INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGIES
www.journalsresearchparks.org/index.php/IJOT e-ISSN: 2615-8140|p-ISSN: 2615-7071
Volume: 03 Issue: 05 | May 2021

Reducing the Viscosity of High Paraffin Oils by Surface Active Substances

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ABSTRACT

The aim of our work is to develop composite systems based on high and low molecular weight surfactants for cleaning various surfaces. The experimental work was carried out on a model system (quartz, glass), with an oil layer of the Dzharkurgan field deposited on its surface. In our work, to clean the water surface from oil pollution, the effectiveness of the magnetic fluid was also studied.

Key words: Sulfanol, polyethylene polyamine, кinetics of displacement of the oil substrate, composite system.

Introduction

Intensive oil production in the southern regions of Uzbekistan has led to a sharp disruption of the ecological situation. Almost irreversible oil contamination with oil and oil waste is observed. Water bodies (natural and artificial) are also polluted as a result of oil refining. Therefore, the problem of cleaning various surfaces from oil contamination is of paramount importance. The purpose of our work is to develop composite systems based on high and low molecular weight surfactants for cleaning various surfaces. Composite systems are based on sulfanol and polyethylene polyamine (PEPA) in a ratio of 1: 1, 1: 2, 1: 3. The initial concentration of the components is 1%. It was found that at the indicated concentration, the solutions of the components have the lowest surface tension at the water-air interface (≈ 30-32 mJ / m2) and at the water-oil interface (≈ 3-4 mJ / m2. The detergent effect of the composite mixture was determined by applying a drop of solution to the interface between a clean solid surface/oil substrate and recording the displacement value (mm). The experimental work was carried out on a model system (quartz, glass) with an oil layer of the Dzharkurgan field deposited on its surface.

Main part

Using the Dean-Stark method, it was found that the water content in oil is 35%. The individual components of the sulfanol and PEPA mixture differ in their surface activity at the water / air interface. Sulfanol noticeably reduces the surface tension (σ) of water at a concentration of 0.1%; with a further increase in concentration, the value of σ decreases with a constant value (≈30-32 mJ / m2). The surface tension of aqueous solutions of PEPA with different concentrations indicates an insignificant surface activity of PEPA macromolecules (σ≈60-64 mJ / m2). Such a weak activity is characteristic for all high-molecular surfactants since the process of formation of the adsorption layer is determined by the rate of diffusion of macromolecules to the interface and the subsequent differentiation of their segments by polarity according to the Rebinder polarity equalization rule

The contribution of each of these factors to the formation of the adsorption layer of macromolecules depends on nature, degree of hydrophobicity, and concentration of the polymer solution[2].

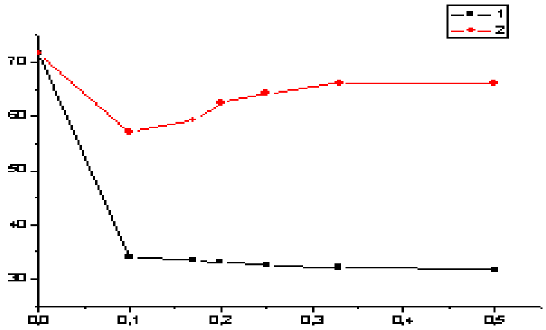


Figure 1. Isotherms of surface tension of aqueous solutions of sulfanol (1) and PEPA (2)

The isotherm of the surface tension of composite systems is shown in Figure 2. There is a slight increase in σ, within 0.9 mJ / m2, with an increase in the concentration of the added component in the composite mixture[1]. Changing the status of components (main component, added component) does not significantly affect the surface tension value. At the water/oil interface, sulfanol lowers the interfacial tension to 15 mJ / m2, the composite system exhibits greater surface activity in comparison with individual sulfanol, and with an increase in PEPA concentration σ decreases to 10 mJ / m2. The presence of an organic phase promotes the differentiation of component molecules at the interface and a decrease in the value of σ.

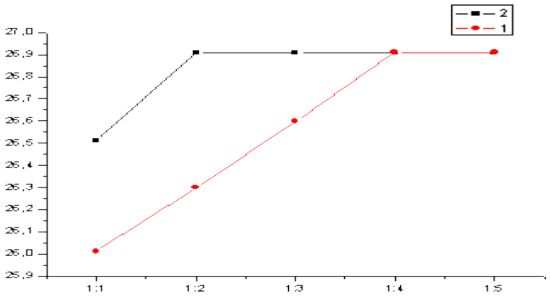
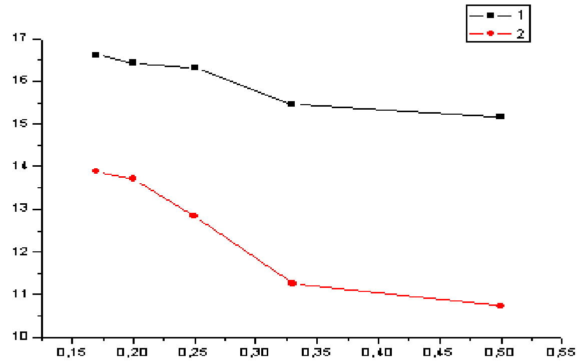


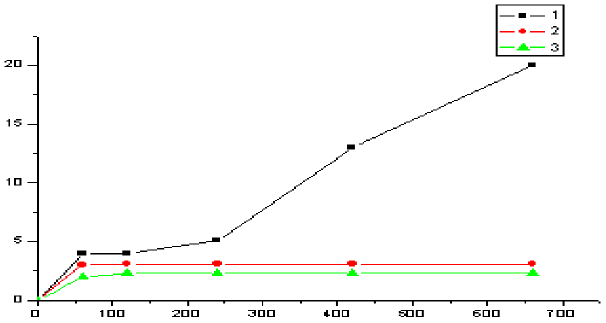
Figure 2. Isotherms of surface tension of composite systems based on sulfanol and PEPA



Sulfanol 1% (1); sulfanol + PEPA (2)

Figure 3. Isotherms of surface tension at the water / oil interface

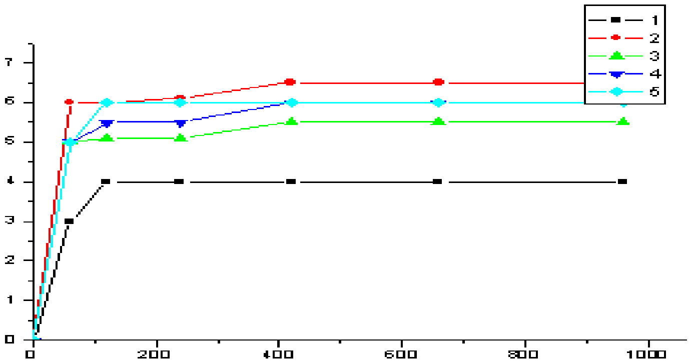
The next stage of our work was to study the washing action on oil substrates formed on the glass surface, both of individual components and of composite systems based on them. An individual 2% sulfanol solution has a good detergent effect: an increase in the displacement of the oil layer up to 20 mm within 11 minutes is observed with spontaneous spreading of a drop of solution. The advancing meniscus of the solution droplet ensures the diffusion of the complex macromolecules under the oil layer (washing action) and a decrease in the surface tension at the oil - aqueous solution of the complex interface. However, lowering the concentration to 1% significantly reduces the washing effect - the maximum displacement of the oil layer is 3.1 mm. An individual PEPA solution has a weaker detergent effect: an increase in the displacement of the oil layer up to 2-3 mm within 4 minutes.



Sulfanol 2% (1); sulfanol 1% (2); PEPA 1% (3)

Figure 3. Kinetics of oil layer displacement under the action of aqueous solutions of individual components

The kinetics of displacement of the oil substrate formed on the glass surface under the action of composite systems is shown in Figures 4 and 5. In general, the displacement of the oil substrate is much larger for composite systems in comparison with individual components. This effect is associated with the high surface activity of composite systems at the water/oil interface. The maximum detergent effect of the sulfanol - PEPA composite system is observed when the ratio of the components is 1: 2 (Fig. 4,). The optimal ratio for the PEPA - sulfanol system is 1: 4. The results obtained show that composite mixtures with a high content of sulfanol exhibit an effective detergent effect. The washing effect of various surfactants, composite systems based on them is determined by the surface diffusion of molecules over the glass surface under oil (washing effect).



Component ratio: 1: 1 (1); 1: 2 (2); 1: 3 (3); 1: 4 (4); 1: 5 (5)

Figure 4. Kinetics of displacement of the oil substrate formed on glass under the action of the sulfanol + PEPA composite mixture

Component ratio: 1: 1 (1); 1: 2 (2); 1: 3 (3); 1: 4 (4); 1: 5 (5)

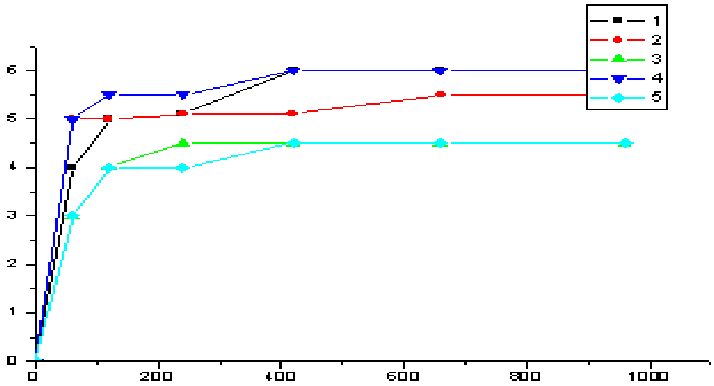


Figure 5. Kinetics of displacement of an oil substrate formed on glass under the action of a composite mixture of PEPA + sulfanol

In our work, the effectiveness of a magnetic fluid was also studied to clean the surface of water from oil pollution[4]. For the experiment, the smallest particles were selected, obtained by sieve screening (74 micron). The area of oil pollution depends on the volume of oil applied to the surface of the water. In our work, the volume of oil was 2 ml. The volume used for the dispersion of magnetic particles in kerosene was from 0.2 ml to 0.6 ml, the concentration of the magnetic fluid was 1%. After 10-15 minutes, kerosene penetrated into the oil layer and contributed to the uniform distribution of magnetite particles on the surface of the oil slick. After the specified time, the kinetics of the displacement of the oil layer under the action of the magnet was recorded[5].

Discussions

When the oil slick moved to the wall of the Petri dish, a displacement of the slick relative to the main direction of movement was observed. In this case, in some cases, there is a deviation from the shape of the spot of the correct circle. For more accurate measurement of the displacement value, the counting was carried out from the wall of the Petri dish to the border of the spot[6]. Therefore, over time, we did not have an increase in the value of the displacement, but, on the contrary, a decrease. With an increase in the volume of the injected magnetic fluid, the value of the displacement (the distance from the wall of the Petri dish to the boundary of the oil slick) decreased from 3.3 to 1.7 cm. In this case, the most important characteristic is the time of maximum displacement. The time to reach the maximum displacement is 133 min with the addition of 0.2 ml of magnetic fluid. With the introduction of 0.6 ml, the time to reach the maximum displacement is 5 minutes. When the oil layer is displaced, the surface of the treated water remains clean, without any residual oil streaks. In this experiment, it was difficult to achieve a uniform distribution of magnetic particles in the volume of kerosene. Sticking of particles and their subsequent settling on the walls of the vessel is observed. To avoid the above effects, we modified dry dispersed magnetite particles with 2% aqueous solutions of sulfanol and OP-10. The holding time was 1 day, after which the particles were filtered off, dried in air, and then a magnetic fluid in kerosene was prepared from these particles. No adhesion of the modified particles to each other and no sedimentation on the walls of the vessel was observed. In the case of modified particles, the dependence on the volume of the injected magnetic fluid remained. With the volume of the magnetic fluid equal to 0.5 ml and 0.6 ml, the time to reach the maximum displacement drops sharply and amounts to 4 and 3 min, respectively, for a magnetic fluid with sulfanol-modified particles. Modification of particles with OP-10 solution for the indicated volumes of magnetic fluid, the time to reach the maximum displacement is 4 and 2 min, respectively. By adjusting the size of the particles, the volumes of the injected magnetic fluid, and the nature of the modifying substance, it is possible to achieve maximum cleaning of the water surface[7].

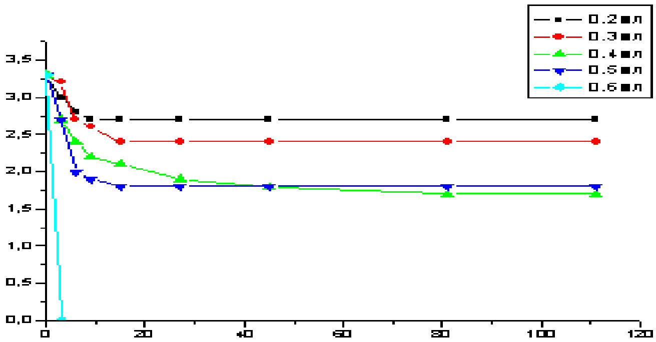


Figure 6. Kinetics of displacement of the oil layer on the water surface under the action of magnetic fluid

Thus, using various composite systems with a certain ratio of components, it is possible to carry out a complete cleaning of the surface of a solid from oil contamination. In the case of a liquid surface, cleaning with a magnetic fluid can be recommended[8].

Conclusion

The surface activity of composite systems and individual components of this mixture has been studied. It was found that both individual components and compositions based on them exhibit high surface activity at the water / air interface (decrease in σ to 32 mJ / m^2) and at the water / oil interface (decrease in σ to 4 mJ / m^2). It is shown that the studied individual components and mixtures based on them have a detergent effect on oil substrates formed on the glass surface. The optimal ratios of the components to achieve the maximum washing effect have been established: sulfanol - PEPA 1: 2, PEPA - sulfanol 1: 4. It was found that the liquidation of oil pollution from the water surface can be carried out using a magnetic fluid. By adjusting the particle size, the volume of the injected magnetic fluid and the nature of the modifying substance, it is achievable maximum cleaning of the water surface.

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