

Chemistry

EFFECT OF VITAMIN E ON INTERMOLECULAR INTERACTIONS IN ETHANOL SOLUTIONS OF SODIUM PENTADECYLSULFONATE

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The effect of vitamin E on intermolecular interactions in ethanol–sodium pentadecylsulfonate solutions by conductivity and viscosity methods was studied. It was shown that solvophobic interactions between components of system played the main role. It was established that the complex between molecules of vitamin E and ethanol in the premicellar region of sodium pentadecylsulfonate at $(2-3) \cdot 10^{-5} \text{ mol} \cdot \text{L}^{-1}$ concentration of vitamin E was formed. As a result, the structure of ethanol was stabilized.

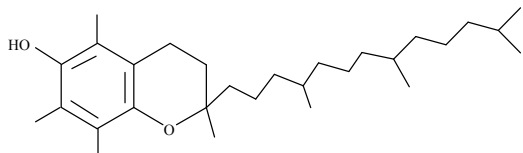
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Introduction. The aggregation behavior of surfactants in nonaqueous polar solvents and aqueous-organic mixed solvents has been the subject of much attention in the past decades [1–17]. This interest is due to two reasons: (i) the necessity of elucidating the effects of solvent quality on the nature of self-assembly of amphiphiles and (ii) the appearance of certain applications of surfactants, where the presence of water is undesirable. Polar organic solvents with properties resembling those of water, such as ethylene glycol, glycerol, formamide and alcohols, have been the most widely investigated. These solvents share three physical properties [6]: high cohesive energy, high dielectric constant, and hydrogen bonding. However, it has been proposed that the ability of a solvent to form hydrogen bonds is the key condition for micellization [18].

In this paper the structural changes of solvent were studied by conductivity and viscosity methods in the sodium pentadecylsulfonate–vitamin E–ethanol system. The aim of this study was to obtain information on the role of solvophobic interactions in the structural changes of solvent.

Materials and Methods. Anionic surfactant sodium pentadecylsulfonate (SPDS, $\text{C}_{15}\text{H}_{31}\text{SO}_3\text{Na}$) (“VEB-Leuna”) was purified as described in [19]. Basic substance content in purified samples was higher than 99%. Vitamin E (2,5,7,8-tetramethyl-2-(4,8,12-trimethyltridecyl)chromen-6-ol, α -tocopherol) (“Sigma-Aldrich”) was used without further purification and has the following formula:

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Vitamin E is not soluble in water, and, therefore, ethanol was used as solvent, which had been absolutised as described in [20].

The conductivity of solutions was measured on conductometer “Jenway 4330”. The mean square error is no more than 2%.

The flow times of the solutions and the solvents were measured using an Ubbelohde type viscometer placed in a thermostated water bath. The flow time for pure water at 303.15 K was 215.4 s, the constancy of temperature of thermostat was ± 0.05 K. The relative viscosities (η_r) have been calculated as the ratio of flow times of solution and solvent ($\eta_r = t_{\text{solution}}/t_{\text{solvent}}$).

Results and Discussion. The study of physical-chemical properties of solutions, which contain surfactants and additives, has great importance for identification of intermolecular interactions. The importance of this problem is also related to the study of influence of additives on structural changes of solvent.

The effect of vitamin E on relative viscosity (η_r) and conductivity (k) of premicellar and postmicellar solutions of SPDS at 298.15 and 310.15 K was studied. The choice of methods is not random: these macroscopic methods are very sensitive to intermolecular interactions in multicomponent systems.

The isotherms of relative viscosity and conductivity for SPDS–vitamin E–ethanol system below critical micelle concentration (*cmc*) (a) and above *cmc* (b) of SPDS [21] are given in Fig. 1 and 2 respectively. In studied systems the maximums are detected on isotherms of relative viscosity and conductivity only in the premicellar regions of SPDS at vitamin E concentration $\sim (2-3) \cdot 10^{-5} \text{ mol} \cdot \text{L}^{-1}$.

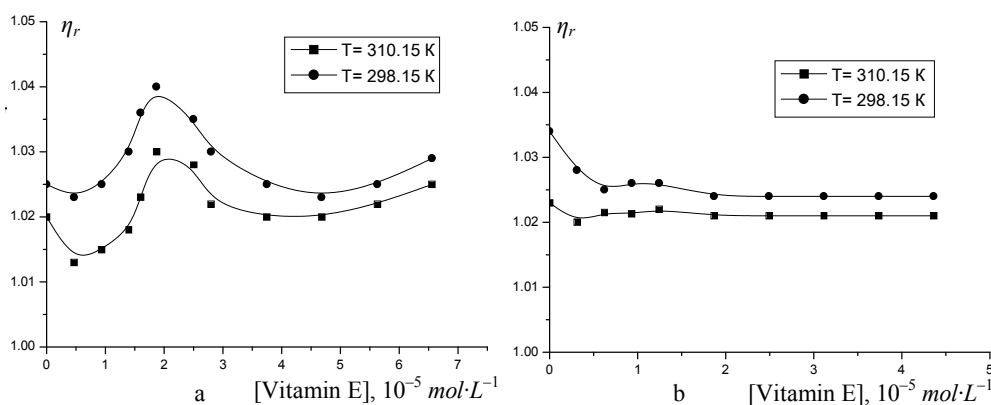


Fig. 1. Relative viscosity of SPDS–vitamin E–ethanol system vs. vitamin E concentration in premicellar (a) and postmicellar (b) regions of SPDS: a – $[\text{SPDS}] = 1 \cdot 10^{-3} \text{ mol} \cdot \text{L}^{-1}$; b – $6 \cdot 10^{-3} \text{ mol} \cdot \text{L}^{-1}$.

The maximums on the isotherms of relative viscosity in the premicellar region of SPDS (Fig. 1, a) mean that the complex between components of systems is formed [22].

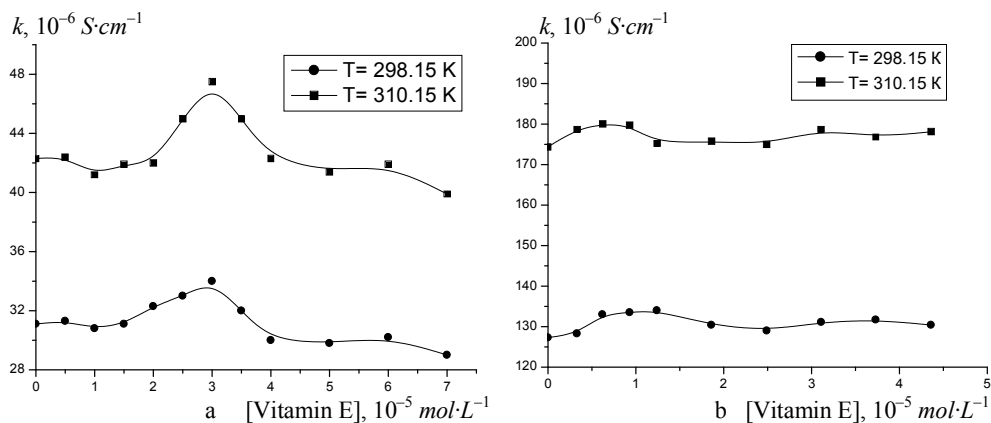


Fig. 2. Conductivity of SPDS–vitamin E–ethanol system vs. vitamin E concentration in premicellar (a) and postmicellar (b) regions of SPDS: a – $[SPDS]=1\cdot 10^{-3} \text{ mol}\cdot\text{L}^{-1}$; b – $6\cdot 10^{-3} \text{ mol}\cdot\text{L}^{-1}$.

The isotherms of relative viscosity of the SPDS–ethanol system in the premicellar region of SPDS (Fig. 3) and vitamin E–ethanol (Fig. 4) systems were also studied for understanding whether the molecules of SPDS participate in the complex formation or not. It is evidenced from Fig. 3 and 4, that the dependence of relative viscosity from SPDS concentration for SPDS–ethanol system in the premicellar region of SPDS is linear, and there are maximums on the isotherms of relative viscosity of vitamin E–ethanol system, practically at the same concentrations of vitamin E $(2\text{--}3)\cdot 10^{-5} \text{ mol}\cdot\text{L}^{-1}$ as on the isotherms of relative viscosity of SPDS–vitamin E–ethanol system in the premicellar region of SPDS (Fig. 1, a). Thus, it can surely tell that the main interactions occur between molecules of vitamin E and ethanol, and the complex is formed exactly between the molecules of these components.

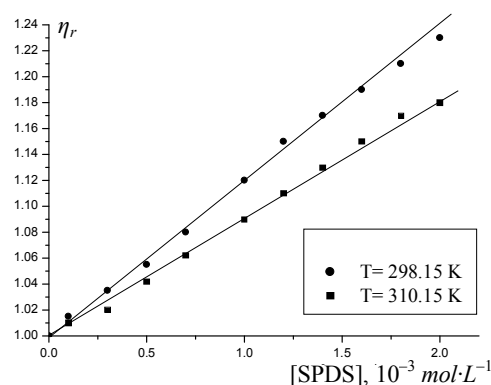


Fig. 3. Relative viscosity of SPDS–ethanol system vs. SPDS concentration in the premicellar region of SPDS.

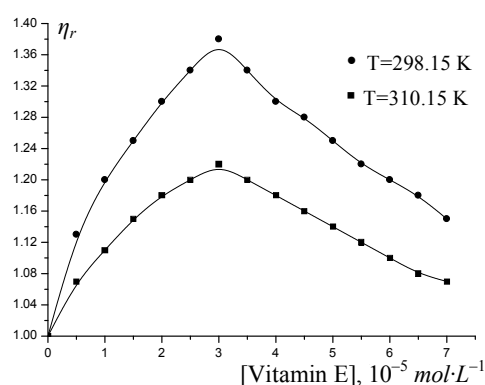


Fig. 4. Relative viscosity of vitamin E–ethanol system vs. vitamin E concentration.

The extreme behavior of conductivity isotherms in the premicellar region of SPDS is also result of strong intermolecular interactions in the SPDS–vitamin E–ethanol system (Fig. 2, a). According to [23], the maximums on the conductivity isotherms evidence that in the studied system the conductivity is carried by

prototropic mechanism. Based on that theory and obtained data (Fig. 2, a), it can be concluded, that in the premicellar region of SPDS at vitamin E concentration below $\sim 3 \cdot 10^{-5} \text{ mol} \cdot \text{L}^{-1}$ vitamin E stabilizes the structure of ethanol, which exactly is the basic reason for the increase of conductivity [23]. But the further increase of vitamin E concentrations leads to disruption of ethanol structure, and due to this, the conductivity of system decreases.

Quite other phenomenon is observed on the isotherms of relative viscosity (Fig. 1, b) and conductivity (Fig. 2, b) of the SPDS–vitamin E–ethanol system in the postmicellar regions of SPDS. In these cases only deviations from linearity are observed on the relative viscosity and conductivity isotherms, but they are so negligible that they can't be observed as a result of specific intermolecular interactions. It can be suggested that these deviations are due to penetration (solubilization) of vitamin E into micelles and, as a result, the further strong interactions between vitamin E and ethanol molecules are practically absent.

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