1691

Disperse aqueous systems based on (*S*)-lysine in a wide range of concentrations and physiologically important temperatures*

I. S. Ryzhkina,[a]* S. Yu. Sergeeva,[a] R. A. Safiullin,[b] L. I. Murtazina,[a] L. R. Sabirzyanova,[a]
M. D. Shevelev,[a,c] M. K. Kadirov,[a] and A. I. Konovalov[a]

[a]*A. E. Arbuzov Institute of Organic and Physical Chemistry, Kazan Scientific Center of the Russian Academy of Sciences,
8 ul. Akad. Arbuzova, 420088 Kazan, Russian Federation.
Fax: +7 (843) 273 1872. E-mail: ryzhkina@iopc.ru*
[b]*Kazan National Research Technological University,
68 ul. K. Marksa, 420015 Kazan, Russian Federation*
[c]*A. M. Butlerov Chemical Institute, Kazan (Volga Region) Federal University,
18 ul. Kremlevskaya, 420008 Kazan, Russian Federation*

It was shown for the first time using a complex of physicochemical methods (dynamic and electrophoretic light scattering, nanoparticle tracking analysis, transmission electron and atomic force microscopy, conductometry, pH-metry) that in a temperature range of 25—60 °C (*S*)-lysine aqueous solutions ($1 \cdot 10^{-17}$—$1 \cdot 10^{-2}$ mol L^{-1}) are disperse systems, where the nature and parameters of the disperse phase change with dilution, which affects the non-monotonic dependences of the specific conductivity and pH of the system. Nanoassociates hundreds of nanometers in size were found to contain ordered water structures that are responsible for the size and ζ-potential of the disperse phase in the aqueous systems and also participate in the formation of spatially organized systems on the support.

Key words: (*S*)-lysine, aqueous disperse system, low concentrations, temperature, nano-associates, domains, nonmonotonic dependences, physicochemical properties.

It has recently been established experimentally that highly diluted aqueous solutions of many biologically active substances are self-organized disperse systems that undergo with dilution a rearrangement of the disperse phase supramolecular domain—nanoassociate accompanied by a change in the physicochemical and biological properties of the system.[1,2] In addition, domains[3—5] and nanoassociates[1,2,6,7] were shown to be fractal objects hundreds of nanometers in size formed in dilute aqueous and water-organic systems involving solute and solvent molecules, which have an electrically charged interface and an increased viscosity compared to that of the disperse medium. According to the nanoparticle tracking analysis (NTA),[7,8] the number of domains and nanoassociates in 1 mL of solution ranges from $1 \cdot 10^7$ to $1 \cdot 10^{10}$. The domains are usually formed at calculated concentrations of $1 \cdot 10^{-5}$—1 mol L^{-1}, while the nanoassociates are formed at considerably lower concentrations: from $1 \cdot 10^{-6}$ to $1 \cdot 10^{-20}$ mol L^{-1}.

As a rule, domains undergo structural rearrangement to transform into nanoassociates in a narrow range of dilutions corresponding to the calculated concentrations

$1 \cdot 10^{-8}$—$1 \cdot 10^{-5}$ mol L^{-1} (threshold concentrations C_{thr}). This substantially changes their parameters (size, ζ-potential), nonmonotonic run of the concentration dependences, topology of images obtained by atomic force (AFM) and transmission electron microscopy (TEM), and physicochemical and biological properties of the systems.[1,2,7,9] The direct proof of different natures of the nanoassociates and domains was found by experiments in a permalloy container, which protects the contents from external electromagnetic fields (EEF).[1,2] It is shown that nanoassociates are formed only upon keeping solutions under ambient conditions, including in the presence of EEF. Therefore, to form nanoassociates, low-frequency EEF are required, which are an essential component of the natural biotope of living organisms.[10] Domains are formed when solutions are kept in both the presence and absence of EEF.

The transformation of a disperse phase with dilution can be related to the fact that the domain hundreds of nanometers in size contains many solute molecules,[3] the number of which is estimated as $1 \cdot 10^3$—$1 \cdot 10^8$ depending on the chemical structure and concentration, while in nanoassociates the number of solute molecules is probably lower by several orders of magnitude and that of water molecule is higher. It is shown[11] that water and dilute