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Borders of the Liquid Crystalline Phase in the Triton X-114 – Water Binary System*

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Abstract. In the present study the boundaries are outlined of the two-phase regions around the liquid crystalline phase in the Triton X-114 — water binary system. The phase behavior is studied as a function of the concentration of the detergent in the system and of the temperature. The phase diagram contains an eutectic point appearing as the peak with respect to the temperature of the liquid crystal domain existing there.

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1 Introduction

Triton X-114 is a typical non-ionic detergent. Surface-active substrata of this kind are widely used in biology, biochemistry, industry, cosmetics, etc. In particular, this detergent is widely used for isolation and purification of membrane proteins, which are solubilized in the aggregates formed by the surfactant in water solutions. The control of this and some other processes requires knowledge of the phase behavior of the system detergent — water at different temperatures and different concentrations of the detergent in the solution.

There are several studies of the polymorphism of the Triton X-114 — water binary system [1-3]. The aim of these investigations was to outline the borders of the phases in the phase diagram, as well as to establish the microscopic structure of the different phases. The experimental methods used were optical microscopy, electron microscopy, and viscosimetry. The results of these studies showed that a lamellar liquid crystalline domain existed in the phase diagram, situated in the 0–63°C temperature range and in the concentration interval

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48–83 wt% of the surfactant in the solution. In the detergent concentration–temperature coordinates, the domain has a bell-like shape with its peak situated at 63 wt% of the detergent and at 64°C. This concentration corresponds to two water molecules per oxygen of the oxyethylene chain. Recently, a theoretical interpretation was proposed of these experimental findings [4].

The liquid crystalline domain is surrounded by an isotropic phase whose domain is singly connected in the phase diagram. Because of the difference in the symmetries of the liquid crystalline and the isotropic phase, the phase transition between them is of the first order. Consequently, a two-phase region exists in the phase diagram, containing a liquid crystalline and isotropic phase in equilibrium. The first investigation of this region was carried out using differential scanning calorimetry measurements [5]. The specific restrictions of the method only permitted the outlining of the two-phase region between the liquid crystal phase and the isotropic phase for higher surfactant concentrations. The aim of the present study is the complete determination of the two-phase region between the liquid crystalline phase and the isotropic phase surrounding it in the Triton X-114 — water binary phase diagram.

2 Materials and methods

The Triton X-114 (Fluka commercial product) was used. The samples were prepared with bidistilled water.

One of the classical methods of phase diagram investigation was applied. Samples sealed in glass tubes were prepared with weight concentrations of the detergent between 46 wt% and 84 wt%, with a step inferior to 0.33 wt%. The temperature of all the samples was fixed through their immersion into water bath. The temperature varied in the 20–63°C range. The temperatures were maintained with an accuracy of 0.1°C. Before any change in the temperature, all the tubes had been heated up to 63°C and carefully shaken to assure the homogeneity of the solutions.

To determine the existence of an anisotropic phase, the samples with the bath temperature were placed between crossed polarizers. The observation enabled us to determine whether every one of the probes contained an isotropic phase, an anisotropic phase or a mixture of both for the temperature and the detergent concentration of the sample.

3 Results and discussion

The results of our study are shown in Figure 1. They present the part of the phase diagram of the Triton X-114 — water mixture, containing the liquid crystalline domain and the biphase region adjacent to it. The temperature in °C is plotted against the weight percent of Triton X-114. The boundaries of the liquid

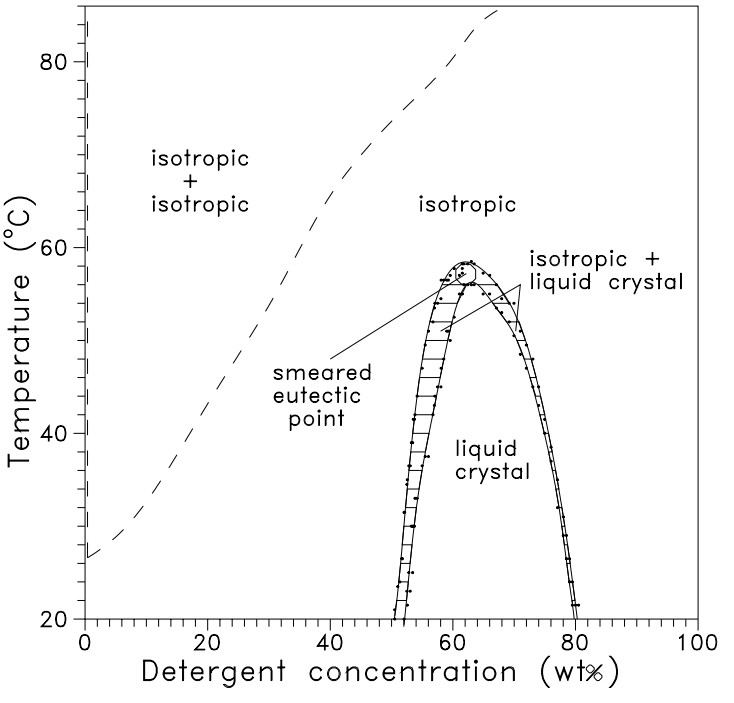

Figure 1. Phase diagram of the Triton X-114 — water binary system for temperatures higher than 20°C.

• experimental data for the boundaries of the two-phase region containing an isotropic and lamellar liquid crystalline phase (the two-phase equilibria inside this region are also presented);

—— the (interpolated) boundaries of the same region;

– – the boundaries of the two-phase region where the micellar phase coexists with the monomer solution of the detergent (according to the data of Walsh [1])

crystalline domain are in good agreement with the former experimental results [1-3]. The two-phase region, containing liquid crystal in equilibrium with an isotropic phase, surrounds the monophase liquid crystalline region. According to the thermodynamic rules, a binary phase diagram of this type possesses an eutectic point. The detergent we used contains different kinds of molecules (with a different number of oxyethylene groups). In such case, the eutectic point and its vicinity in the phase diagram could be smeared and/or replaced by some other structure, *e.g.*, a three-phase region. With the method employed by us, this region will appear as a two-phase (instead of three-phase) domain. This was exactly the behavior of the phase diagram we observed around the peak of the liquid crystalline domain.

For the sake of completeness, the boundaries of the two-phase region obtained

by Walsh [1] where the micellar phase coexists with the monomer solution of the detergent are also presented in the phase diagram in Figure 1.

The results of the present work permit the choice of the Triton X-114 — water ratio, appropriate for the particular application of the detergent and the avoidance of the two-phase region, in case it is undesirable.

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