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# DETERMINATION OF THE OPTIMAL CONCENTRATION OF DEPRESSOR ADDITIVES DIFRON-3970 AND DIFRON-4201 IN VARIOUS OIL MIXTURES

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Oil samples prepared in 1:1, 1:2, and 2:1 ratios from wells No. 680 and 690 of the Narimanov OGR, SOCAR, were used as research objects in this study. The results showed that increasing the concentration of the reagents enhances their efficiency. The highest efficiency of the depressor additive Difron-3970 in all three ratios was observed at a concentration of 1000 g/t, reducing the freezing points of the oil mixtures to $-7^0$C, $-6^0$C, and $-4^0$C, respectively. The performance of the Difron-4201 reagent varied depending on the medium: the highest efficiency was recorded at a concentration of 1000 g/t for the 1:1 mixture of well No. 680 and No. 690, lowering the freezing point to $-8^0$C. However, in the other two mixtures, the highest efficiency was observed at a concentration of 800 g/t, with the freezing points reaching $-9^0$C for the 1:2 mixture and $-7^0$C for the 2:1 mixture. The greatest effect of the Difron-3970 additive was observed at 1000 g/t for the 1:1 mixture, reducing the freezing temperature from $+12^0$C to $-7^0$C. In contrast, Difron-4201 exhibited the highest efficiency at 800 g/t in the 1:2 mixture, lowering the freezing point to $-9^0$C.

**Keywords***:* depressor additive, reagent, high-paraffin oil, oil mixtures, freezing point, depressor efficiency.

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***Introduction***

Currently, one of the most pressing challenges for oil-producing countries is the removal of asphaltene-tar-paraffin deposits that form at relatively low temperatures. During oil transportation, significant deposits of these substances can accumulate on the inner walls of pipelines, hindering the flow and, in some cases, leading to a complete blockage. One of the key factors contributing to this issue is temperature reduction.

At present, the oils produced in our republic exhibit considerable diversity in their physical and chemical properties, as well as in their rheological behavior. This variability is reflected in differences in viscosity, resin, asphaltene, and paraffin content, among other characteristics [1]. Most Azerbaijani crude oils contain asphaltenes, resins, and paraffins to varying degrees. Consequently, the deposition of these components at the bottom of wells and along pipeline walls is an unavoidable process.

Since oil is a multicomponent dispersed system, its natural surfactants do not follow rheophysical and chemical regularities at low temperatures. This is due to the formation of crystals by high-molecular-weight components under these conditions. The presence of resins in oil allows solid hydrocarbons to retain undissolved single crystals in various centers, leading to the formation of dendritic (i.e., interconnected) crystal structures. An increased resin content in oil slows down crystal growth, surface deformation, and the formation of new crystallization centers. The predominance of certain hydrocarbon groups in oil influences their adsorption onto forming crystals or co-crystallization with solid hydrocarbons. These factors are crucial for understanding the temperature dependence of viscosity in oil dispersion systems, the mechanism and structure of their flow, and the relationship between external influences and the deformation process. Oil temperature significantly affects not only the selection of technological parameters but also transportation conditions and the quality of products obtained during processing [2].

Oilfield practice shows that the processes of oil collection, preparation, and transportation rarely occur without mixing. Recent studies confirm that blending and diluting oils significantly affect their rheological, physical, and chemical properties [3,4]. In many cases, heavy, fast-freezing oils are mixed with lighter oils or condensates to facilitate transportation. Such additives improve the flowability of rheologically complex oils, thereby reducing energy consumption. However, operational experience with technological oil pipelines indicates that oil blending can lead to complications, increase energy and transportation costs, and ultimately reduce pipeline efficiency [5].

Special chemical inhibitors and depressor additives are used to prevent paraffin deposition. When added to oil at optimal concentrations, paraffin deposition inhibitors influence the crystallization process, lowering the freezing point and viscosity of the oil while also reducing asphaltene, tar, and paraffin deposition (ATPD). It is well known that small amounts of surfactants can significantly weaken or even prevent the formation of dispersed spatial structures formed by paraffin crystals. Resinous components, which vary depending on the type and composition of the oil, primarily due to their polarity, act as natural depressors that lower the freezing point of oil and its products. However, the presence of resins in the system can have both positive and negative effects on the depressor performance [6,7].

Depressor additives prevent the formation of bulk crystal lattices by modifying their structure. As a result, the rheological properties of oil improve, the freezing point decreases, and, consequently, frictional pressure losses are reduced. Additionally, chemical reagents can be used to facilitate the hydraulic transport of highly viscous oils.

The mechanism of action of depressor additives is not yet fully understood. It is believed that these additives adsorb onto the surface of forming crystals, restricting their growth to the outer layers. As a result, the crystals acquire a needle-like, branched structure with comparable length-to-width ratios. The solution contains surface crystals of different modifications, reducing the likelihood of their aggregation. The variability in the effectiveness of additives is attributed to differences in their composition and the method of introduction into oil.

In industrial applications, the use of depressor additives typically involves heating, preparing liquid solutions, and dosing them into oil through dispensers. At this stage, it is crucial to consider the specific interaction of each oil type with the additives from a technological perspective. In other words, the most effective additive for a particular oil must be determined experimentally. Furthermore, when selecting the optimal depressor characteristics, it is economically essential to determine the minimum concentration that provides the maximum depressor effect [8–10].

The objective of this study is to investigate the properties of individual reagents under laboratory conditions.

***Experimental***

The freezing of previously prepared oil samples, both with and without additives, was carried out under laboratory conditions following the sequence outlined in the RD 39-3-812-82 methodology.

The specified volume of the tested oil sample was poured into bottles with a diameter of 20 mm and a height of 160 mm, heated to temperatures between 55–60$^0$C. Depressor additives of different concentrations were then added, and the mixture was gradually cooled down to a temperature range of 30–40$^0$C. For comparison, no additives were added to the control bottle. The test bottles were subsequently placed in a thermostat, where the cooling process continued. During the temperature drop, the test bottles were held at a 45$^0$ angle and checked every three degrees. At each stage, the temperature at which the oil level in the test bottles became stationary was recorded. The test bottle was then held in a horizontal position for 5 seconds, and the complete solidification of the liquid was determined by the immobility of the top layer.

Oil samples were prepared from wells No. 680 and 690 of the Narimanov OGR in the ratios of 1:1, 1:2, and 2:1. The physical and chemical parameters of each oil were determined (Tables 1–3).

As shown in Tables 1–3, the prepared oil sample is high-paraffin and has a high freezing point.

During the experiment, the depressor additives Difron-4201 and Difron-3970 were used as individual reagents. The physical and chemical parameters of these additives are presented in Table 4.

Table 1

**Physical and chemical properties of oils from well No. 680 of Narimanov OGR**

| Property | Value | Method of determination |
|---|---|---|
| composition: | | |
| – paraffin | 6.9% | SS 11851-85 |
| – asphaltene | 0.26% | SS 11851-85 |
| – tar | 23% | SS 11851-85 |
| freezing temperature | +9$^0$C | SS 20287-91 |
| content of water | no water | SS 24477-65 |

Table 2

**Physical and chemical properties of oils from well No. 690 of Narimanov OGR**

| Property | Value | Method of determination |
|---|---|---|
| composition: | | |
| – paraffin | 19.8% | SS 11851-85 |
| – asphaltene | 2.65% | SS 11851-85 |
| – tar | 23.3% | SS 11851-85 |
| freezing temperature | +4$^0$C | SS 20287-91 |
| content of water | 25% | SS 24477-65 |

Table 3

**Physical and chemical properties of oil mixtures prepared in different ratios**

| Property | Value | Method of determination |
|---|---|---|
| **1 No. 680:1 No. 690** | | |
| composition: | | |
| – paraffin | 13.35 | SS 11851-85 |
| – asphaltene | 0.15 | SS 11851-85 |
| – tar | 23.15 | SS 11851-85 |
| freezing temperature | +12$^0$C | SS 20287-91 |
| content of water | 12.50% | SS 24477-65 |
| **1 No. 680:2 No.690** | | |
| composition: | | |
| – paraffin | 15.50% | SS 11851-85 |
| – asphaltene | 1.85% | SS 11851-85 |
| – tar | 23.20% | SS 11851-85 |
| freezing temperature | +15$^0$C | SS 20287-91 |
| content of water | 16.67% | SS 24477-65 |
| **2 No.680:1 No. 690** | | |
| composition: | | |
| – paraffin | 11.20% | SS 11851-85 |
| – asphaltene | 1.06% | SS 11851-85 |
| – tar | 23.10% | SS 11851-85 |
| freezing temperature | +11$^0$C | SS 20287-91 |
| content of water | 8.33% | SS 24477-65 |

Table 4

**Physical and chemical parameters of depressor additives**

| Parameter | "Difron-4201" | "Difron-3907" |
|---|---|---|
| external appearance | yellow to brown liquid | clear yellowish (brown) liquid |
| density, 20$^0$C | no more than 790 kg/m$^3$ | 940 kg/m$^3$ |
| closed vessel ignition temperature | no less than –28$^0$C | above 65$^0$C |
| solubility in water | insoluble | insoluble |
| solubility in aromatic solvents | soluble | soluble |

***Results and discussion***

The influence of the depressor additives Difron-3970 and Difron-4201 on the freezing point of high-paraffin oil samples was investigated, and their efficiency in lowering the freezing point was evaluated. The experimental results for both reagents are presented in Tables 5 and 6.

As seen from Tables 5 and 6, an increase in the depressor additive concentration led to a greater effect. According to the results of laboratory experiments, the most significant impact of the depressor additive Difron-3970 was observed in the oil sample with a 1:1 ratio of well No. 680 to well No. 690 at a concentration of 1000 g/t, reducing the freezing point from +12$^0$C to −7$^0$C. For the Difron-4201 additive, the highest efficiency was recorded in the oil sample with a 1:2 ratio of well No. 680 to well No. 690 at a concentration of 800 g/t, lowering the freezing point from +15$^0$C to −9$^0$C. The results for both reagents are more clearly illustrated in Figures 1 and 2.

The effect of the depressor additives Difron-4201 and Difron-3970 on the freezing point of high-paraffin oil mixtures was studied under laboratory conditions. Oil samples were prepared in 1:1, 1:2, and 2:1 ratios from wells No. 680 and 690

Table 5

**Influence of the depressor additive Difron-3970 on the freezing point of oil mixtures with different ratios**

| Concentration of the depressor additive, g/t | Freezing temperature, $^0$C | Effect on freezing temperature, % |
|---|---|---|
| 1 No. 680:1 No. 690 | | |
| 0 | +12 | 0 |
| 200 | +6 | 58 |
| 400 | +2 | 92 |
| 600 | –1 | 117 |
| 800 | –5 | 150 |
| 1000 | –7 | 167 |
| 1 No. 680:2 No. 690 | | |
| 0 | +15 | 0 |
| 200 | +8 | 53 |
| 400 | +2 | 93 |
| 600 | –2 | 120 |
| 800 | –5 | 140 |
| 1000 | –6 | 147 |
| 2 No. 680:1 No. 690 | | |
| 0 | +11 | 0 |
| 200 | +9 | 27 |
| 400 | +5 | 64 |
| 600 | 0 | 100 |
| 800 | –2 | 127 |
| 1000 | –4 | 145 |

of Narimanov OGR, SOCAR, and used as the research objects in the experiments. It was found that both depressors effectively reduced the freezing point of high-paraffin oil samples. The study demonstrated that increasing the reagent concentration enhances its efficiency.

The highest efficiency of Difron-3970 was observed at a concentration of 1000 g/t across all three oil ratios, resulting in freezing points of −7, −6, and −4$^0$C, respectively. The efficiency of Difron-4201 varied depending on the oil composition. In the 1:1 ratio (No. 680:No. 690), the highest efficiency was observed at a concentration of 1000 g/t, reducing the freezing point to −8$^0$C. However, in the 1:2 and 2:1 ratios, the highest efficiency was recorded at a concentration of 800 g/t, with freezing points of −9$^0$C and −7$^0$C, respectively.

Based on the experimental results, Difron-3970 exhibited the greatest effect at an optimum concentration of 1000 g/t in the 1:1 ratio (No. 680:No. 690), lowering the freezing point from +12$^0$C to −7$^0$C. Meanwhile, Difron-4201 demonstrated the highest efficiency at an optimum concentration of 800 g/t in the 1:2 ratio (No. 680:No. 690), achieving a freezing point reduction to −9$^0$C.

Table 6

**Influence of the depressor additive Difron-4201 on the freezing point of oil mixtures with different ratios**

| Concentration of the depressor additive, g/t | Freezing temperature, $^0$C | Effect on freezing temperature, % |
|---|---|---|
| 1 No. 680:1 No. 690 | | |
| 0 | +12 | 0 |
| 200 | +8 | 41 |
| 400 | +4 | 75 |
| 600 | 0 | 100 |
| 800 | –4 | 142 |
| 1000 | –8 | 175 |
| 1 No. 680:2 No. 690 | | |
| 0 | +15 | 0 |
| 200 | +10 | 40 |
| 400 | +4 | 80 |
| 600 | –2 | 120 |
| 800 | –9 | 167 |
| 1000 | –5 | 140 |
| 2 No. 680:1 No. 690 | | |
| 0 | +11 | 0 |
| 200 | +7 | 45 |
| 400 | +2 | 91 |
| 600 | 0 | 100 |
| 800 | –7 | 173 |
| 1000 | –4 | 145 |

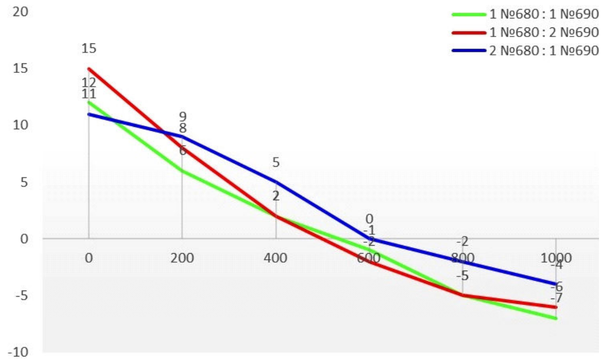


Fig. 1. Effect of the depressor additive Difron-3970 on the freezing point of oil mixtures at different ratios

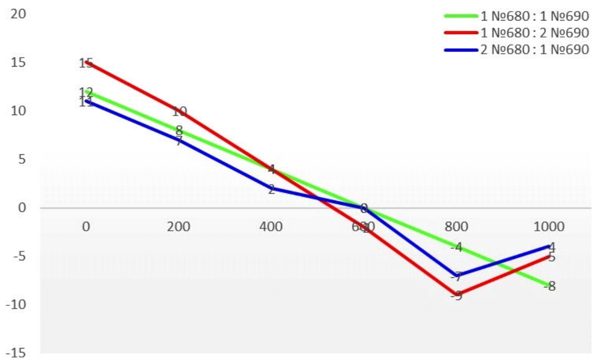


Fig. 2. Effect of the depressor additive Difron-4201 on the freezing point of oil mixtures at different ratios

***Conclusions***

1. The influence of depressor additives Difron-4201 and Difron-3970 on the freezing point of oil samples prepared in 1:1, 1:2, and 2:1 ratios from oils extracted from wells No. 680 and 690 of Narimanov OGR, SOCAR, was investigated for the first time under laboratory conditions.

2. It was established that the maximum efficiency of the depressor additive Difron-3970 was observed at a concentration of 1000 g/t across all three oil ratios, resulting in freezing points of −7$^0$C (167% reduction in freezing temperature), −6$^0$C (147%), and −4$^0$C (145%), respectively.

3. The highest efficiency of the Difron-4201 additive was recorded at a concentration of 800 g/t in the 1:2 ratio (No. 680 : No. 690), where the freezing point was reduced to −9$^0$C, corresponding to a 167% decrease in freezing temperature.

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### ВИЗНАЧЕННЯ ОПТИМАЛЬНОЇ КОНЦЕНТРАЦІЇ ДЕПРЕСОРНИХ ДОБАВОК DIFRON-3970 ТА DIFRON-4201 У РІЗНИХ НАФТОВИХ СУМІШАХ

***С. Пашаєва***

Як об'єкти дослідження використовувалися зразки нафти, взяті у співвідношеннях 1:1, 1:2 та 2:1 із свердловин № 680 і 690 родовища Нарімановського НГР, SOCAR. Результати показали, що зі збільшенням концентрації реагентів їх ефективність зростає. Найвища ефективність депресорної добавки Difron-3970 у всіх трьох співвідношеннях спостерігалася за концентрації 1000 г/т, що знижувало температуру застигання нафтових сумішей до $-7^0$C, $-6^0$C і $-4^0$C відповідно. Ефективність реагенту Difron-4201 змінювалася залежно від середовища: найвищий ефект було зафіксовано за концентрації 1000 г/т для суміші 1:1 (свердловини № 680 і № 690), що знижувало температуру застигання до $-8^0$C. Однак у двох інших сумішах найвища ефективність спостерігалася за концентрації 800 г/т, при цьому температура застигання досягала $-9^0$C для суміші 1:2 і $-7^0$C для суміші 2:1. Найбільший ефект від добавки Difron-3970 було зафіксовано за концентрації 1000 г/т для суміші 1:1, що знизило температуру застигання з $+12^0$C до $-7^0$C. Натомість Difron-4201 продемонстрував найвищу ефективність за концентрації 800 г/т у співвідношенні 1:2, знижуючи температуру застигання до $-9^0$C.

**Ключові слова**: депресорна добавка, реагент, високо парафіниста нафта, нафтові суміші, температура застигання, ефективність депресора.

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