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X-RAY INVESTIGATIONS OF A REENTRANT NEMATIC PHASE FORMED OF TERMINAL-NONPOLAR COMPOUNDS

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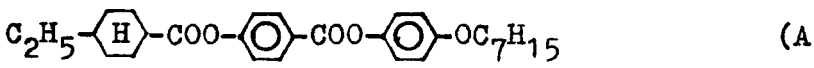
ABSTRACT: A binary system of terminal-nonpolar compounds is presented in which a stable reentrant nematic phase occurs. X-ray investigations were carried out in the N, S_A, N_{re}, and S_C phase.

Up to now it was believed generally that the reentrant phenomenon is a characteristic feature of the terminal-nonpolar compounds or of their mixtures [1, 2]. Recently we could show that a reentrant nematic phase (N_{re}) occurs in a binary system of terminal-nonpolar compounds [3]. This case was predicted theoretically by Longa and de Jeu [4]. In this system the N_{re} phase was found in the supercooled state and crystallized after formation. Now we present a new binary system of terminal-nonpolar compounds in which a stable N_{re} phase exists in a limited concentration range.

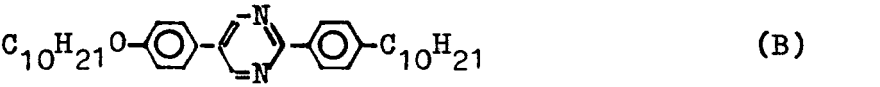
The first component of the binary system is an assymetrically substituted three-ring compound possessing a nematic phase in a large temperature range and additionally a metastable S_C phase.



(A)

Cr 60 (S_C 40) N 183 Is [3, 5]

The second component is a symmetrically substituted three-ring pyrimidine which exhibit smectic tetramorphism (S_A, S_C, S_F, S_G)

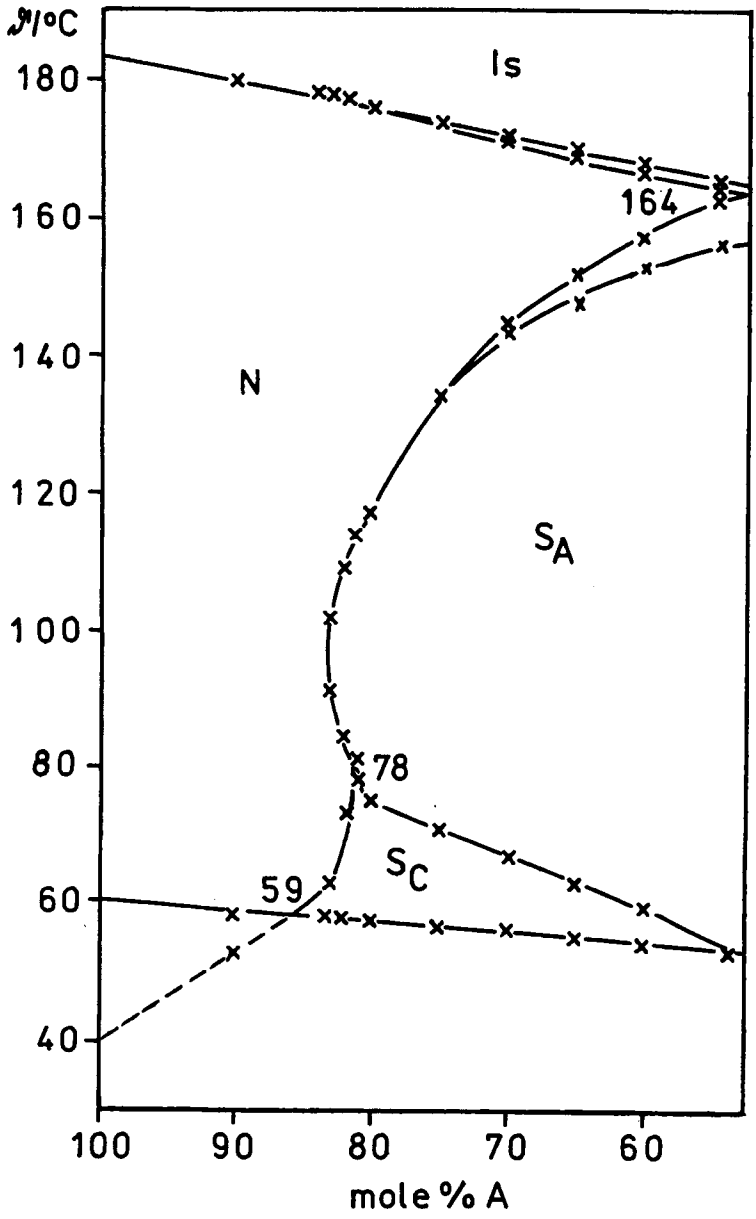


(B)

Cr 87.5 S_G 117 S_F 133.5 S_C 179 S_A 183 Is [5]

Fig. 1 shows the part of the diagram of state in which the N_{re} phase appears. This diagram was studied by means of microscopical observations as well as by calorimetric measurements. It is seen from Fig. 1 that between 81 und 84 mole% A a stable N_{re} phase occurs on cooling of the S_A phase. By further cooling the S_C phase is formed.

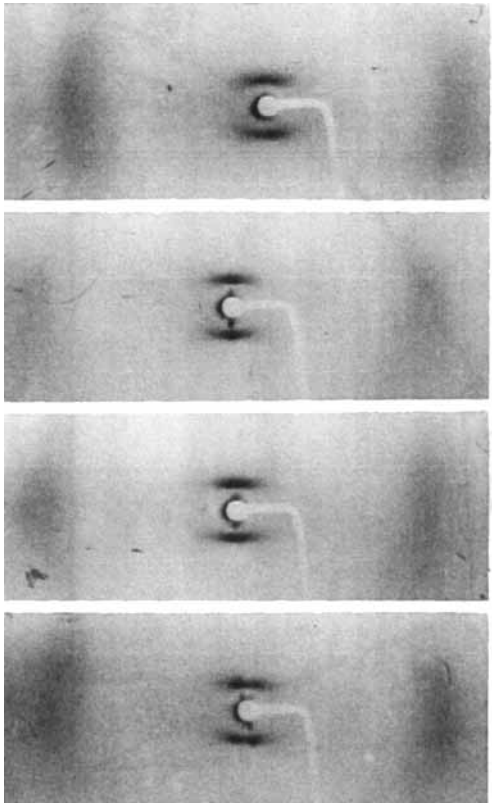
X-ray investigations were performed at a mixture with $x_B = 0.18$. By means of oriented samples we proved the phase sequence N, S_A, N_{re}, S_C with decreasing temperature (Fig. 2a - d, respectively). To obtain the accurate d-values we used a small-angl equipment in connection with an intensity recording. The scattering regions between $1^o \leq \theta \leq 2^o$ at different temperatures are given in Fig. 3a - d. The intensity of the four examples was recorded with the



A: C_2H_5-(H)-COO-(○)-COO-(○)-OC_7H_{15}

B: $C_{10}H_{21}O$-(○)-(N=N)-(○)-$C_{10}H_{21}$

FIGURE 1



a) N
T = 140 °C

b) S_A
T = 105 °C

c) N_{re}
T = 74 °C

d) S_C
T = 65 °C

FIGURE 2

same amplification. Therefore only very small and diffuse scattering is visible in the N phase (Fig. 3a). The smectic phases exhibit the strong inner ring (Figs. 3b, 3d) whereas Fig. 3c proves the degeneration of the layer order within the N_{re} phase. However a comparison of the Figures 3a and 3c suggests the existence of cybotactic groups in the N_{re} phase.

Using Bragg's law we calculate the d-value in the S_A, N, and S_C phase, $d_{S_A} = 32.7$ Å, $d_{N_{re}} = 32.8$ Å, and $d_{S_C} = 31.3$ Å, respectively.

The comparison of the d-values with the averaged molecular length ($L_{av} = x_A L_A + x_B L_B = 34$ Å) shows that there is no hint for a kind of dimerization found in reentrant systems with polar substances. Therefore, it must be concluded that the appearance of the N_{re} phase is not connected with the formation of dimers with $d > L$. The observed difference $L - d$ is in agreement with the results of other high temperature phases and can be explained by the presence of long non-rigid aliphatic chains.

The tilt angle of the S_C phase is calculated by

$$\cos \beta = \frac{d_{S_C}}{d_{S_A}}$$

The value $\beta = 17^{\circ}$ is in agreement with the values estimated from the inner spots of the oriented patterns (Fig. 2d).

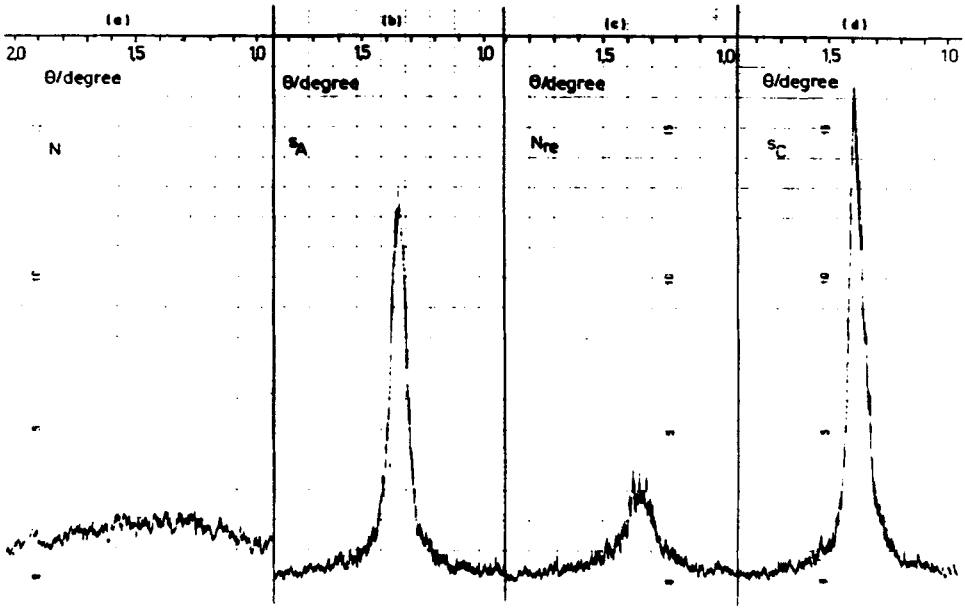


FIGURE 3

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