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Visco-Elastic Properties of Liquid Crystalline Mixtures

M. F. Grebyonkin [a] , G. A. Beresnev [a] & V. V. Belyaev [a]
[a] Organic Intermediates and Dyes Institute, 103787, Moscow, USSR, B. Sadovaya, 1

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Visco-Elastic Properties of Liquid Crystalline Mixtures

M. F. GREBYONKIN, G. A. BERESNEV and V. V. BELYAEV

Organic Intermediates and Dyes Institute, 103787, Moscow, USSR, B. Sadovaya, 1

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In the present paper we have investigated the elastic moduli ratio and the rotational viscosity coefficient of liquid crystalline derivatives different chemical classes: biphenyls, phenylcyclohexanes, phenylpyrimidines, phenylbicyclooctanes etc., which are broadly used in electrooptical devices. We also have considered the mixtures of these substance with the liquid crystalline matrix of azoxycompounds, having the value of the dielectric anisotropy close to zero ($\Delta\epsilon = \epsilon_{\parallel} - \epsilon_{\perp} \lesssim 0$).

The experimental data, obtained on the rotational viscosity coefficient γ_1 and the ratio of the elastic moduli K_{33}/K_{11}, testify to the influence of the molecular structure on the considered properties, having a very complicated character especially for the mixtures of nematic liquid crystals of different chemical classes.

I. INTRODUCTION

The ratio of the elastic moduli for bend (K_{33}) and splay (K_{11}) deformations as well as the rotational viscosity coefficient γ_1 are the important parameters of a nematic liquid crystal (NLC), defining its static and dynamic characteristics. In particular, the steepness of the transmission-voltage curve of a twisted nematic display increases with decreasing the ratio K_{33}/K_{11},[1] which, in turn, results in improving the matrix addressability of the liquid crystalline material.[2] The decrease of γ_1 provides the higher operation speed of electrooptical devices, based on liquid crystals.

In the present paper we have investigated the elastic moduli ratio and the rotational viscosity coefficient of liquid crystalline derivatives different chemical classes: biphenyls, phenylcyclohexanes, phenylpyrimidines, phenylbicyclooctanes, etc., which are broadly used in electrooptical devices. We also have considered the mixtures of these substance with the liquid crystalline matrix of azoxycompounds, having the value of the dielectric anisotropy close to zero ($\Delta\epsilon = \epsilon_{\parallel} - \epsilon_{\perp} \lesssim 0$). The work is aimed at revealing the influence of molecular factors on K_{33}/K_{11} and γ_1.

2. EXPERIMENTAL TECHNIQUE

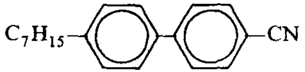
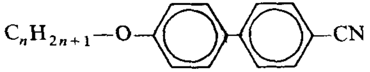
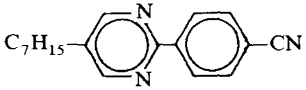
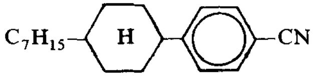
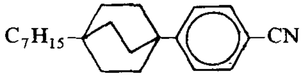
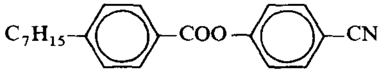
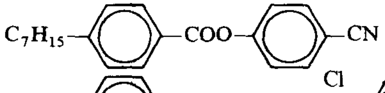
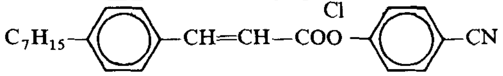
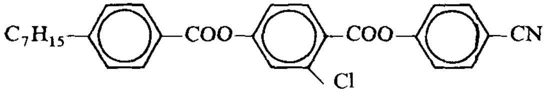
The ratio of elastic moduli K_{33}/K_{11} was measured by the method, which we developed earlier using the optical properties of a "sandwich" cell with a planar NLC orientation on one of the electrodes and homeotropic on the other (homeoplanar orientation).[3, 4] To facilitate the measurements we used, in fact, the doubled cell, having both homeoplanar and planar orientation regions with the same thickness. The temperature in the measuring cell was maintained with the accuracy of ±0.1°C. The error in K_{33}/K_{11} measurements did not exceed 2%.

The value of the rotational viscosity γ_1 was defined from the relaxation time of Frederiks transition in planar NLC layer, deformed by an external electric field.[5] The thickness of the NLC layer (~ 60 microns) was determined by the interferometer technique. The error in the measurements of the γ_1 value was less than 7%.

The investigations were carried out using the fifth and the seventh homologs of the cyanoderivatives of different chemical classes and the mixture of azoxycompounds. The structural formulas and the clearing temperatures (T_c) for the seventh homologs of the cyanoderivatives are given in Table I. The significant part of the viscosity coefficient measurements were made with two-component mixtures of the fifth and the seventh cyanoderivatives homologs with the mole ratio 40 : 60. We investigated the mixtures instead of the corresponding individual components in order to provide a sufficiently wide temperature range of the nematic phase, having nevertheless the definite chemical structure of the substance. The elastic moduli ratio was measured for the seventh homologs of the cyanoderivatives as well as for the mixtures of the fifth and the seventh homologs and for the mixtures of the seventh homologs of the cyanoderivatives of different chemical classes with the matrix of the azoxycompounds. The last is a mixture of

TABLE I

Liquid crystalline cyanoderivatives

Notation	Structural formula	Chemical name	T_c, °C
1. CB		4, 4′-heptylcyano-biphenyl	42
2. OCB		4, 4′-*n*-alkyloxy-cyanobiphenyl	74 $n = 1 - 8$
3. Py		5-*n*-heptyl-2-(4-cyanophenyl)-pyrimidine	50
4. PCH		Trans-4-*n*-heptyl-(4-cyanophenyl)-cyclohexane	57
5. BCO		1-*n*-heptyl-4-(cyanophenyl)-bicyclo [2. 2. 2] octane	94
6. PEBA		*n*-cyanophenyl-ester of *p*-*h*-heptylbenzoic acid	56
7. CPEBA		4-cyan-3-chloride-phenyl-ester of 4-*n*-heptylbenzoic acid	$(-10)^a$
8. PECA		*n*-cyanophenyl-ester of *p*-*n*-heptylcinnamate acid	112
9. PECBOBA		*n*′-cyanophenylester-ester of *o*-chloride-*p*-(*P*-*n*-heptyl-benzoyloxy)-benzoic acid	161

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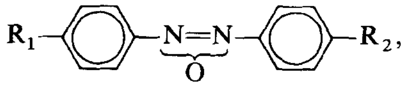
[a] Monotropic transition

substances with a general formula



where $R_1 = C_4H_9$—, $R_2 = OCH_3$ or $OCOC_6H_{13}$. The clearing temperature for the mixture of the azoxycompounds is +73°C and $\Delta\epsilon = -0.4$ (25°C).[6] The concentration of the cyanoderivatives (C) in the matrix of the azoxycompounds was varied from 1.5 to 80 mol.%. The majority of the investigated cyanoderivatives were rather well dissolved in the chosen matrix, providing a sufficiently wide temperature range of the nematic phase for the mixtures.

3. RESULTS

Temperature dependencies of the rotational viscosity γ_1 (in Poise) and the ratio of the elastic moduli K_{33}/K_{11} have been measured for the mixtures of the fifth and the seventh homologs of the CB, OCB, Py, BCO and PCH cyanoderivatives. The temperature dependencies of γ_1 are given in Figure 1. These dependencies are approximated by the corresponding straight lines within the whole temperature range except on the temperatures close to the clearing point. The activation energy E was determined using the tangent of the angle of the straight line slope with the accuracy of ± 0.010 eV ($\gamma_1 \sim \exp E/kT$). The values of γ_1, E, the clearing temperatures and the ratio K_{33}/K_{11} are given in Table II. There are also shown for references the values of the elastic modulus K_{11}, dielectric $\Delta\epsilon$ ($f = 500$ Hz) and optical Δn($\lambda = 633$ nm) anisotropy, obtained in the experiment ($\tau = T/T_c$ is the reduced temperature). The rotational viscosity coefficient γ_1 values, measured in our work, are close to those ones, given in the paper,[7] and the activation energies are slightly lower. The values of K_{33}/K_{11} are also close to those ones in the paper[8] for the similar mixtures of the fifth and the seventh homologs of the certain classes of liquid crystalline substances.

Figure 2 shows the concentration dependencies of E, γ_1 (at 25°C) and T_c for the mixture of PCH and the azoxycompounds. The sharp decrease of E and γ_1 with increasing of the concentration of PCH as well as a considerable deviation of the dependence $T_c = T_c(C)$ from the linear one, corresponding to the additivity rule are the marked peculiarity of this figure.

The dependencies of the elastic moduli ratio K_{33}/K_{11} vs a reduced temperature measured for the mixtures of different concentrations of

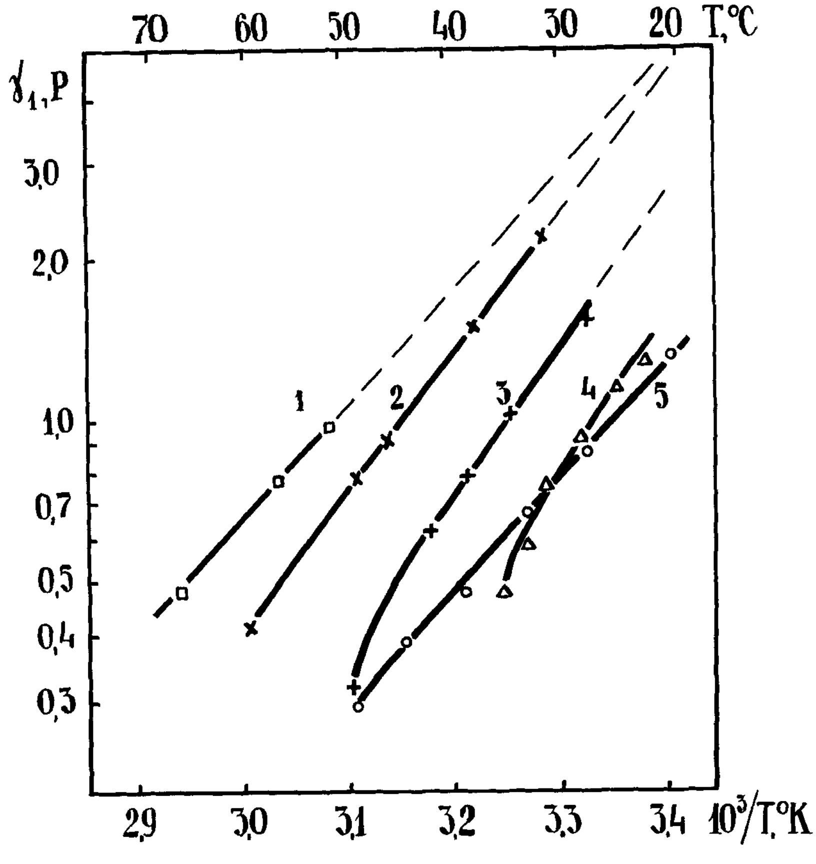
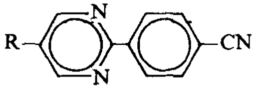
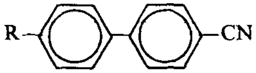
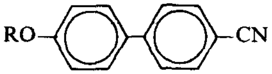
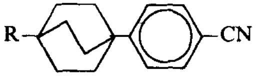
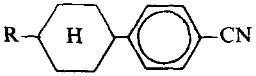


FIGURE 1 Temperature dependence of the rotational viscosity coefficient γ_1. 1–BCO, 2–COB, 3–Py, 4–CB, 5–PCH.

Py, CB, OCB, BCO and PCH cyanoderivatives in the matrix of the azoxycompounds are given in Figure 3. The value of K_{33}/K_{11} decreases with reducing the temperature for the majority of the mixtures. The sharp increase of some curves, which observed when decreasing the temperature (for instance, the curves 4a, 4b and 4b′ in Figure 3), is connected with the formation of the pretransition smectic order.[9] The ratio K_{33}/K_{11} is seen to vary with varying concentrations of the cyanoderivatives. When C = 1.5 mol.% the ratio K_{33}/K_{11} is practically the same for all the investigated cyanoderivatives and must be considered as that one of the azoxycompounds matrix. When increasing the concentration, the ratio K_{33}/K_{11} begins to drop, but it increases again, if the concentration exceeds 50 mol.%

TABLE II

NLC mixture properties (R = C_5H_{11}—40 mol.% and C_7H_{15}—60 mol.%)

NLC	Structural formula	T_c, °K (T_c, °C)	γ_1, Poise 25 °C	E, eV	$K_{11} \times 10^7$, dyne		k_{33}/K_{11} $\tau = 0.95$	$\Delta\epsilon$ $\tau = 0.95$	Δn $\tau = 0.95$
					25 °C	$\tau = 0.95$			
Py		324.4 (51.2)	1.9[a]	0.551	10.24	8.03	1.06	+18.8	0.174
CB		312.2 (39.0)	1.1	0.546	7.65	8.01	1.37	+11.7	0.184
OCB		345.2 (72.0)	3.4[a]	0.517	10.90[a]	6.12	1.25	+10.1	0.177
BCO		369.7 (96.5)	3.7[a]	0.426	11.20[a]	7.05	1.93	+8.6	0.114
PCH		329.6 (56.4)	1.0	0.410	11.50	7.60	1.68	+11.7	0.100

[a] The values of γ_1 and K_{11} are obtained by the extrapolation procedure down to 25 °C.

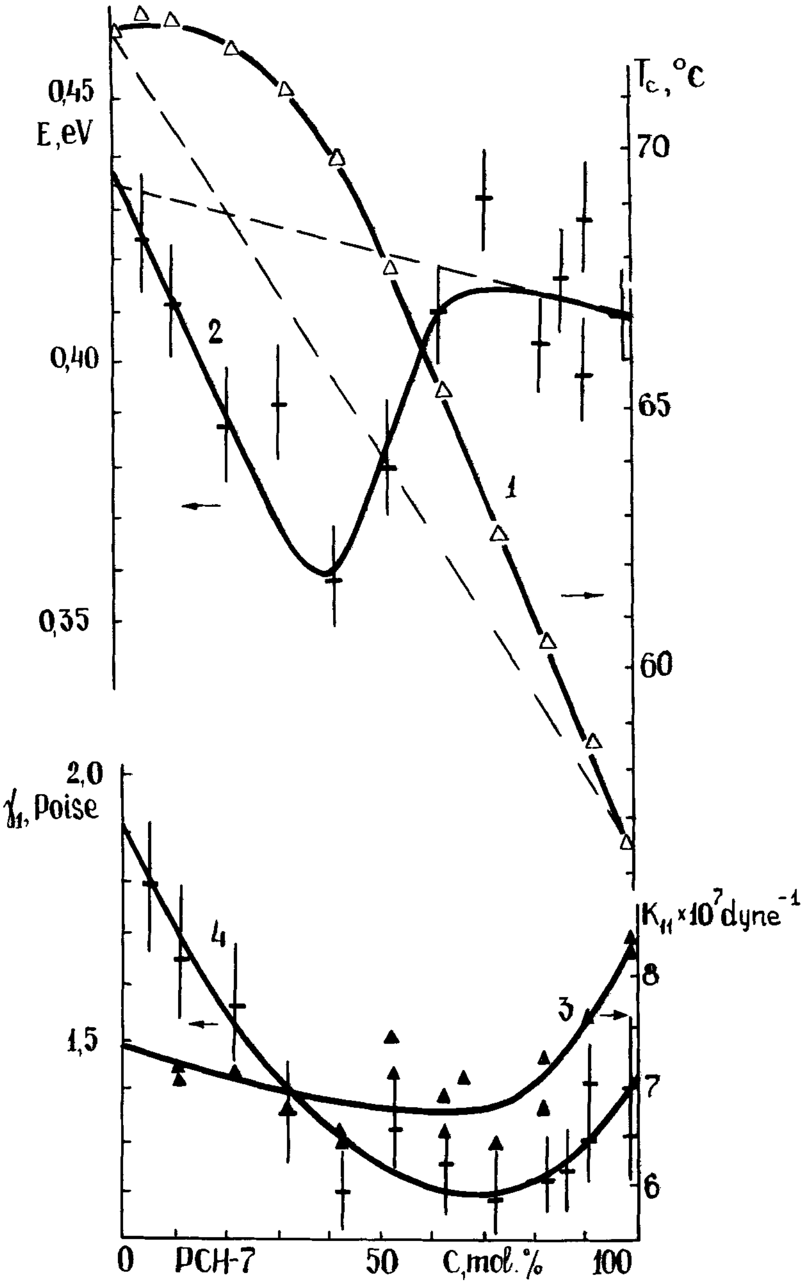


FIGURE 2 Concentration dependencies of the clearing temperature T_c (1), the activation energy E (2), the elastic constant K_{11} at $\tau = 0.95$ (3) and the rotational viscosity γ_1 at 25 °C (4) for the mixtures of the seventh homologue of PCH in the matrix of the azoxycompounds.

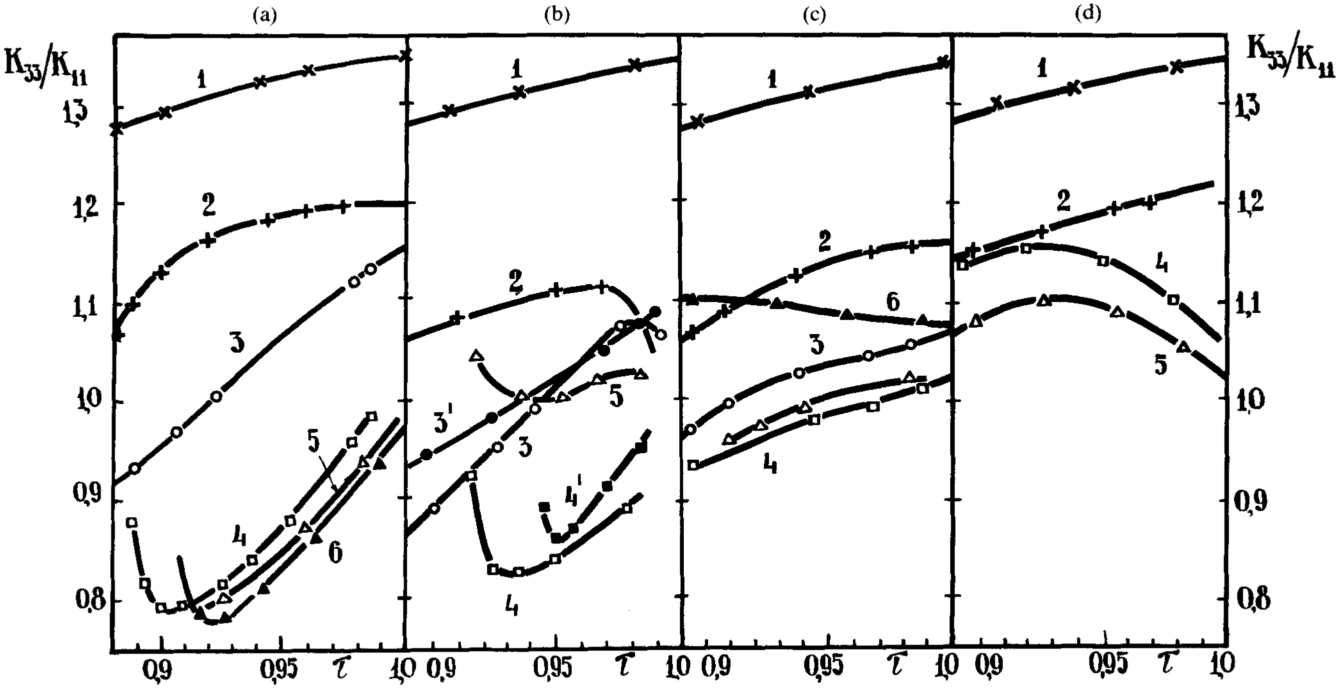


FIGURE 3 Temperature dependencies of the ratio K_{33}/K_{11} for the mixtures of the azoxycompounds with Py(a), CB and OCB (b), PCH(c) and BCO(d). The concentration of the cyanoderivatives in the matrix: 1–1.5%, 2–10%, 3–30%, 4–40%, 5–50%, 6–60%. The curves 3′ and 4′ are related to OCB.

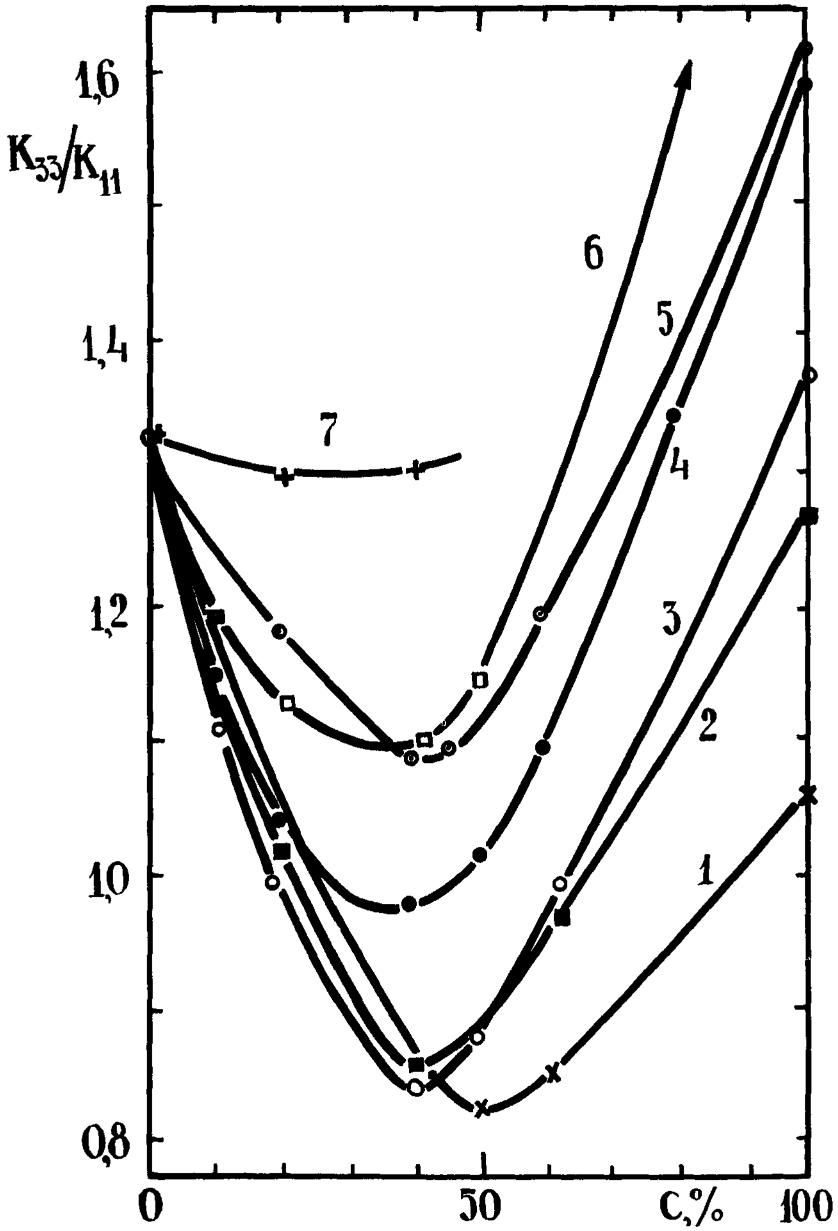


FIGURE 4 Dependences of the ratio K_{33}/K_{11} on the concentration of the cyanoderivatives in the matrix of the azoxycompounds at the reduced temperature $\tau = 0.95$. 1-Py, 2-OCB, 3-CB, 4-PCH, 5-PEBA, 6-BCO, 7-PECBOBA.

The concentration dependences of K_{33}/K_{11} for various cyanoderivatives at given reduced temperature $\tau = 0.95$ are shown in Figure 4. The values of K_{33}/K_{11} on the right axis correspond to those ones of the pure heptylcyanoderivatives. The ratios K_{33}/K_{11}, measured in our experiment, are very close to the data, obtained elsewhere for the same compounds.[10] On the left axis in Figure 4 there is shown the value of K_{33}/K_{11} for the matrix of the azoxycompounds. The concentration dependences reveal a clearly defined minimum at the concentration 40–50 mol.% for practically all the investigated substances. The comparative dependences of K_{33}/K_{11} vs a temperature for the mixtures, contained 40 mol.% of heptylcyanoderivatives from different chemical classes are given in Figure 5.

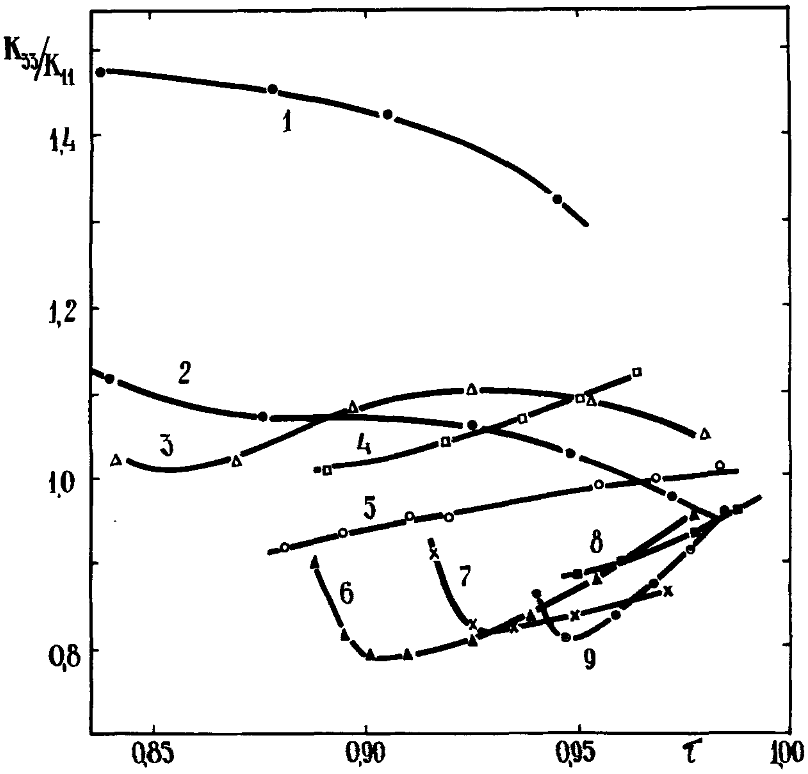


FIGURE 5 Dependences of the ratio K_{33}/K_{11} on temperature for the 40 mol.% mixtures of the cyanoderivatives with the azoxycompounds. 1-PECBOBA, 2-PECA, 3-BCO, 4-PEBA, 5-PCH, 6-Py, 7-CB, 8-CPEBA, 9-OCB.

Figures 3, 4, 5 show, that the ratio K_{33}/K_{11} is not quite the same both for the cyanoderivatives themselves having a different molecular structure (see also Table II), and for their mixtures with the azoxy-compounds. The variation of K_{33}/K_{11} is also observed in the mixtures with different members of one homologue series. Figure 6 shows the temperature dependences of K_{33}/K_{11} for the homologue series of alkoxycyanobiphenyls (in this case the concentration of the cyano-derivative has also been 40 mol.%).

Special experiments for a number of mixtures make it clear, that the decrease of K_{33}/K_{11} with increasing the concentration of the cyano-derivative in the matrix of azoxycompounds takes place in the main due to the increase of splay elastic modulus K_{11}, while K_{33} undergoes only a slight variation.

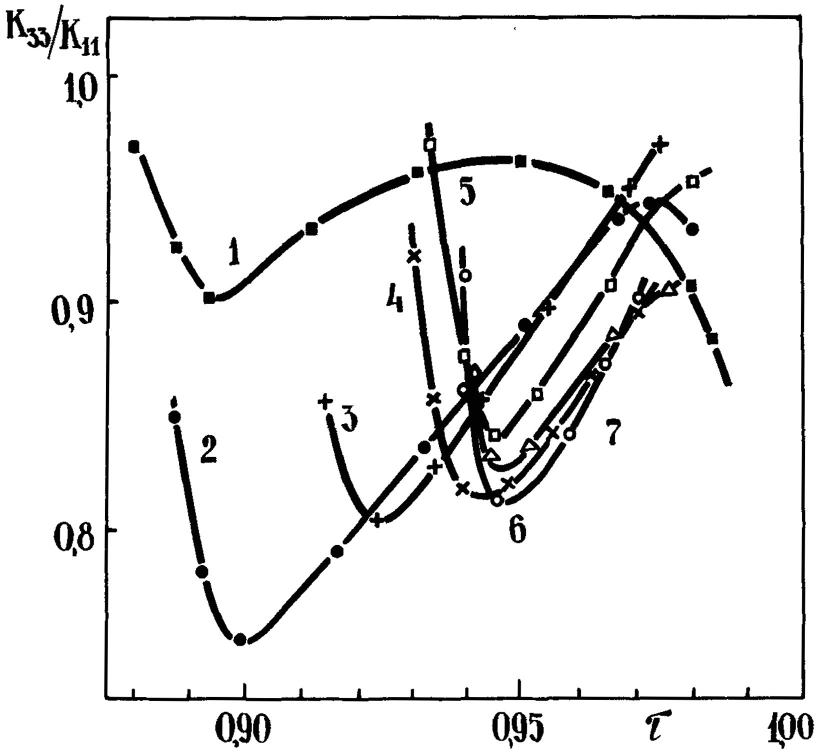


FIGURE 6 Temperature dependences of the ratio K_{33}/K_{11} for the 40 mol.% mixtures of the terms of the 4,4′-alkoxycyanobiphenyl homologue series with the azoxy-compounds. 1–n = 1 (■), 2–n = 3 (●), 3–n = 4 (+), 4–n = 5 (×), 5–n = 6 (□), 6–n = 7 (○), 7–n = 8 (△).

4. DISCUSSION

a) Rotational viscosity coefficient γ_1

For convenience we analyze the data on the rotational viscosity coefficient γ_1 for the group of substances: CB, OCB, Py, PCH, BCO, having an approximately similar molecular structure (see Table II). These compounds have two-rings structure and similar end groups (alkyl and CN-groups); one ring is always a phenyl one, while the other ring is pyrimidine, phenylene, cyclohexane and bicyclo-octane one respectively. The geometrical sizes of the molecules remain practically the same, only bicyclo-octane fragment is slightly bigger than the others.

As it is seen from Table II, the investigated substances can be divided in two groups according to their activation energies: Py and CB with a high activation energy (E = 0.54–0.55 eV) and BCO and PCH having a lower activation energy. Such a separation could be connected with the differences in the nature of the intermolecular interaction. In case of Py and CB the interaction of π-electron clouds of benzene and pyrimidine rings of the neighbouring molecules plays an important role. In the case of BCO and PCH this interaction is appreciably weakened due to the presence of the bicyclo-octane and cyclohexane rings with saturated bonds and due to reducing of the conjugation chain in the molecule. In fact, these very phenomena must be responsible for the formation of molecular associates in these substances having an antiparallel dipole correlation, the corresponding conception being given in[10] to explain the differences in the values of K_{33}/K_{11}. The activation energy for OCB is of an intermediate value, though this substance could be related to the first group due to the structure of the molecule.

According to the theory of the NLC rotational viscosity, proposed by Diogo and Martins,[11] where the intermolecular interaction is described by the potential of Maier-Saupe, the dependence of the coefficient γ_1 vs a temperature is defined by the following cofactors:

$$\gamma_1 \sim T^{1/2} \cdot S^2 \exp\left(\frac{\epsilon S}{kT} + \frac{\theta S^2}{T - T_0}\right), \qquad (1)$$

where S is the order parameter, ϵS is the altitude of the Maier-Saupe potential, θ and T_0 are the characteristics of the substance. Let us make certain simplifying assumptions. First of all, we assume that the inequality $\theta S^2/T - T_0 \ll \epsilon S/kT$ is correct for the nematic liquid crystals, investigated in our experiments, because this inequality is valid practically within the whole nematic phase temperature range for all the members of 4, 4′-dialkoxyazoxybenzene series investigated in [11]. Secondary, the contribution of the cofactor, connected with the absolute temperature and the order parameter, to the temperature dependence of γ_1 is far less than the contribution of the exponential cofactor. In view of these assumptions the temperature dependence of γ_1 is defined, principally, by the cofactor $\exp(\epsilon S/kT)$.

According to [11], if only the short steric order is taken into account, the altitude of the potential barrier is given by the expression

$$\epsilon S = \frac{3}{2}\frac{A}{mV^2}S, \tag{2}$$

where A = const, m – is the coordination number, i.e. the number of molecules forming the rotating particle (cluster), V is the molar volume. The parameters of the expression (2) are connected with the temperature T_c by the relation: $A/mV^2 = 4.54\ kT_c$ (see, for instance [12]). It follows from this, that the altitude of Maier-Saupe potential is proportional to the clearing temperature:

$$\epsilon S = 6.82 \times kT_c \times S \tag{3}$$

The experimental data, concerning the clearing temperature and the activation energies for the cyanoderivatives of different chemical classes lead to the following relations:

$$\frac{T_c(\mathrm{BCO})}{E(\mathrm{BCO})} = \frac{T_c(\mathrm{PCH})}{E(\mathrm{PCH})} \simeq 0.10$$

and

$$\frac{T_c(\mathrm{Py})}{E(\mathrm{Py})} = \frac{T_c(\mathrm{CB})}{E(\mathrm{CB})} = 0.07$$

(here the energy is expressed in terms of Kelvin degrees). Thus, one can say, that the activation energy E is proportional to the clearing temperature of a nematic liquid crystal, but that is valid only for one or another group of substances chosen in accord with the type of the intermolecular interaction. By the way, the correctness of such an approach is confirmed by the measured values of T_c and E for alkylcyanophenylpyridines (Pd), which can be related to the group, containing CB and Py due to the character of the intermolecular interaction. For the analogous mixture of Pd $T_c = 44.2°C$, $E = 0.550$ eV and $T_c(\mathrm{Pd})/E(\mathrm{Pd}) = 0.067$, that is the same as for Py and CB.

Introducing the mentioned above simplifying assumptions, we can write the expression for the rotational viscosity coefficient in the following form:

$$\gamma_1 = g_1 S^2 \exp(E/kT), \tag{4}$$

where g_1 is a product of the substance parameters [11]. As the values of these parameters are unknown, it is not possible to calculate γ_1 in accordance with the theory [11] and to compare the result with the value, obtained in the experiment. However, we would like to note, that the substances having a similar character of the intermolecular interaction, are characterized by an approximately equal preexponential cofactor g_1S^2: $\sim 10^{-5}$ Poise for PCH and BCO and $\sim 10^{-7}$ Poise for Py and CB ($t = 25°C$). In case of Pd g_1S^2 is practically equal to the pre-exponential cofactor of Py and CB, in accordance with our expectations (for Pd $\gamma_1 = 1.46$ Poise at 25°C). From one side it means, that the factors, defining the value of the viscosity coefficient γ_1 for the substances, having an identical molecular structure and a similar character of the intermolecular interaction, happen to be really equal. From the other side, the values of the pre-exponential cofactor, calculated in this way, differ considerably for the substances with a different character of the intermolecular interaction. Such a disagreement can not be related only to the difference in the geometrical factors, taking into consideration the various size of the associates due to the dipole correlation, or unequal numbers of molecules in the basic state and on the top of the potential barrier, which the rotating particle is to overcome and which in the frame works of the theory [11] may depend on the substance.

The difference in the values of cofactor g_1S^2 and of the proportionality coefficient between T_c and E for different groups of substances, as well as the difference between the activation energy and the altitude of Maier-Saupe potential testify to the fact, that utilizing Maier-Saupe mean field potential in the theory of the rotational viscosity does not give an adequate description and one should consider more carefully the specific interaction between the nearest (neighbouring) molecules. The fact, that such an interaction is considerable, is confirmed by the data, given in Figure 2, where the variation of the activation energy with increasing the concentration of the cyanoderivative (PCH) in the matrix of the azoxycompounds shows a clearly defined nonadditive character.

b) Ratio of elastic moduli K_{33} / K_{11}

Having analyzed the data we would like to note the following results.

A. Comparing the ratio of K_{33}/K_{11} at one reduced temperature ($\tau = 0.95$) for the concentration of the cyanoderivative in the mixture of the azoxycompounds equal to 40 mol.% (or less), we can see, that the lowest values of the ratio K_{33}/K_{11} are obtained for OCB, CB and Py; PCH, PEBA, BCO and PECA have considerably higher ratio K_{33}/K_{11} and the maximum value of K_{33}/K_{11} is observed for the three-ring ester PECBOBA. These values of K_{33}/K_{11} measured for the mixtures correlate on the whole with the values of K_{33}/K_{11} for the corresponding pure cyanoderivatives (see Figure 1 and, also, [10]). As it is shown in [13], the value of K_{33}/K_{11} depends on the ratio L/W, where L and W are the length and the thickness of the rigid skeleton of the molecule respectively (without flexible alkyl chains). PECBOBA is sure to possess the maximum value of L/W, which leads to the maximum ratio of K_{33}/K_{11}, measured in the mixture of this substance with the azoxycompounds. The esters (PECA, PEBA, CPEBA) have more elongated molecules, than the cyanoderivatives with single bond between the rings (Py, CB, OCB, BCO and PCH) and, consequently the higher corresponding ratios K_{33}/K_{11}. In case of Py, CB, PCH and BCO, having approximately equal ratios of L/W, the variation of the values K_{33}/K_{11} could be referred to the influence of molecular associates of different types, formed due to the dipole correlation, as it is proposed in [4]. In Py and CB two molecules seem to form an associate, having a doubled thickness and the length close to the length of one molecule, while in PCH and BCO the length of the associate is in the rough approximation 1.5 times as much as the length of one molecule and the thickness is slightly more than that one of a single molecule. The decrease of K_{33}/K_{11} with lengthening the alkyl chain in the homologue series in case of mixtures is obtained, as well as in case of the pure liquid crystalline substances [14]. We have verified this not only for OCB, but also for the other homologues series of different cyanoderivatives classes. It is also appreciable an even-odd alternation of the K_{33}/K_{11} value (a common feature of homologue series): even homologues of OCB in mixtures with the azoxycompounds have the lower value K_{33}/K_{11}, than odd ones (see Figure 6). Thus, for the mixtures of the cyanoderivatives in the matrix of the azoxycompounds there are valid in the main these very relations between the values of K_{33}/K_{11}, as in the pure liquid crystalline cyanoderivatives of different chemical classes and within the limits of one homologue series of a single class. Moreover, we can say, that the associates, which are forming in the case of pure cyanoderivatives, remain to all appearance in the mixtures with the azoxycompounds up to the concentrations of 40–50 mol.%. In this case the correlation factor may be varying and this variation may be different for various NLCs. This is confirmed by that fact, that the value K_{33}/K_{11} for the Py-azoxycompounds mixtures is slightly higher than that one for the CB-azoxycompounds mixtures, while for the pure cyanoderivatives the relationship is reverse.

Starting from the above-stated we may speculate on the elastic properties of the cyanoderivatives themselves, as it follows from the measurements of the value K_{33}/K_{11} for its mixtures with the corresponding matrix. For instance, according to Figure 5, we may expect, that the ratio of K_{33}/K_{11} in the pure CPEBA (curve 8) will be lower, than this for a pure PEBA (curve 4). The reducing of K_{33}/K_{11} for CPEBA, compared with that one for PEBA may be explained by increasing the effective thickness of the molecule due to introducing the atom of chlorine into the ortho-position in the PEBA molecule (structural formulas are given in Table I).

B. Practically in all the cases the introduction of cyanoderivatives into the matrix of the azoxycompounds leads to reducing the ratio K_{33}/K_{11} as compared with the pure cyanoderivatives. Moreover, the concentration dependencies (at one reduced temperature) have a clearly defined minimum at the 40–50 mol.% concentrations of cyanoderivatives. The value K_{33}/K_{11} for these mixtures is lower, than this one for any of the initial components (the matrix of the azoxycompounds and the pure cyanoderivative). This is not like this in case of the mixtures of the cyanoderivatives themselves. For instance the 1 : 1 mixture of Py and BCO has the value of $K_{33}/K_{11} = 1.55$ at $\tau = 0.95$, i.e. the additivity law is approximately correct.

The presence of the minimum on the concentration dependence of K_{33}/K_{11} confirms a strong interaction between the cyanoderivatives molecules and the molecules of the azoxycompounds. The nature of such an interaction remains unknown. We can only note, that there is the CN-group, which plays here an essential role, because, as shown in [15], introducing the liquid crystalline substances without CN-group in para-position into a matrix of esters does not provide a sharp decrease of K_{33}/K_{11}. In the first case the associates of the molecules of the matrix and the cyanoderivatives can form, caused the decrease of the effective length to the thickness ratio, which, in turn, must lead to reducing K_{33}/K_{11}. The concentration dependences of the clearing temperature measured for the same mixtures are, in particular, testified to this fact. For example, in case of OCB-azoxycompounds mixtures the concentration dependence of the clearing temperature has a clearly defined maximum at the 40–60 mol.% concentration of the cyanoderivative. (T_c is 75 °C for the seventh homologue of OCB, 73°C for the matrix of the azoxycompounds and 86 °C for the mixtures of the 40% and 60% concentrations). The other mixtures with the cyanoderivatives (except on PECBOBA and CPEBA) reveal the similar, though slightly less pronounced, dependences (see, for instance, Figure 2).

In that way, using the data obtained we can state the fact, that the mixtures are to a great extent preserving the individual properties of the molecules (or the associates) of the cyanoderivatives, and at the same time a strong interaction between the cyanoderivatives and the matrix is observed, resulting in the effective decrease of the elastic moduli ratio K_{33}/K_{11}.

The dependence of the considered phenomena on the choice of the matrix itself, having $\Delta\epsilon$ close to zero, is the subject of the further investigations. A number of the similar results were noticed in the paper [15], where the mixtures of esters had been used as the matrix.

5. CONCLUSION

The experimental data, obtained on the rotational viscosity coefficient γ_1 and the ratio of the elastic moduli K_{33}/K_{11}, testify to the influence of the molecular structure on the considered properties, having a very complicated character especially for the mixtures of nematic liquid crystals of different chemical classes. To clarify this influence, the further experimental investigations are to be carried out, as well as the development of the theory, taking into account the specific intermolecular interaction.

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