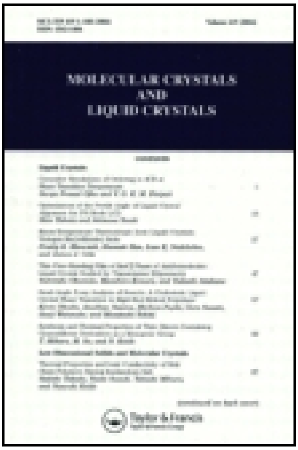

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Viscosity of Lyotropic Nematic Calamitic Liquid Crystals

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Viscosity of Lyotropic Nematic Calamitic Liquid Crystals

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Coneplate viscometry measurements as a function of temperature were made on two lyotropic nematic calamitic liquid crystals involving the potassium laurate/decanol/water and potassium laurate/potassium chloride/water systems. It was observed that whereas, at nematic calamitic phase (system with decanol), the viscosity measurements are smaller than those nematic calamitic phases (systems with potassium chloride). The results are discussed and compared to other liquid crystal sytems.

Keywords: viscosity; lyotropic liquid crystals; nematic calamitic

INTRODUCTION

Lyotropic liquid crystals are formed by mixtures of amphiphilic molecules[1] and a solvent (usually water), under convenient temperature and concentrations conditions. The basic units of these systems are anisotropic micelles[2]. Under concentration change, or temperature change, have been observed two uniaxial phases and another one is biaxial [3]. In the temperature-concentration phase diagram, the biaxial phase appears to be an intermediate phase all along the border between the two uniaxial phases. The uniaxial nematic phases are known as discotic (N_D) and calamitic (N_C) depending on their magnetic susceptibility anisotropy[2]. Few measurements of viscosity have been reported on nematic lyotropic phases. In particular, Labes[4] *et al.*, have carried out measurements of viscosity (η) as a function of temperature for two lyotropic nematic systems involving the surfactants potassium laurate (KL) and sodium decylsulfate (SDS). The authors observed anomalies in the behavior viscosity when passing from N_C to N_D phases. Measurements of the viscosity obtained with a cone plate rheometer from the two lyotropic systems composed of potassium laurate (KL), decanol (DeOH) and water and (KL), potassium chloride (KCl) and water are reported as a function of temperature. The phase diagrams of these systems studied have been published elsewhere[3,5].The experimental results show that the viscosity of N_C phases (systems with potassium chloride) is larger than one nematic calamitic phase (system with decanol). This fact can be associated with the replacement of the decanol by the potassium chloride and to produce an increase of the ionic contribution in the systems.

EXPERIMENTAL

Experiments were carried out on the KL/DeOH/H_2O and KL/KCl/H_2O systems as a function of temperature in the range of the nematic calamitic phases. The relative concentrations in weight percent of the lyotropic mixtures investigated were: KL (29.4), DeOH (6.6), H_2O (64) - mixture 1; KL(34.5), KCl (3), H_2O

(62.5) - mixture 2 and KL (36.34), KCl (3.16), H_2O (60.5) - mixture 3. All the systems are in the nematic calamitic phase (N_c) at room temperaure.The components of the lyotropic mixtures were carefully mixed to form a homogeneous phase by using a centrifuge and mechanical agitation. Viscosity measurements were determined by means of an Brookfield Cone/Plate Rheometer model LVDV-III. The rheometer was calibrated with standard oil of known viscosity. The sample temperature was controlled by a Haake K-20/DC-5 circulating temperature bath. The temperatures of the sample were stable at 0.01K. Special care was taken during the experiments, in order to prevent the hydrolysis of the samples. In this sense, the viscosity measurements, at all samples were realized below 40^0C. Then, the phase transition temperatures were checked by using a polarized light microsocope.

RESULTS AND DISCUSSION

Figure 1 shows the behavior of the viscosity as function of temperature within of the nematic calamitic phase (N_C) of the mixture 1. In this temperature range (~ 20^0C), the viscosity determined was found in the range: $65 < \eta < 100$ centiPoise (cP). The viscosity data were recorded after 15 min each temperature was reached. The measurements were repeated and showed to be reproductible. As one can see from Figure 1, on descending temperature the viscosity values increases when passing from N_C to isotropic phase. Labes[4] *et al.*, measured the viscosity of the some lyotropic mixtures. The variation of the viscosity values observed by them was similar to ours experimental data. The authors have suggested that for the N_C phase the viscosity can be associated to the Leslie-Ericksen coefficients[4,6]. In general, the signal and magnitude of these coefficients may change through a phase transition.in addition to the reorientation of the director.

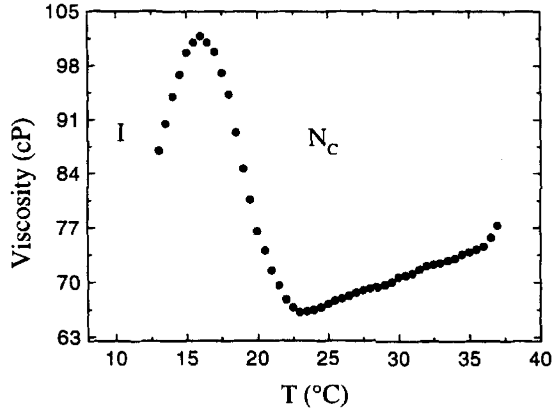

FIGURE 1 Viscosity vs temperature at isotropic-to-nematic calamitic phase transition; KL(29.4)/DeOH(6.6)/H_2O (66) wt %.

Figure 2 on descending temperature from 35^{0}C to 10^{0}C, we can note an increase ($500 < \eta < 1000$ cP) in the viscosity values of the mixture 2. In this lyotropic system, and upon heating, transforms to an hexagonal phase (H_α) about 40^{0}C [7]. Figure 3 shows the behavior of the viscosity of the of the mixture

3 (60.5 wt % H_2O), where the ratio KL/KCl=11.5 (concentrations in weight percent) is the same [5] of the mixture 2 (62.5 wt % H_2O). Below 30^0C a N_C phase is stable, and upon decreasing temperature from 30^0C to 10^0C the viscosity present a variation in the range: $1500 < \eta < 4000$ cP.

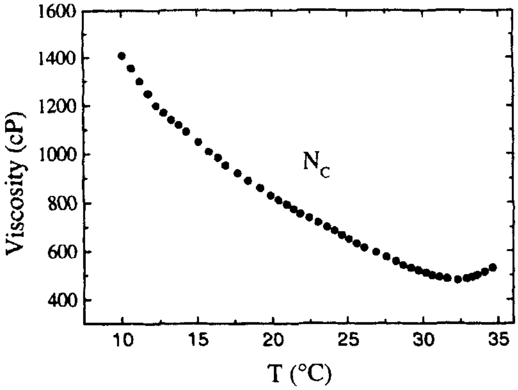

FIGURE 2 Viscosity vs temperature at nematic calamitic phase; KL(34.5)/KCl (3)/H_2O (62.5) wt %.

In a typical phase diagram of the lyotropic ternary mixtures increasing the decanol concentration the curvature of the amphiphile-water interface decreases. Neutron-scattering experiments[8] show that the alcohol concentrates at the flat core of the micelles rather than at the high-curvature rim. Otherwise, when the relative concentration water content is increased, the curvature of the amphiphile-water interface increases and the stacking of the aggregates becomes more disordered[9].

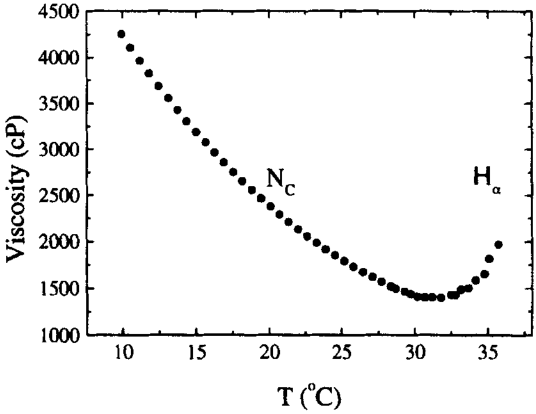

FIGURE 3 Viscosity vs temperature at nematic-to-hexagonal phase transition; KL(36.34)/KCl (3.16)/H_2O (60.5) wt %.

In the mixtures 2 and 3 the decanol was replaced by a salt (potassium chloride). In this case, under convenient concentration conditions, can occur an increase of the ionic contribution in the system near the amphiphile-water interface. This fact, point out for a growth of the micellar aggregate correlation.

Macroscopically the phases of these systems appear rather viscous. The higher values of the measured viscosities in mixture 2 and 3 are probably due to the replacement of DeOH by KCl. It is confirmed by ours experimental data. To our knowledge, there is no independent measurements of this parameter regarding this micellar system (KL/KCl/H_2O).

To sum up, we have carried out a detailed viscosity study in the range of the nematic calamitic phases and near the isotropic – N_C and N_C-hexagonal phase transitions for ternary mixtures of some lyotropic systems. The results are consistent with the viscosity studies realized by Labes[4] *et al.* and confirm the viscous nature for the samples (KL/KCl/H_2O). The study of the density[10] and kinematic viscosity in these lyotropic systems would be of considerable interest.

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