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Study of the properties of depressor additive “Difron-3970” and the new composition

Badanie właściwości dodatku depresującego „Difron-3970” i nowej kompozycji

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ABSTRACT: This article is the first to investigate the effect of the depressor additive “Difron-3970” and the new composition with the conventional name A-1 as an original depressor against asphaltene-resin-paraffin deposits and freezing temperature in a highly paraffinic oil sample. Laboratory tests were conducted to examine the effects of “Difron-3970” depressant additive and A-1 composition on asphaltene-resin-paraffin deposits in the absence of reagents using the cold-finger method. Experiments were conducted at temperatures of 0°C, 5°C, 10°C, 15°C, 20°C, 25°C and 30°C for a period of two hours and the mass of paraffin deposits collected on the tube surface was then determined using an analytical balance. It was determined that, in all three cases, the amount of paraffin deposits increased over time, but decreased as temperature rose. The effectiveness of the “Difron-3970” depressant additive and the new composition A-1 was evaluated at concentrations of 350, 450, 550, 650, 750 g/t. In comparison to the depressant additive, the A-1 composition demonstrated superior efficacy against paraffin deposits in experiments conducted using the cold-finger method, resulting in a significant reduction. Based on the results of numerous experiments carried out using the cold-finger method, the efficiency of both reagents at the temperature of 5°C was mathematically calculated, and their effectiveness against paraffin precipitation was determined. At the optimal concentration of 750 g/t, the effectiveness rates of “Difron-3970” and the A-1 composition against paraffin precipitation over 120 minutes were 90.8% and 95%, respectively. The percentages of asphaltene, resin and paraffins in oil deposits were determined. It was observed that asphaltene and resin levels increase in deposits formed at higher temperatures in the cold-finger over extended periods, while paraffin levels decrease. The impact of “Difron-3970” and A-1 composition on the freezing point was also determined showing that, at optimal concentrations, the oil’s freezing temperature dropped from +18°C to –1°C and –5°C, respectively. Additionally, the effect of A-1 composition on the growth rate of sulfate-reducing bacteria in Postgate-B nutrient medium was studied over fifteen days. The bactericidal effect of the composition at different concentrations was calculated based on the change in the concentration of biogenic hydrogen sulfide in the medium. It was found that the bactericidal effect of A-1composition at concentrations of 350, 450, 550, 650, 750 g/t ranged from 26–62%, 29–68%, 41–77%, 48–89%, 55–98%, respectively.

Key words: asphaltenes, resins, paraffins, “Difron-3970”, composition, bactericidal effect, cold finger method.

STRESZCZENIE: Niniejszy artykuł stanowi pierwszą próbę zbadania wpływu dodatku „Difron-3970” i nowej kompozycji o umownej nazwie A-1 jako oryginalnego depresatora na proces powstawania osadów asfaltenowo-żywiczno-parafinowych i temperaturę krzepnięcia próby ropy wysokoparafinowej. W celu zbadania wpływu depresatora „Difron-3970” i kompozycji A-1 na powstawanie osadów asfaltenowo-żywiczno-parafinowych przy braku odczynników, przeprowadzono testy laboratoryjne metodą *cold-finger*. Eksperymenty przeprowadzono w temperaturach 0°C, 5°C, 10°C, 15°C, 20°C, 25°C i 30°C przez dwie godziny, a masa osadów parafinowych osadzonych na powierzchni rurki została zmierzona za pomocą wagi analitycznej. Ustalono, że we wszystkich trzech przypadkach ilość osadów parafinowych wzrastała w czasie, ale malała wraz ze wzrostem temperatury. Skuteczność depresatora „Difron-3970” i nowej kompozycji A-1 oceniono przy stężeniach 350, 450, 550, 650, 750 g/t. W porównaniu do depresatora, kompozycja A-1 wykazała większą skuteczność przeciw osadom parafinowym w eksperymentach przeprowadzonych metodą *cold-finger*, redukując je do minimum. Na podstawie wyników szeregu eksperymentów przeprowadzonych metodą *cold-finger* obliczono matematycznie skuteczność obu odczynników w temperaturze 5°C i określono ich skuteczność przeciwko wytrącaniu parafiny. Przy optymalnym stężeniu 750 g/t, wskaźniki skuteczności „Difron-3970” i kompozycji A-1 przeciwko wytrącaniu parafiny w ciągu 120 minut wynosiły odpowiednio 90,8% i 95%. Określono procentową zawartość asfaltenów, żywic i parafin w osadach olejowych. Zaobserwowano, że poziom asfaltenów i żywic wzrasta w osadach powstających w wyższych temperaturach w „zimnej rurze” przez dłuższy czas, podczas gdy poziom parafin spada. Określono również wpływ kompozycji „Difron-3970” i A-1 na temperaturę krzepnięcia, wykazując, że przy optymalnych stężeniach temperatura krzepnięcia ropy spadła odpowiednio z +18°C do –1°C i –5°C. Dodatkowo zbadano wpływ kompozycji A-1 na tempo wzrostu bakterii redukujących siarczany w pożywce Posgate-B przez piętnaście dni. Działanie

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bakteriobójcze kompozycji w różnych stężeniach obliczono na podstawie zmiany stężenia biogenicznego siarkowodoru w pożywce. Stwierdzono, że działanie bakteriobójcze kompozycji A-1 w stężeniach 350, 450, 550, 650, 750 g/t wynosiło odpowiednio 26–62%, 29–68%, 41–77%, 48–89%, 55–98%.

Słowa kluczowe: asfalteny, żywice, parafiny, „Difron-3970", kompozycja, działanie bakteriobójcze, metoda cold finger.

Introduction

The asphaltene-resin and paraffin components are critical factors that complicate the processes of oil production, collection, preparation and transportation. During these processes, with changes in temperature initial paraffin crystals begin to form within the oil, gradually enlarging through coagulation, until sedimentation occurs due to gravitational forces (Akramov, 2017). This leads to the accumulation of asphaltene-resin-paraffin deposits accumulate in equipment flow section and on the inner surface of pipelines (Aliyeva, 2003). Consequently, the operational efficiency of oil production, transportation and pumping units decreases well service life reduced and repair costs increase. Additionally, sediments accumulate in the well production collection system obstructing transportation and necessitating periodic cleaning of pipe interiors (Espolov et al., 2016). One approach to addressing paraffin deposits involves chemical methods for preventing or removing the deposits. Long-term experience with high-paraffin oil wells has demonstrated that it is impossible to fully optimize oil production without effective prevention and removal of paraffin deposits from oilfield equipment, lifting pipes and flow lines (Glushchenko, 2007).

Currently, there is no universal method to completely prevent the formation and precipitation of asphaltene-resin-paraffin deposits (Ivanova et al., 2022). Among available methods, the application of chemical reagents – particularly inhibitors – is considered the most promising. It should be noted, however, that the effectiveness of individual inhibitors is often unsatisfactory and to achieve a good effect, a large amount of reagent is required per ton of oil, which is not economically viable (Jenning and Weispfenning, 2005). Additionally, there are limited inhibitors available that effectively balance consumption, price, and effectiveness. Thus, expanding the range of reagents with an effective impact against asphaltene-resin-paraffin deposits a priority for oil researchers (Khidr, 2011). At the same time, in the current period of the world oil industry, the development of complex-effect – more precisely, multifunctional – compositions and the study of their properties in laboratory conditions remain relevant (Matiev et al., 2018). The production of a wide range of surfactants and polymeric substances allows for the creation of highly effective compositions from ready-made individual components, which, in turn, is a more realistic and cost-effective solution to the problem without synthesizing new substances (Miller et al., 2021). Therefore, the search for and creation of complex synergistic compositions of inhibitors against oil deposits in oil emulsions, both directly in the production and collection system and during pipeline transportation, remains an urgent issue (Mingalev et al., 2022).

It should be noted that during the analysis of the main problems arising in the transport system of highly paraffinic oils in oil-producing countries, and the scientific-research efforts directed at their elimination, it became clear that eliminating the processes of corrosion and paraffin deposition is crucial for the effective transportation of this type of oil (Polataeva et al., 2019). However, in published scientific articles and research efforts in this direction, some authors consider it appropriate to focus on eliminating corrosion, while other focus solely on paraffin deposition (Rasulov, 2017). Given that developing an effective technology for the simultaneous elimination of both factors that create complications, namely corrosion and paraffin precipitation, would yield higher economic and environmental benefits during the transportation of high-paraffin oils, the presented research work was carried out with this objective (Sharifullin et al., 2006).

The purpose of this research work is to study the multifunctional properties of the new composition in laboratory conditions.

Research methodology

The physical and chemical characteristics of the oil sample taken for laboratory research are given in Table 1.

Table 1. Physical-chemical characteristics of the oil sample
Tabela 1. Właściwości fizykochemiczne próbki ropy

Density 20°C [kg/m^3]	Narimanov oil
Dynamic viscosity 20°C [mP·s]	986.4
Water content [mass %]	2563
Chlorine salts content [mg/l]	38
Mechanical impurities content [mass %]	502
Resins content [mass %]	5,6
Asphaltenes content [mass %]	9.2
Paraffins content [mass %]	4.24
Freezing temperature [°C]	15.4
Density 20°C [kg/m^3]	+18

As can be seen from the table, the oil sample taken for the experiment under laboratory conditions is characterized by a high percentage of asphaltene, resin, and paraffin, as well as a high freezing temperature.

To study the effect of reagents on asphaltene-resin-paraffin sediments in the oil sample, the depressor additive "Difron-3970", local raw materials-based MARZA-1, which can be produced industrially in Azerbaijan, and a composition of "Difron-3970" + MARZA-1, in a ratio of 70:1, with the conventional name A-1, were used.

To achieve the research goal, the effect of the depressor additive "Difron-3970" and the A-1 composition on asphaltene-resin-paraffin deposits at different concentrations and temperatures was studied experimentally using the cold-finger method, and the optimal concentration of both reagents was determined (RD 39-3-812-82, 1982). It should be noted that this method is particularly suitable for field conditions, allowing for an accurate qualitative and quantitative assessment of the effectiveness of chemical reagents against oil deposits. Moreover, this method supports the development of the application technology for effective reagents against paraffin precipitation (Xu and Gu, 2014). Research conducted under laboratory conditions using the cold-finger method allows for the study of reagent effectiveness based on changes in the amount of oil deposits collected on the cold-finger, resulting from the altered freezing temperature of the oil sample due to chemical reagents' effects (Xu et al., 2016). To conduct experiments with this method, the device shown in Figure 1 was used.

During the cold-finger method, the procedure is performed in the following order. First, a crude oil sample with a volume of 1.5 L is poured into the container shown in Figure 1. Then, in order to prevent the initial formation of paraffin crystals, the oil is heated to a temperature of 60°C, and this temperature is maintained using a contact thermometer. During the experiments, the mixer in the dewar container is turned on. In the second thermostat, the temperature is lowered to 0°C, and the experiment continues. The oil sample is held under conditions for 20 minutes, after which the amount of paraffin accumulated on the cold-finger is determined by weighing it on an analytical scale. Experiments for this research were carried with cold-finger temperatures of 0°C, 5°C, 10°C, 20°C and 30°C. Predetermined amounts of reagents are added to the oil samples, and the experiments are performed in the specified sequence. At the end, the amount of asphaltene-resin-paraffin deposits collected on the cold-finger at different temperatures is determined by weighing on an analytical scale. It should be noted that the error rate in experiments conducted with this method is 1–3%. The effect of both reagents on the freezing temperature of the oil sample, the growth rate of sulfate-reducing bacteria, and the percentage of oil deposit components were also studied using known methods (Talybov et al., 2020).

Results and discussion

To study the effect of "Difron-3970" and its new composition with the conventional name A-1 on asphaltene-resin-paraffin deposits (ARPD), experiments were carried out under laboratory conditions at cold-finger temperatures of 0°C, 5°C, 10°C, 15°C, 20°C, 25°C and 30°C over a two-hour period. The mass of paraffin deposits collected on the surface of the metal tube was measured at intervals of 0, 20, 40, 60, 80, 100 and 120 minutes at temperatures of 0°C, 5°C, 10°C, 15°C , 20°C, 25°C and 30°C using an analytical balance. Table 2 shows the mass of deposits collected on the tube surface in the absence of reagent according to temperature and time.

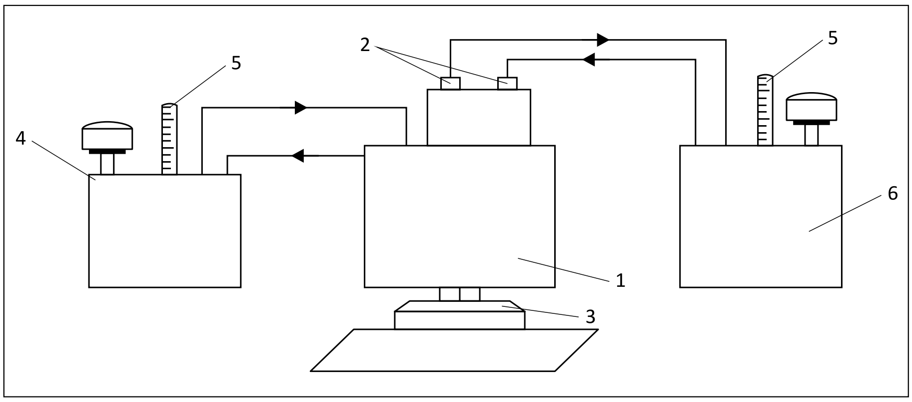

Figure 1. Principle design of the special device for the determination of paraffin precipitation using the cold-finger method: 1 – dewar container; 2 – cold-finger; 3 – mixer, 4 – heater; 5 – thermometer; 6 – refrigerating unit

Rysunek 1. Zasada działania specjalnego urządzenia do określania ilości wytrąconej parafiny metodą *cold-finger*: 1 – naczynie Dewara; 2 – *cold-finger*; 3 – mieszadło, 4 – grzałka; 5 – termometr; 6 – agregat chłodniczy

As it can be seen from Table 2, as the temperature of the cold-finger increases, the amount of asphaltene-resin-paraffin deposits accumulated on its surface gradually decreases. Over time, the amount of oil deposits collected on the surface of the cold-finger increases, with some exceptions.

The laboratory experiments were repeated in the sequence mentioned above for the oil samples to which the optimal concentrations of the depressor additive "Difron-3970" and the new A-1 composition were added, and the mass of asphaltene-resin-paraffin deposits collected on the cold-finger was determined (Tables 3 and 4).

Table 2. Masses of deposits collected on the surface of the cold-finger in the absence of reagent
Tabela 2. Ilość osadów nagromadzonych na powierzchni walca przy braku odczynnika

Time [minutes]	Cold-finger temperature						
	0°C	5°C	10°C	15°C	20°C	25°C	30°C
	mass of oil deposits [g]						
0	0.114	0.088	0.081	0.076	0.069	0.065	0.042
20	0.162	0.141	0.104	0.098	0.092	0.068	0.039
40	0.223	0.171	0.142	0.135	0.121	0.059	0.037
60	0.294	0.189	0.160	0.156	0.134	0.063	0.035
80	0.338	0.231	0.169	0.166	0.157	0.065	0.040
100	0.343	0.255	0.193	0.186	0.160	0.074	0.039
120	0.354	0.263	0.192	0.186	0.173	0.072	0.040

Table 3. Masses of deposits accumulated on the surface of the cold-finger in the presence of "Difron-3970" additive
Tabela 3. Ilość osadów nagromadzonych na powierzchni walca przy użyciu dodatku "Difron-3970"

Time [minutes]	Cold-finger temperature						
	0°C	5°C	10°C	15°C	20°C	25°C	30°C
	mass of oil deposits [g]						
0	0.114	0.084	0.078	0.071	0.066	0.062	0.040
20	0.158	0.137	0.098	0.092	0.088	0.064	0.037
40	0.220	0.167	0.137	0.132	0.117	0.056	0.033
60	0.290	0.187	0.156	0.151	0.128	0.060	0.031
80	0.333	0.228	0.165	0.161	0.152	0.061	0.035
100	0.338	0.251	0.190	0.182	0.156	0.071	0.034
120	0.350	0.259	0.188	0.182	0.168	0.069	0.032

The data in Table 3 can be characterized as follows:

1. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 0°C over 0–120 minutes varies between 0.114–0.350.
2. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 5°C over 0–120 minutes varies between 0.084–0.259.
3. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 10°C over 0–120 minutes varies between 0.078–0.188.
4. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 15°C over 0–120 minutes varies between 0.071–0.182.
5. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 20°C over 0–120 minutes varies between 0.066–0.168.
6. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 25°C over 0–120 minutes varies between 0.062–0.069.
7. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 30°C over 0–120 minutes varies between 0.040–0.032.

Table 4. Masses of deposits accumulated on the surface of the cold-finger in the presence of composition A-1
Tabela 4. Ilość osadów nagromadzonych na powierzchni walca przy użyciu dodatku kompozycji A-1

Time [minutes]	Cold-finger temperature						
	0°C	5°C	10°C	15°C	20°C	25°C	30°C
	mass of oil deposits [g]						
0	0.114	0.080	0.075	0.065	0.061	0.057	0.037
20	0.154	0.132	0.093	0.088	0.085	0.061	0.033
40	0.215	0.164	0.133	0.127	0.111	0.052	0.030
60	0.286	0.182	0.151	0.146	0.122	0.055	0.026
80	0.329	0.223	0.161	0.157	0.148	0.057	0.028
100	0.332	0.247	0.186	0.179	0.152	0.066	0.026
120	0.343	0.249	0.175	0.176	0.157	0.051	0.017

The results with the A-1 composition, as presented in Table 4, can be characterized as follows:

1. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 0°C over 0–120 minutes varies between 0.114–0.343.
2. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 5°C over 0–120 minutes varies between 0.080–0.249.
3. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 10°C over 0–120 minutes varies between 0.077–0.175.
4. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 15°C over 0–120 minutes varies between 0.065–0.176.
5. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 20°C over 0–120 minutes varies between 0.061–0.157.
6. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 25°C over 0–120 minutes varies between 0.057–0.051.
7. The amount of oil deposits in grams accumulated on the surface of the cold-finger at a temperature of 30°C over 0–120 minutes varies between 0.037–0.017.

Thus, from the analysis of the results, it is clear that the amount of deposit collected on the surface of the cold-finger is directly proportional to time and inversely proportional to temperature. Furthermore, as it can be seen in all three tables, the experiments carried out using the cold-finger method with the individual reagent "Difron-3970" and the new A-1 composition show that the A-1 composition is more effective against asphaltene-resin-paraffin deposits.

Based on the results of numerous experiments conducted using the cold-finger method, the effectiveness of both reagents against paraffin deposit was calculated at the cold-finger temperature of 5°C using the following mathematical formula. The time-dependent results for the reagents are given in Figure 2.

$$K = \frac{m_1 - m_2}{m_1} 100\%$$

where:

K – reagent efficiency;

m_1 – mass of ARPD in reagent-free environment,

m_2 – mass of ARPD in the medium containing the reagent.

As it can be seen from Figure 2, the efficiency of both reagents against oil deposits increases with time. The A-1 composition demonstrates the highest efficiency at 120 minutes. The effectiveness rates of "Difron-3970" and A-1 composition over time intervals od 0, 20, 40, 60, 80, 100, 120 minutes are as follows: 64.9, 67.5%, 76.6, 78.6%, 85, 86.1%, 89.3, 90.9%, 89.5, 91.5%, 89.9, 92.2% and 90.8, 95%.

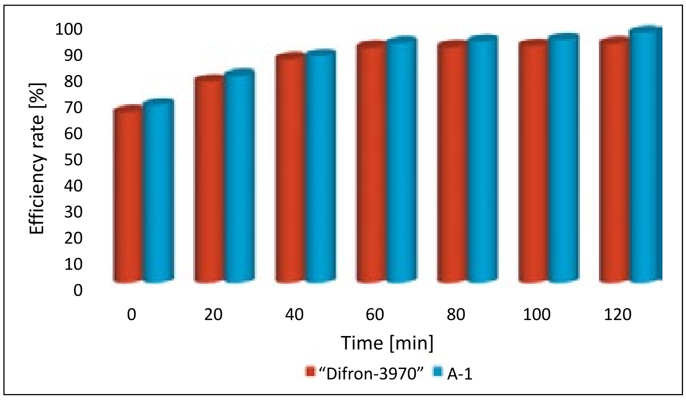

Figure 2. Time dependence of the efficiency of reagents

Rysunek 2. Zależność skuteczności odczynników od czasu

Figure 3 shows the dependence of temperature on the percentage of asphaltene, resin and paraffin components in the oil deposit collected on the cold surface over time intervals of 0, 20, 40, 60, 80, 100, 120 minutes.

The laboratory tests given in Figure 3 can be characterized as follows:

1. At the beginning of the experiment, the percentages of sediment components in the oil film formed on the metal surface of the cold-finger at temperatures of 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 20, 21, 22, 23, 26, 32, 37%; resin – 28, 30, 32, 33, 33, 31, 30%; paraffin – 52, 49, 46, 44, 41, 37, 33%.
2. After 20 minutes, the percentages of sediment components in the oil film formed on the metal surface of the cold-finger at 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 18, 19, 23, 25, 30, 32, 38%; resin – 26, 28, 30, 33, 32, 32, 30%; paraffin – 56, 53, 47, 42, 38, 35, 32%.
3. After 40 minutes, the percentages of sediment components in the oil film formed on the metal surface of the cold-finger at 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 15, 17, 20, 24, 29, 34, 39%; resin – 27, 29, 34, 35, 36, 34, 33%; paraffin – 58, 54, 46, 41, 35, 32, 28%.
4. After 60 minutes, the percentages of sediment components in the oil film formed on the metal surface of the cold-finger at 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 9, 18, 25, 32, 37, 39, 41%; resin – 30, 32, 34, 37, 36, 35, 34%; paraffin – 61, 50, 41, 31, 27, 26, 25%.
5. After 80 minutes, the percentages of sediment components in the oil film formed on the metal surface of the cold-finger at 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 10, 19, 26, 33, 39, 41, 43%; resin – 27, 33, 36, 38, 36, 35, 34%; paraffin – 63, 48, 38, 29, 25, 24, 23%.
6. After 100 minutes at temperatures of 0, 5, 10, 15, 20, 25, and 30°C, the percentages of sediment components in the oil film formed on the metal surface of cold-finger are as follows: asphaltene – 10, 20, 28, 34, 39, 43, 46%; resin – 25,

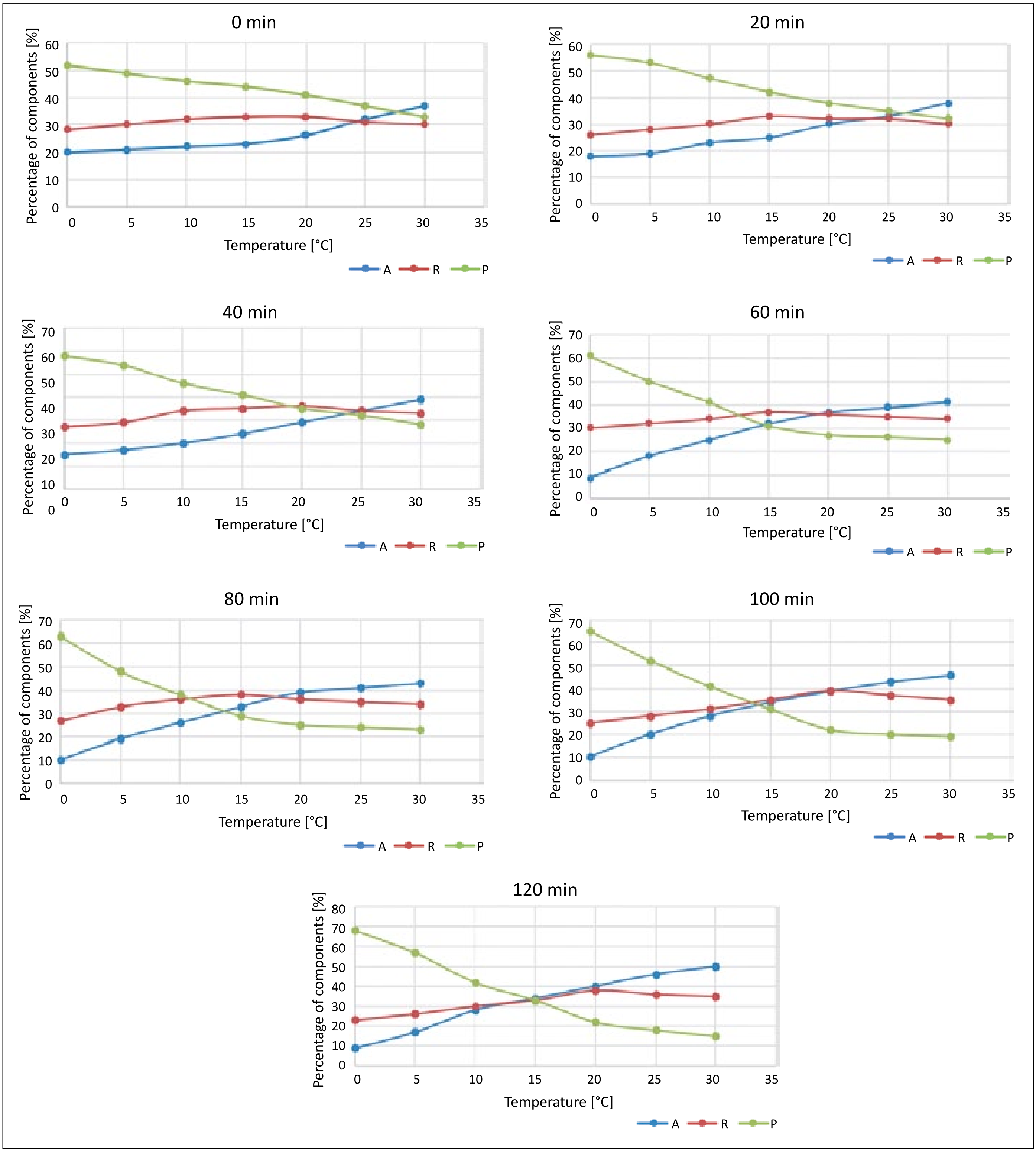

Figure 3. Dependence of the percentage of components in oil deposit at different temperatures: A – asphaltene; R – resin; P – paraffin

Rysunek 3. Zależność procentowej zawartości składników w osadzie wytrąconym z ropy dla różnych temperatur: A – asfalteny; R – żywice; P – parafiny

28, 31, 35, 39, 37, 35%; paraffin – 65, 57, 41, 31, 22, 20, 19%.

7. After 120 minutes, the percentages of sediment components in the oil field film formed on the metal surface of the cold-finger at 0, 5, 10, 15, 20, 25, and 30°C are as follows: asphaltene – 9, 17, 28, 34, 40, 46, 50%; resin – 23, 26, 30, 33, 38, 36, 35%; paraffin – 68, 57, 42, 33, 22, 18, 15%.

The effects "Difron-3970" and A-1 composition at concentrations of 350, 450, 550, 650, 750 g/t on the freezing temperature of the high-paraffin oil sample were studied using

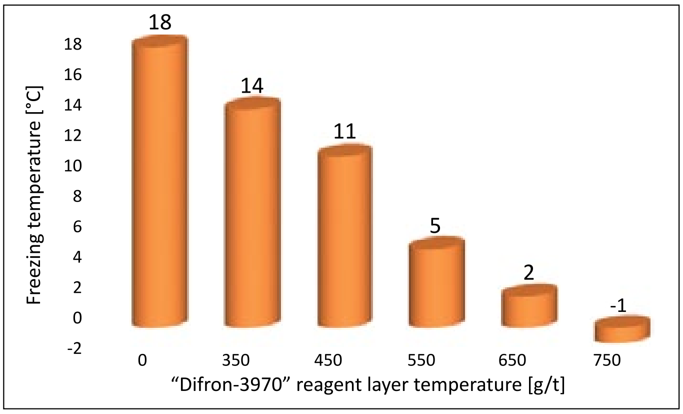

Figure 4. Effect of "Difron-3970" additive on oil freezing temperature

Rysunek 4. Wpływ dodatku „Difron-3970" na temperaturę krzepnięcia ropy

the known methods. Figure 4 shows the results of the effect of "Difron-3970" depressor additive on the freezing temperature of the oil sample.

As it can be seen from the Figure 4, increasing the concentration of the depressor additive in the oil results in a greater impact on freezing point reduction. Specifically, by adding 350, 450, 550, 650, and 750 g/t of "Difron-3970" additive to an oil sample with an initial freezing temperature of +18°C, the freezing temperature of the oil is progressively lowered from +18°C to +14, +11, +5, +2, and finally to –1°C.

The results shown in Figure 5 demonstrate that the A-1 composition, at an optimal concentration of 750 g/t, reduces the freezing temperature of the oil sample from +18°C to –5°C.

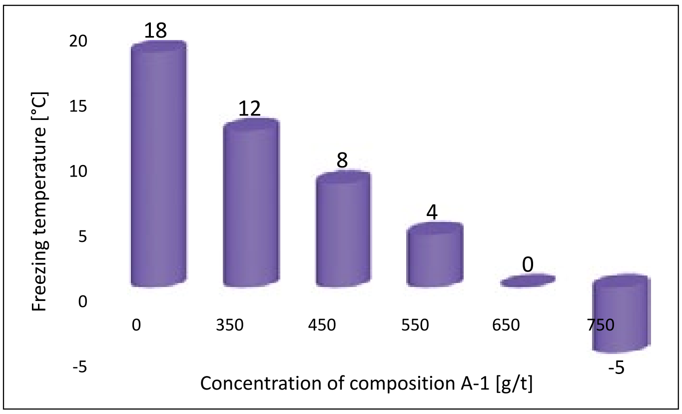

Figure 5. Effect of composition A-1 on oil freezing temperature

Rysunek 5. Wpływ kompozycji A-1 na temperaturę krzepnięcia ropy

This indicates that, compared to the "Difron-3970" depressor additive, the A-1 composition has a more effective impact on lowering the freezing point of the oil.

Additionally, during the research, the effect of A-1 composition on the growth rate of sulfate-reducing bacteria in

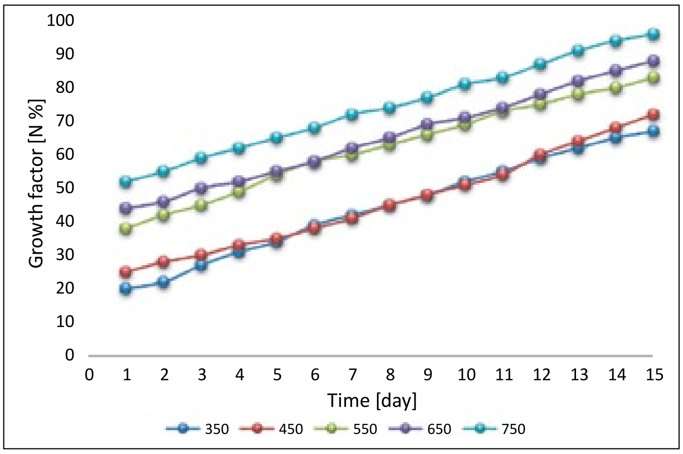

Figure 6. Effect of A-1 composition on the growth rate of sulfate-reducing bacteria at different concentrations

Rysunek 6. Wpływ kompozycji A-1 na tempo wzrostu bakterii redukujących siarczany, przy różnych stężeniach

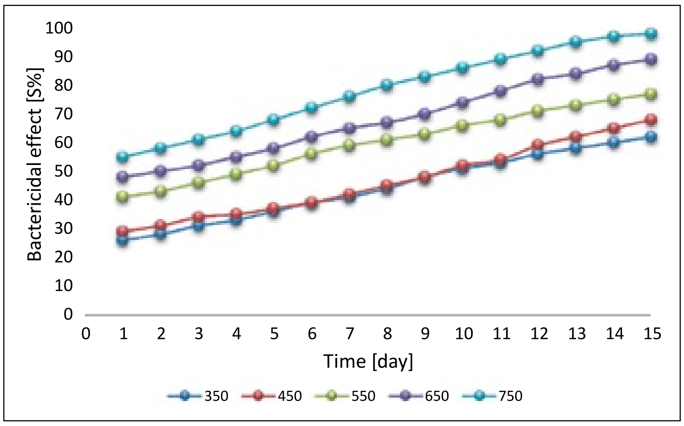

Figure 7. Bactericidal effect of composition A-1 at different concentrations

Rysunek 7. Bakteriobójcze działanie kompozycji A-1 w różnych stężeniach

Postgate-B nutrient medium over a 15-day period was studied, following the procedures outlined in the established methodology. The results of this study are given in Figure 5.

Figure 6 shows that when increasing the concentration of A-1 composition its effect also increases with time. The highest effect was observed at the optimal concentration of 750 g/t. At this concentration, the effect on the growth rate of bacteria ranged between 52–96% over a 15-day period.

Based on the change in the concentration of biogenic hydrogen sulfide formed during the life activity of sulfate-reducing bacteria in the nutrient medium, the bactericidal effect was calculated for different concentrations of the A-1 composition. The results are shown in Figure 7.

As can be seen from the graph, the bactericidal effect increases as the amount of new A-1 composition increases in the Postgate-B nutrient medium. This increase can be characterized as follows: at concentrations of 350, 450, 550, 650, 750 g/t of the A-1 composition, the bactericidal effect is 26–62%, 29–68%, 41–77%, 48–89%, and 55–98%, respectively.

Conclusion

Thus, for the first time, the effect of the "Difron-3970" depressor additive and the new A-1 composition, prepared under laboratory conditions, against asphaltene-resin-paraffin deposits in high-paraffin oil using the cold-finger method was studied. The effect on the freezing point was also analyzed, and the optimal concentrations of these additives were determined. The A-1 composition was found to be more effective than the depressant additive.

Additionally, the effect of the A-1 composition on the growth rate of sulfate-reducing bacteria in Postgate-B nutrient medium over a 15-day period was studied. The composition was shown to significantly affect the growth rate of bacteria at its optimal concentration. The bactericidal effect was calculated for different concentrations of A-1 composition according to the change in the concentration of biogenic hydrogen sulfide in the nutrient medium. It was determined that the bactericidal effect of the composition at the optimal concentration was 98%.

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