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Research of the deemulsification and corrosion protection properties of a new multi-functional composition

Badanie właściwości demulgujących i antykorozyjnych nowej kompozycji wielofunkcyjnej

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ABSTRACT: This article presents the results of laboratory experiments on the effect of Dissolvan-4411 demulsifier and DM composition on the deemulsification of a Bulla-sea field oil sample with a dilution rate of 75%, as well as the effect of MARZA-1 inhibitor and DM composition on the corrosion rate in formation water with a mixed aggressive medium. The demulsification process was conducted at temperatures of 20°C, 40°C, and 60°C, with both reagents tested at concentrations of 300–600 g/t. Based on multiple tests, the DM composition demonstrated higher efficiency compared to the Dissolvan 4411 demulsifier at the same concentration. Specifically, the amount of residual water in the oil sample with 75% dilution at the optimal consumption concentration of 600 g/t was 1.3 for the Dissolvan 4411 demulsifier and 0.2% for the DM composition. Additionally, the effect of MARZA-1 inhibitor and DM composition in aggressive media containing hydrogen sulfide, carbon dioxide, and a combination of both gases were investigated, along with their impact on corrosion protection and the vital functions of Postgate-B nutrient medium in relation to sulfate-reducing bacteria. The experiments determined that the optimal consumption rate was 10 mg/l for the MARZA-1 inhibitor and 600 g/t for the DM composition. At these optimal concentrations, the corrosion protection efficiency of MARZA-1 inhibitor and DM composition was 97.6% and 99.3% in a hydrogen sulfide medium, 95.2%, and 98.1% in a carbon dioxide medium, and 93.8%, 95% in the medium where both gases were present. Regarding sulfate-reducing bacteria, the bactericidal effect of the MARZA-1 inhibitor was 90%, while that of the DM composition was 99%.

Key words: demulsifier, inhibitor, composition, dilution factor, corrosion, protection effect, sulfate-reducing bacteria.

STRESZCZENIE: W niniejszym artykule przedstawiono wyniki eksperymentów laboratoryjnych dotyczących wpływu demulgatora Dissolvan-4411 i kompozycji DM na deemulgację próbki oleju ze złoża Bulla przy rozcieńczeniu 75%, a także wpływu inhibitora MARZA-1 i kompozycji DM na tempo korozji w wodzie złożowej z mieszanym agresywnym medium. Proces demulgowania przeprowadzono w temperaturach 20°C, 40°C i 60°C, przy czym oba odczynniki testowano w stężeniach 300–600 g/t. W oparciu o wielokrotne testy, kompozycja DM wykazała wyższą skuteczność w porównaniu do demulgatora Dissolvan 4411 w tym samym stężeniu. W szczególności ilość wody resztkowej w próbce ropy o 75% stopniu rozcieńczenia przy optymalnym stężeniu 600 g/t wynosiła 1,3% dla deemulgatora Dissolvan-4411 i 0,2% dla kompozycji DM. Dodatkowo zbadano wpływ inhibitora MARZA-1 i składu DM w agresywnych mediach zawierających siarkowodór, dwutlenek węgla i kombinację obu gazów, a także ich wpływ na ochronę antykorozyjną i funkcje życiowe pożywki Postgate-B w odniesieniu do bakterii redukujących siarczany. Eksperymenty wykazały, że optymalne dawki wynosiły 10 mg/l dla inhibitora MARZA-1 i 600 g/t dla kompozycji DM. Przy tych optymalnych stężeniach skuteczność ochrony antykorozyjnej inhibitora MARZA-1 i kompozycji DM wynosiła 97,6% i 99,3% w środowisku siarkowodoru, 95,2% i 98,1% w środowisku dwutlenku węgla oraz 93,8% i 95% w środowisku, w którym obecne były oba gazy. W odniesieniu do bakterii siarczanoredukcyjnych działanie bakteriobójcze inhibitora MARZA-1 wynosiło 90%, natomiast kompozycji DM – 99%.

Słowa kluczowe: deemulgator, inhibitor, kompozycja, współczynnik rozcieńczenia, korozja, efekt ochronny, bakterie redukujące siarczany.

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Introduction

Mineral oils differ from formation soils in terms of their concentration and other quality indicators. Strict requirements are imposed on quality parameters such as the content of water, sulfur, chlorine salts, mechanical impurities, and paraffin in the oils that enter the processing stages after preparation for transportation. Currently available mathematical models and techniques do not allow for the precise determination or prediction of the quality indicators of various types of studied oils and their mixtures with the accuracy required for engineering calculations. Furthermore, during in-field oil collection, the well product continuously changes its physicochemical and rheological properties, as well as its commodity qualities. For this reason, failing to account for the structural and commodity characteristics of well products – particularly those diluted to varying degrees and transported through technological pipelines – may result in the selection of an inadequately justified mathematical model and calculation method, ultimately leading to increased complications and energy costs, as well as inaccurate accounting of oil in mines (Simon et al., 2010; Nebogina and Yudina, 2020; Khrisonidi et al., 2021; Hadi and Ali, 2022).

The preparation of oil for transportation in mines is considered one of the most critical stages in the main processes of oil extraction. Research has shown that one of the key factors contributing to difficulties and additional costs in oil collection and preparation for transportation is oil dilution. The degree of dilution – specifically, the amount of water contained in the oil – acts as ballast and can lead to increased transportation costs. In most cases, the emulsion of water in oil, i.e. the degree of dispersion, is considered an important characteristic of water-oil emulsions and determines their main properties. However, due to certain objective limitations, accurately determining the degree of water dispersion in oil under mining conditions is not always feasible.

Taking into account the above-mentioned issues, an important step is conducting laboratory studies using the "droplet sample" method to determine the water dispersibility or dilution rate of oil. It should be noted that the "droplet sample" method has been known in scientific research for a long time and has been successfully applied to the analysis of diesel oils (Ismayilov et al., 2011; Adygezalova et al., 2016; Bahadori, 2016; Gurbanov and Qasimzade, 2024).

Depending on the stability and other properties of oil emulsions, various methods are studied globally for oil emulsion dehydration (demulsification). In most cases, thermochemical demulsification method is applied for demulsification of hard-to-break emulsions. This method typically involves the use of various reagents – demulsifiers – along with the heat factor. The technological method of deemulsification should be carried out in such a way as to ensure the maximum amount of dehydrated oil with the lowest residual water, and at the same time the consumption of demulsifier should be minimal. Notably, complications arising during the production, storage, preparation for transportation, and transportation of high-paraffin oils with a high freezing manifests as deposits on the internal surface of pipelines and technological facilities. The most effective way to prevent these issues is the application of chemical reagents (Ashrafizadeh et al., 2012; Zolfagharia et al., 2016; Adeyanju and Oyekunle, 2019; Wang et al., 2021; Hadi and Ali, 2022). On the other hand, it should be noted that one of the main problems of oilfield equipment operating in complex working conditions is electrochemical corrosion of its internal surfaces. Corrosion protection of remains a real problem, as the economic losses due to internal surface corrosion in developed oil industry countries amount to billions of dollars. The primary factors contributing to intense electrochemical corrosion of the internal surfaces of pipelines and facilities include the presence of hydrogen sulfide, carbon dioxide, oxygen, sulfate-reducing bacteria, and dissolved mineral salts in oil and formation waters. Corrosion of internal surfaces of equipment causes both economic and environmental damage (Vigdorovich and Tsygankova, 2011; Milovzorov et al., 2012; Dubinskaya et al., 2013; Azimov et al., 2015; Gurbanov and Mammadli, 2018; Menshikov and Shein, 2018; Gurbanov et al., 2023).

The research objective is to investigate multifunctional properties of the new composition under laboratory conditions.

Performance of work

The physical and chemical properties of Bulla-deniz field oil, analyzed under laboratory conditions with a dilution rate of 75%, are presented in Table 1.

Table 1. Physico-chemical properties of oil

Tabela 1. Właściwości fizykochemiczne ropy

Parameter	Quantity	Determination method
Water content in the sample [%]	75	SS 2477-65
Density ρ_{20}^{4} [kg/m^3]	973.8	SS 3900-85
Viscosity 20°C [mP·sec.]	2445.8	
Paraffin content [%]	12.9	SS 11851-85
Resin content [%]	9.3	SS 11851-85
Asphaltene content [%]	0.18	SS 11851-85
Freezing temperature [°C]	12	SS 20287-91
Chlorine salt content [mg/l]	493.8	–
Mechanical impurities content [mass%]	4.53	SS 11858-83

As can be seen in Table 1, the oil sample analyzed in this study belongs to the group of high paraffin oils and is characterized by a high paraffin hydrocarbon content, an elevated freezing temperature, and a water content of 75%.

In order to conduct laboratory experiments, Disolvan-4411 demulsifier and MARZA-1 inhibitor were used as individual reagents. Dissolvan-4411 demulsifier was obtained by dissolving ethylene oxide and propylene in methanol. Disolvan-4411 reagent-demulsifier modifies the structural-mechanical properties of rheologically complex oils, facilitates high-quality oil preparation, enhances its transportation efficiency. Additionally, under laboratory conditions, a new composition with conventional name DM was prepared at a 39:1 ratio of Disolvan-4411 demulsifier to MARZA-1 inhibitor.

The efficiency of the oil dehydration process was investigated under laboratory conditions by measuring the emulsion decomposition time as a result of the tests conducted without reagent and with reagent according to the generally accepted methodology, i.e. "bottle test". The amount of water settled in the bottle during deemulsification and the residual water content in the oil were determined based on the balance after deposition. Disolvan-4411 reagent, currently used as a demulsifier in field facilities for oil emulsion dehydration, was tested for effectiveness. To this end, oil samples with varying dilution levels were treated with different reagent concentrations, and the temperature was maintained at 20°C, 40°C, 60°C throughout the study. The efficiency of oil emulsion demulsification with the demulsifier was assessed using the "bottle test" method, based on the volume of water released from a stable water-oil system over time. The water content in crude oil was determined using the Dean-Stark method. To ensure precise measurement of the volume of water released during decomposition, a special-sized separating glass funnel was utilized.

The emulsions tested underwent deposition following thermochemical treatment, and after a certain time interval, the dynamics of separation of water from oil and deposition was monitored. The residual water content in oil was calculated using the following formula:

$$W = \frac{m_0 - m}{m_0} \cdot 100 \qquad (1)$$

where:

m_0 – initial water content before deemulsification [gr],

m – amount of water released during deemulsification [gr].

The ballast water content in the oil was determined according to the following formula:

$$X = \frac{m_0 - m}{m_1 - m} \cdot 100 \qquad (2)$$

where:

m_0 – initial water content before deemulsification [gr],

m – amount of water released during deemulsification [gr],

m_1 – amount of oil sample [gr].

The physical and chemical properties of Disolvan-4411 demulsifier are presented in Table 2.

Table 2. Physical and chemical parameters of Disolvan-4411 demulsifier

Tabela 2. Parametry fizyczne i chemiczne demulgatora Disolvan-4411

Appearance	Yellowish liquid
Composition	Ethylene oxide/propylene dissolved in methanol
Density [g/sm^3] at 20°C (ASTM D1475/DIN 51757)	0,95 ±0,02
Freezing temperature (ASTM D 97/DIN ISO 3016)	close to –36°C
Viscosity [mm^2/s] (ASTM D 445/DIN 53015)	25 mPa·s at 0°C 400 mPa·s at –20°C
pH (in 1% distilled water at 20°C)	close to 9
Ignition temperature (ASTM D 93)	11°C
Effectiveness (EQG method)	Meets the standard
Solubility at 20°C	soluble in 10% water soluble in 50% water soluble in 10% methanol soluble in 50% methanol soluble in 10% xylene soluble in 50% xylene miscible, stratified in 10% kerosene miscible, stratified in 50% kerosene

Ct-20 steel samples with dimensions 30 × 20 × 1 mm were used to determine the corrosion protection effect of MARZA-1 inhibitor and DM composition under laboratory conditions. The chemical composition of Ct-20 steel sample is given in Table 3.

Table 3. Chemical composition of Ct-20 brand steel (%)

Tabela 3. Skład chemiczny stali Ct-20 (%)

Type	C	Mn	Si	P	S	Cr	Ni	Cu	As	Fe
Ct-20	0.17–0.24	0.35–0.65	0.17–0.37	up to 0.04	up to 0.04	up to 0.25	up to 0.25	up to 0.25	up to 0.08	~98

The corrosion rate of the steel sample was determined through laboratory experiments based on mass loss. For this purpose, concentrations of 3 mg/l, 5 mg/l, 7 mg/l and 10 mg/l of MARZA-1 inhibitor (Table 4) (an organic compound with a triple bond that contains carbon, hydrogen, halogen, oxygen, etc. elemental atoms in its molecules) (Gurbanov and

Table 4. Physico-chemical characteristics of MARZA-1 reagent
Tabela 4. Właściwości fizykochemiczne odczynnika MARZA-1

Appearance	Clear, colorless liquid
Resolution	Soluble in oil, dispersible in water
Freezing temperature [°C]	–25
Relative density [20°C]	896 kg/m^3
Boiling temperature [°C]	123–125 (1 mm Hg)
Kinematic viscosity [20°C]	5.8 mm^2/sec
Ignition temperature [°C]	<38

Mammadli, 2018) and 300 g/t, 400 g/t, 500 g/t and 600 g/t of ED composition were tested for 6 hours at a temperature of 25°C.

During the experiment, the surface of the steel samples was ground, cleaned with acetone and alcohol, washed with distilled water, and treated with 15% HCl solution for 60 seconds. After surface activation they were rewashed with distilled water and dried with filter paper. After being placed in a desiccator for one hour, their mass was measured using an analytical balance. For comparison, all experiments were carried out in parallel in the same medium, both with and without inhibitors and composition.

The corrosion rate was calculated according to the following formula:

$$K = \frac{m_1 - m_2}{S \cdot \tau} \tag{3}$$

where:
m_1 – mass of the steel sample before testing [g],
m_2 – mass of the steel sample after corrosion product removal following the test [g],
S – area of the steel plate ($SN = 2ah + 2ab + 2hb$) [m^2],
τ – duration of the laboratory test [hours].

The retardation coefficient is calculated by the following mathematical expression.

$$\gamma = \frac{K_0}{K_{inh}} \tag{4}$$

where:
K_0 – corrosion rate in medium without inhibitor or composition [g/m^2·h],
K_{inh} – corrosion rate in medium containing inhibitor or composition [g/m^2·h].

The protection effect of the inhibitor or composition was calculated using the following formula.

$$Z = \frac{K_0 - K_{inh}}{K_0} 100\% \tag{5}$$

where:
K_0 – corrosion rate in a medium without inhibitor or composition [g/m^2·h],
K_{inh} – corrosion rate in a medium containing inhibitor or composition [g/m^2·h].

Penetration depth is determined by the following formula according to the corrosion rate.

$$K_p = 1.12\ K_{inh}\ \text{[mm/year]} \tag{6}$$

where:
K_p – penetration depth [mm/yr],
K_{inh} – corrosion rate [g/m^2·h].

Under laboratory conditions, the bactericidal properties of MARZA-1 inhibitor and DM composition against sulfate-reducing bacteria was investigated using Postgate-B nutrient medium (Table 5).

Table 5. Content of Postgate-B nutrient medium [g/l]
Tabela 5. Zawartość pożywki Postgate-B [g/l]

Environment name	Postgate-B
NH_4Cl	1.0
K_2HPO_4	0.5
$MgSO_4 \times 7H_2O$	2.0
$CaSO_4$	1.0
laktot-Ca	2.6
Na_2S	0.2
Na_2SO	2.0
$FeSO_4$ (5% solution in 1% HCl)	0.5

For the corrosion studies, a formation water sample taken from well No. 1082 of SOCAR's Bibiheybatneft OGPD and bacterial strains *Desulfomicrobium* and *Desulfovibrio desulforicans* were used.

The bactericidal effect of the inhibitor and the composition was calculated using the following formula based on the amount of hydrogen sulfide:

$$S[\%] = \frac{C_0 - C_{inh}}{C_{inh}} 100 \tag{7}$$

where:
C_0 – concentration of biogenic hydrogen sulfide in an inhibitory or composition-free environment [g],
C_{inh} – concentration of biogenic hydrogen sulfide in an inhibitory or composite reagent medium.

Results and their discussion

Thermochemical deemulsification of Bulla-deniz oil at 75% dilution was carried out under laboratory conditions in the presence of a reagent. The deemulsification process was performed at temperatures of 20°C, 40°C and 60°C with demulsifier dosages of 300–600 g/t and different water settling durations (40 min, 60 min, 80 min, 120 min).

The results are presented in Table 6. As can be seen in table, the efficiency of deemulsification of water-oil emulsions with the reagent at t = 20°C and t = 40°C is relatively low. The best result was achieved at 60°C. The residual water content varied from 7.5% to 2.1% within the range of 300–600 g/t concentration of Dissolvan-4411 reagent at a temperature of 60°C and is shown in Table 6.

As can be seen in Table 7, the DM composition exhibited a higher effect in comparison with Dissolvan-4411 demulsifier. The composition was most effective at 60°C, where, depending on the concentration, the residual water content in the oil varied from 1.3% to 0.2%. The dependence of the amount of ballast water on the temperature under the influence of the optimum concentration of both reagents is shown in Figure 1.

As can be seen in Figure 1, since the temperature increases, the amount of ballast water in the oil sample decreases signifi-

Table 6. Results of the deemulsification of oil from the Bulla-Deniz field
Tabela 6. Wyniki deemulsyfikacji ropy naftowej ze złoża Bulla-Deniz

Reagent name	Reagent consumption [g/t]	T [°C]	Amount of water separated at sedimentation time [min], [%]				Amount of separated water [g]	Amount of residual water after deemulsification [%]	Amount of ballast water after deemulsification [%]
			40	60	80	120			
Without reagent	–		43.7	55.8	79.9	86.9	65.20	13.1	28.6
Disolvan-4411	300	20	45.4	60.3	80.5	90.6	67.95	9.4	21.9
	400		48.6	62.7	82.8	92.7	69.53	7.3	17.9
	500		51.4	65.8	84.4	94.6	70.95	5.7	13.9
	600		54.3	68.6	89.5	95.2	71.40	4.8	12.6
	300	40	47.3	62.5	82.4	92,6	69.45	7.4	18.2
	400		49.7	64.5	89.5	94,3	70.73	5.7	14.6
	500		56.6	67.3	91.8	95,5	71.63	4.5	11.9
	600		60.5	76.4	93.2	96,9	72.68	1.3	4.8
	300	60	64.4	69.2	86.4	93.5	70.13	7.5	16.3
	400		67.3	71.5	89.8	94.2	70.65	5.8	14.8
	500		69.5	73.4	92.2	96.7	72.53	3.3	8.9
	600		72.6	76.8	94.4	97.9	73.43	2.1	5.9

Table 7. Results of the deemulsification of oil from the Bulla-Deniz field with DM composition
Tabela 7. Wyniki deemulgacji ropy ze złoża Bulla-Deniz z użyciem odczynnika DM

Reagent name	Reagent consumption [g/t]	T [°C]	Amount of water separated at sedimentation time [min], [%]				Amount of separated water [g]	Amount of residual water after deemulsification [%]	Amount of ballast water after deemulsification [%]
			40	60	80	120			
Without reagent	-		45.3	58.5	80.1	90.0	67.50	10.0	23.0
Disolvan-4411	300	20	47.6	62.1	81.8	92.3	69.23	7.7	18.8
	400		49.4	64.2	83.4	94.5	70.88	5.5	14.2
	500		52.5	66.8	86.1	95.2	71.40	4.8	12.6
	600		56.7	69.3	91.2	97.6	73.20	2.4	6.7
	300	40	49.2	66.8	84.3	94.6	70.95	5.4	1.9
	400		51.2	66.4	92.3	96.5	72.38	3.5	9.5
	500		58.8	69.1	94.9	97.8	73.35	2.2	6.5
	600		62.3	82.6	96.8	98.9	74.18	1.1	3.2
	300	60	67.2	70.3	88.2	96.5	72.38	1.3	9.5
	400		69.7	73.5	91.3	98.4	73.80	1.0	4.6
	500		71.3	75.8	93.4	99.1.	74.33	0.9	2.6
	600		74.2	78.1	95.2	99.8	74.85	0.2	0.6

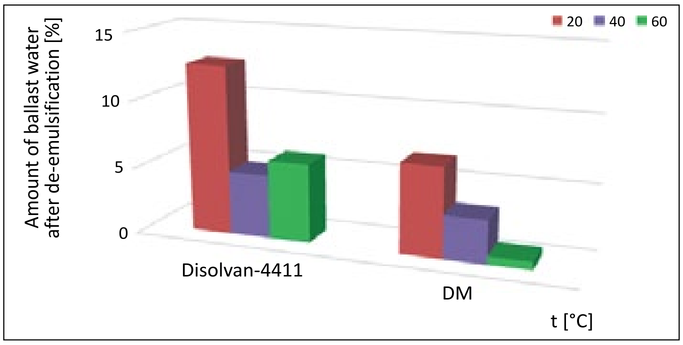

Figure 1. Dependence of the amount of ballast water after deemulsification on temperatures

Rysunek 1. Zależność ilości wody balastowej po deemulgacji od temperatury

cantly. The greatest reduction of ballast water occurs in the presence of DM composition.

Inhibitory and bactericidal properties of MARZA-1 inhibitor and DM composition were investigated under laboratory conditions. The inhibitor property of the reagents was investigated in the aggressive corrosion medium where hydrogen sulfide, carbon dioxide and both gases coexist. Table 8 shows the results of laboratory tests conducted for 6 hours at room temperature.

As can be seen in Table 8, the protection effect of MARZA-1 inhibitor at concentrations of 3 mg/l, 5 mg/l, 7 mg/l, 10 mg/l in H_2S medium ranged from 89.4% to 97.6%, while for the DM composition at 300 g/t, 400 g/t, 500 g/t, 600 g/t, it ranged from 90.6% to 99.3%. In CO_2 medium with inhibitor, these indicators vary in the range of 79.2–95.3% and 81.2–98.1%, respectively. It is observed that the protection effect increases with the increase in its concentration in $H_2S + CO_2$ medium. In other media the protection effect changes in the range of 76.2–93.1% with the presence of the inhibitor, and 80.6–95.1% with the presence of the DM composition. The analysis of the results suggests that the highest value of the protection effect is in hydrogen sulfide medium. When comparing the results obtained in all three aggressive media, it was found that the DM composition showed a higher protection effect in comparison with MARZA-1 inhibitor. At the same time, the good results obtained correspond to 10 mg/l

Table 8. Dependence of the amount of ballast water after deemulsification on temperatures

Tabela 8. Zależność ilości wody balastowej po deemulgacji od temperatury

C [g/t]	S [m²]	m_1 [g]	m_2 [g]	$m_1–m_2$ [g]	K_0 [g/m²•h]	K [g/m²•h]	γ	K_p [mm/year]	Z [%]
Marza-1 inhibitor in H_2S medium									
0	0.0013	8.6697	8.66630	0.003400	0.4328	–	–	–	–
3	0.0013	8.6697	8.66930	0.000300	0.4328	0.0459	9.43	0.05141	89.4
5	0.0013	8.6697	8.66950	0.000200	0.4328	0.0294	14.72	0.03293	93.2
7	0.0013	8.6697	8.66960	0.000100	0.4328	0.0203	21.32	0.02274	95.3
10	0.0013	8.6697	8.66960	0.000081	0.4328	0.0104	41.62	0.01165	97.6
C_{comp}	**DM composition H_2S medium**								
0	0.0013	8.6697	8.66630	0,003400	0.4328	–	–	–	–
300	0.0013	8.6697	8.66938	0.000320	0.4328	0.0407	10.63	0.04558	90.6
400	0.0013	8.6697	8.66951	0.000193	0.4328	0.0247	17.52	0.02766	94.3
500	0.0013	8.6697	8.66960	0.000100	0.4328	0.0121	35.77	0.01355	97.2
600	0.0013	8.6697	8.66967	0.000023	0.4328	0.0030	144.27	0.00336	99.3
Marza–1 inhibitor in CO_2 medium									
0	0.0013	8.6697	8.66782	0.001880	0.2417	–	–	–	–
3	0.0013	8.6697	8.66931	0.000390	0.2417	0.0503	4.81	0.05634	79.2
5	0.0013	8.6697	8.66941	0.000290	0.2417	0.0375	6.45	0.04200	84.5
7	0.0013	8.6697	8.66958	0.000120	0.2417	0.0155	15.59	0.01736	93.6
10	0.0013	8.6697	8.66961	0.000089	0.2417	0.0115	21.02	0.01288	95.3
C_{comp}	**DM composition CO_2 medium**								
0	0.0013	8.6697	8.66782	0.001880	0.2417	–	–	–	–
300	0.0013	8.6697	8.66968	0.000020	0.2417	0.0024	100.71	0.00269	81.2
400	0.0013	8.6697	8.66947	0.000230	0.2417	0.0283	8.54	0.03169	88.3
500	0.0013	8.6697	8.66963	0.000070	0.2417	0.0092	26.27	0.01030	96.2
600	0.0013	8.6697	8.66966	0.000040	0.2417	0.0046	52.54	0.00515	98.1

cont. Table 8/cd. Tabela 8

C [g/t]	S [m^2]	m_1 [g]	m_2 [g]	m_1–m_2 [g]	K_0 [g/m$^2 \cdot$ h]	K [g/m$^2 \cdot$ h]	γ	K_p [mm/year]	Z [%]
Marza–1 inhibitor in $H_2S + CO_2$ medium									
0	0.0013	8.6697	8.66703	0.002670	0.3414	–	–	–	–
3	0.0013	8.6697	8.66906	0.000640	0.3414	0.0816	4.18	0.09139	76.2
5	0.0013	8.6697	8.66938	0.000320	0.3414	0.0413	8.27	0.04626	87.9
7	0.0013	8.6697	8.66949	0.000210	0.3414	0.0263	12.98	0.02946	92.3
10	0.0013	8.6697	8.66952	0.000180	0.3414	0.0236	14.47	0.0264	93.1
C_{comp}	**DM composition $H_2S + CO_2$ medium**								
0	0.0013	8.6697	8.66703	0.002670	0.3414	–	–	–	–
300	0.0013	8.6697	8.66912	0.000520	0.3414	0.0662	5.16	0.07414	80.6
400	0.0013	8.6697	8.66947	0.000230	0.3414	0.0297	11.49	0.03326	91.3
500	0.0013	8.6697	8.66956	0.000140	0.3414	0.0178	19.18	0.01994	94.8
600	0.0013	8.6697	8.66957	0.000130	0.3414	0.0167	20.44	0.01870	95.1

S – sample area [m^2]; m_1 – mass of the sample to be tested [g]; m_2 – mass after test [g]; m_1–m_2 – sample mass loss [g]; K_0 – corrosion rate of the sample in reagent–free medium [g/m^2·h]; K – corrosion rate in the presence of reagent [g/m^2·h]; γ – retardation factor; K_p – penetration coefficient; Z – corrosion inhibitor protection degree [%]

concentration of the inhibitor, and 600 g/t concentration of the DM composition. Thus, the optimal concentrations were determined as 10 mg/l for MARZA-1 and 600 g/t for the DM composition.

Inhibitory and bactericidal properties of the composition were also investigated. The effect of the reagents on the vital functions of two types of bacteria *Desulfomicrobium* and *Desulfovibrio desulforicans* in Postgate-B nutrient medium was observed for 15 days based on the results of laboratory tests. The bactericidal effect of MARZA-1 inhibitor and DM composition was calculated by changing the concentration of hydrogen sulfide (Figure 2).

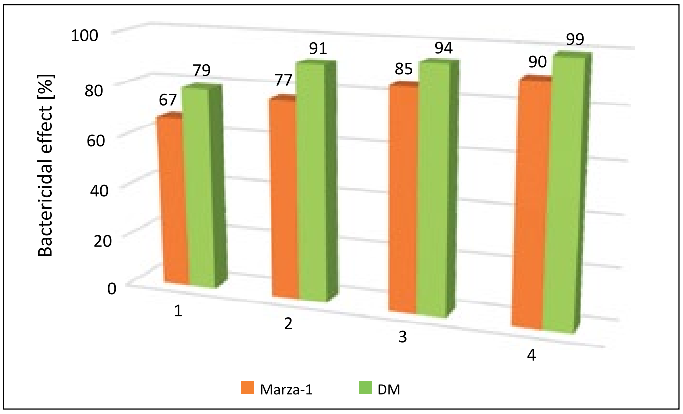

Figure 2. Bactericidal effect of Marza-1 inhibitor and DM reagent based on the amount of hydrogen sulfide: Marza-1: 1 – 3 mg/l; 2 – 5 mg/l; 3 – 7 mg/l; 4 – 10 mg/l; DM: 1 – 300 g/t; 2 – 400 g/t; 3 – 500 g/t; 4 – 600 g/t

Rysunek 2. Bakteriobójcze działanie inhibitora Marza-1 i odczynnika DM w zależności od ilości siarkowodoru: Marza-1: 1 – 3 mg/l; 2 – 5 mg/l; 3 – 7 mg/l; 4 – 10 mg/l; DM: 1 – 300 g/t; 2 – 400 g/t; 3 – 500 g/t; 4 – 600 g/t

As shown in Figure 2, at concentrations of 3–10 mg/l, the bactericidal effect of MARZA-1 inhibitor ranged from 68% to 90%, whilst at concentrations of 300–600 g/t, the effect of the DM composition, it ranged from 80% to 97%. The highest bactericidal effect was observed at 10 mg/l of MARZA-1 inhibitor (90%) and 600 g/t of DM composition (97%). Although biogenic hydrogen-sulfide content in the Postgate B nutrient medium with the presence of both inhibitor and composition sulfate-reducing bacteria was observed to decrease sharply, sulfate reduction process did not stop completely. By day 15 of the experiments, the inhibitor had destroyed 90% of the sulfate-reducing bacteria, and the composition had destroyed 97% of sulfate-reducing bacteria and stopped their vital functions.

Conclusion

1. The effect of Dissolvan-4411 demulsifier and DM composition on the deemulsification of Bulla-deniz field oil at 75% dilution rate was investigated for the first time under laboratory conditions. The optimal dosage for both the demulsifier and the composition was found to be 600 g/t. At the temperature of 60°C, the residual and ballast water contents were 2.2%, 5.9%, and 0.2%, 0.6%, respectively.
2. The effect of MARZA-1 inhibitor and DM composition on corrosion rate in formation water medium with hydrogen sulfide, carbon dioxide and mixture of both gases and vital functions of sulfate-reducing bacteria in Postgate-B medium was investigated. At the optimum consumption rate of the inhibitor and the composition, the corrosion protection effect was observed to be 97.6 and 99.3% in hydrogen sulfide

medium, 95.2% and 98.2% in carbon dioxide medium, and 93.1% and 95.1% in hydrogen sulfide and carbon dioxide medium, and the bactericidal effect was 90% and 99%.

3. As a result of the research, it has been determined that new DM composition and Dissolvan 4411 demulsifier has a higher effect in comparison with MARZA-1 inhibitor, and it is proposed to be widely used as an economically beneficial multifunctional reagent in mining conditions.

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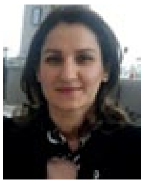

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