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PROPERTIES OF WATER SOLUTIONS OF COMPERLAN KD

The surface-active and optical properties of surfactant specimen Comperlan KD have been recearched using various methods of analysis. The surface activity, adsorption, micelle formation and solubilization quantitative characteristics have been determined; hydrophilic-lipophilic balance has been calculated. It is shown that specimen Comperlan KD can be used with anionic surfactant specimens as a component of hygienic detergent. It was confirmed that this surfactant specimen performs the functions of stabilizer of foarm and solubilizer of essential oil.

Introduction. Surface-active materials (SAM) are widely used in different branches of industry including cosmetics [1, 2] as emulsifiers, foam-forming solutions, structure-forming agents, detergents and etc. All SAM are united by the fact that their application is characterized by boundary adsorption and ability to reduce surface tension. These properties are defined by diphilicity of molecules, i.e. by presence of hydrophilic and hydrophobic groups in them.

It is known that for evaluation of SAM effectiveness on revealing of this or that functional action there are the following methods [3]:

– direct evaluation of SAM action (for example, evaluation of detergent effect on removing the pollutants);

– usage of criteria offered on basis of qualitative properties, (for example, HLB system – hydrophilic-lipophilic balance);

– usage of characteristics being by nature of constants and fundamental equations (for example, evaluation of surface or adsorption activity).

Earlier, we studied properties of water solutions of the following SAM – Cremophor A25, Genapol LRO and Texapon K12G [4, 5]. Studying of properties of water solutions of SAM product Comperlan KD (by Cognis manufacturer) was the aim of this work.

Main part. Product Comperlan KD (coconut diethanolamide) is a blend of non-ionic surface-active materials with general formula

$$C_nH_{2n+1}C(O)N(CH_2CH_2OH)_2,$$

n = 7–17 (preferably 11) [6].

This non-ionic product is used in composition of hygienic detergents (HD) together with anionic SAM. It is known that it regulates viscosity of cosmetic products and has soft effect on skin [2]. The main characteristics of the product are in Table 1.

Hydrophilic-lipophilic balance of SAM product (HLB=15) are calculated according to the method of Davis [3]. Obtained data testify that Comperlan KD product can function as emulsifier of oil-in-water emulsion, detergent and solubilizer but it is not possible to evaluate its capability to foam forming. That is why surface-active and optical properties of water solutions of SAM products with concentrations of 0.001–20.000 g / l were studied

Table 1
Technical characteristics of product Comperlan KD

Name of parameter	Parameter value
Physical form	Cream-colored spread
SAM concentration, %	90.7
Water content, %	0.5
Compound esters content, %	4.5
Free fatty acids content, %	0.9
Free amines content, %	4.6
pH 1%-per cent water solution	8.9

Surface tension of water solutions of SAM product (temperature 19°C) was established by stalagmometric method [7]. The results are presented in fig. 1.

Analysis of isotherm revealed that on the diagram three areas can be singled out that are different by the character of concentration dependence of surface tension.

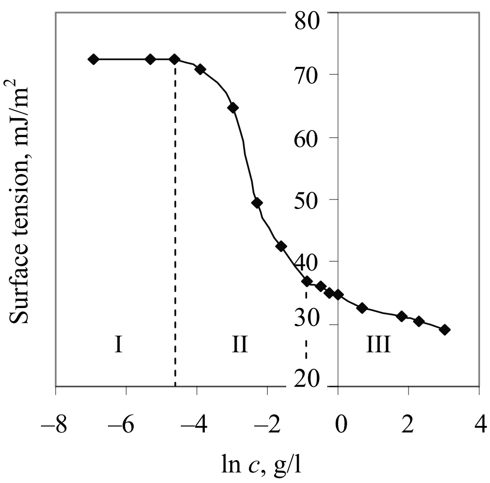

Fig. 1. Isotherm of surface tension of water solutions of SAM product

Area I (c = 0.001–0.010 g / l): surface tension is practically always and numerically equals to surface tension at boundary “water – air”. Therefore, in this area the Comperlan KD product behaves as surface-inactive material as the number of its molecules at the surface layer of liquid is negligibly small.

Area II (c = 0.01–0.40 g / l): at concentration increase there is decrease of surface tension as much as twice (from 72.5 to 36.8 mJ / m^2). This shows that there is intensive concentration of molecules of the product in the surface layer of the solution, i.e. it shows its surface active properties. Area III (c = 0.4–20.0 g / l): decrease of surface tension with increase of concentration is less important than in the previous area (from 35.9 to 29.2 mJ / m^2). At the concentration of the solution c = 0.4 g / l (ln c = –0.9) thick layer of surface-active molecules was formed at its surface that is why decrease of surface tension at concentration increase in this area, to our point of view, is connected with its reorientation. This is connected with the fact that: more surface-active molecules, i.e. having longer hydrocarbonic radical, remove less surface-active molecules [8]. Supposably, critical concentration of micelle formation (CCM) is at the interval 0.2–0.4 g / l. Value of surface tension in CMF area makes 42.7–36.8 mJ / m^2.

For evaluation of surface-active characteristic of SAM product and its water solutions isotherm of surface tension at concentration 0.0025–0.600 g / l was built and Gibbs adsorption was calculated. Isotherms of surface tension are presented in fig.2 (σ, mJ / m^2) and Gibbs adsorptions (G, mole/m^2). According to the received experimental data the main surface-active parameters of the product have been established [9]: surface-activity g, maximum Langmure adsorption a_∞, average area, occupied by 1 molecule of SAM in thick monomolecular layer S_0, constants of Shishkov equation A and B and adsorption work W_{ads}. The results are presented in the table 2.

Analysis of the received data in comparison with surface-active parameters of other SAM products studied earlier has been carried out [4]. It has been established that Comperlan KD cannot be regarded as a good foam-forming product but it can contribute to foam-forming if it is used together with anion SAM. Besides, its presence in liquid adsorptive films of foam considerably increases their stability.

With the help of turbidimetric method [9] ability of water solutions of SAM product with concentrations 0.005–20.000 g / l to defuse light (temperature 18°C) has been investigated. On photometer KFK-3-01 at the length of waves 390, 440, 480, 540 nm optical density of solutions has been measured (width of cuvettes was 5 and 1 cm). According to the received data turbidity of the systems (τ, cm^{-1}) showing the part of defused by particles light in relation to the intensity of incident light has been established. According to the Rayleigh’s theory of light scattering [10], turbidity of the system depends on the amount of particles presenting in it and it is in direct proportion to radius of a particle in the sixth power. In fig.3 turbidity dependence on concentration of the solution of Comperlan KD product is presented.

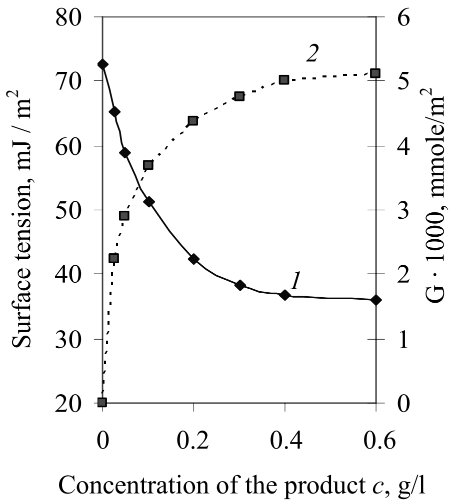

Fig. 2. Isotherms of surface tension (*1*) and Gibbs adsorptions (*2*) of water solutions of SAM product

Table 2

Surface-active parameters of Comperlan KD

Parameters	Values
g, (J · l)/(m^2 · g)	0,356
$a_\infty \cdot 10^6$, mole/m^2	5,26
$S_0 \cdot 10^{20}$, m^2/mole.	31,5
A, g/l	0,036
B, J/m^2	0,0129
W_{ads}, kJ/mole	19,6

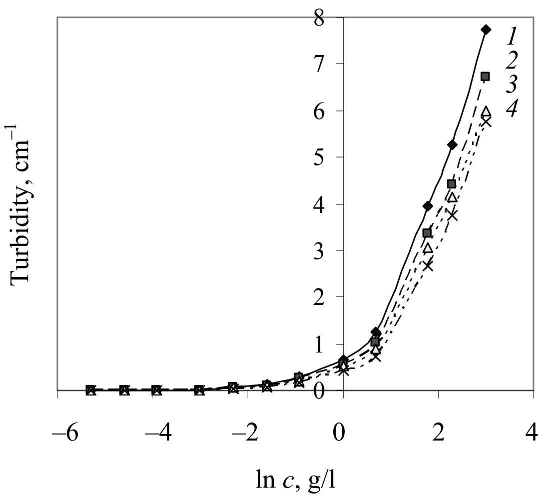

Fig. 3. Dependence of turbidity of water solutions on concentration. Length of wave of incident light, nm: *1* – 390; *2* – 440; *3* – 480; *4* – 540

The presence of turbidity was revealed in all SAM solutions. In the area of SAM product concentrations equal 0.005–0. 200 g / l it is less important and makes 0.0009–0.1300 cm^{-1}. As these concentrations are lower than CCM value, therefore, in these systems there are no micelles and the light diffuses, to our mind, by the tiniest particles of compound esters and free fatty acids constituting the SAM product in the form of admixtures (table 1). In case of increasing the concentration of the solution from 0.4 to 20.0 g / l considerable increase of turbidity of systems from 0.31 to 7.75 cm^{-1} is observed, that is connected with appearance of micelles forming by molecules of SAM, with increasing in size and in number and also with their shape changing.

Refraction of light in water solutions of Comperlan KD (concentration of solutions 0.005–20.000 g / l, refractometer IRF-454B2M, temperature 18°C) was examined by refractometric method [11].

It is known that index of refraction depends on density of solution (density of the examined solutions was close to the density of water) and on molecular refraction of material.

Molecular refraction is the sum of atomic refractions and refractions of increments connections. It has been established that in the area of true solutions refraction remains practically unchanged; index of refraction of solutions is close to the index of water refraction (1.3327).

In colloid solutions total refraction conforms to the rule of additivity where volume fraction of appearing new phase comes into account as well as increments connections inside of micelles. That is why in solutions with micelles, index of refraction increases to 1.3350 with the growth of their number and size.

Being a part of different cosmetic goods varied biological active substances, for example, ether oil of tea tree are widely used. It is a transparent yellowish liquid with a pleasant odor and it is a natural antiseptic, having a favorable effect on skin cells and body in general [12].

Ether oils will not mix with water but can be solubilized by colloid solutions of SAM. That is why solubilization of tea tree oil in colloid solutions of SAM product with concentrations 5, 10 and 20 g / l was studied with the help of refractometric method. Mechanical shaking of the systems during 10 and 30 minutes was used for intensification of solubilization process.

In Fig. 4 dependences of refraction index of solubilized systems on the volume of the added oil are shown.

According to the laboratory manual [13] coefficient of solution refraction increases with increase of the amount of colloid dissoluted in it solubilizer, reaching the biggest and permanent value during the formation of the rich with oil solution. With the help of the dependences presented in fig. 4 it has been established that saturation of colloid solutions with concentrations 5, 10 and 20 g / l corresponds to the values of refraction index 1.3340, 1.3351 and 1.3369 correspondently. According to the obtained data volumes (milliliters) of tea tree oil have been measured and it has been revealed that they are able to solubilized in 10 ml of Comperlan KD solutions with different concentrations. Addition of the abundant number of oil influences the estimation of refraction index; systems become turbid and phase boundary cannot be clearly seen that is connected with emulsification of solubilizer.

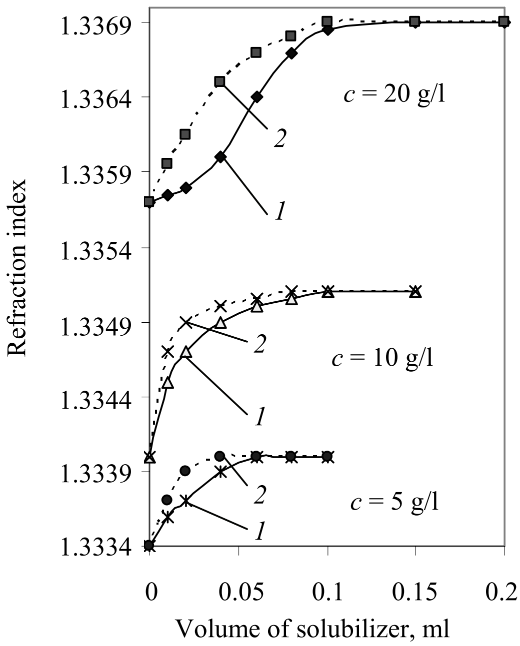

Fig. 4. Dependence of refraction indexes of SAM water solutions on volume of solubilizer.
Duration, min: *1* – 10; *2* – 30

Conclusion. Studies have confirmed advisability of usage of Comperlan KD in composition of GMR as additional to anion SAM products, for example, such as Genapol LRO, Texapon K12G. Effective functions of Comperlan KD are increase of foam-forming ability of anion SAM and solubilization of ether oil. This is stipulated by surface-active and colloid properties of its water solutions.

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