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Aysel V. Gasimzade

STUDY OF A MULTIFUNCTIONAL COMPOSITION IN THE PREPARATION AND TRANSPORTATION OF HEAVY OILS

Azerbaijan State Oil and Industry University, Baku, Republic of Azerbaijan

Under laboratory conditions, a novel composition comprising ND-12, Gossypol resin, and isopropanol in a ratio of 4:1.5:0.5, denoted as A-3, was investigated for the first time. Its efficacy in the demulsification of Muradkhanli and Umbaki heavy oil samples, with emulsion degrees of 41% and 31% respectively, was studied, along with its effects on freezing point, dynamic viscosity, and corrosion rate in hydrogen sulfide reservoir water. The optimal concentration of the reagent was determined to be 600 g/t. Over a two-hour period, the demulsification of Muradkhanli oil was conducted at 40^0C, 50^0C, and 60^0C, and of Umbaki oil at 40^0C, 50^0C, 60^0C, and 70^0C. The minimum amount of ballast water, with optimal composition thickness participation, was observed at 60^0C for Muradkhanli oil and 70^0C for Umbaki oil, constituting 0.1% and 0.13%, respectively. The freezing temperature of Muradkhanli oil decreased from $+12.5^0$C to $+5^0$C, and Umbaki oil from $+11^0$C to $+4^0$C due to the optimal viscosity effect of A-3 composition. At $+20^0$C, with 600 g/t of composition A-3, the dynamic viscosity of Muradkhanli oil decreased from 201 Pa·s to 111 Pa·s and from 1540 Pa·s to 237 Pa·s for emulsion degrees of 0.0%, 5%, 10%, 20%, 30%, and 41%. At $+40^0$C, the dynamic viscosity of Umbaki oil decreased from 182 Pa·s to 64 Pa·s and from 1183 Pa·s to 163 Pa·s for emulsion degrees of 0.0%, 5%, 10%, 20%, and 31%. Furthermore, A-3 composition exhibited higher efficiency in affecting the corrosion rate in hydrogen sulfide formation water compared to its constituent Gossypol resin. While the corrosion protection effect of Gossypol resin at optimal concentrations was 90%, A-3 composition reached 98%. These results indicate the complex and synergistic effects of the A-3 composition due to its constituent components. In conclusion, numerous laboratory tests revealed that the A-3 composition, comprising ND-12 demulsifier, corrosion agent Gossypol resin, and isopropanol solvent, is suitable for the demulsification, freezing point reduction, and dynamic viscosity adjustment of heavy oils such as Muradkhanli and Umbaki, as well as for effectively influencing corrosion rates in acidic environments. Therefore, the application of the new A-3 composition is recommended as an economically and ecologically efficient reagent for demulsification and transportation of heavy oils in mining conditions, as well as for corrosion protection of internal surfaces of transportation preparation facilities.

Keywords: demulsification, corrosion rate, freezing point, effective viscosity, composition, reagent, demulsifier.

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Introduction

It is known that the dilution rate of oil produced from wells in the first period of operation in developed oil countries is expressed in very small figures. However, after a certain period of time, an increase in the amount of water in the well causes an increase in the dilution rate of hydrocarbon raw materials extracted from the oil well. From this point of view, both in Republic of Azerbaijan and in other countries with oil industry, the share of production of heavy oils with a very high dilution rate in wells at the last stage of operation is increasing. It should be noted that oils in wells, as well as formation water, differ in the amount of components included in their composition. Water-oil emulsions are formed by rapid mixing of formation water and oil with different physical and chemical properties. It is the amount of such components as asphaltenes, resins, paraffins in oil and predominantly mineral salts and mechanical mixtures in formation water that determines the formation of aggregative and kinetically stable oil-water emulsions. More precisely, the stability of the formed water-oil emulsions increases with increasing amount of the mentioned substances. For this reason heavy oils have stable water-oil emulsions [1,2].

More effective chemical reagents are required to decompose stable water-oil emulsions formed in heavy oils into aqueous and oil phases. Because demulsifiers used in demulsifying water-oil emulsions formed in relatively light oils are less effective in decomposing water-oil emulsions formed in heavy oils. For this reason, the use of compositions with high surface activity in the preparation of oils with stable water-oil emulsion for transportation remains the most important issue. In this connection, during the course of the research, in order to study how the effect of compositions on stable water-oil emulsions formed by heavy oils changes depending on its components, as well as by preparing new compositions from different ratios of reagents for the same purpose, their effectiveness in demulsifying stable water-oil emulsions was studied under laboratory conditions. The effect of new composition A-3, developed to achieve the goal, on demulsification process and rheological parameters of Muradkhanli and Umbaki oil samples, belonging to the group of heavy oils, was studied.

Experimental

The samples of crude oil produced at Muradkhanli and Umbaki fields of SOCAR were used for laboratory research. The purpose of selecting the oils of the mentioned fields is that they have different rheophysical and chemical properties and belong to the type of heavy oil with stable water-oil emulsion. In addition, various chemical reagents are used to enhance oil recovery in the existing fields, which in turn leads to an increase in the aggregative and kinetic stability of water-oil emulsions. Physical and chemical properties of the oils taken for the study are given in Table 1.

As is seen from Table 1, both oil samples taken for the research exhibit relatively high values of concentration, viscosity, chloride salts and mechanical mixtures. In general, the physicochemical properties of the oils indicate that they have the ability to form

Table 1

Physicochemical properties of oil samples

Property	Value	
	Muradkhanli	Umbaki
Density (20^{0}C), kg/m^3	947.3	962.5
Viscosity (20^{0}C), mPa·s	2157	2246
Amount of water, wt.%	41	31
Amount of chlorine salts, mg/l	534.3	152.1
Amount of mechanical mixtures, wt.%	5.86	1.9
Amount of resins, wt.%	18.1	9.7
Amount of asphaltenes, wt.%	4.5	5.0
Amount of paraffins, wt.%	5.8	6.2
Freezing point, ^{0}C	+19.5	+16

a stable water-oil emulsion. It should be noted that the rheophysical and chemical properties of oils are largely determined by the analysis technique used. For this reason, it is considered expedient to carry out analyses according to modern standards [3].

One of the important conditions for analyses is compliance of the taken oil sample with the requirements of the state standard GOST 2517-85. Inserting the hydrometer into the oil sample, the concentration of oil at 20^{0}C was determined by the scale value of the hydrometer at the current temperature [4]. Saturated vapor pressure, which can be generated by volatile gases in the oil at a temperature of 37.8^{0}C, was determined according to the state standard GOST 2517-85 [5]. The amount of water in the oil was determined based on the sequence given elsewhere [6], the amount of mechanical mixtures and the amount of chlorine salts were determined based on the procedures described in ref. [7], and the amount of sulfur was determined based on the procedures described in ref. [8]. In addition, the determination of the amount of resins and asphaltenes, which are high molecular weight components of oil, was carried out according to the method given in [9], and the determination of paraffin hydrocarbons - according to the method given in ref. [10].

To determine the dynamic viscosity of the studied oil samples, we used Anton Paar SVM 3001 device, which has exceptional accuracy and can operate in a wide range of temperatures (from 60^{0}C to 135^{0}C). Determination of kinematic and dynamic viscosity of oil samples was carried out based on the international standard 11858 [11]. It should be noted that the error between the results of analyses carried out according to international standards (GOST and ASTM) did not exceed the permissible limits [12–14].

The determination of oil emulsion composition by the bottle method was based on the percentage of water released from the oil at a given temperature.

The mechanism of the process was based on the separation of water due to dispersion of emulsion in oil after mixing with oil at an intensive speed of demulsifier added to a pre-selected oil sample. 3–4 drops of demulsifier added to the oil in the vial should fulfill its specific properties according to regulatory requirements. The oil extracted from the mine is initially analyzed by appearance, and the next appearance analysis is carried out for a specified time under normal conditions. Finally, after adding the specified temperature and chemical reagent, the amount of water released from the oil is determined by mathematical express analysis method.

Results and discussion

In terms of evaluating the efficiency of the composition used in the research process, first of all, the time dependence of demulsification of both oil samples at temperatures of 40, 50, 60 and 70^{0}C was studied and the obtained results are given in Table 2.

As shown in Table 2, the amount of water released from the emulsion increases with time and with increasing temperature. Compared to Muradkhanli oil, Umbaki oil produces smaller amount of water, which can be explained by the fact that it forms a more stable water-oil emulsion.

An increase in the share of production of heavy oils capable of forming aggregative and kinetically stable water-oil emulsion systems requires improvement of traditional technologies and preparation of hydrocarbon raw materials for further processing. An important aspect in the preparation and transportation of this type of oil is the development of reagent compositions with high surface activity. In this connection, in the course of our research, a new composition A-3 was prepared from various reagents and its multi-functional properties were studied under laboratory conditions. Composition A-3 contains ND-12, Gossypol resin and isoproponol in a content ratio of 4:1.5:0.5, respectively.

The effect of A-3 composition on demulsification of crude oil samples produced from Muradkhanli and Umbaki fields at 40^{0}C was studied and the obtained results are presented in Table 3.

As can be seen from Table 3, with an increase in the concentration of the composition, the amount of released water in the tested oil samples increases and the highest result is observed at the optimum concentration. After demulsification with the presence of composition A-3 of optimum viscosity, the amount of ballast water in Muradkhanli oil samples with initial

Table 2

Demulsification of stable water-oil emulsions

Oil sample	Temperature, ^{0}C	Amount of released water, g, at different period of demulsification (s)				Amount of ballast water after demulsification, %
		0.5	1.0	1.5	2.0	
Muradkhanli	40	2.9	6.4	8.2	10.2	34.3
Umbaki		1.7	2.1	2.7	3.1	28.8
Muradkhanli	50	3.2	7.4	10.5	12.1	32.9
Umbaki		2.7	3.2	4.1	4.6	27.6
Muradkhanli	60	5.2	10.4	16.7	18.8	27.3
Umbaki		3.5	5.7	8.3	9.6	23.6
Muradkhanli	70	8.5	14.9	22.8	31.4	14.1
Umbaki		7.2	12.4	14.5	18.9	14.9

Table 3

Demulsification of oil samples in the presence of composition A-3 at 40^{0}C

Oil sample	Reagent consumption, g/t	Amount of released water, g	Residual amount of water, g	Amount of ballast water after demulsification, %
Muradkhanli	200	24.8	16.2	21.5
	400	27.1	13.9	19.1
	600	30.6	4.4	6.9
Umbaki	200	11.7	19.3	21.9
	400	17.6	13.4	16.3
	600	24.2	6.8	8.9

dilution rate of 41% and Umbaki oil samples with dilution rate of 31% becomes 6.9% and 8.9%, respectively. In order to study the effect of A-3 composition on demulsification of the mentioned emulsion oils, «bottle test» experiments were carried out in the next stage of research at temperatures of 50^0C and 60^0C for Muradkhanli oil and 50^0C, 60^0C and 70^oC for Umbaki oil. The results for A-3 composition are shown in Tables 4 and 5.

As shown in Table 4, when the concentration of composition A-3 increases between 300–600 g/t at temperatures of 50^0C and 60^0C, the amount of ballast water in the Muradkhanli oil sample with an initial dilution rate of 41% varies between 3.0–0.12% and 2.7–0.1%, respectively.

As shown in Table 5, the amount of ballast water in Umbaki oil sample with initial dilution rate of 31% varies between 10.96–4.33%, 7.71–2.26% and 1.11–0.13% at temperatures of 50^0C, 60^0C and 70^0C, respectively, while the concentration of A-3 composition is increased between 300–600 g/t. As shown in Tables 4 and 5, the percentage amount of ballast water is reduced in the presence of A-3 composition to a minimum in Muradkhanli and Umbaki oil samples at initial dilution rate of 31% and 41%, respectively.

The efficiency degree of the demulsification process of composition A-3 in demulsification was calculated using the following empirical formula based on the percentage amount of ballast water in a 100 gram oil sample:

$$Z(\%) = \frac{V_0 - V}{V_0} \cdot 100\%,$$

where Z is the composition efficiency (%); V_0 is the amount of water before demulsification; and V is the amount of ballast water after demulsification.

It was found that in the process of demulsification of Muradkhanli oil sample with the initial dilution rate of 41% at temperatures of 50^0C and 60^0C, the concentration of A-3 composition increased in the range of 300–600 g/t, with the change of efficiency index in the range of 92.7–99.7% and 93.4–99.8%,

Table 4

Demulsification of Muradkhanli oil sample with presence of A-3 composition

Initial dilution rate, %	Demulsification temperature, ^{0}C	Consumption, g/t	Amount of released water, vol.%				Percentage of residual water, vol.%	Amount of ballast water after deemulsification, %
			30	60	90	120		
41	50	300	59.7	78.9	91.2	95.4	4.6	3.0
		400	67.2	87.4	93.5	97.8	2.2	1.5
		500	78.1	90.7	95.2	99.1	0.9	0.6
		600	81.3	93.6	97.4	99.82	0.18	0.12
41	60	300	63.4	82.6	93.1	96	4.0	2.7
		400	70.4	88.7	95.3	98	2.0	1.4
		500	81.6	92.4	97.1	99.4	0.6	0.4
		600	85.7	94.8	98.3	99.86	0.16	0.1

Table 5

Demulsification of Umbaki oil sample in the presence of composition A-3

Initial dilution rate, %	Demulsification temperature, ^{0}C	Consumption, g/t	Amount of released water, vol.%				Percentage of residual water, vol.%	Amount of ballast water after deemulsification, %
			30	60	90	120		
31	50	300	57.4	61.9	67.2	72.6	27.4	10,96
		400	65.3	70.4	76.7	81.5	18.5	7.67
		500	68.6	70.7	75.3	84.2	15.8	6.63
		600	71.3	79.8	87.6	89.94	10.06	4.33
31	60	300	58.4	66.7	73.2	81.4	18.6	7.71
		400	64.5	73.7	80.1	83.6	16.4	6.86
		500	70.8	76.4	82.3	89.5	10.5	4.50
		600	79.6	88.2	91.4	94.86	5.14	2.26
31	70	300	65.4	86.7	94.2	97.5	2.5	1.11
		400	72.4	89.5	95.9	98.4	1.6	0.71
		500	83.2	93.1	97.8	99.5	0.5	0.22
		600	87.2	96.3	99.6	99.72	0.28	0.13

respectively. In the process of demulsification of Umbaki oil sample with the initial dilution rate of 31% at temperatures of 50⁰C, 60⁰C and 70⁰C, the increase in the concentration of A-3 composition in the range of 300–600 g/t results in the change of efficiency index in the range of 65.8–86.0%, 75.1–92.7% and 96.4–99.6%, respectively.

Therefore, the reduction in the percentage of required ballast water to a minimum in both the Muradkhanli and Umbaki oil samples, initially diluted at 41% and 31%, respectively, upon the addition of the A-3 composition suggests a notable surface activity of the reagent. This implies that the surface activity of the A-3 composition surpasses that of natural emulsifiers present in heavy oil samples, which contribute to the formation of aggregative and kinetically stable water-oil emulsions. The development of such a property within the composition can be attributed to the emergence of positive synergism among its constituent components.

The effect of A-3 composition on the freezing point of Muradkhanli and Umbaki commercial oil samples was studied in laboratory conditions according to the method of РД 39-3-812-82 [15]. The results of laboratory studies are given in Table 6.

As can be seen from Table 6, the freezing point of Muradkhanli and Umbaki commercial oil samples at increasing the concentration of A-3 composition in the range of 200–600 g/t ranges from +8.5...+5.0⁰C to +8.5...+4⁰C and the impact effect is in the ranges of 32.0–60% and 22.7–63.6%, respectively.

The effect of the new composition A-3 on the dynamic viscosity of commercial and emulsion forms of Muradkhanli and Umbaki oil samples was also studied. The experiments were conducted in a "Reotest-2" viscometer at 20⁰C and 40⁰C for Muradkhanli oil and Umbaki oil, respectively. The change in the dynamic viscosity of Muradkhanli oil samples without added composition with increasing velocity gradient in the range of 5.4–145.8 s^{-1} was studied (Fig. 1). As can be seen, despite the increase in the volume of water in the emulsion characterized by a low viscosity value, the viscosity of the emulsion increases by more than seven times. This situation is justified by the fact that the adsorption layer and the associated solvate coating themselves have a high degree of structural viscosity. In addition, when the phase separation surface is saturated, this layer has flexibility and mechanical strength. As shown in Fig. 1, as the velocity gradient increases, the dynamic viscosity of the commercial oil and emulsion decreases. Thus, the increase in the velocity gradient from 5.4 to 145.8 leads to a decrease in the dynamic viscosity of commercial oil by 45.4%, emulsion of 5% by 51.8%, emulsion of 10% by 61%, emulsion of 20% by 73%, emulsion of 30% by 79.8% and emulsion of 41% by 84.6%.

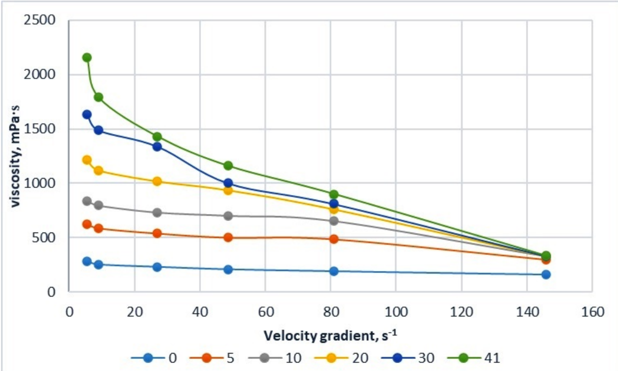

Fig. 1. Dependence of viscosity of Muradkhanli water-oil emulsion at 20⁰C on velocity gradient (without reagent)

Experimental tests were carried out by adding the optimum concentration of A-3 composition to Muradkhanli oil samples characterized by dilution rates of 5, 10, 20, 30, and 41%. The results of viscometric experiments are presented in Fig. 2. As can be seen, when adding the optimal concentration of composition A-3 at the studied velocity gradient, the dynamic viscosity of commercial oil and oil samples with a dilution rate of 5, 10, 20, 30, and 41% decreases by 60.6, 65.7, 72.2, 80.8, 85.6 and 89.0%, respectively. This shows further reduction in dynamic viscosity by 15.2%, 13.9%, 11.2%, 7.8%, 5.8% and 4.4%, respectively compared to crude oil samples.

It was experimentally studied how the dynamic viscosity changes with the change of velocity gradient in the range of 5.4–145.8 s^{-1} in the samples of Umbaki

Table 6

Effect of A-3 composition on freezing point of commercial oils

C_{A-3}, g/t		$T_{freezing}$, ⁰C		Impact effect, %	
Muradkhanli	Umbaki	Muradkhanli	Umbaki	Muradkhanli	Umbaki
0	0	+12.5	+11.0	0.0	0.0
200	150	+8.5	+8.5	32.0	22.7
400	300	+6.0	+6.0	52.0	45.5
600	450	+5.0	+4.0	60.0	63.6

oil without composition and at optimal flow rates of composition A-3, and the results obtained at a temperature of 40⁰C are shown in Figs. 3 and 4.

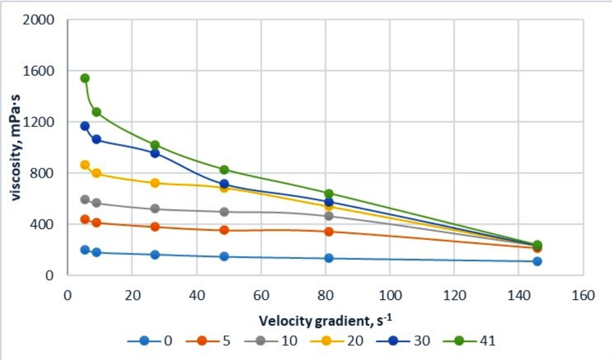

Fig. 2. Dependence of viscosity of Muradkhanli water-oil emulsion at 20⁰C on velocity gradient ((with A-3 reagent)

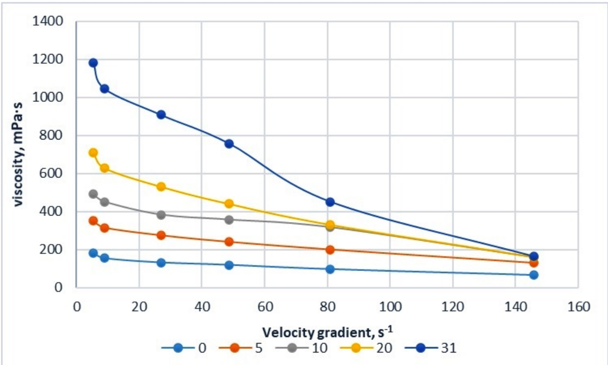

Fig. 3. Dependence of viscosity of Umbaki oil-water emulsion at 40⁰C on velocity gradient (without reagent)

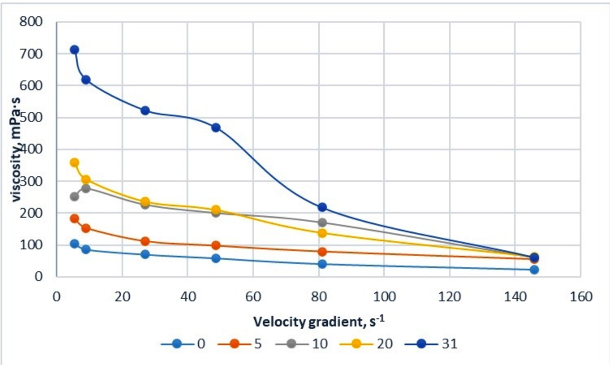

Fig. 4. Dependence of viscosity of Umbaki oil-water emulsion at 40⁰C on velocity gradient (without reagent)

As can be seen from Fig. 3, as the velocity gradient increases between 5.4–145.8 s^{-1}, the dynamic viscosity of Umbaki oil samples with dilution rate of 0.0%, 5%, 10%, 15%, 20%, and 31% without adding the composition decreases (182–64, 350–130, 490–158, 710–160, and 1183–162 mPa·s, respectively).

As follows from Fig. 4, as the velocity gradient increases between 5.4–145.8 s^{-1}, the dynamic viscosity of Umbaki oil samples with dilution rate of 0.0%, 5%, 10%, 15%, 20%, and 31% without adding the optimal consumption rate of A-3 composition decreases (105–22, 182–56, 251–61, 359–63, and 712–62 mPa·s, respectively).

The laboratory test results regarding the freezing temperature and viscosity of oil samples suggest that the novel A-3 composition exhibits depressant additive properties. This observation can be rationalized by the amalgamation of reagents with distinct purposes in specific ratios, leading to the emergence of a novel property absent in any individual constituent component of the composition.

In formation water, the presence of mineral salts, carbon dioxide, hydrogen sulfide and sulfate-reducing bacteria generating water-oil emulsion causes electrochemical corrosion of internal surface of transport preparation facilities. In this connection, along with demulsifying effect of Gossypol resin and A-3 composition as a corrosion reagent included in the composition, the corrosion protection effect was studied too. Hydrogen sulfide formation water was used as an aggressive corrosive medium. The corrosion rate was determined by gravimetric method in both agent-free and reagent-free medium and the corrosion protection effects of Gossypol resin and A-3 composition were calculated (Tables 7 and 8). As shown in Table 7, when the amount of gossypol resin increases by 100, 150, and 200 g/t, its protection efficiency gets the value of 68%, 84%, and 90%, respectively. Table 8 shows that the protection efficiency of A-3 composition at concentration of 200, 400, and 600 g/t is equal to 81%, 93%, and 98% respectively.

The comparative analysis of the experimental data presented in Tables 7 and 8 reveals that the corrosion protection effectiveness of the A-3 composition exceeds that of Gossypol resin, which serves as a corrosion agent.

Therefore, the comparative analysis of the aforementioned results indicates that the extensive utilization of the A-3 composition in mining conditions proves to be more economically and ecologically efficient, enhancing the transportation process by significantly reducing the pronounced demulsification effect, freezing temperature, and viscosity, and demonstrating high corrosion protection during the preparation of heavy oils with stable water-oil emulsions for transportation. This is because the multifunctional A-3 composition facilitates emulsion breakdown, enhances transportation, shields the inner

Table 7

Corrosion protection effect of Gossypol resin in hydrogen sulfide formation waters

C_{inh}, g/t	S, m^2	m_1, g	m_2, g	m_1–m_2, g	K_0, g/m^2·s	K_{inh}, g/m^2·s	γ	K_p, mm/year	Z, %
0	0.0013	8,6697	8.6589	0.0108	1.3840	0	0	0	0
100			8.6662	0.0035		0.4429	3.12	0.496	68
150			8.6679	0.0017		0.2214	6.25	0.248	84
200			8.6686	0.0011		0.1384	10	0.155	90

Table 8

Corrosion protection effect of composition A-3 in hydrogen sulfide formation waters

C_{inh}, g/t	S, m^2	m_1, g	m_2, g	m_1–m_2, g	K_0, g/m^2·s	K_{inh}, g/m^2·s	γ	K_p, mm/year	Z, %
0	0.0013	8.6697	8.6589	0.0108	1.3840	0	0	0	0
200			8.6676	0.0002		0.2629	5.26	0.294	81
400			8.6689	0.0007		0.0968	14.29	0.108	93
600			8.6694	0.0002		0.0277	49.96	0.031	98

surface of transportation preparation equipment and pipelines from corrosion, and prolongs the intervals between their operation and maintenance.

Conclusions

1. A new composition with conventional name A-3 was prepared for the first time under laboratory conditions using reagents of three different purposes; its properties were studied using Muradkhanli and Umbaki oil samples as a research object. It was established that the new composition is multifunctional and has a complex effect. In the course of experiments, the composition consumption rates of 200, 400, 600 g/t were taken, and the optimal rate of its consumption was revealed to be 600 g/t.

2. The amount of ballast water was 6.9%, 0.12%, and 0.1% depending on the effect of optimal concentration of A-3 composition for two hours on demulsification of crude oil samples produced in Muradkhanli field at temperatures of 40^0C, 50^0C, and 60^0C, respectively. The amount of ballast water was 8.9%, 4.3%, 2.26% and 0.13% when the composition was affected on demulsification of Umbaki crude oil samples at temperatures of 40^0C, 50^0C, 60^0C, and 70^0C, respectively.

3. When adding the optimal concentration of composition A-3, the dynamic viscosity of commercial and Muradkhanli oil samples with dilution rates of 5, 10, 20, 30, and 41% decreases by 60.6, 65.7, 72.2, 80.8, 85.6 and 89.0%, respectively. This shows a further decrease in dynamic viscosity by 15.2%, 13.9%, 11.2%, 7.8%, 5.8% and 4.4%, respectively, compared to the uncomposed oil samples.

4. When the velocity gradient increases in the range of 5.4–145.8 s^{-1} and the optimal consumption rate of the A-3 composition is added, the dynamic viscosity of Umbaki oil samples with dilution rate of 0.0%, 5%, 10%, 15%, 20%, and 31% decreases between 105–22, 182–56, 251–61, 359–63, and 712–62 mPa·s, respectively.

5. It was found that composition A-3 in hydrogen sulfide formation water showed a high corrosion protection effect. Thus, corrosion protection efficiency of A-3 composition at the concentration of 200, 400, and 600 g/t was 81%, 93%, and 98% respectively.

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ДОСЛІДЖЕННЯ БАГАТОФУНКЦІОНАЛЬНОЇ КОМПОЗИЦІЇ У ПІДГОТОВЦІ ТА ТРАНСПОРТУВАННІ ВАЖКИХ НАФТ

Айсель В. Гасимзаде

За лабораторних умов уперше було досліджено нову композицію, що складається з ND-12, смоли госсипол і ізопропанолу в співвідношенні 4:1.5:0.5, позначену як А-3. Було вивчено її ефективність у демульсифікації зразків важкої нафти з родовищ Мурадханли та Умбаки зі ступенем емульсії відповідно 41% і 31%, а також її вплив на температуру замерзання, динамічну в’язкість і швидкість корозії у воді водоносного шару з сірководнем. Оптимальна концентрація реагенту була визначена як 600 г/т. Протягом двох годин демульсифікація нафти з родовища Мурадханли проводилася при 40^{0}С, 50^{0}С і 60^{0}С, а нафти з родовища Умбаки – при 40^{0}С, 50^{0}С, 60^{0}С і 70^{0}С. Мінімальна кількість баластної води за участі оптимальної товщини композиції була виявлена при 60^{0}С для нафти Мурадханли і 70^{0}С для нафти Умбаки, становлячи 0.1% і 0.13%, відповідно. Температура замерзання нафти Мурадханли знизилася з +12.5^{0}С до +5^{0}С, а нафти Умбаки – з +11^{0}С до +4^{0}С завдяки оптимальному ефекту в’язкості композиції А-3. При +20^{0}С, з 600 г/т композиції А-3, динамічна в’язкість нафти Мурадханли зменшилася з 201 Па·с до 111 Па·с і з 1540 Па·с до 237 Па·с для ступенів емульсії 0.0%, 5%, 10%, 20%, 30% і 41%. При +40^{0}С динамічна в’язкість нафти Умбаки зменшилася з 182 Па·с до 64 Па·с і з 1183 Па·с до 163 Па·с для ступенів емульсії 0.0%, 5%, 10%, 20% і 31%. Крім того, композиція А-3 виявила вищу ефективність впливу на швидкість корозії у водоносному шарі з сірководнем порівняно з її складовою смолою госсипол. В той час як ефект захисту від корозії смоли госсипол при оптимальних концентраціях становив 90%, композиція А-3 дозволила досягти значення 98%. Ці результати свідчать про комплексний і синергетичний вплив композиції А-3 завдяки взаємодії її складових компонентів. На завершення, численні лабораторні випробування показали, що композиція А-3, що складається з демульсифікатора ND-12, антикорозійного агента смоли госсипол та розчинника ізопропанолу, підходить для демульсифікації, зниження температури замерзання та коригування динамічної в’язкості важких нафтових продуктів, таких як нафта Мурадханли та Умбаки, а також для ефективного впливу на швидкість корозії в кислих середовищах. Отже, застосування нової композиції А-3 рекомендується як економічно та екологічно ефективного реагенту для демульсифікації та транспортування важких нафтових продуктів у гірничих умовах, а також для захисту від корозії внутрішніх поверхонь обладнання для підготовки транспортування.

Ключові слова: демульсифікація, швидкість корозії, температура замерзання, ефективна в’язкість, композиція, реагент, деемульсифікатор.

STUDY OF A MULTIFUNCTIONAL COMPOSITION IN THE PREPARATION AND TRANSPORTATION OF HEAVY OILS

Aysel V. Gasimzade

Azerbaijan State Oil and Industry University, Baku, Republic of Azerbaijan

e-mail: qasimzade92@inbox.ru

Under laboratory conditions, a novel composition comprising ND-12, Gossypol resin, and isopropanol in a ratio of 4:1.5:0.5, denoted as A-3, was investigated for the first time. Its efficacy in the demulsification of Muradkhanli and Umbaki heavy oil samples, with emulsion degrees of 41% and 31% respectively, was studied, along with its effects on freezing point, dynamic viscosity, and corrosion rate in hydrogen sulfide reservoir water. The optimal concentration of the reagent was determined to be 600 g/t. Over a two-hour period, the demulsification of Muradkhanli oil was conducted at 40^0C, 50^0C, and 60^0C, and of Umbaki oil at 40^0C, 50^0C, 60^0C, and 70^0C. The minimum amount of ballast water, with optimal composition thickness participation, was observed at 60^0C for Muradkhanli oil and 70^0C for Umbaki oil, constituting 0.1% and 0.13%, respectively. The freezing temperature of Muradkhanli oil decreased from $+12.5^0$C to $+5^0$C, and Umbaki oil from $+11^0$C to $+4^0$C due to the optimal viscosity effect of A-3 composition. At $+20^0$C, with 600 g/t of composition A-3, the dynamic viscosity of Muradkhanli oil decreased from 201 Pa·s to 111 Pa·s and from 1540 Pa·s to 237 Pa·s for emulsion degrees of 0.0%, 5%, 10%, 20%, 30%, and 41%. At $+40^0$C, the dynamic viscosity of Umbaki oil decreased from 182 Pa·s to 64 Pa·s and from 1183 Pa·s to 163 Pa·s for emulsion degrees of 0.0%, 5%, 10%, 20%, and 31%. Furthermore, A-3 composition exhibited higher efficiency in affecting the corrosion rate in hydrogen sulfide formation water compared to its constituent Gossypol resin. While the corrosion protection effect of Gossypol resin at optimal concentrations was 90%, A-3 composition reached 98%. These results indicate the complex and synergistic effects of the A-3 composition due to its constituent components. In conclusion, numerous laboratory tests revealed that the A-3 composition, comprising ND-12 demulsifier, corrosion agent Gossypol resin, and isopropanol solvent, is suitable for the demulsification, freezing point reduction, and dynamic viscosity adjustment of heavy oils such as Muradkhanli and Umbaki, as well as for effectively influencing corrosion rates in acidic environments. Therefore, the application of the new A-3 composition is recommended as an economically and ecologically efficient reagent for demulsification and transportation of heavy oils in mining conditions, as well as for corrosion protection of internal surfaces of transportation preparation facilities.

Keywords: demulsification; corrosion rate; freezing point; effective viscosity; composition; reagent; demulsifier.

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