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Comparison of HLB and Surface Activity of Nonionic Surfactants from Fatty Acids of Natural Oils

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ABSTRACT: This article presents the results of a study of the hydrophilic-lipophilic balance (HLB) and surface activity of nonionic surfactants synthesized from fatty acids of various natural oils. The article highlights experimental methods for extracting fatty acids and their interaction with diethanolamine to create effective surfactants. The study results provide new information on the properties and potential applications of nonionic surfactants, which may be useful in various industrial fields, including cosmetics, pharmaceuticals and chemicals.

KEYWORDS: nonionic surfactants, fatty acids, diethanolamine, critical micelle concentration, surfactant.

I.INTRODUCTION

In recent decades, there has been increasing interest in the study and development of environmentally friendly and biodegradable nonionic surfactants (surfactants) derived from fatty acids of natural oils. These compounds are of significant interest for a wide range of industrial applications, including cosmetics, pharmaceuticals, food processing and oil and gas. The main parameter that determines the effectiveness and scope of surfactants is their hydrophobic-lipophilic balance (HLB), which directly affects the surface and colloidal chemical properties of these compounds [1-3].

This article is devoted to a comparative analysis of HLB and surface activity of nonionic surfactants synthesized from various fatty acids of natural oils. The main attention is paid to studying the influence of the structural features of fatty acids on HLB and the surface properties of surfactants obtained from them. The work discusses such key aspects as surfactant synthesis methods, their characteristics, surface tension of solutions and their ability to form micelles [4, 5].

The study aims to gain a deep understanding of the relationship between the chemical structure of fatty acids and the functional properties of surfactant derivatives, which is important for the development of new effective and environmentally friendly surfactants for various industrial applications.".

II. SIGNIFICANCE OF THE SYSTEM

This article presents the results of a study of the hydrophilic-lipophilic balance (HLB) and surface activity of nonionic surfactants synthesized from fatty acids of various natural oils. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY

In the process of obtaining surfactants, various vegetable oils were used as starting materials, including sunflower, cottonseed and coconut, as well as animal fats such as fat tail and internal fats. The diethanolamine used, complies with TU 2423-178-00203335-2007, is characterized as a viscous transparent liquid with a mass fraction of the active substance of at least 98.0% and a refractive index η_D^20 in the range of 1.476-1.478.

In addition to this, sodium hydroxide (Florida Laboratories) with a mass fraction of at least 99.0% and sulfuric acid (Sigma Aldrich) with a concentration of 95.5%, KCl 99.9% according to DIN ISO 9001 were used to implement certain stages of the process.

The following process was performed to obtain fatty acids from animal fat. First, 95.1 g of NaOH was dissolved in 1000 ml of water and heated to 70 °C. After this, 740 g of fat was added and heating was continued with intense stirring for 6 hours. Then a 20% sulfuric acid solution was prepared from 122.0 g of concentrated sulfuric acid and 461.0 g of water.

To convert soap back into fatty acids, 583.0 g of this solution was used. The process was completed when the litmus paper showed a red color.

The reaction between diethanolamine and fatty acids was carried out in a solvent-free system at a 1:1 ratio. Added 3% Al_2O_3 catalyst by weight of fatty acids and carried out the reaction in a round-bottomed flask under an N2 atmosphere. The mixture was heated to 70°C for 30 minutes, then to 140°C, stirring at 200 rpm. The reaction lasted 3 hours. Product yield was 93-97%.

The synthesized surfactants were conventionally named SSUNO, SCOTO, SCOCO, STAIF, SCAUF for surfactants obtained on the basis of sunflower, cottonseed, coconut oils and fat tail and internal fat, respectively.

To determine the HLB of synthesized surfactants, studies were carried out according to data from [6]. The surface tension of the surfactant was determined using the Du Nouy method [7].

IV. EXPERIMENTAL RESULTS

Based on experimental studies, the HLB values for the synthesized surfactants were obtained, which are given in Table. 1.

Table 1.
HLB values and molecular weight of synthesized surfactants

surfactant	GLB		Molecular mass
	Experimental	Estimated	
SSUNO	15.6	15.9	368.1
SCOTO	15.0	15.1	361.6
STAIF	14.8	14.6	360.9
SCAUF	14.9	14.5	361.1
SCOCO	9.9	9.4	308.8

For all the studied surfactants, good agreement is observed between the experimental and calculated HLB values. This indicates the reliability of the experimental methodology and the fact that the theoretical approaches used to calculate HLB adequately reflect the real properties of the surfactant.

HLB values for most surfactants range from 14.5 to 15.9, with the exception of SCOCO, which has a significantly lower HLB value (9.4-9.9). This may indicate a difference in the hydrophobic and hydrophilic properties of SCOCO compared to other surfactants studied. Low HLB values usually indicate a higher hydrophilicity of the surfactant.

The molecular weights of surfactants vary from 308.8 to 368.1. SCOCO, which has the lowest HLB value, also has the lowest molecular weight. This may indicate a correlation between the structural features of the surfactant molecule (which affect the molecular weight) and their hydrophilic-hydrophobic properties.

The HLB values and molecular weights of synthesized surfactants provide important information about their chemical structure and potential applications. Surfactants with higher HLB tend to have stronger hydrophobic properties and therefore may be more effective in applications where increased hydrophobic interactions are required, such as emulsion systems. Lower HLB surfactants such as SCOCO may be preferred in applications requiring higher hydrophilicity, such as wetting or dispersing systems.

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The dependence of surface tension on the concentration of solutions of synthesized surfactants with concentrations from 0 to 2% by weight is shown in Fig. 1.

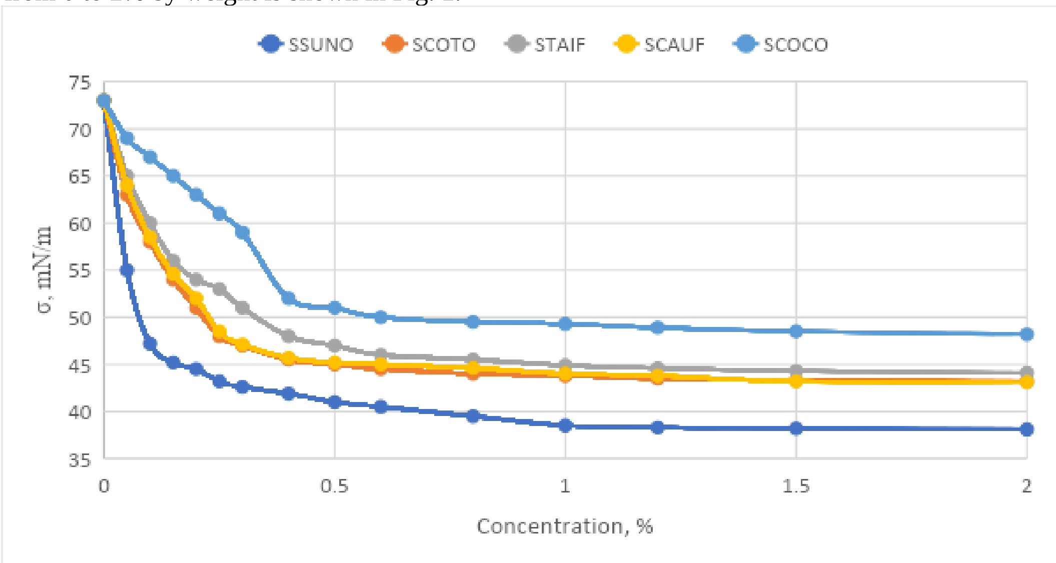

Figure. 1. Change in surface tension of surfactant solutions (25°C).

The graph presented in Figure 1 shows a gradual decrease in the surface tension of water with increasing surfactant concentration. This decrease is associated with enhanced adsorption of surfactant molecules at the water-air interface, as a result of which the surface tension stabilizes at 38.1, 43.2, 44.1, 43.1 and 48.2 mN/m for SSUNO, SCOTO, STAIF, SCAUF and SCOCO, respectively.

Among the compounds studied, SCOCO shows the highest surface tension value, highlighting the importance of the size of the hydrophobic alkyl chain in the context of its effect on surface tension reduction. Experimental data also show that with increasing alkyl chain length, a decrease in surface tension is observed, which indicates the influence of chain length on the properties of surfactants.

The surface tension and critical micellar concentration (CMC) of the synthesized surfactants decrease with increasing alkyl chain length, confirming the importance of lipophilic-lipophilic balance (HLB). High HLB indicates a stronger tendency of amphiphilic molecules to reduce the surface tension of the system. As a result, the synthesized surfactant SSUNO shows the highest efficiency in reducing surface tension, while SCOCO shows the least ability in this regard.

Analyzing the relationship between CMC and other properties of surfactants, such as their foaming ability or foam stability, begins with estimating the CMC for different surfactant samples. Using the dependence of surface tension on the logarithm of the surfactant concentration in the solution, the CMC values (expressed in mg/l) were determined for each sample, which are presented in table. 2.

Table 2.
CMC of synthesized surfactants

Sample	SSUNO	SCOTO	STAIF	SCAUF	SCOCO
KKM_1	18,7	15,6	17,1	23,5	15,3
KKM_2	36,7	31,2	36,9	73,2	28,8

The table shows two different CMC values for each surfactant. Based on the table, SCOCO shows the lowest values of CMC1 and relatively low values of CMC2, which may indicate better micelle formation ability in more dilute solutions compared to other surfactants.

SCAUF exhibits the highest values of CMC1 and CMC2, which may indicate that a higher surfactant concentration is required for micelle formation, possibly due to higher molecular weight or lower surface activity.

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Assuming that lower CMC values correlate with better foaming properties and higher surface activity, then SCOCO would be expected to perform best as a foaming agent in low concentration solutions, while SCAUF may require higher concentrations to achieve similar results. effect.

There is an inverse relationship between CMC values and the surface activity of a surfactant: the lower the CMC, the higher the surface activity and, accordingly, the better the foaming and micelle-forming properties of the surfactant. This is confirmed by comparison with the foaming and foam stability characteristics presented earlier. Surfactants with lower CMC values usually show better results in flotation processes.

V. CONCLUSION AND FUTURE WORK

Experimental studies have shown that synthesized nonionic surfactants exhibit different hydrophilic-lipophilic balance (HLB) and surface activity values, which correlate with their molecular weight and structure.

A study of the critical micelle concentration (CMC) of various surfactant samples showed that the CMC varies depending on the chemical structure and properties of the surfactant. This makes it possible to predict the behavior of surfactants in various systems and their application in accordance with needs.

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