W.; Xie, M. G.; Jiang, Q. *Chem. J. Chin. Univ.* **1998**, 19, 1422 (in Chinese).
- 9 Wu, Y. J.; Zhao, B.; Zhao, L. W. *Chin. J. Chem.* **1993**, 11, 360.
- 10 Xie, M. G.; Peng, M. S.; Jiang, Q.; Hu, Z. L. Wang, X. J. *Liq. Cryst.* **1996**, 21, 461.
- 11 Perrin, D. D.; Armarego, W. L. F.; Perrin, D. R. *Purification of Laboratory Chemicals*, 2nd. ed., Pergamon Press, **1980**, Translated by Shi, Y., Chemical Industrial Press, Beijing, **1987**, p. 155; p. 291; p. 312; p. 346; p. 408.
- 12 He, K. K.; Zhang, X. J.; Li, Z. F.; Zhang, S. Y.; Zheng, S. J.; Yang, Z. H.; Guo, K.; Zhou, Q. F. *Chem. J. Chin. Unvi.* **2002**, 23, 2000 (in Chinese).
- 13 Zhou, Q. F. *Advances in Liquid Crystalline Polymers and Supramolecules*, Huazhong University of Science and Technology Press, Wuhan, **2002**, pp. 44—48 (in Chinese).
- 14 Li, Z. F.; Ning, C. F.; Zheng, S. J.; Zhang, S. Y.; Cao, S. K. *Marcromolecules* **1999**, 32, 7040.

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