УДК 66.069.85:544.77

**G. G. Emello, Zh. V. Bondarenko, T. V. Kharlan**
Belarusian State Technological University

# FOAMING PROPERTIES OF SURFACTANTS' WATER SOLUTIONS OF ZETESOL GROUP

Foaming process in surfactants' water solutions of ZETESOL ZN and ZETESOL MG in concentration 0.01–5.00 g/l has been investigated. The Ross-Miles device has been used to obtain foams. The foam ability was characterized by the initial foam volume and foam stability. It was proved that optimal foaming ability has been observed with concentration of above-mentioned surfactants above 0.2 g/l. All received foams have been highly resistant. Besides, it was established that foam stability of preparations depends on surface-active and colloidal-chemical properties. Studying the kinetics of foam stability showed that foam destructions happened at first 3.5 minutes of existence.

The composition of hygienic detergent was developed based on experimental data. The detergent prototype was analyzed on the main organoleptic and physicochemical characteristics. The carried out analysis of prototype proved its compliance to requirements of STB 1675-2006 "The cosmetic hygienic washing products. General characteristics".

**Key words:** anion surfactant specimens, foamy number, stability of foams, kinetics stability of foams, hygienic detergent.

**Introduction.** Many industries are associated with foaming. Thus, on the one hand, the appearance of foam in the main process or individual steps can be highly undesirable. In other cases, the technology provides a special addition of foaming agents to improve the efficiency of the process. For example, the action of detergents is not possible without foaming.

The main individual foaming agents are surface-active substances (surfactants) and their preparations. Due to the increasing demand for these components, including hygienic detergents (GSD), the production of the surfactant preparations in recent years has increased significantly. Ethoxylated surfactant preparations are of particular importance because they have dermatological milder effect compared to non-ethoxylated anionic surface-active agents. This group includes agents based on laureth sulfates metals which are not individual surfactants. The properties of these products may differ from the properties of surfactant ingredients as they contain impurities in their composition. Such surfactant preparations are poorly studied and are not represented in the reference literature.

**Main part**. The aim of this work was to study the foaming properties of surfactant preparations based on zinc laureth sulphate (ZETESOL ZN) and magnesium laureth sulfate, (ZETESOL MG) with a degree of ethoxylation of 3.

Composition of the surfactant group ZETESOL preparations is shown in Table 1, from which it follows, that the preparations are significantly different in surfactant-containing active ingredient (metal lauryl sulphate) as well as the amount of impurities therein.

Foam preparation was performed on the instrument Ross-Miles at a temperature of 17°C. The concentration of the solutions was varied in the interval 0.01–5.00 g/l (as surfactant ingredient). The solutions were prepared in distilled water to avoid the influence of hardness salts. The ability to foam was evaluated by the foam number (FN, mm) according to [1]. The results are shown in Fig. 1.

Table 1
**Composition of the surfactant preparations**

| Ingredient name | The content of ingredient, % | |
|---|---|---|
| | ZETESOL ZN | ZETESOL MG |
| Laureth Sulfate metal | 25.00 | 50.00 |
| Laureth-3 | 1.00 | 5.00 |
| Metal Sulfate | 0.30 | 2.00 |
| Phenoxyethanol | – | 0.15 |
| Water | 73.70 | 42.85 |

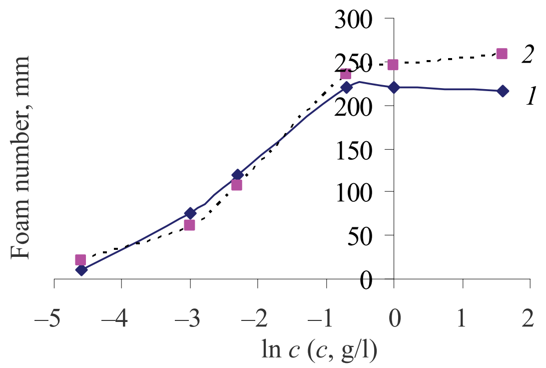


Fig. 1. The dependence of the foam number on the concentration of surfactant solutions:
*1* – ZETESOL MG; *2* – ZETESOL ZN

It is known [2] that the foaming ability of the surfactant is associated with the surfactants and colloid-chemical properties of their aqueous solutions. Previously, we have studied the properties of surfactants ZETESOL MG and ZETESOL ZN preparations and conducted a comparative analysis [3]. Fig. 2 shows the dependence of the surface tension on the concentration of surfactant solutions. Surface tension (σ, mJ/m$^2$) was determined by stalagmometric method at 18°C, the surfactant concentration in the solution was 0.01–5.00 g/l. Fig. 2 shows that the studied preparations are colloidal surfactants. Previously determined critical concentration micelle formation (CCMF) were similar and amounted to 0.8–1.0 g/l (1.22 · 10$^{-3}$ mol/l for ZETESOL MG and 1.16 · 10$^{-3}$ mol/l for ZETESOL ZN) [3].

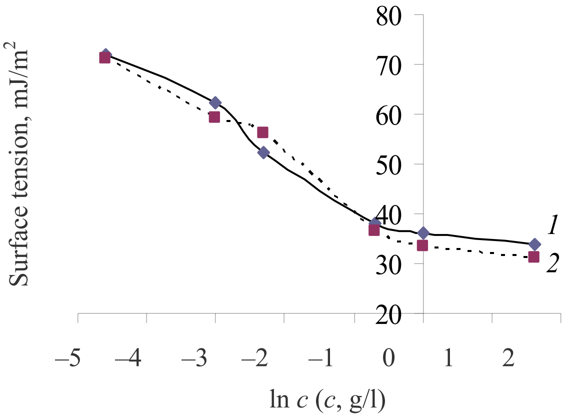


Fig. 2. Dependence of surface tension on the concentration of surfactant solutions:
*1* – ZETESOL MG; *2* – ZETESOL ZN

Analysis of Fig. 1 and 2 showed a correlation dependencies FN = f (ln *c*) and σ = f (ln *c*). In the field of molecular (true) surfactant solutions with increasing concentration of 0.01 (ln *c* = –4.6) and 0.50 g/l (ln *c* = –0.69) interfacial tension on "surfactant solution – air" decreases by 1.9–2.0 times that facilitates the process of foaming: foam number increases by 20 times. The numerical values of the foam number are close to the two preparations at similar concentrations of solutions. This is natural, since the surface-active properties are determined by the properties of preparations surfactant anion $S_{12}N_{25}–O–(CH_2CH_2O)_3–SO_3^-$.

In colloidal preparations solutions with increasing surfactant concentration from 1.0 to 5.0 g/l (ln *c* from 0 to 0.6), the surface tension is practically constant due to the formation of surface tension saturated mono-layer on the surface of the solution. The ability to foam in the circumstances is almost unchanged for both surfactant preparations, because the CCMF achieving maximum amount of foam is formed, since the forming of the adsorption layer acquires a maximum mechanical strength [2]. It should be noted that in micelle solutions of the two preparations at the same concentrations, the surface tension of the numerical values are lower and the foam numbers for the surfactant ZETESOL ZN are higher that can be explained by a lower impurity content in its composition (Table 1). According to the requirements to hygienic detergents [4], the foam number for shampoo should not be less than 100 mm and not less than 145 mm for shower gels, foam for baths, etc. Fig. 1 shows that the necessary foaming capacity is achieved in the preparations ZETESOL ZN and ZETESOL MG at the concentration of surfactant solutions greater than 0.2 g/l (ln *c* = –1.6).

An important factor for detergency GSD is the stability of foams, i.e. the ability to maintain the original amount at the time. Quantitatively, the foam stability can be assessed "stability" parameter (FS, %), which is a ratio of the foam column height in 5 minutes to the initial height. Fig. 3 shows the foam stability of the concentration of surfactant solutions.

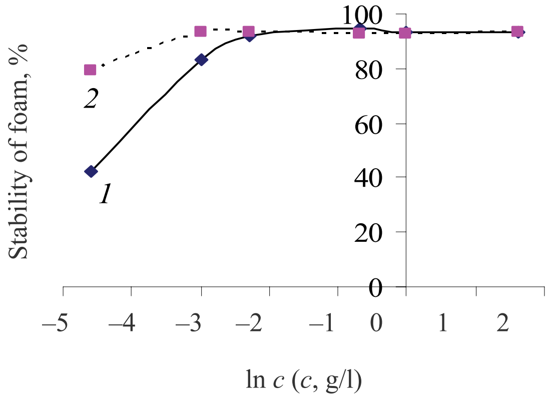


Fig. 3. The stability of foams on the concentration of surfactant solutions:
*1* – ZETESOL MG; *2* – ZETESOL ZN

Studies have shown that the stability of foams from solutions ZETESOL MG with concentration from 0.01 to 0.10 g/l increase be 2.2 times, reaching the value of 91.9%, while the stability of foams formed in the solutions of ZETESOL ZN, increases in the concentration range of 0.01–0.50 g/l of 79.5 to 93.1%.

The stability of the foams is determined by the containment structure around the air bubbles, formed of surfactant anions. At the same time the electrostatic stabilization factor is implemented (air bubbles acquire a negative charge due to adsorption of laureth sulfate ions) and structural and mechanical stabilization factor (long-chain hydrocarbon radicals surfactant ions are intertwined, forming a mesh structure). Contact impurities (phenoxyethanol, laureth-3,) on the border "surfactant solution – air" section does not contribute to stability of the foam. Therefore, the foams prepared from solutions of the preparations based on zinc laureth sulfate have higher resistance.

Fig. 3 shows that the most stable foam are formed during the concentration of the solution, not reached the CCMF: 0.05 g/l for the preparation ZETESOL ZN and 0.1 g/l for ZETESOL MG. Above all these foam concentrations are highly stable, their stability is 92–94%. According to the requirements for GSD [4], the stability of the foam should not be less than 80%, which is feasible in solution ZETESOL ZN preparation with a surfactant concentration of 0.02 g/l, and in solutions ZETESOL MG – more than 0.04 g/l.

When using GSD it is important that foam kept stability throughout some time. This indicator is especially important for such means as bath foam. In this regard, the kinetics of destruction of the foams was investigated. Fig. 4 shows the dependence of the height of the column foams prepared from aqueous solutions of the studied drugs with surfactant concentrations of 0.01–5.00 g/l, from the time of their existence.

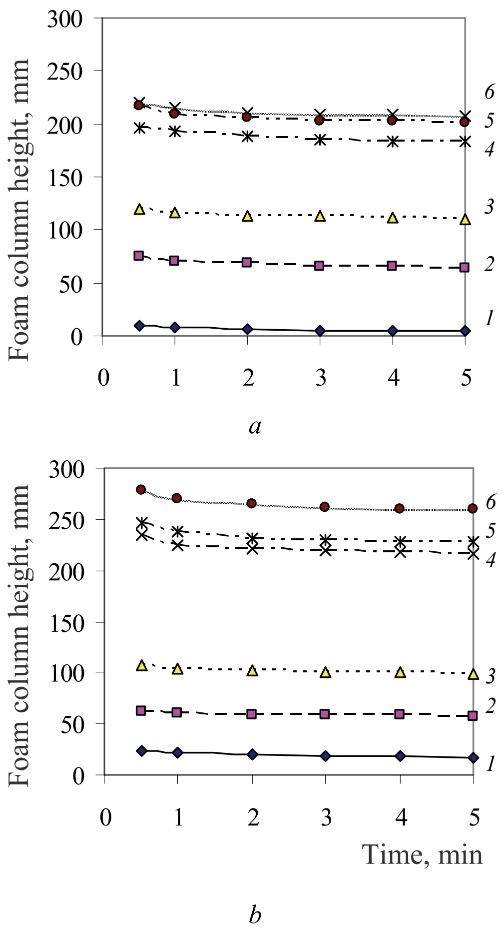


Fig. 4. Kinetics of destruction of the foams obtained from solutions:
*a* – ZETESOL MG; *b* – ZETESOL ZN.
The surfactant concentration in solution, g/l:
*1* – 0.01; *2* – 0.05; *3* – 0.1; *4* – 0.5;
*5* – 1.0; *6* – 5.0

As it is shown in Fig. 4, the destruction of foams occurred within the first 3.5 minutes of their existence. Depending on the concentration of surfactant solution preparations of ZETESOL group, the reduction of foam column height during the test time period was 6–10 mm. Relative maximum speed of foam destruction was marked in the first 30 s: as the surfactant concentration in the solution from 0.01 to 5.00 g/l it increased from 16–18 to 2.5–3.4 mm/min. In the range of 0.5–3.5 min speed of foam destruction is reduced, after 4.0 minutes, the system reaches equilibrium, the foam height of the column does not change, the destruction of the foams doesn't occur.

Based on research and analysis of the literature designed the structure GSD is worked out – bubble bath, which included the following components: anionic surfactant preparation ZETESOL MG, a non-ionic surfactant preparation COMPERLAN KD, polyvinylpyrrolidone, essential oil, salt, colorings, preserving agent and water. In the laboratory environment a sample of GMS was received and its organoleptic and physicochemical parameters were defined. They are presented in the Table 2 in comparison with the requirements of STB 1675-2006.

Table 2

**Quality indicators of cosmetic products**

| Indicator name | Indicator description | |
|---|---|---|
| | sample | according to STB 1675-2006 |
| Colour | Blue | Relevant to the color of specific products |
| Smell | The smell of lavender | Relevant to the smell of specific products |
| Value pH | 7.44 | 5.0–8.5 |
| FN, mm | 152 | Not less than 145 |
| FS, % | 98 | Not less than 80 |

**Conclusion.** Thus foaming is investigated in aqueous solutions of surfactants ZETESOL ZN and ZETESOL MG preparations at concentrations 0.01–5.00 g/l. It is established that the foaming ability required (not less than 145 mm) is attained in preparations ZETESOL ZN and ZETESOL MG surfactant solution at a concentration more than 0.2 g/l; obtained at this concentration are highly resistant foam. The connection between the foaming ability of drugs to their surfactant and colloid-chemical properties is shown. On the basis of the experimental data, the structure of hygienic detergent is developed as well as test foam bath sample is obtained, which is analyzed According to major organoleptic and physicochemical parameters. The analysis showed its compliance with the requirements of STB 1675-2006 "Cosmetic hygienic cleaning. General specifications".

**References**

1. GOST 22567.1–77. The synthetic detergents. Method of determination of foam-forming ability. Moscow, Standartinform Publ., 1986. 7 p. (In Russian).

2. Tikhomirov V. K. *Peny. Teoriya i praktika ikh polucheniya i razrusheniya* [Foams. Theory and practice of their formation and decomposition]. Moscow, Khimiya Publ., 1975. 264 p.

3. Emello G. G., Bondarenko Zh. V., Gerasimovich V. A., Kharlan T. V. The properties of water solution of surfactant specimens of Zetesol group. *Trudy BGTU* [Proceedings of BSTU], 2015, no. 4: Chemistry, Organic Substances Technology and Biotechnology, pp. 14–18 (In Russian).

4. STB 1675–2006. The cosmetic hygienic washing products. General specifications. Minsk, State Committee on Standardization of Republic of Belarus Publ., 2014. 12 p. (In Russian).

**Information about the authors**

**Emello Galina Gennadi'yevna** – PhD (Engineering), Assistant Professor, Assistant Professor, the Department of Physical and Colloid Chemistry. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail:galina-emello@rambler.ru

**Bondarenko Zhanna Vladimirovna** – PhD (Engineering), Assistant Professor, Assistant Professor, the Department of Chemical Processing of Wood. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: bondarenko_zhanna@belstu.by

**Kharlan Tatyana Vladimirovna** – student. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus).

*Received 18.02.2016*