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# Physysichemical Properties of Quaternary Ammonium Salts Formed by Undecanoic and Tetradecanoic Acids with Trietanolamine

## Abstract

The article presents the results of the study of the oil collecting and oil dispersing properties of the quaternary ammonium salts formed by undecanoic and tetradecanoic acids, which are monobasic carboxylic acids, with triethanolamine (TEA) in distilled, drinking, and sea waters contaminated with Balakhani Oil. The surface activity property of the products of different concentrations of these complexes was calculated using a tensiometer, and the elemental composition was calculated using the calculation method. A comparative study of the element composition of the salts of both acids formed with TEA shows that the mass fraction of carbon in the complex formed by tetradecanoic acid with TEA is higher than in the other complex.

Comparison of the surface activity property of the complexes formed by undecane and tetradecanoic acid with TEA shows that the complex compound formed by tetradecanoic acid with TEA shows more surface activity property.

Therefore, as the mass fraction of carbon element increases in the complexes formed by undecane and tetradecanoic acid with TEA, the complex compound shows more surface activity properties.

***Keywords:*** *carbonic acid, oil accumulation, oil dispersion, surface tension, surfactant*

## Introduction

Currently, removal of oil and oil products from the water surface remains an actual problem. Oil spills spilled into water can be removed by mechanical, thermal, physico-chemical and biological methods. The most ecologically safe way to remove small thicknesses of spilled oil is to use oil collecting and oil dispersing reagents based on various surfactants (Asadov et al., 2017a; Asadov et al., 2011a; Asadov et al., 2017b). The study of surfactants has been the focus of attention in the beginning.

Surfactants are also used as demulsifier (Abdelrahman et al., 2023, p. 3162). The demulsifier's emulsion breaking mechanism is very complex (Al-Yaari et al., 2015, pp. 54-61).

### Methodology of the Experiment

Undecanoic acid is a monobasic saturated carbonic acid with the formula $C_{10}H_{21}COOH$, well soluble in methanol, ethanol, acetone, chloroform, molar mass 186.3 g/mol, melting point 28-30.5°C, boiling point 284°C in the form of a white powder at room temperature.

Tetradecanoic acid is a monobasic saturated carbonic acid with formula $C_{13}H_{27}COOH$, molar mass 228.4 g/mol, melting point 58.8°C, boiling point 326.2°C in the form of a white powder at room temperature. Triethanolamine (TEA) is a colorless, transparent, ammonia-smelling liquid with a molar mass of 149.19 /mol-1, a density of 1.124 g/ml-1, a solidification point of 22°C, a boiling point of 335°C, and a refractive index of 1.4850 (20°C).

IR-spectra of salts of undecanoic and tetradecanoic acids formed with TEA were recorded on FT-IR, Spectrum BX and ALPHA (Bruker) spectrometers using a KBr disk.

The surface activity of substances was determined at the air-water interface using a KSV Sigma 702 (Finland) tensiometer using a Du Nui ring.

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**Conduct of Research**

The reaction between undecanoic acid and TEA was carried out in laboratory conditions in a 1:1 mol ratio at 34 °C for 3-4 hours with intensive stirring.

The general scheme of reactions can be shown as follows:

$C_{10}H_{21}COOH + N(C_2H_4OH)_3 \rightarrow [C_{10}H_{21}COO^- N^+ H(C_2H_4OH)_3]$

The reaction between tetradecanoic acid and TEA was carried out in laboratory conditions in a 1:1 mol ratio at 60 °C for 3-4 hours with intensive stirring.

The general scheme of reactions can be shown as follows:

$C_{13}H_{27}COOH + N(C_2H_4OH)_3 \rightarrow [C_{13}H_{27}COO^- N^+ H(C_2H_4OH)_3]$

The relative molecular mass of salts of undecanoic and tetradecanoic acids based on TEA is 335.5 and 377.6 g/mol, respectively. The salts formed by both acids with TEA are well soluble in ethyl and isopropyl alcohol. Based on the calculation, the element composition of the salts formed by octane and nonanoic acid with TEA was calculated. In the salts formed by undecanoic and tetradecanoic acids with TEA, the mass fraction of carbon is 60.9 % and 63.6 %, the mass fraction of hydrogen is 11.2 % and 11.5 %, the mass fraction of oxygen is 23.4 % and 21.1 %, and the mass fraction of nitrogen is 4.5 % and 3.8 %, respectively.

A comparative study of the element composition of the salts of undecanoic and tetradecanoic acids formed with TEA shows that the mass fraction of carbon in the complex formed by tetradecanoic acid with TEA is higher than in the other complex.

**Results and their Discussion**

The study of oil-collecting and oil-dispersing properties of surfactants has been the focus of various scientists (Asadov et al., 2011b, pp. 1012–1017; Asadov et al., 2010, pp. 327–331; Asadov et al., 2017c, pp. 3297–3305; Asadov et al., 2018, pp. 247–254; Asadov et al., 2017d, p. 244, pp. 533–539).

Taking this into account, the oil collecting and oil dispersing properties of the synthesized new complexes were studied in laboratory conditions.

The surface activity property of the complex formed by undecane and tetradecane acid with TEA was determined using a tensiometer at the water-air interface at a temperature of 21ºC (Table 1).

**Table 1.**
**Surface Activity Properties of the Complex Formed by Undecane and Tetradecane Acid with TEA at the Water-Air Interface (21°C)**

| Item name | Density of SAM (% by mass) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.00025 | 0.0005 | 0.00075 | 0.001 | 0.0025 | 0.005 | 0.0075 | 0.01 | 0.025 | 0.05 | 0.075 | 0.1 |
| | Values of surface tension at the air-water boundary, $mN \cdot m^{-1}$ | | | | | | | | | | | |
| Undecanoic Acid + TEA | 48.4 | 39.5 | 35.8 | 33.1 | 28.6 | 26.8 | 25.8 | 25.2 | 23.6 | 23.1 | 23.2 | 23.0 |
| Tetradecanoic Acid + TEA | 45.9 | 43.3 | 40.1 | 37.5 | 33.6 | 31.9 | 30.6 | 29.9 | 28.2 | 28.8 | 28.4 | 28.7 |

The complex formed by undecanoic acid with TEA shows high surface activity by reducing the surface tension from 71.98 mN/m to 23 mN/m at that boundary.

The complex formed by tetradecanoic acid with TEA shows high surface activity by reducing the surface tension from 71.98 mN/m to 28.7 mN/m at that boundary.

A comparison of the surface activity property of the salts formed by undecane and tetradecanoic acid with TEA shows that the complex compound formed by tetradecanoic acid with TEA shows more surface activity property.

The salts formed by undecanoic and tetradecanoic acids with TEA were studied as an oil collecting and oil dispersing agent in cleaning the water surface clouded with an oil layer with a

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thickness of 0.17 nm. The effectiveness of this reagent was studied in the laboratory on waters with different degrees of mineralization using the Balakhani light oil sample. The reagent was used both in its pure form and in the form of a 5 % aqueous solution. The reduction of the area of the initial oil layer due to the penetration of the reagent into oil-contaminated waters determines its effectiveness. The oil accumulation coefficient is a quantity that characterizes this effect. K is calculated as the ratio of the initial area of the oil layer to the area of the oil spot formed by the effect of the reagent.

**Table 2.**
**Research results of the oil collection and oil dispersing ability of the TEA complex of undecanoic acid (Balakhani Oil; thickness 0.17 mm)**

| The case of giving the reagent to the surface of the oil | Distilled water | | Drinkable water | | Sea water | |
|---|---|---|---|---|---|---|
| | τ, hour | K ($K_D$, %) | τ, hour | K ($K_D$, %) | τ, hour | K ($K_D$, %) |
| Undiluted Product | 0-24<br>48-72<br>72-96 | 15.1<br>8.7<br>12.2 | 0-24<br>48-72<br>72-96 | 10.3<br>8.7<br>7.6 | 0-24<br>48-72<br>72-96 | Dispersed |
| 5 % Aqueous Dispersion | 0-24<br>48-72<br>72-96 | 15.2<br>2.6<br>2.5 | 0-24<br>48-72<br>72-96 | 12.2<br>3.5<br>Dispersed | 0-24<br>48-72<br>72-96 | 17.3<br>15.2<br>11.1 |

**Table 3.**
**Research results of the oil collection and oil dispersing ability of the TEA complex of tetradecanoic acid (Balakhani oil; thickness 0.17 mm)**

| The case of giving the reagent to the surface of the oil | Distilled water | | Drinkable water | | Sea water | |
|---|---|---|---|---|---|---|
| | τ, hour | K ($K_D$, %) | τ, hour | K ($K_D$, %) | τ, hour | K ($K_D$, %) |
| Undiluted product | 0-24<br>48-72<br>72-96 | Dispersed | 0-24<br>48-72<br>72-96 | 3.9<br>7.5<br>7.5 | 0-24<br>48-72<br>72-96 | 7.5<br>8.6<br>6.1 |
| 5 % aqueous dispersion | 0-24<br>48-72<br>72-96 | 12.2<br>7.6<br>6.7 | 0-24<br>48-72<br>72-96 | Dispersed | 0-24<br>48-72<br>72-96 | 8.7<br>7.5<br>6.7 |

As can be seen from Table 3, the complex of Undecanoic acid and TEA exhibits the ability to accumulate oil in seawater for the 5 % application forms of the reagent.

## Conclusion

Based on the results of the study, quaternary ammonium salts formed by undecanoic and tetradecanoic acids with TEA show high surface-activity properties, similar to quaternary ammonium salts formed by TEA of other higher carboxylic acids (Shahverdiyeva, 2024, pp. 21-25; Shahverdiyeva & Salamova, 2024, pp. 34-38).

Solutions of new complexes of undecanoic and tetradecanoic acids synthesized on the basis of TEA in different concentrations have oil-dispersing and oil-collecting properties.

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