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Research Article

THE STUDY OF PHYSICOCHEMICAL PARAMETERS OF SOME DETERGENTS WITH THE ANIONIC NATURE

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ABSTRACT

The physico-chemical parameters of detergents with the anionic nature, namely sodium myreth sulfate and sodium lauryl sarcosinate used most often when developing domestic foaming products for personal hygiene, at the cosmetic enterprises of Ukraine have been studied and analyzed. The indicators of the foaming ability (foam number, foam stability) of the test samples at different pH values, namely at the neutral pH (5.5-6.0) and at the acid pH (3.5-4.0), have been determined and studied. The study of the foam structure at the pH intervals under research has been also conducted using the method of microphotography. According to the results of the study, the conclusion has been made that different pH values do not affect the foaming ability; however, they affect the foam structure.

Key words: sodium myreth sulfate, sodium lauryl sarcosinate, foaming ability, pH value, foam structure

INTRODUCTION

It is well known that detergents are the base for any foaming product – shampoo, liquid soap, gel, etc[1]. This group of substances affects the skin protective barrier to a greater or lesser extent. But if some substances only alter permeability of the protective barrier for a period of time, the others, damage its structure in varying degrees. It is the degree of this damaging effect that is defined as hardness of a surfactant. The hardness of sodium lauryl sulfate (SLS) is used as a specific reference standard. It is one of the first semi-synthetic surfactants, applied since the 30s of the twentieth century. Therefore, it is common practice to put SLS at the beginning of the "hardness – softness of the surfactant's action" scale (though there is a number of surfactants, which are much harder)[2,3].

In general, most hard emulsifiers are laundry detergents. Detergent surfactants action are intended for dissolving fats, for example, when washing clothes or washing dishes. The mechanism of their action is as follows: detergents "stick" to fat deposits and break them to droplets, which are easily washed off with water. However, in contact with the skin, these detergents act on the protective barrier and fat contamination: they are embedded in the lipid layers, disrupt their structure and break up into individual microdroplets, which are then removed by water[4,5].

However, in foaming detergents with the cleansing action, the mechanism of action of surfactants is fundamentally different: surfactants do not change the formula of fat – do not saponify it; moreover, they bind it into a colloidal (micellar) structure, which is easily washed from the surface of the skin or hair[6].

When analyzing the formulations of detergents, in particular shampoos for children and gels for intimate hygiene, that are presented at the Ukrainian market, it has been found that exactly anionic surfactants, such as sodium laureth sulfate (SLES) and sodium lauryl sulfate (SLS), takes the three-fourths of the surfactant market[2,7]. A surface-active anion – a negatively charged particle of the molecule – provides their detergent properties. In water, it decomposes up into a positively charged sodium ion and a negatively charged ion (anion) of lauryl sulfate. The anions produce huge amount of foams. Although, the surface of our skin has a polymosaic charge, the cleaning efficiency with such surfactants is not ideal. Therefore, in recent years, modern manufacturers most often replace the so-called "aggressive" surfactants by the mild ones, such as sodium myreth sulfate and sodium lauryl sarcosinate[8,9].

The main aim of our work, was to study and compare the physico-chemical properties of mild detergents with the anionic nature, namely sodium myreth sulfate and sodium lauryl sarcosinate at different pH values.

MATERIALS AND METHODS

Mild detergents with the anionic nature, used in manufacturing products for cleansing of the skin and its appendages, we choose 70 % sodium myreth sulfate and 35 % sodium lauryl sarcosinate ("EOC", Belgium)[2,3].

Sodium myreth sulfate is one of the anionic surfactants, containing in many products for personal hygiene (soaps, shampoos, toothpastes etc.). Sodium myreth sulfate is a cheap and very effective foaming agent and emulsifier. The main advantage of this surfactant, is that, it possesses satisfactory detergent properties, namely it effectively dissolves dirt and sebum, forms a stable foam when dissolved in water, easily washable from the surface of the skin and its appendages.

Sodium lauryl sarcosinate is a surfactant with the anionic nature, having such perfect characteristics as: wetting, dispersing and foaming, which are so important for modern and universal foaming products with the cleansing effects. The greatest assets of this surfactant, over every other surfactants, such as sodium lauryl sulfate and sodium laureth sulfate, is it "softness". Because of this, it is most often used in foaming products for sensitive skin. Sodium lauryl sarcosinate is compatible with nonionic, anionic and many cationic surfactants, and it can be used to improve the characteristics of detergents on a common base. In contrast to most consumer anionic surfactants, the salts of sodium lauryl sarcosinate are compatible with many quaternary ammonium compounds and phenolic resins used as bactericides; for example in antibacterial foaming hand cleaners. Unlike many other anionic surfactants, sodium lauryl sarcosinate is also classified as a substance that is easily decomposed and harmless to the environment.

The samples of the substances selected were given by the Pharmaceutical Science and Research Centre "Aliyance Krasoty" (Beauty Alliance, Kyiv, Ukraine). A pH regulator for the foaming base value of lactic acid (Lactic Acid, "Galactic", Belgium) is allowed for use in foaming detergents for children, according to the EU Regulation No.1907/2006.

The test samples were prepared according to the conventional technology: the required amount of the surfactant was calculated and dissolved in water at the desired temperature (40 – 45 °C). For further studies, 5 % aqueous solutions of the surfactant obtained were adjusted to the required temperature (37 °C). The time for preparing the samples was from 30 to 60 min. All samples were prepared and calculated with reference to 100 % substance[10]. These studies were conducted at the Research laboratory of the Commodity Science Department of the National University of Pharmacy.

One of the main physico-chemical parameters of any detergents is the foaming ability, namely the foam number (mm) and the foam stability (c.u.). According to the current normative documents, namely the State Standard of Ukraine – DSTU "Cosmetic products for cleansing the skin and hair" and specifications of Ukraine – TU U 24.5-31640335-002:2007 "Skin care cleaning products" the foam number should be not less than 145.0 mm, and the foam stability – 0.8-1.0 c.u.[11,12].

Determination of the above parameters were performed using the Ross-Miles foam analyzer, as a standard device for measuring the foaming ability of soaps and synthetic detergents. The foaming ability of the test samples was determined by the method given in DSTU ISO 696:2005 "Determination of the foaming ability by the modified method of Ross-Miles"[13] and GOST 22567.1-77 "Synthetic detergents. The method for determining the foaming ability". To conduct this test using Ross-Miles foam analyzer, we used ultrathermostat UT-15, a stopwatch timer, a rubber squeeze bulb, the analytical balance of the accuracy class III for general purposes, pipettes: 1-2-50, pipettes: 1-2-1-2(10), flasks: 1-1000-2, measuring glasses B-1-100(500)(1000) TC[9]. The water jacket was connected to a thermostat, switched on, and the temperature of the liquid in the water jacket was adjusted to (37 ± 2) °C. Simultaneously 300 cm^3 of the solution of the surfactant studied, was adjusted to the same temperature. From this amount, 50 cm^3 of the solution was taken and poured down to the sides of the graduated cylinder, in order not to form the foam. In 10 min using a rubber squeeze bulb or a pump the test solution of the surfactant in the volume of 200 cm^3 was introduced into the pipette in such a way that no foam could form. The pipette with the solution was fixed to the stand so that its outlet was at a distance of 900 mm from the level of the liquid in the cylinder, and the flow could get to the center of the liquid. Then the tap of the pipette was opened. When there was no solution in the pipette, a stopwatch timer was switched on, and the height of the foam column formed (mm) was measured. The measurement was carried out in 30 sec. In 5 minutes the height of the foam column, formed (mm) was measured.

In the process of our work, the following indicators were also studied: appearance, organoleptic indicators (color, odor), determination of the pH value. These indicators were considered for the qualitative assessment of modern foaming products, according to DSTU 4315:2004 and TU U 24.5-31640335-002:2007.

The level of the pH value of the foaming test samples was determined by potentiometry (SPhU 1.2, 2.2.3) using a "pH Meter Metrohm 744" device (Germany)[14].

Additionally, the microscopic analysis of the foam was also conducted using a "Konus-Akademy" laboratory microscope with the ScopeTek DCM510 eyepiece camera. For the visualization of the images obtained by the ScopePhoto™ software (version 3.0.12.498), it allowed measuring linear dimensions in real time and static image[15,16,17].

RESULTS AND DISCUSSION

As known, depending on the application of foaming products, there are two ranges of pH – the neutral pH (5.5-6.0) (e.g., shampoos for children) and the acid pH (3.5-4.0) (e.g., gels for intimate hygiene). Therefore, our initial objective was to study the foaming ability of the detergents, choosen at the neutral pH value (5.5-6.0). The foaming bases were prepared with sodium myreth sulfate and sodium lauryl sarcosinate, according to the above technology, homogeneous liquids of a transparent color with a characteristic odor of surfactants and without impurities, they corresponded to the requirements of the current normative documents. The results of the study of the test samples are given in Table 1.

Table 1: The physicochemical parameters of sodium myreth sulfate and sodium lauryl sarcosinate

No.	Sample	Appearance, organoleptic indicators	Temperature of dissolution, °C	pH value (10 % solution)	Foaming ability	
					The foam number, mm	The foam stability, c.u.
1	Sodium myreth sulfate	A homogeneous solution of a transparent color with a characteristic odor of detergents	43±1	5.7±0.2	212	0.92
2	Sodium lauryl sarcosinate		40±2	5.8±0.2	184	0.93
After pH adjusting						
3	Sodium myreth sulfate	A homogeneous solution of a transparent color with a characteristic odor of detergents	43±1	3.3±0.2	217	1.0
4	Sodium lauryl sarcosinate		40±2	3.7±0.2	247	1.0

Note. n = 5, P = 95 %

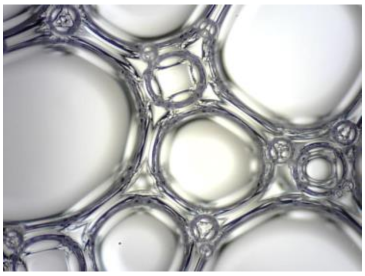

Figure 1a: The spherical structure of the foam bubbles with sodium myreth sulfate

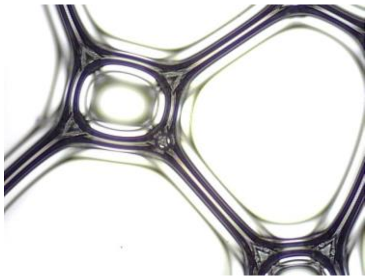

Figure 1b: The structure of Plateau–Gibbs canal with sodium myreth sulfate

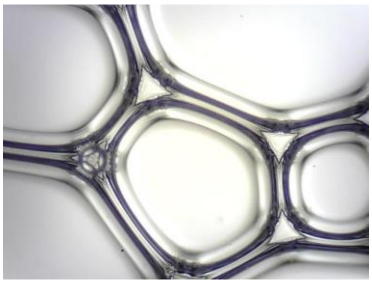

Figure 1c: The polyhedral form of the foam bubbles with sodium lauryl sarcosinate

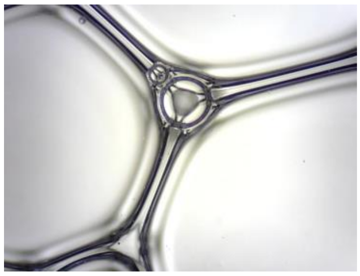

Figure 1d: The structure of Plateau–Gibbs canal with sodium lauryl sarcosinate

Figure 1: Microscopy of the foam with sodium myreth sulfate and sodium lauryl sarcosinate at pH (5.5-6.0)

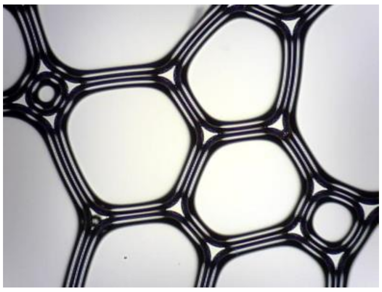

Figure 2a: Microscopic analysis of the foam with sodium myreth sulfate at the acid pH value (3.3)

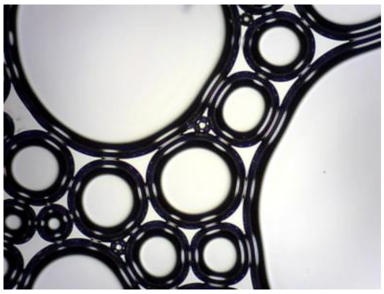

Figure 2b: The process of coalescence of the foam with sodium myreth sulfate at the acid pH value (3.3)

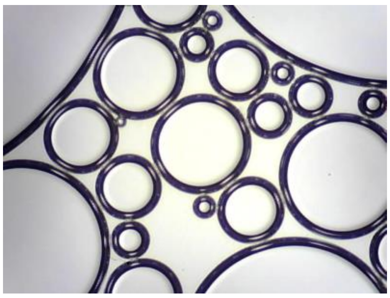

Figure 2c: Microscopic analysis of the foam with sodium lauryl sarcosinate at the acid pH value (3.7)

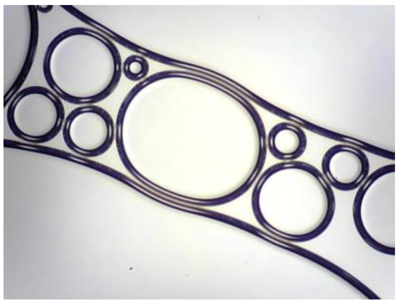

Figure 2d: The process of coalescence of the foam with sodium lauryl sarcosinate at the acid pH value (3.7)

Figure 2: Microscopy of the foam with sodium myreth sulfate and sodium lauryl sarcosinate at pH (3.5-4.0)

When analyzing the data obtained from the foaming ability of the test samples from the surfactant chosen, it was determined that sample 1 had the higher value of the foam number (212 mm), than sample 2, but its value of the foam stability was less (0.92 c.u.).

However, in spite of that, both samples have satisfactory values of the foam number and the foam stability (they correspond to the requirements of the current normative documents of Ukraine).

Taking into account the peculiarities of the development of foaming products, the next stage of our study was to compare the physico-chemical properties (the foaming ability determination) of sodium myreth sulfate and sodium lauryl sarcosinate at the acid pH value (3.5-4.0). The test samples were prepared according to the technology mentioned above. The pH was adjusted using lactic acid. The results of the study of the test sample are given in Table 1.

The data obtained showed that sample 4 significantly increased its value of the foam number (247 mm) at the acid pH value compared to sample 3 (217 mm). The value of the foam stability in both samples also increased and was 1.0 c.u. Analyzing the data obtained, the possibility of using these surfactants can be considered when developing various detergents in the ranges of pH studied, since the pH value of the foaming ability in different ranges is regulated within the current normative documents of Ukraine.

It is well known, the presence of a thick, soft and stable foam is the main requirement of modern consumer for foaming products. Therefore, presently the foam must meet the following requirements: it should be rich, finely divided, creamy, pleasant to the touch, easily washed away, have structural strength, should not slide spontaneously from the surface of the skin and its appendages. Hence, the final stage of our research was devoted to the study of the foam structure, using the method of microphotography. The test samples of the foaming bases with the anionic surfactants were prepared according to the technology mentioned above. Immediately before the study, a massive foam was formed using a "Deluxe Cordless Mini Mixer" manual mixer (China), which was then put on a glass slide, and the foam was examined under the microscope with the above mentioned characteristics.

When studying the freshly prepared massive foam, it was determined that in the samples with sodium myreth sulfate and sodium lauryl sarcosinate at pH (5.5-6.0), the main structural elements of the foam were gas bubbles systematically arranged, i.e. small bubbles were around large bubbles joining together and creating an equilibrium structure in the foam volume (a pseudocrystalline system) (Figure 1a). When studying the foam of the test samples, the conclusion was also made that it's cells had a spherical shape transforming into a polyhedral shape in the course of time. The films of the liquid between the bubbles formed the so-called Plateau triangles (Figure 1b, Figure 1d). Three thin films converged on each edge of the polyhedron; they were the walls of the bubbles. These films formed angles of approximately 120°C between themselves. In the places of the film joints, the thickenings called canals were formed. Canals in cross section were in the form of triangles with concave sides. As a result, the capillary pressure causing the flow of liquid from the films into the canals appeared. Under the action of gravity, the liquid collected in the canals flowed into the lower part of the foam along cross links. It was coalescence (combination of several bubbles into a larger one) that occurred when the liquid flowed through these canals. After that, the bubble shape began slowly changing from spherical to polyhedral (Figure 1c).

The next stage of our research was to study the structure of the foam at the acid pH value (3.5-4.0), in the test samples with the detergents selected.

Analyzing the microscopic pictures, we obtained the conclusion that the foaming base with sodium myreth sulfate at the acid pH value had unstable foam. As can be seen from Figure 2a, the foam had the shape of polyhedron, while films separating them were of the same thickness throughout the volume of the foam. As a result, (Figure 2a), the structure that was similar to a honeycomb in section was observed. However, because of a rapid flow of the liquid through Plateau–Gibbs canals, a rapid coalescence – combination of adjoining gas bubbles – was observed (Figure 2b).

While studying the foam of the test sample with sodium lauryl sarcosinate at the acid pH value (3.7) it was found that, within the given pH range the massive foam was not stable, the life time of the foam was very small. In Fig. 2c the chaotic arrangement of the foam bubbles of different sizes, which were not created by the pseudocrystalline system among themselves, was observed; as a result, there was almost instant coalescence (Figure 2d)

CONCLUSIONS

According to the results of the experiment conducted, it has been concluded that all samples within the pH ranges during the research, comply with the standard values of the existing state standards of Ukraine, by their physico-chemical parameters studied (appearance, organoleptic indicators, foaming ability).

It has been determined that when studying the structure of the massive foam in the samples at the pH ranges of 5.5-6.0 using microscopy, the foam has a stable structured system, namely it has a spherical shape and is characterized by the minimal surface energy; therefore, it indicates the foam stability. Analyzing the foaming bases after adjusting pH with lactic acid (3.5-4.0), it has been found that the foam in these samples is unstable with a short life cycle due to a rapid coalescence. The data obtained will be considered, when developing parapharmaceutical products within the pH ranges studied.

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