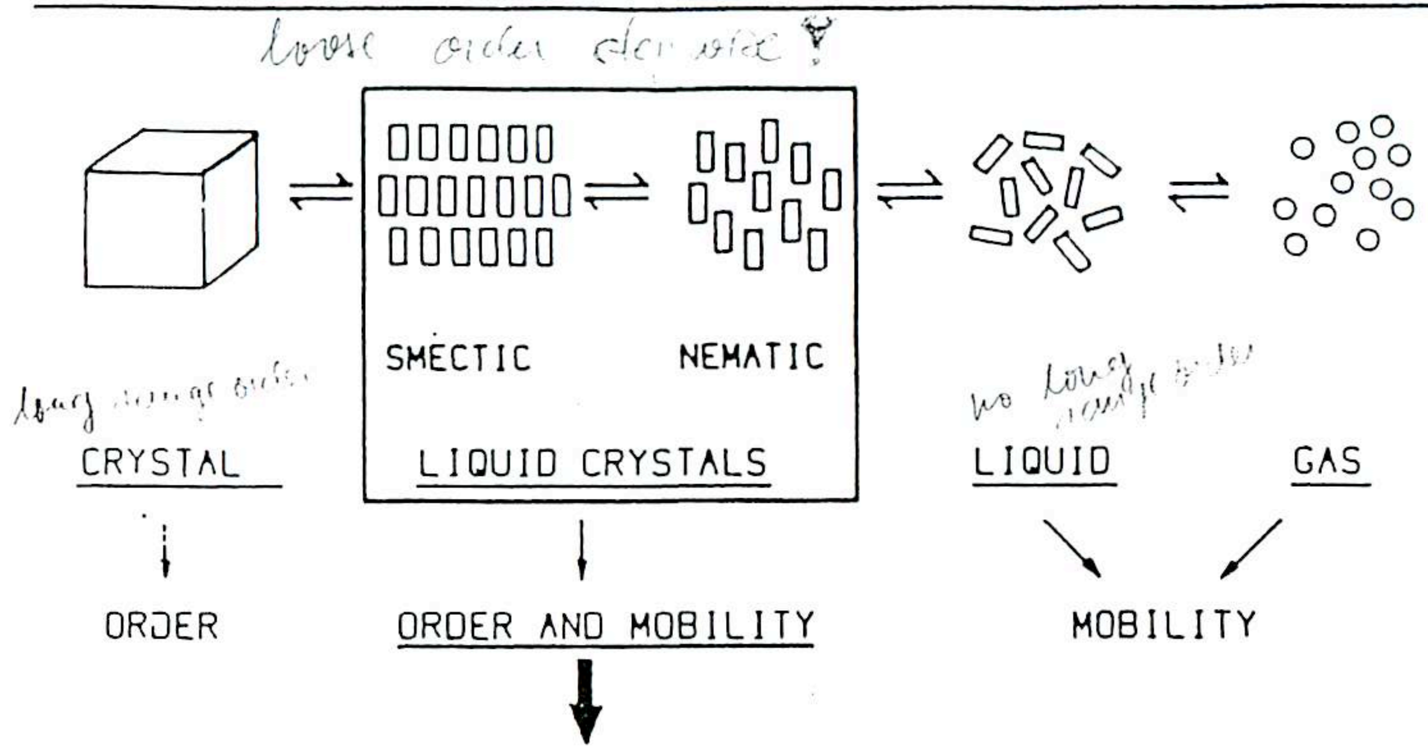
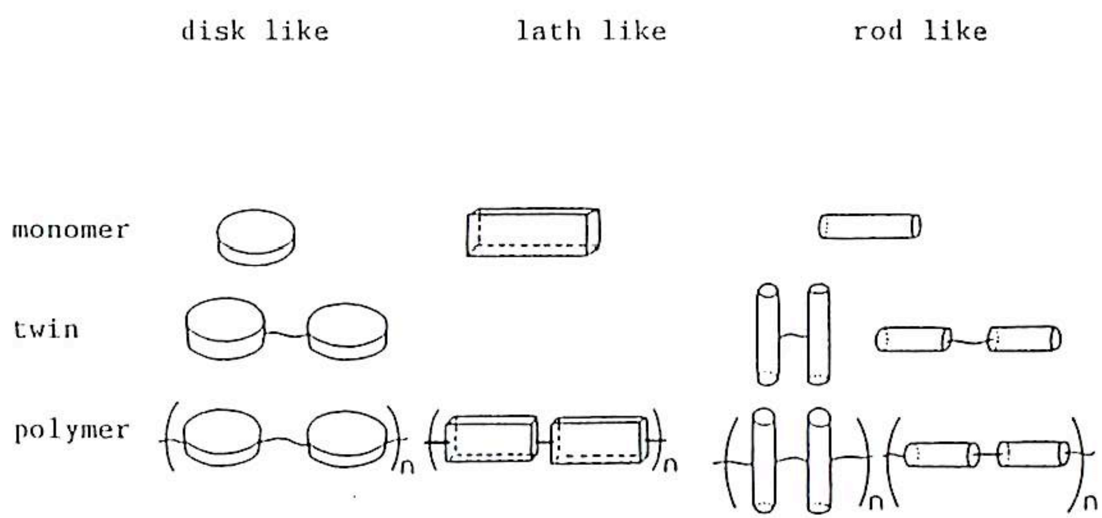
THE LIQUID CRYSTALLINE PHASE : A "FOURTH" STATE OF MATTER

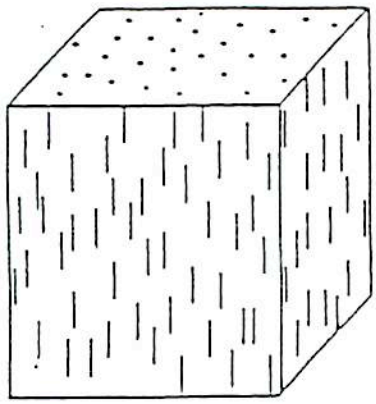


FORMANISOTROPIC MOLECULES PERMIT SELF-ORGANIZATION WHILE RETAINING MOBILITY IN THE BULK STATE (THERMOTROPIC) AND IN SOLUTION (LYOTROPIC)

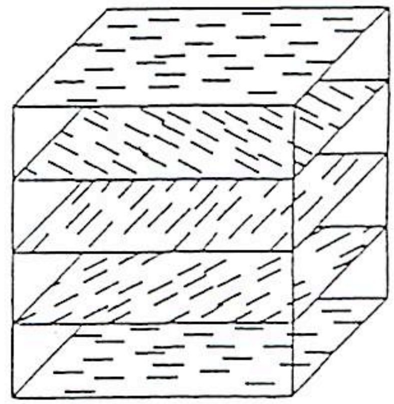
Geometrical structures of mesogenic molecules



STRUCTURE OF CALAMITIC MESOPHASES

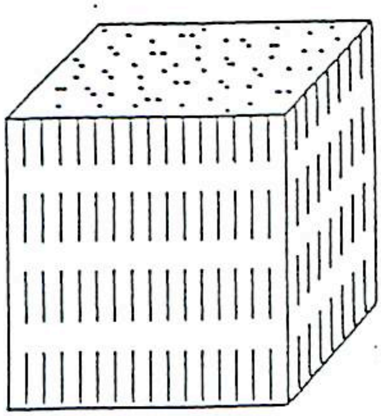


nematic

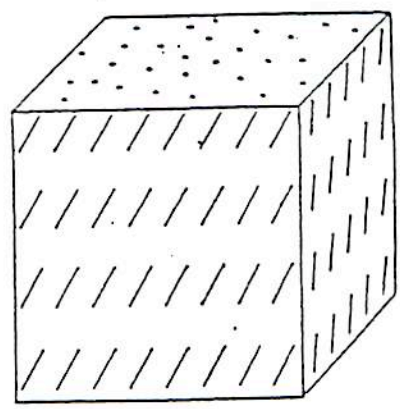


cholesteric

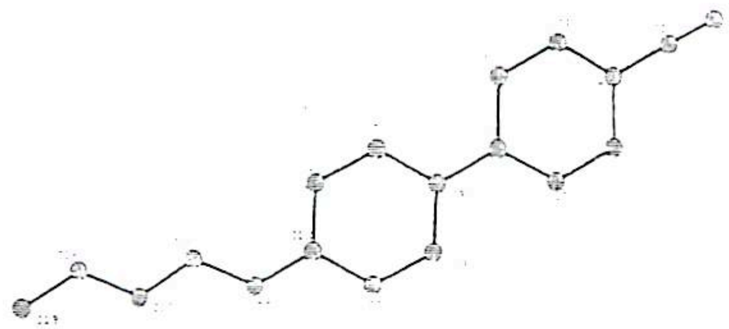
twisted nematic (chiral compounds)



smectic A



smectic C



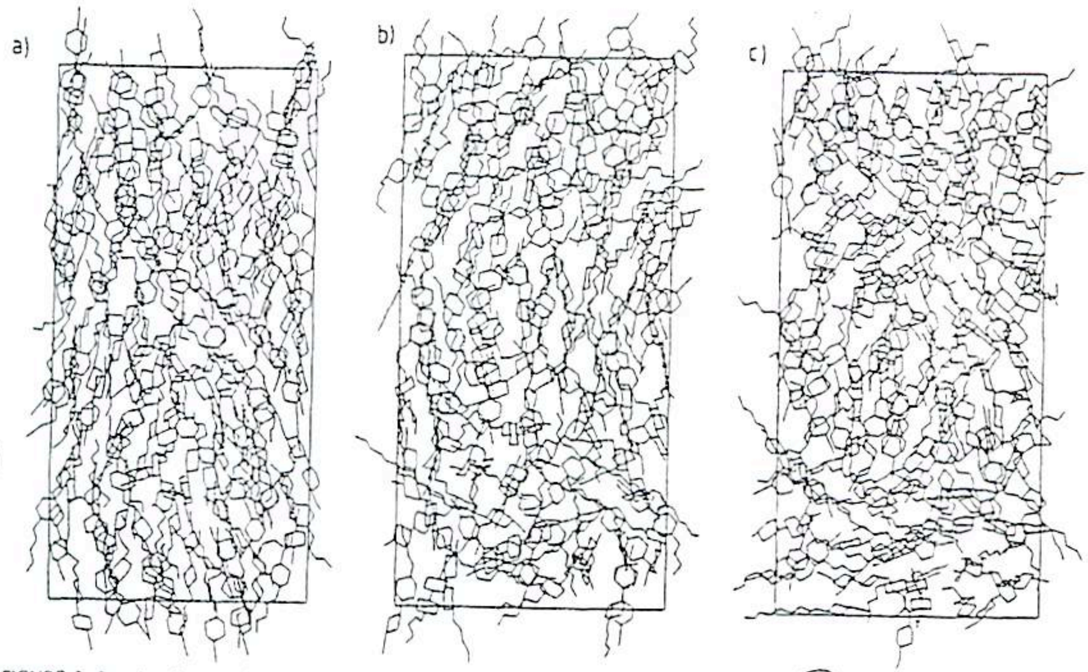


FIGURE 3 Snapshots from simulations of CCH5 at different temperatures. a) Nematic phase at 350 K, $S = 0.64$. b) Nematic phase at 370 K, $S = 0.39$. c) Isotropic phase at 390 K, $S = 0.18$.

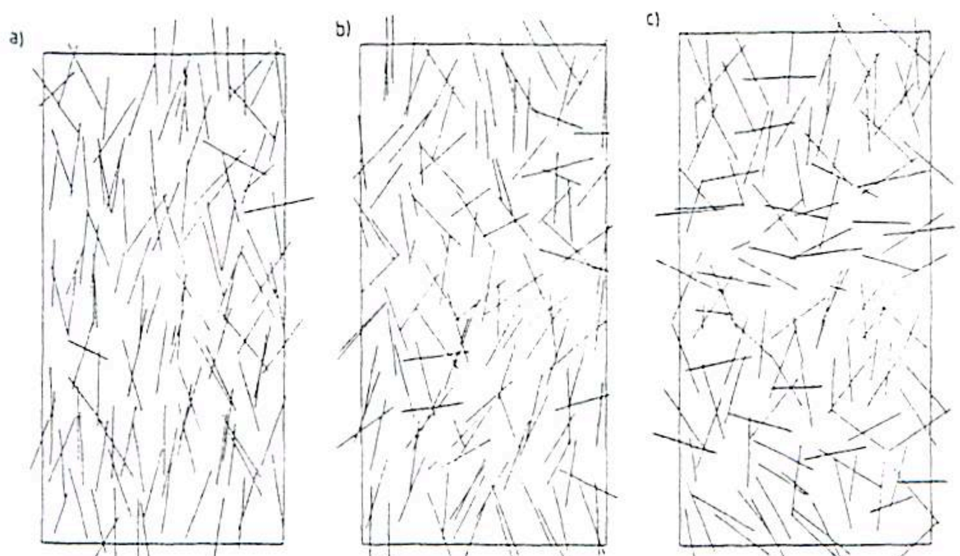


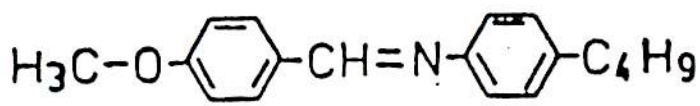
FIGURE 4 Snapshots from simulations of CCH5 at different temperatures showing the alignment of the principal moment of inertia axis for each molecule. a) Nematic phase at 350 K, $S = 0.64$. b) Nematic phase at 370 K, $S = 0.39$. c) Isotropic phase at 390 K, $S = 0.18$.

order parameter
$0 < S < 1$

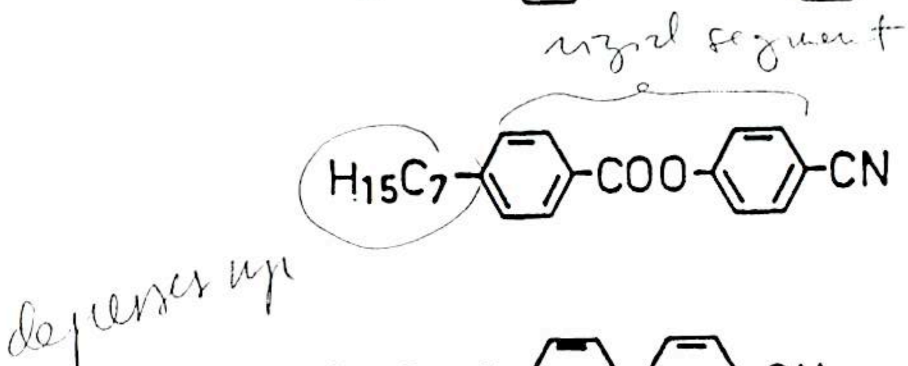
$0.4 \leq S$
→ LC!

Mol. Cryst. Liq. Cryst., 1991, Vol. 198, pp. 465-477; Mark R. Wilson and Michael P. Allen,
Computer Simulations of Mesogenic Molecules Using Realistic Atom-Atom Potentials

CHEMICAL STRUCTURE OF LOW MOLAR MASS NEMATIC LIQUID CRYSTALS

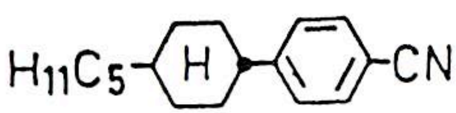


k 21 n 45 i



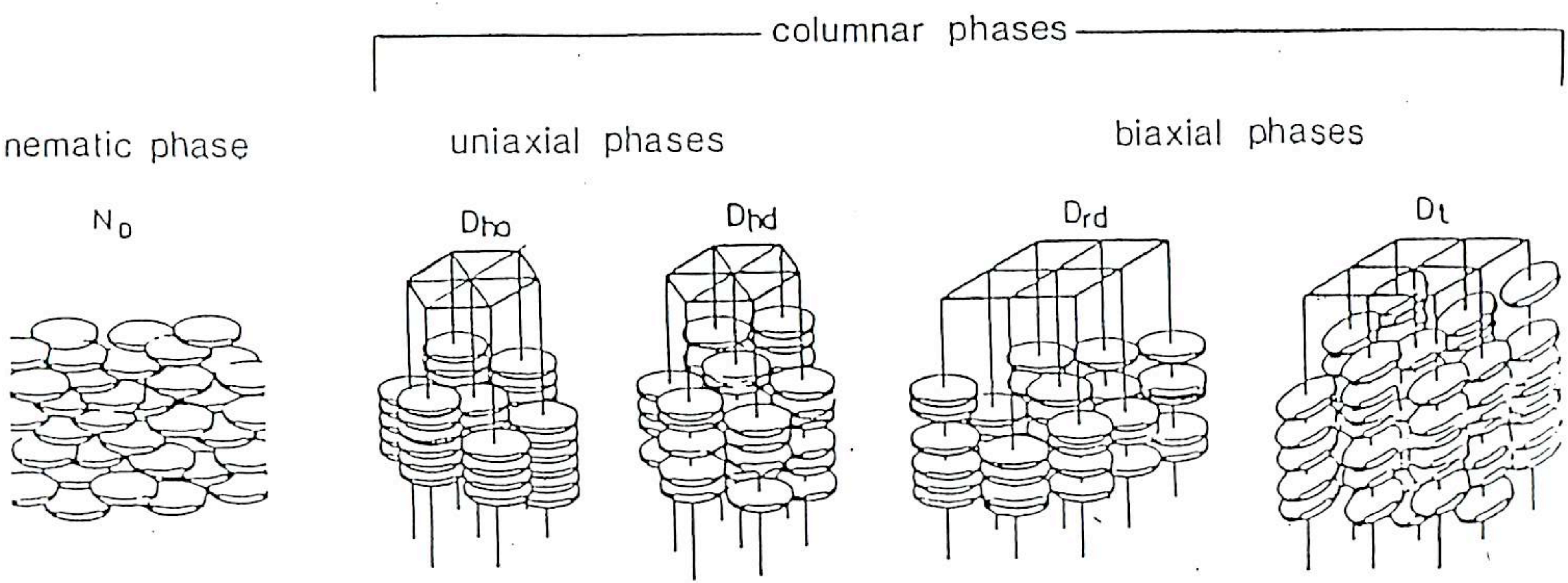
k 44 n 56 i

k 23 n 35 i



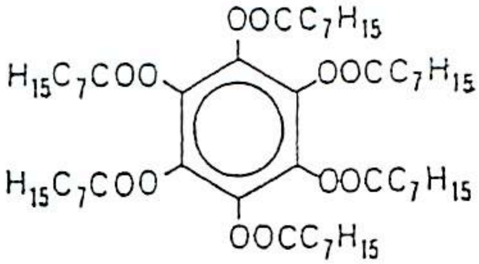
k 30 n 55 i

STRUCTURE OF DISCOTIC MESOPHASES

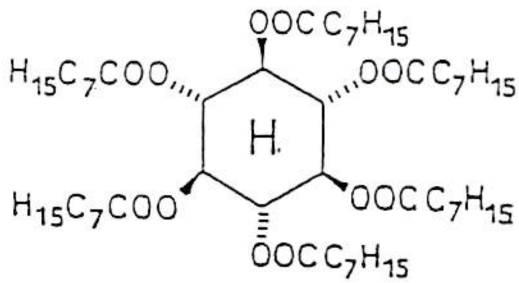


D. Goldfarb, R. Poupko, and Z. Luz, H. Zimmermann, J. Chem. Phys. 79(8), 15 Oct. 1983

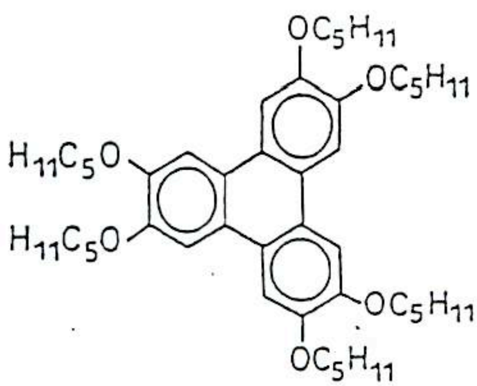
CHEMICAL STRUCTURE OF LOW MOLECULAR MASS DISCOTICS



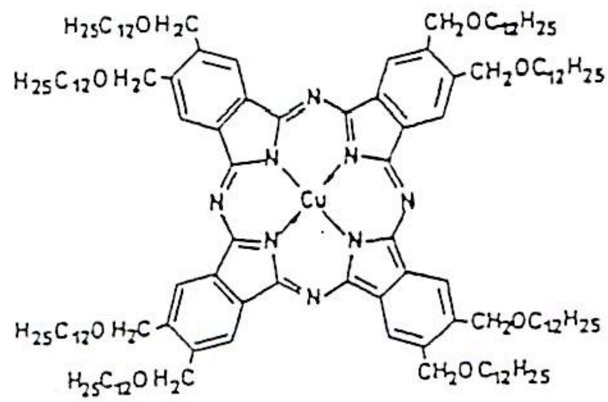
k 80 D 83 I [1)]



k 76 D 199 I [2)]



k 69 D_{ho} 122 I [3)]



k 53 D 300 dec. [4)]

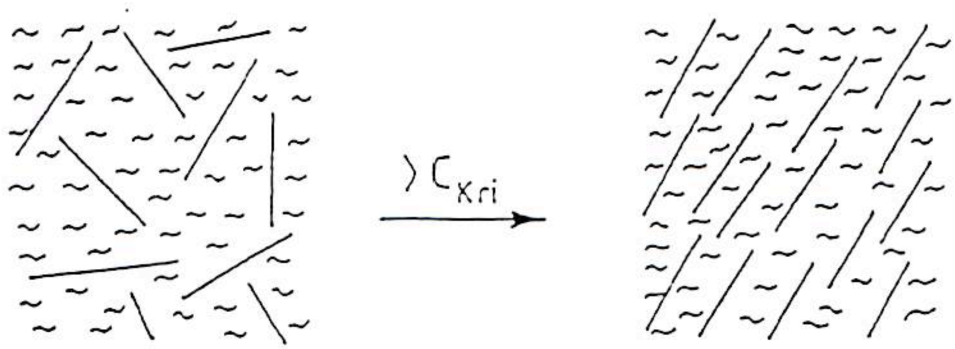
1) S. Chandrasekhar et al., Pramana 9, 471 (1977)

2) B. Kohne, K. Praefcke, Angew. Chem. 96 , 70 (1984)

3) J. Billard et al. , Nouv. J. Chim. 2 , 535 (1978)

4) C. Piechocki , J. Simon et al. , J.Am.Chem.Soc.104,5245(1982)

Lyotropic LC-Solutions

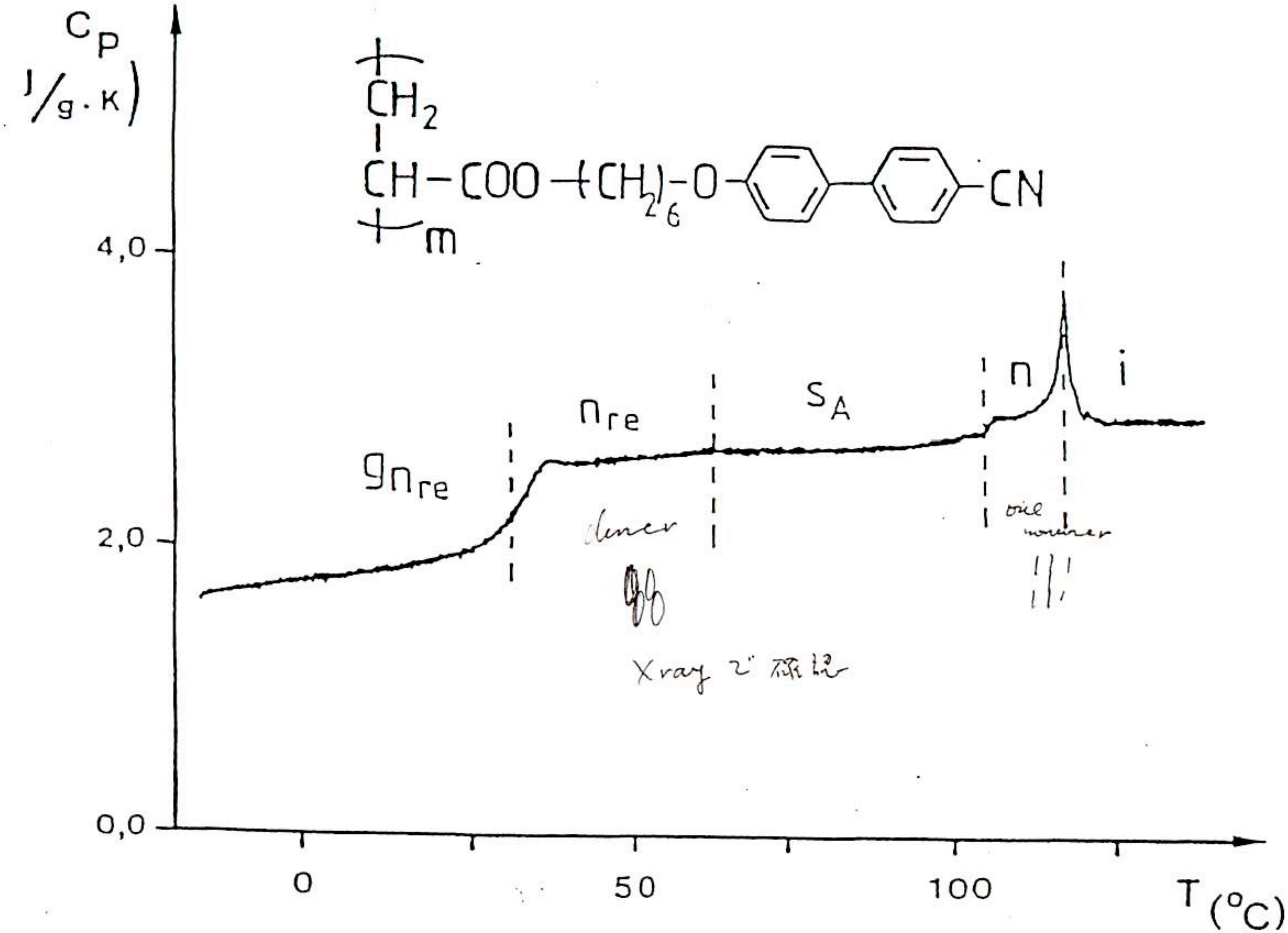


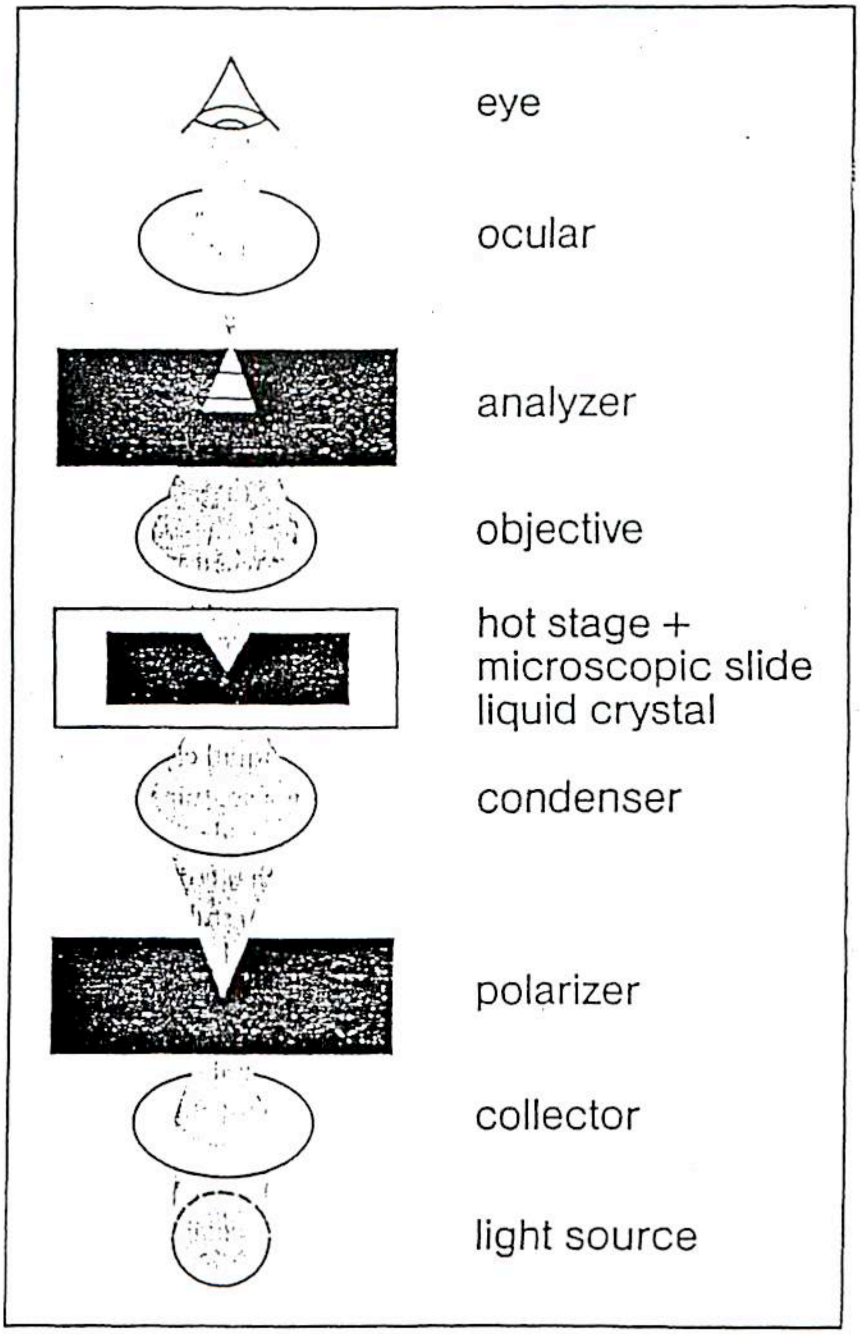
Formation depends on:

- chain stiffness (axial ratio)
- molecular weight
- concentration
- solubility
- temperature

Problems for rod-like polymers:

- viscosity
- gelation or crystallization at RT
- limited temperature stability


Cp
J/g.K)
4,0
2,0
0,0
gnre
nre
SA
n
i
0
50
100
T (°C)
Xray で確認


eye
ocular
analyzer
objective
hot stage +
microscopic slide
liquid crystal
condenser
polarizer
collector
light source

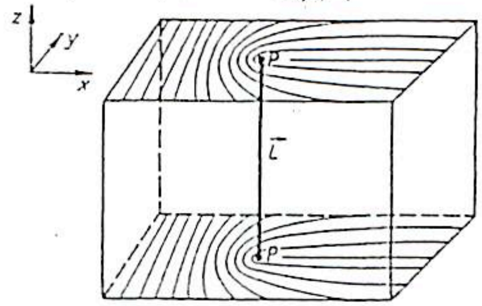


Figure 15. Topology of a $s = +\,^1/_2$ singularity line. The end of the line attached to the glass appears as the "point" $s = +\,^1/_2$ (P). The director field does not change, being translated into the z direction. The director field is drawn in the upper and the lower surface, only.

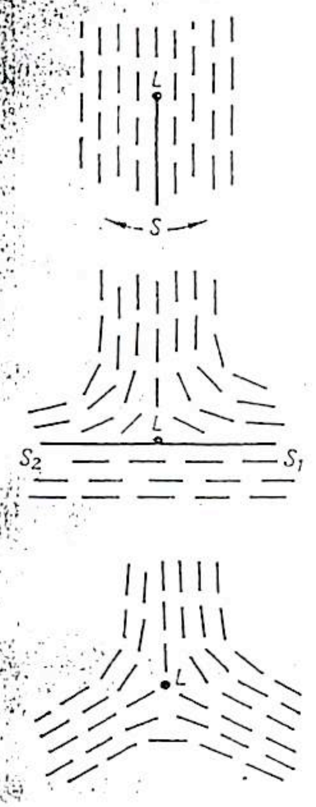


Figure 16 (a-c). Creation of a $s = -\,^1/_2$ singularity line (see text).

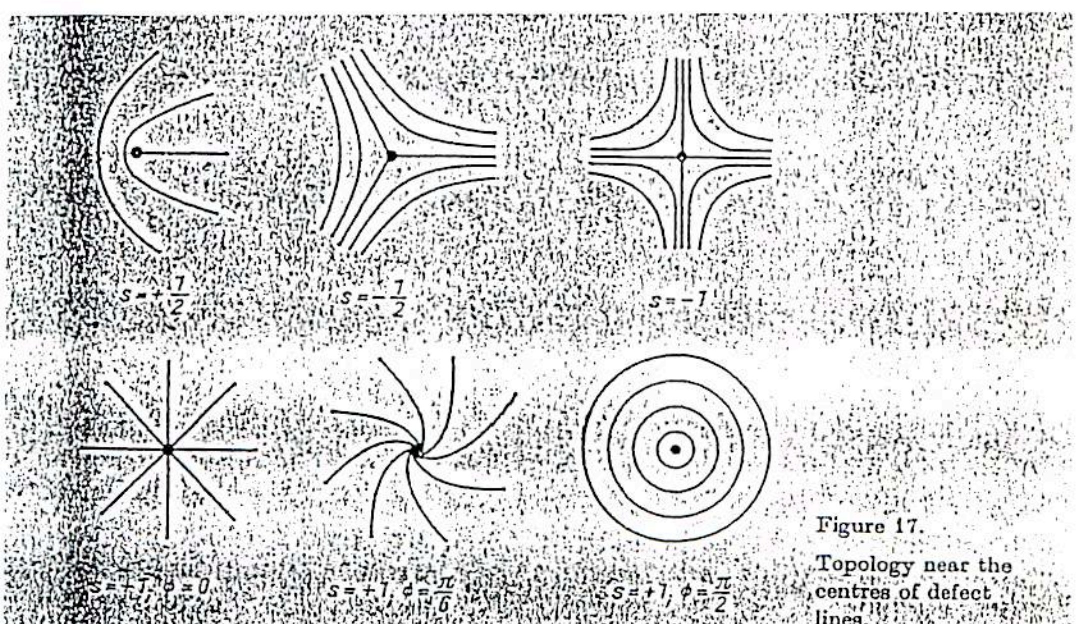
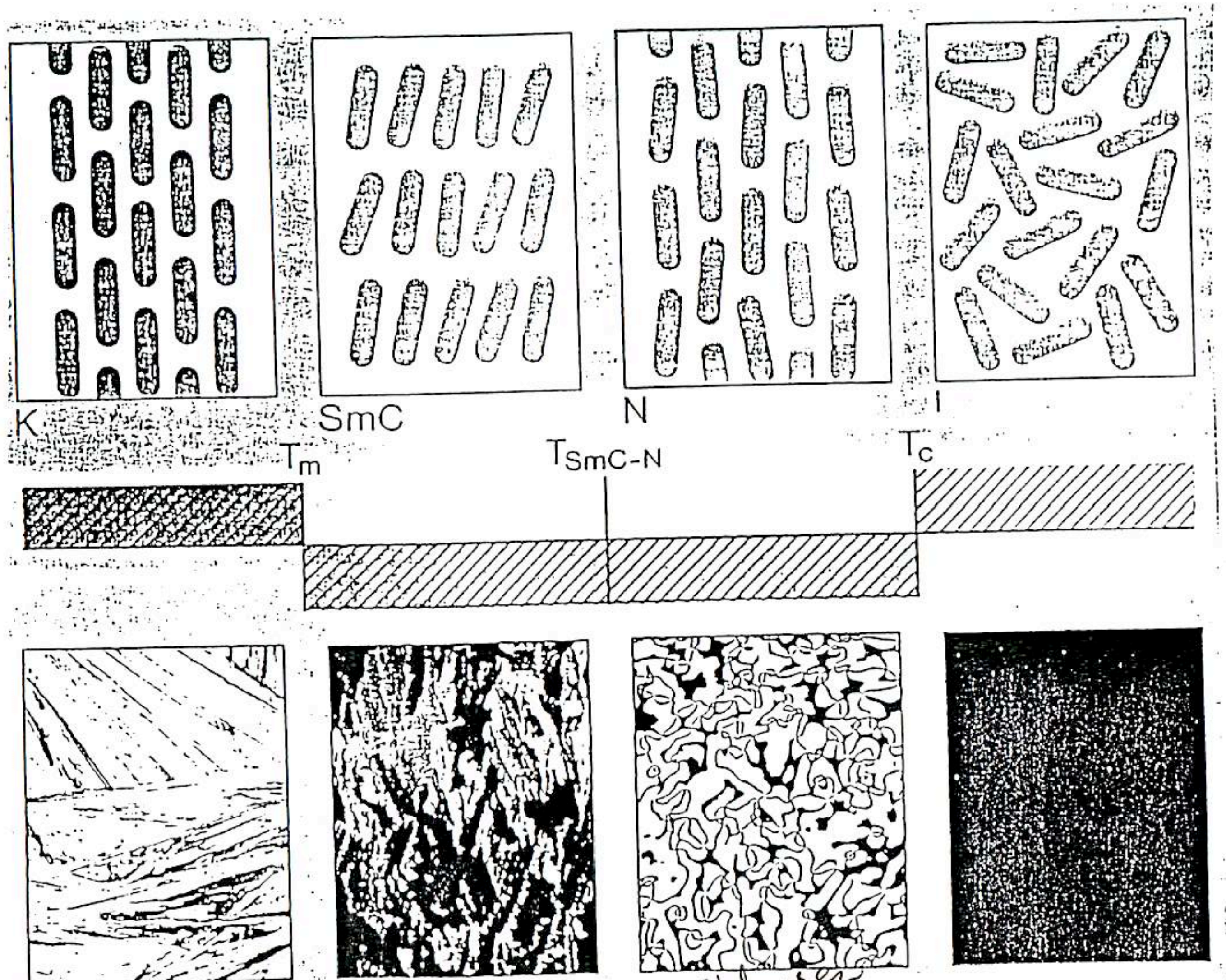


Figure 17. Topology near the centres of defect lines.

(a) $s = +\,^1/_2$; (b) $s = -\,^1/_2$; (c) $s = -1$; (d) $s = +1,\ \Phi = 0$; (e) $s = +1,\ \Phi = \pi/6$; (f) $s = +1,\ \Phi = \pi/2$.

Demus, Dietrich and Richter, Lothar, *Textures of Liquid Crystals*, Verlag Chemie, Weinheim, New York, 1978.

PHASE BEHAVIOR OF A THERMOTROPIC LIQUID CRYSTAL

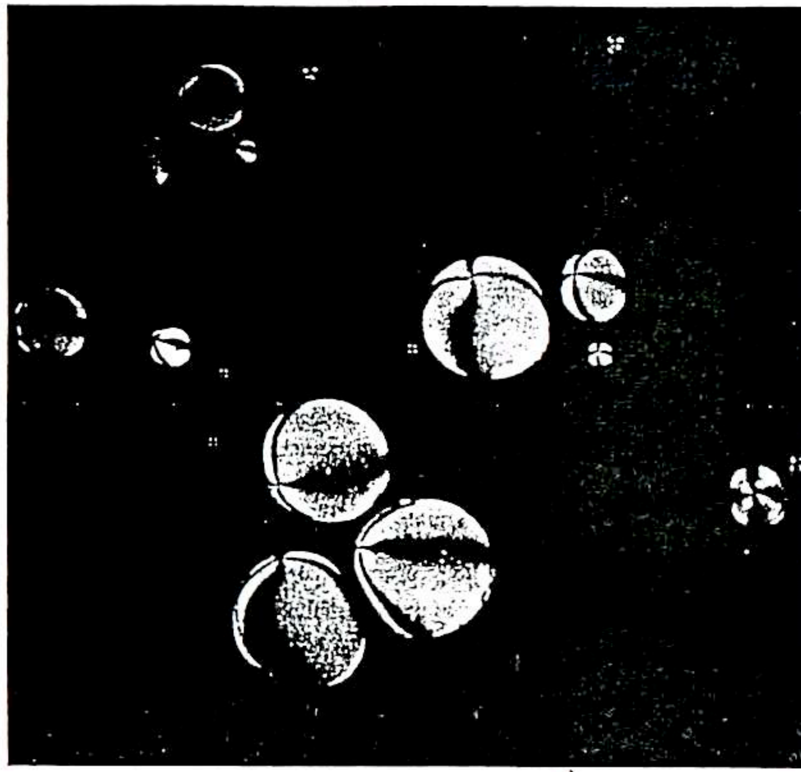


おさえて texture がうごくかどうかみる

うごかない

うごく

(Finkenzeller, Kontakte 1988)



Nematic droplets.

大きくなって → Schlieren になる

iso → cool down → Nematic drop

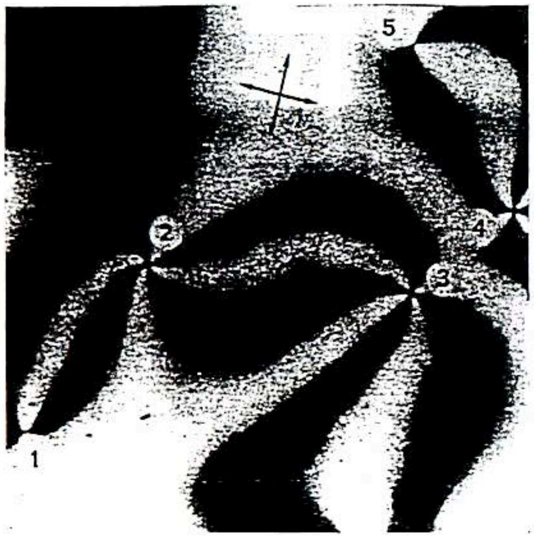


Plate 1

Nematic schlieren texture. Orientation of the crossed polarizers is indicated by the plotted cross. Strength of the points: No. 1: $s = -\frac{1}{2}$.

No. 2: $s = -1$, Nos. 3 and 4: $s = -1$,

No. 5: $s = -\frac{1}{2}$.

4-n-Octyloxyphenyl 4-n-butyl-cyclohexanecarboxylate 71 °C, x 150.

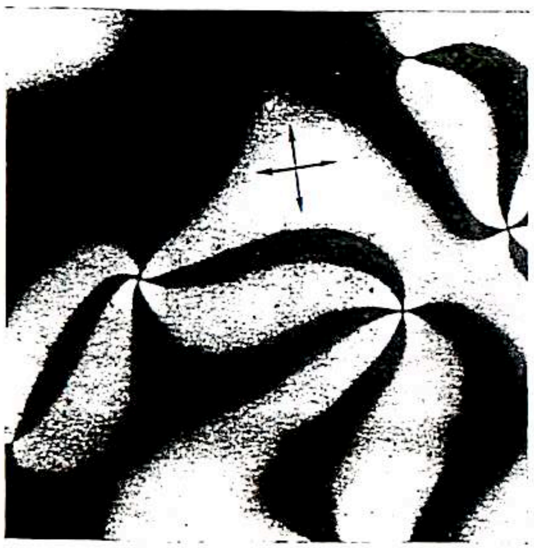


Plate 2

Same section as in plate 1. Polarizers rotated counter-clockwise by 22.5°.

Plate 3 45

Same section as in plate 2. Polarizers rotated counter-clockwise by 22.5°.

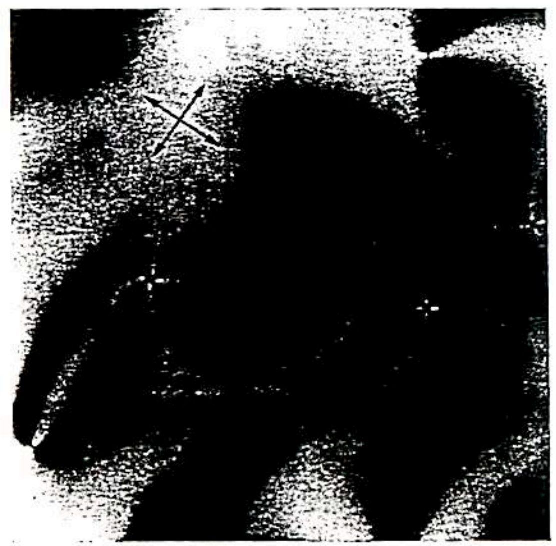


Plate 4

Same section as in plate 3. Polarizers rotated counter-clockwise by 22.5°.

VARIANTS OF POLYMORPHISM IN CALAMITIC LIQUID CRYSTALS

monomorphism	N	trimorphism	B A N
	A		C A N
	B		G A N
	C		B C N
	E		E B A
			B C A
dimorphism	A N		C D A
	B N		F C A
	C N		G C A
	G N		G B A
	B A		
	C A	tetramorphism	B C A N
	E A		G C A N
	C D		G F C A
	B C		G B A N
	E B		E B A N
		pentamorphism	G B C A N

N = nematic (or cholesteric for chiral compounds)

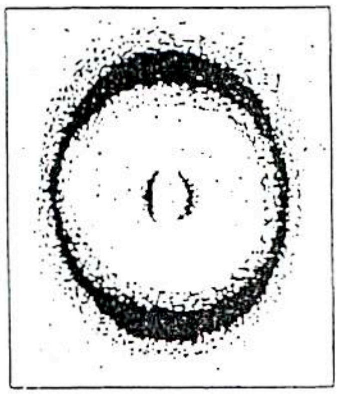
A, B...G = smectic A, B....G

After: Demus, Dietrich and Richter, Lothar, *Textures of Liquid Crystals,* Verlag Chemie, Weinheim, New York, 1978

The Most Frequently Occuring Textures of the Different Structure Types

Structure Type Texture	Nem- atic	Chole- steric	Blue phase	S_a	S_c	S_c twisted	S_F	S_B hexa- gonal	S_B mono- clinic	S_B twisted	S_B	S_E	S_G	S_P
isotropic			+											+
homeotropic	+			+								+		
homoegneous	+			+	+				+					
marbled	+													
planar		+				+				+				
stepped drops				+	+							+		
mosaic								+	+	+	+	+	+	+
schlieren	+				+		+		+					
simple focal conic		+		+				+				+		
broken focal conic					+	+	+							

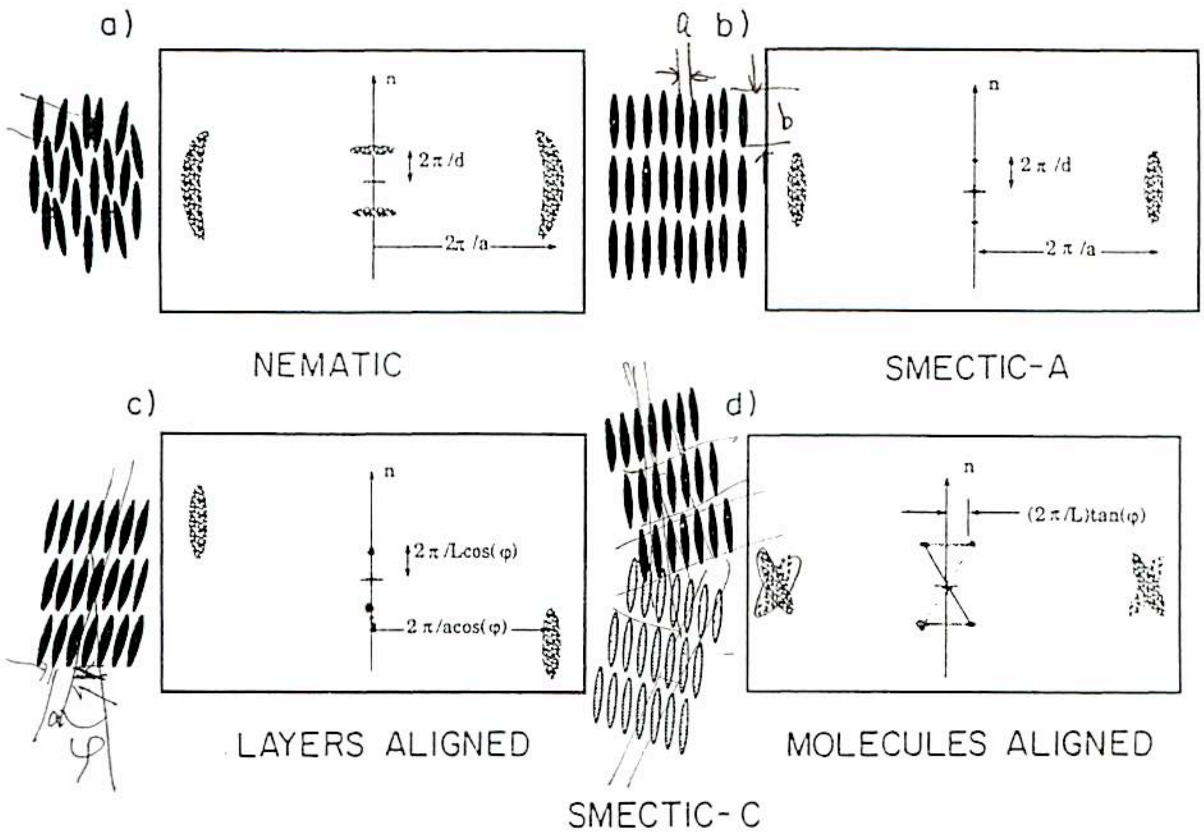
After: Demus, Dietrich and Richter, Lothar, *Textures of Liquid Crystals*, Verlag Chemie, Weinheim, New York, 1978.

a 

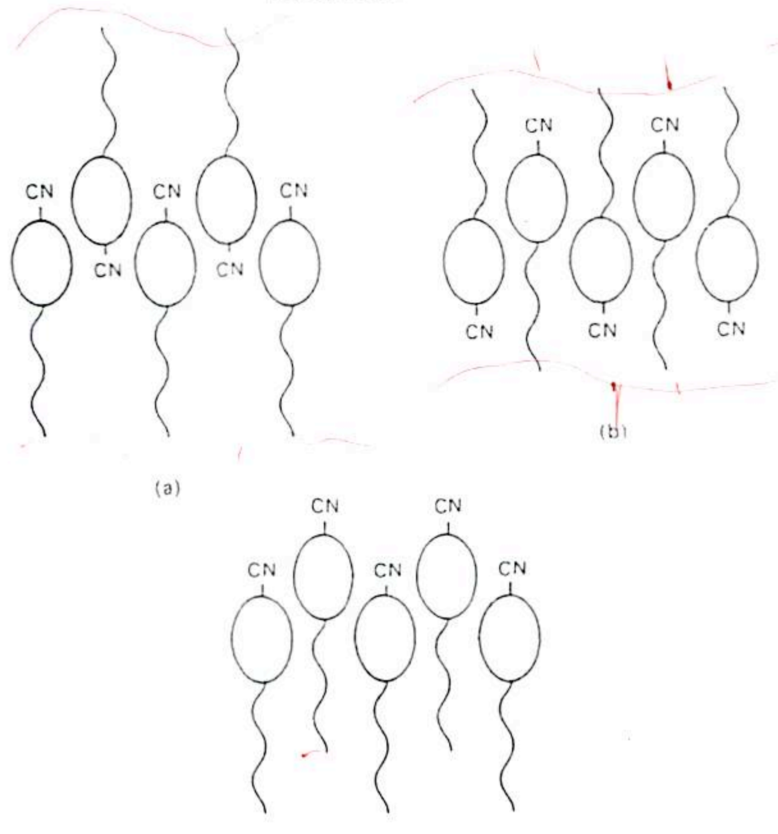
b 

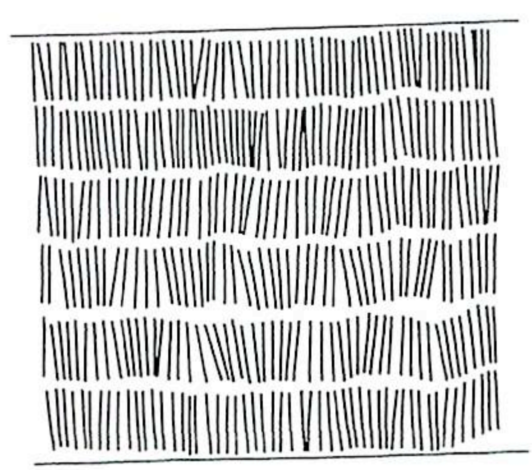
Fig. 1.10. a X-ray pattern of a non-oriented nematic sample
b X-ray pattern of a nematic sample oriented in a magnetic field orthogonal to the direction of the X-ray beam

Birendra, Bahadur, *Liquid Crystals Applications and Uses*, Vol. 1, World Scientific Publishing, Singapore, New Jersey, London, Hong Kong, 1990



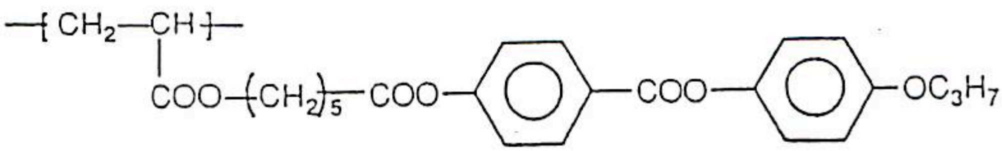
Pershan, P.S., <u>*Structure of*</u> *Liquid Crystal Phases*, World Scientific Notes In Physics, Vol. 23, World Scientific, Singapore, New Jersey, Hong Kong, 1988



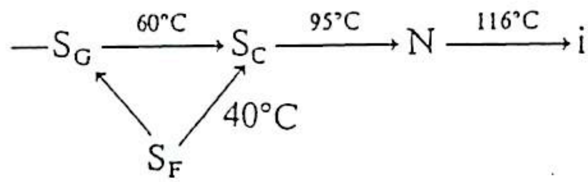


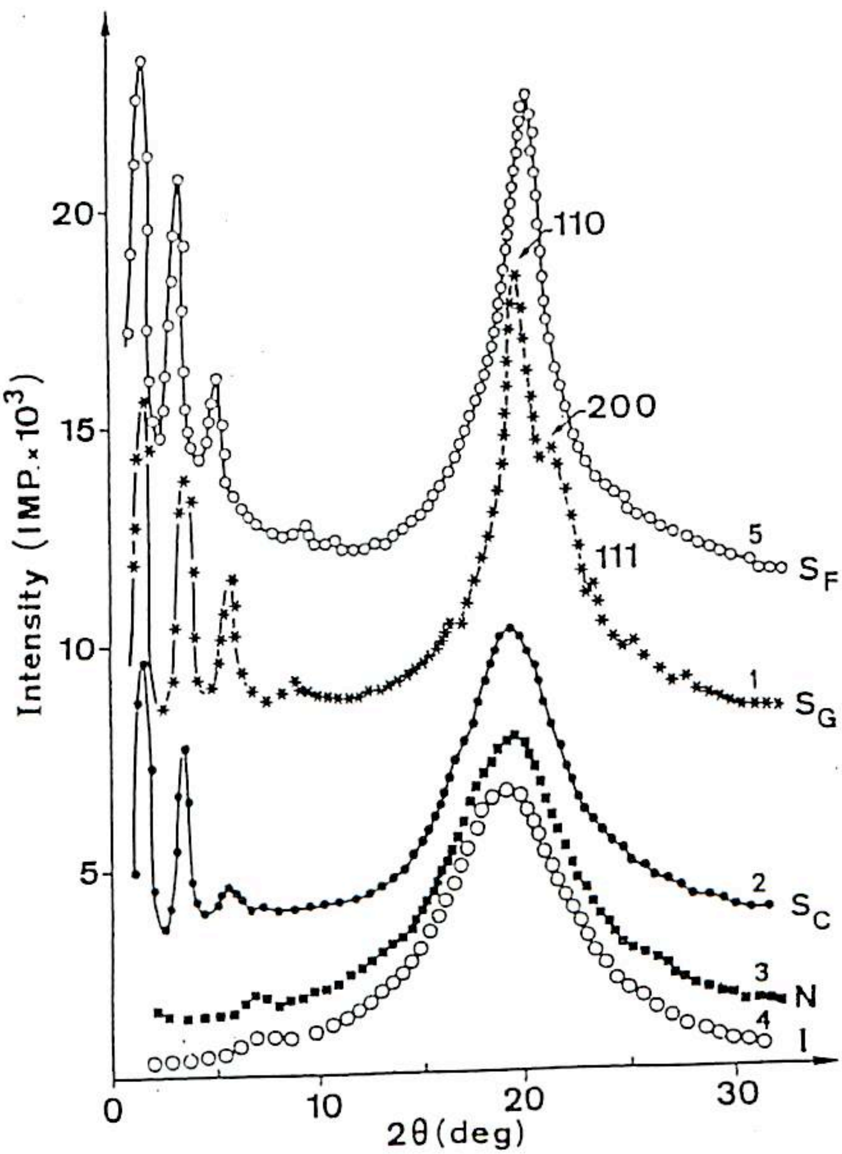
Gray, G.W. (Professor of Organic Chemistry University of Hull, UK, and Goodby, J.W.G., (AT&T Bell Laboratories), New Jersey, *Smectic Liquid Crystals, Textures and Structures*, Leonard Hill, Glasgow and London, Hayden & Son, Inc. Philadelphia, 1984.

X-RAY SCATTERING CURVES OF A SLCP



(annealing at
35°C for
several days)





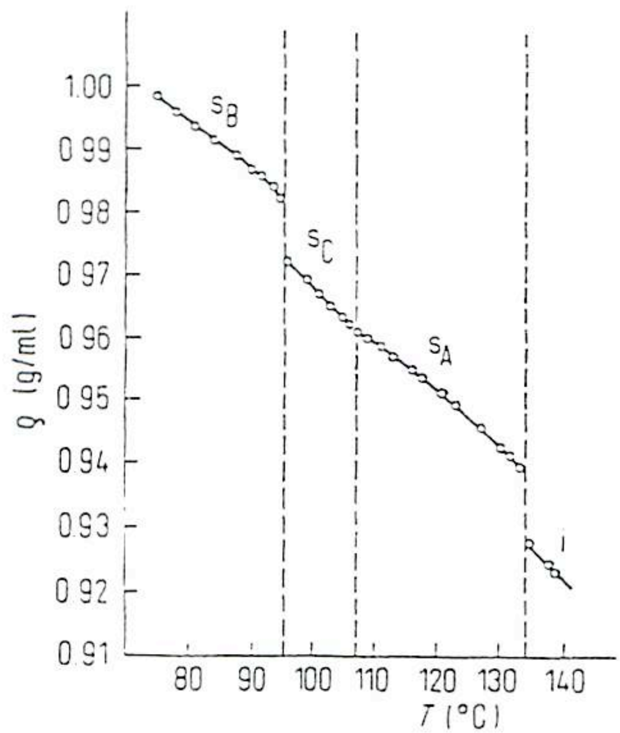


Fig. 8.27. Density-temperature plots (ρ vs. *T*) for *n*-amyl 4-(4-*n*-dodecyloxybenzylideneamino)cinnamate (from [93]).

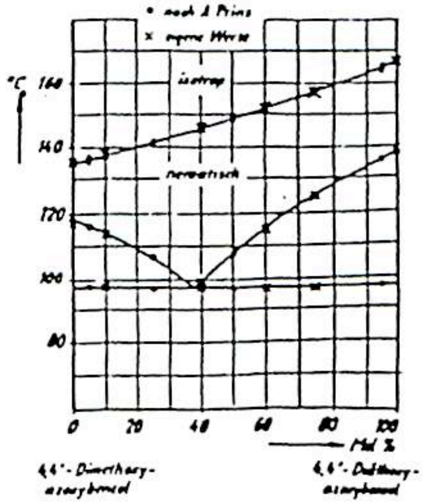
Kelker, Hans and Hatz, Rolf, *Handbook of Liquid Crystals*, Verlag Chemie, Weinheim, Deerfield Beach, Florida, Basel, 1980.

MIXTURES OF LOW MOLAR MASS LIQUID CRYSTALS

MISCIBILITY RULE OF SACKMANN:

-Z. physik. Chem. 213, 145 (1960)

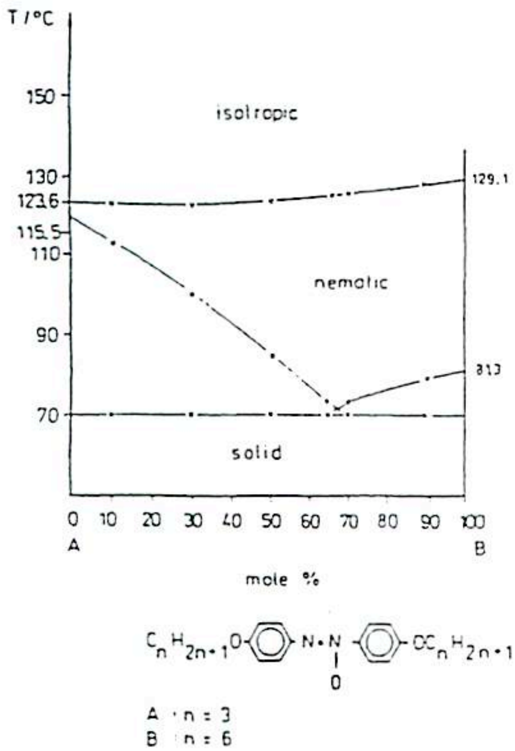
LOW MOLAR MASS LIQUID CRYSTALS EXHIBITING THE SAME MESOMORPHIC STRUCTURE ARE MISCIBLE OVER THE WHOLE RANGE OF CONCENTRATION.



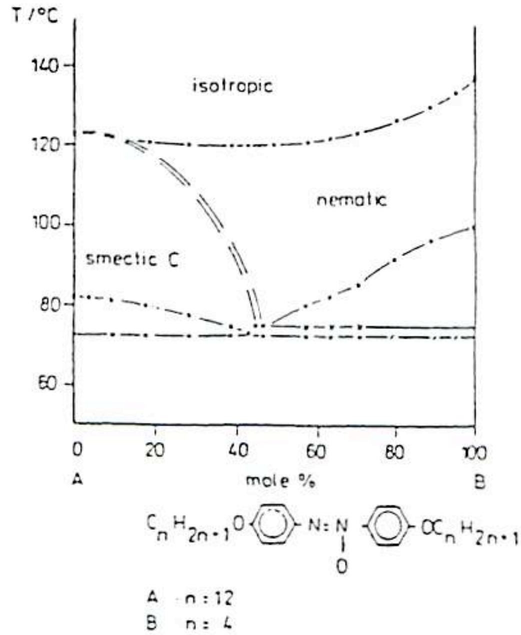
— ENLARGEMENT OF LC RANGE ESPECIALLY TO LOWER TEMPERATURES

— ADJUSTMENT OF VARIOUS PARAMETERS OF THE MATERIAL (viscosities, elastic constants, electric field behaviour etc.)

→ MIXTURES ENABLED A COMMERCIAL APPLICATION OF LIQUID CRYSTALS



Phase diagram with complete miscibility



Phase diagram with miscibility gap

Birendra, Bahadur, *Liquid Crystals Applications and Uses*, Vol. 1, World Scientific Publishing, Singapore, New Jersey, London, Hong Kong, 1990