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ORIGINAL RESEARCH ARTICLE

Nanodemulsifiers with the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors

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ABSTRACT

The provided material presents a priority article on the scientific discovery titled “The phenomenon of simultaneous destruction of water-oil and oil-water emulsions”. The authors propose the corresponding formula: the previously unknown phenomenon of simultaneous destruction of water-oil and oil-water emulsions occurs when polynanostructured surfactant demulsifiers with characteristics akin to crystalline liquids, intramolecular interblock activity, and enduring intramolecular nanomotors (such as block copolymers of ethylene and propylene oxides, which act as sources of oligomer homologues of oxyethylene ethers) are added to crude oil during primary oil processing. This phenomenon is attributed to the redistribution of oligomer homologues, with the most hydrophobic oxyethylene ethers being dispersed in water-oil emulsions and the most hydrophilic ones in oil-water emulsions, resulting in robust nanodispersed phases with crystalline liquid properties.

Keywords: the phenomenon of simultaneous destruction of water-oil and oil-water emulsions; polynanostructured surfactant demulsifiers; crystalline liquids; intramolecular interblock activity; eternal intramolecular nanomotors

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1. Introduction

The authors conducted a thorough analysis of existing literature in the field but found no specific information on the subject of “Nanodemulsifiers with the properties of crystalline liquids, intramolecular interblock activity, and eternal intramolecular nanomotors.” As a result, there are certain gaps in applied nanocolloid chemistry, particularly in relation to demulsifiers used in primary oil preparation. However, despite these gaps, the authors consider the presentation of conclusions based on the available literature data to be both intriguing and valuable.

- Academician A. H. Mirzajanzadeh is credited with laying some of the foundational principles of nanotechnology in the global context of oil production[1].
- In 2012, for the first time at the Zhetibai field of the Republic of Kazakhstan, under the leadership of R. A. Dashdiev, experimental-industrial tests (EIT) were carried out for the destruction of hard to destroy water-oil emulsions (HDWOE) using the nanodemulsifier “ND-1/4”, developed by a group of scientists at the Institute “NIPI Neftegaz” SOCAR (State Oil Company of Azerbaijan Republic). The results of the EIT were found to be successful[2];

- The liquid crystalline nanodemulsifier TND (Tyumen nanodemulsifier) was developed by scientists at Tyumen State University. However, there is currently no available data in the literature regarding the widespread application of this reagent[3];
- Research on mathematical modeling conducted by Azerbaijani scientists (G.Ch. Kalbaliev, S.R. Rasulov, etc.) related to the formation and decomposition of oil emulsions is one of the priority issues in this area[4];
- The use of reverse demulsifiers, mainly made in China, in the primary preparation of oil (PPO) practice for the purpose of splitting oil-water emulsions has not been confirmed by the results of implementation[5];
- The development and large-scale application of nanoecological technologies used for processing petroleum nanocolloids formed using PPO (primary preparation of oil) technologies is one of the priority areas of modern oilfield nanotechnology;
- No information was found on the emulsifying properties of HDWOE in relation to reverse and direct emulsions;
- No information was found on the use of demulsifiers capable of simultaneously destroying reverse, direct, and medium emulsions (or the intermediate layer, or HDWOE);
- The utilization of conventional substances, such as nonionic surfactants, as a wetting component in demulsifier compositions of new generations is regarded as favorable. However, the impact of the nonionic surfactant structure (such as alkyl radical and oxyethylene chain length) on the effectiveness of the demulsifier has been relatively underexplored.
- Prevention of the formation of persistent water-oil and oil-water emulsions in wells by chemical methods is one of the priorities of modern oilfield chemistry;
- The global market currently offers a wide range of surfactant demulsifiers, including oxyalkylene block copolymers derived from polyhydric alcohols, amines, polyamines, phenol-formaldehyde resins, epoxy resins, and silicon compounds. The selection of surfactant demulsifiers available exceeds a thousand. However, the precise distinction between conventional surfactants and surfactant demulsifiers remains an open question.
- Upon research, no existing information was found regarding the concept of a "desuspensifier" within the framework of the emulsion-emulsifier-demulsifier complex, which complements the concepts of suspension and suspensifier. The concept of a desuspensifier, introducing a new property of substances, holds promising implications for applied colloidal chemistry. This scientific discovery opens potential avenues for further exploration and investigation in the field of desuspension and related phenomena in colloidal systems[6];
- For the components of demulsifiers, issues related to the correlation between property, structure, and efficiency have also been little studied[6];
- Analyzing the relevant literature data, the authors found that nanocolloids in crude oil increase the stability of oil emulsions and form polynanoenergy barriers that reduce the effectiveness of traditional demulsifiers in dispersed and dispersed media[7];
- No information was found on nanodemulsifiers with a polynano structure;
- No relevant information was also found on the following issues: The phenomenon of simultaneous destruction of oil-water and water-oil emulsions; polynanostructured surfactants demulsifiers with the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors.
- The development of multidisciplinary nanotechnology is accompanied by the emergence of certain priority areas, for example, the creation of nanomotors[8–12]. As an example, we can briefly describe a nanomotor made of DNA material[8]. The DNA nanomotor consists of three components: a base, a

platform, and a rotor. The base is about 40 nanometers in height and is attached to the glass plate in solution via chemical bonds on the glass plate. A rotor arm up to 500 nanometers long is mounted on a base so that it can be rotated[8]. Physicists from the University of Cambridge have managed to develop a unique nanomotor. This motor uses light as its energy source[12]. Chinese scientist Professor Zhong from Shanghai University has created eternal nanogenerators (based on triboelectricity) that will produce electricity directly from air[13]. However, Zhong's eternal nanogenerators do not belong to polynanostructured nanodemulsifiers, which have the properties of crystalline liquids, intramolecular interblock activity, and eternal intramolecular nanomotors;

- Generally, there are certain gaps at the level of scientific discoveries in the field of applied nanocolloidal chemistry and nanophysics in primary preparation of oil. In several specific cases, the European Academy of Natural Sciences (EANS) has registered five scientific discoveries by authors in this direction[14–18]. This article is a priority article of the project of the sixth scientific discovery of the authors on the topic "The phenomenon of simultaneous destruction of water-oil and oil-water emulsions". For this project, a scientific discovery was registered in EANS on 5 October 2023[19].

2. Experiment

2.1. Objects and methods of research

2.1.1. Objects of research

The research for this project involved the use of multi-block demulsifiers and complex oil emulsions sourced from the fields of the Republic of Kazakhstan.

Multi-block demulsifiers.

The following were used as multi-block demulsifiers:

OPB–OEB–OPB	knowns three-blocks
OEB–OPB–OEB	knowns three-blocks
OPB–OEB–OPB–OEB–OPB	five-blocks
OPB–OEB–OPB–OEB–OPB–OEB–OPB	seven-blocks
OPB–OEB–OPB–OEB–OPB–OEB–OPB–OEB–OPB	nine-blocks
OPB–OEB–OPB–OEB–OPB–OEB–OPB–OEB–OPB–OEB–OPB	eleven-blocks

where, OPB—oxypropylene block; OEB—oxyethylene block.

For the research, well-known three-block demulsifiers were utilized: "Dissolvan-4411" (OEB–OPB–OEB), "Dissolvan-4795" (OEB-OPB-OEB), "Dissolva-4397" (OEB–OPB–OEB), "Dissolvan- 5748" (OPB–OEB–OPB), ("Clariant" of Switzerland, a subsidiary of "Basf" of Germany); "Randem-2219" (OEB–OPB–OEB), "Randem-2201" (OPB–OEB–OPB), "Randem-2208" (OPB–OEB–OPB) (Nalco USA); "SNPX-4315D" (OPB–OEB–OPB) (Russian); "F-929" ("Toho Chemical Industry Co., Ltd", Japan).

The following were used as our own multi-block demulsifiers:

"IKHLAS-1M-5" (OPB–OEB–OPB), "IKHLAS-1M-7" (OPB–OEB–OPB), "IKHLAS-1M-9" (OPB–OEB–OPB), "IKHLAS-1M-11" (OPB–OEB–OPB) (Azerbaijan-Kazakhstan-China).

Several oil fields in the Republic of Kazakhstan were selected as research objects for this study.

"Uzen" "Ozenmunaigas" JSC; "Zhetibai" "Mangistaumunaygas" JSC; "Zhalgiztobe".

2.1.2. Research methods

The quality of oil, in terms of water content (not exceeding 0.5%), chloride salts (not exceeding 100 mg/dm^3), and mechanical impurities (not exceeding 0.05%), must meet the requirements outlined in current standards[20,21]. Additionally, the quality of formation water, in terms of oil content, should not exceed 50 mg/dm^3. The experimental part of the work was conducted following widely accepted standards:

- Method for determining water in petroleum products and oil[22];
- Method for determining the content of chloride salts in oil[23];
- Method for determining the content of mechanical impurities in oil[24];
- Method for determining oil content in water[21].
- The laboratory test results are presented in **Tables 1** and **2**.

Table 1. Comparative results of laboratory tests of polynanostructured demulsifiers "IKHLAS" regarding the phenomenon of simultaneous destruction of oil-water and oil-water emulsions of the "Jetibay" field[25].

Demulsifier	**Residual consentrations**			**DSC, + or –**	**IC for HDWOE, + or –**	**C_{oil}, mg/dm^3**	**FOSDOWO & OWE + or –**
	water, %	**Cl salts, mg/dm^3**	**mech imp, %**				
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
"IKHLAS-1"	traces	11	0.004	+	+	16	+
"IKHLAS-2"	0.12	37	0.01	+	+	33	+
"IKHLAS-3"	0.06	23	0.01	+	+	32	+
"IKHLAS-4"	0.18	44	0.02	+	+	45	+
"IKHLAS-5"	0.15	36	0.01	+	+	36	+
"IKHLAS-6"	0.09	26	0.01	+	+	19	+
"IKHLAS-7"	0.12	29	0.02	+	+	43	+
"IKHLAS-8"	0.34	58	0.01	+	+	48	+
"IKHLAS-9"	0.07	14	0.009	+	+	28	+
"IKHLAS-10"	0.21	45	0.01	+	+	49	+
"IKHLAS-11"	0.09	22	0.02	+	+	24	+
"IKHLAS-12"	0.12	29	0.01	+	+	31	+
"IKHLAS-13"	0.17	42	0.03	+	+	25	+
"IKHLAS-14"	0.12	35	0.01	+	+	37	+
"IKHLAS-15"	0.10	23	0.01	+	+	20	+
"IKHLAS-16"	0.09	29	0.02	+	+	41	+
"IKHLAS-17"	0,.6	76	0.03	+	+	47	+
"IKHLAS-18"	0.27	48	0.01	+	+	24	+
"IKHLAS-19"	0.40	89	0.03	+	+	45	+
"IKHLAS-20"	0.38	91	0.04	+	+	43	+
"IKHLAS-21"	0.12	29	0.02	+	+	19	+
"IKHLAS-22"	0.32	69	0.01	+	+	38	+
"IKHLAS-23"	0.15	29	0.01	+	+	33	+
"IKHLAS-24"	0.41	87	0.025	+	+	50	+
"IKHLAS-25"	0.06	19	0.02	+	+	24	+
"IKHLAS-26"	0.06	23	0.02	+	+	17	+
"IKHLAS-27"	0.10	34	0.01	+	+	33	+

Table 1. (*Continued*).

Demulsifier	**Residual consentrations**			**DSC, + or –**	**IC for HDWOE, + or –**	**C_{oil}, mg/dm^3**	**FOSDOWO & OWE + or –**
	water, %	**Cl salts, mg/dm^3**	**mech imp, %**				
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
"IKHLAS-28"	0.38	79	0.04	+	+	40	+
"IKHLAS-29"	044	91	0.03	+	+	45	+
"IKHLAS-30"	0.25	53	0.03	+	+	46	+
"IKHLAS-31"	0.24	35	0.01	+	+	32	+
"IKHLAS-32"	0.09	16	0.005	+	+	20	+
"IKHLAS-33"	0.12	29	0.02	+	+	39	+
"IKHLAS-34"	0.19	15	0.01	+	+	25	+
"IKHLAS-35"	0.32	55	0.01	+	+	47	+
"IKHLAS-36"	0.09	16	0.009	+	+	18	+
"IKHLAS-37"	0.07	20	0.006	+	+	19	+
"IKHLAS-38"	0.27	46	0.01	+	+	35	+
"IKHLAS-39"	0.18	49	0.02	+	+	43	+
"IKHLAS-40"	0.43	92	0.04	+	+	47	+
"IKHLAS-41"	0.39	88	0.04	+	+	39	+
"IKHLAS-42"	0.36	74	0.03	+	+	44	+
Prototip [98]	0.83	423	0.07	–	–	184	–
"Randem-2219" (BD)	12.74	5087	1.96	–	–	672	–

Note: test conditions of "IKHLAS" and "Randem-2219" demulsifiers: T = 64 °C; Xs = 150 g/t; settling time τ = 3.5 h; for prototype: T = 70 °C; Xs = 200 g/t; τ = 24 h; mech imp—mechanical impurities; DSC—desuspensifier capacity[14,25]; Inhibitory capacity (IC) for HDWOE[16,25]; C_{oil}—oil concentration in water; BD—basic demulsifier; FOSDOWO&OWE—phenomenon of simultaneous destruction of oil-water and oil-water emulsions.

Table 2. Comparative results of laboratory tests of samples of various demulsifiers of some leading companies in the world for the destruction of oil emulsions from various fields of the Republic of Kazakhstan to reveal the nanobarrier properties of crude oil[7,17] (in brief form).

Demulsifier name	**Dem. effic**	**Sc, g/t**	**T_d, °C**	**τ, hours**	**Dem. stab**	**Con. of wat, %**		**DEID**		**ROCW, mg/dm^3**	**DEDER BD, at times**
						init-l W_i	**res-l W_r**	**D_d, %**	**EDIERBD, at times**		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Crude oil from the "Uzen" field of "Ozenmunaigas" JSC of RK											
5 (Chin com-y PE**)** PNS	HED	100	62	3	St DA	48	0.17	99.6	46	46	17,0
6 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0.03	99.9	260	39	20,1
7 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0	100	∞	35	22,4
8 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0	100	∞	27	29.0
9 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0	100	∞	34	23.0
10 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0	100	∞	28	27.9
11 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0.08	99.8	97	43	18.2
12 (Chin com-y PE**)** PNS	SD	100	62	3	St DA	48	0.03	99.9	260	31	25.2
Proxamine-385 (Rus)	WD	100	62	3	Stable	48	7.8	83.7	1	778	1.00
TND (Rus)	WD	100	62	3	Stable	48	2.1	95.6	3.71	73	10.7
SNPX-4315D (Rus)	WD	100	62	3	Stable	48	8.8	81.7	0.88	290	2.70
Flek-D020 (Rus)	WD	100	62	3	Stable	48	8.2	82.9	0.95	271	2.89

Table 2. (*Continued*).

Demulsifier name	Dem. effic	Sc, g/t	T_d, °C	τ, hours	Dem. stab	Con. of wat, %		DEID		ROCW, mg/dm^3	DEDER BD, at times
						init-l W_i	res-l W_r	D_d, %	EDIERBD, at times		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
NEDRA-1M (Rus)	VWD	100	62	3	ves	48	13.9	71.0	0.56	790	0.99
Dissolvan-4411 (Germ)	WD	100	62	3	hlws	48	8.0	83.3	0.97	792	0.99
Dissolvan V 5748 (Germ)	WD	100	62	3	delam	48	7.6	84.2	1.02	789	0.99
Dissolvan-4795 (Germ)	WD	100	62	3	cmf	48	9.0	81.2	0.87	630	1.24
Dissolvan-4397 (Germ)	WD	100	62	3	cmf	48	9.6	80.0	0.81	810	0.97
IKHLAS-1 PNS	SD	100	62	3	St DA	48	0	100	∞	18	43.5
IKHLAS-3 PNS	SD	100	62	3	St DA	48	0	100	∞	35	22.4
IKHLAS-37 PNS	HED	100	62	3	St DA	48	0.13	99.7	60.0	21	37.3
DEMTROL-2020 (USA DOW)	VWD	100	62	3	Stable	48	21.1	56.0	0.37	882	0.88
DEMTROL-2025 (USA DOW)	VWD	100	62	3	Stable	48	21.6	55.0	0.36	880	0.89
DEMTROL-2030 (USA DOW)	VWD	100	62	3	Stable	48	24.4	49.2	0.32	889	0.88
DMO-86520 (USA BH)	VWD	100	62	3	Cт	48	12.4	74.2	0.63	527	1.48
Randem-2208 (USA RN)	WD	100	62	3	ves	48	7.0	85.4	1.11	529	1.48
Randem-2219 (USA RN)	WD	100	62	3	Stable	48	9.5	80.2	0.82	789	0.99
Control	-	-	62	3	-	48	**34.0**	**29.2**	**0.23**	**828**	**0.95**
Randem-2201 (BD)	WD	100	62	3	ves	48	**7.8 (BD)**	**83,7**	**-**	**783(BD)**	-

Crude oil from the "Zhetybai" field of "Mangistaumunaigas" JSC of RK

Demulsifier name	Demeffic	Sc, g/t	T_d, °C	τ, hours	Dem. stab	Con. of wat, %		DEID		ROCW, mg/dm^3	DEDER BD, at times
						init-l W_i	res-l W_r	D_d, %	EDIERBD, at times		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
5 (Chin com-y PE) PNS	HED	100	64	3	St DA	45	0.12	99.7	124	47	14.5
6 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0.07	99.8	213	42	16.2
7 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0	100	∞	43	15.8
8 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0	100	∞	31	21.9
9 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0.09	99.8	165	32	21.3
10 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0.03	99.9	496	29	23.4
11 (Chin com-y PE) PNS	HED	100	64	3	St DA	45	0.15	99.7	99	49	13.9
12 (Chin com-y PE) PNS	SD	100	64	3	St DA	45	0.09	99.8	165	34	20.0
Proxamine-385 (Rus)	VWD	100	64	3	Stable	45	12.9	71.3	1,15	647	1.05
TND (Rus)	WD	100	64	3	Stable	45	3.7	91.8	2,60	81	8.4
SNPX-4315D (Rus)	WD	100	64	3	Stable	45	8.9	80.1	1.67	369	1.84
Flek-D020 (Rus)	WD	100	64	3	Stable	45	8.1	82.0	1.84	354	1.92
NEDRA-1M (Rus)	VWD	100	64	3	ves	45	13.2	70.6	1.13	830	0.82
Dissolvan-4411 (Germ)	VWD	100	64	3	hlws	45	14.8	67.1	1.00	723	0.94
Dissolvan V 5748 (Germ)	WD	100	64	3	delam	45	7.2	84.0	2.07	707	0.96
Dissolvan-4795 (Germ)	WD	100	64	3	cmf	45	7.5	83.3	2	585	1.16
Dissolvan-4397 (Germ)	VWD	100	64	3	cmf	45	9.6	78.7	1.55	764	0.89
IKHLAS-1 PNS	SD	100	64	3	St DA	45	0	100	∞	23	29.5
IKHLAS-3 PNS	SD	100	64	3	St DA	45	0.06	99.9	248	38	17.9
IKHLAS-26 PNS	SD	100	64	3	St DA	45	0	100	∞	24	28.3
IKHLAS-37 PNS	HED	100	64	3	St DA	45	0.15	99.7	99	25	27.2
DEMTROL-2020 (USA DOW)	VWD	100	64	3	Stable	45	22.8	49.3	0.65	705	0.96

Table 2. (*Continued*).

Demulsifier name	**Dem. effic**	**Sc, g/t**	**T_d, °C**	**τ, hours**	**Dem. stab**	**Con. of wat, %**		**DEID**		**ROCW, mg/dm^3**	**DEDER BD, at times**
						init-l W_i	**res-l W_r**	**D_d, %**	**EDIERBD, at times**		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
DEMTROL-2025 (USA DOW)	VWD	100	64	3	Stable	45	23.1	48.7	0.64	716	0.95
DEMTROL-2030 (USA DOW)	VWD	100	64	3	Stable	45	26.0	42.2	0.57	903	0.75
DMO-86520 (USA BH)	VWD	100	64	3	Stable	45	11.7	74.0	1.27	576	1.18
Randem-2208 (USA RN)	WD	100	64	3	ves	45	6.7	85.2	2.22	427	1.59
Randem-2201 (USA RN)	VWD	100	64	3	ves	45	10.2	77.4	1.46	601	1.13
Control	-	-	64	3	-	45	**31.2**	**30.7**	**0.48**	**875**	**0.77**
Randem-2219 (BD)	VWD	100	64	3	Stable	45	**14.9 (BD)**	**66.9**	-	**680 (BD)**	-

Crude oil from the Subsidiary LLP "Zhalgiztobemunai" field of RK

Demulsifier name	**Demeffic**	**Sc, g/t**	**T_d, °C**	**τ, hours**	**Dem. stab**	**Con. of wat, %**		**DEID**		**ROCW, mg/dm^3**	**DEDER BD, at times**
						init-l W_i	**res-l W_r**	**D_d, %**	**EDIERBD, at times**		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
5 (Chin com-y PE) PNS	HED	400	80	10	St DA	32	0.18	99.4	25	50	17.9
6 (Chin com-y PE) PNS	HED	400	80	10	St DA	32	0.12	99.6	37.5	42	21.3
7 (Chin com-y PE) PNS	HED	400	80	10	St DA	32	0.09	99.7	50	37	24.2
8 (Chin com-y PE) PNS	SD	400	80	10	St DA	32	0	100	∞	27	33.1
9 (Chin com-y PE) PNS	HED	400	80	10	St DA	32	0.09	99.7	50	39	22.9
10 (Chin com-y PE) PNS	SD	400	80	10	St DA	32	0	100	∞	27	33.1
11 (Chin com-y PE) PNS	ED	400	80	10	St DA	32	0.45	98.6	10	46	19.4
12 (Chin com-y PE) PNS	HED	400	80	10	St DA	32	0.21	99.3	21.4	33	27.0
Proxamine-385 (Rus)	VWD	400	80	10	Stable	32	9.3	70.9	0.48	917	0.97
TND (Rus)	WD	400	80	10	Stable	32	3.7	88.4	1.21	97	9.2
SNPX-4315D (Rus)	WD	400	80	10	Stable	32	5.4	83.1	0.83	911	0.98
Flek-D020 (Rus)	WD	400	80	10	Stable	32	4.9	84.7	0.92	599	1.49
NEDRA-1M (Rus)	VWD	400	80	10	ves	32	9.8	69.3	0.46	1170	0.76
Dissolvan-4411 (Germ)	VWD	400	80	10	hlws	32	11.2	65.0	0.40	1184	0.75
Dissolvan V 5748 (Germ)	WD	400	80	10	delam	32	6.2	80.6	1.73	925	0.96
Dissolvan-4795 (Germ)	WD	400	80	10	cmf	32	5.9	81.6	0.76	950	0.94
Dissolvan-4397 (Germ)	VWD	400	80	10	cmf	32	7.2	77.5	0.63	1208	0.74
IKHLAS-1 PNS	SD	400	80	10	St DA	32	0	100	∞	18	49.6
IKHLAS-3 PNS	HED	400	80	10	St DA	32	0.09	99.7	50	38	23.5
IKHLAS-26 PNS	SD	400	80	10	St DA	32	0.03	99.9	150	21	42.5
IKHLAS-37 PNS	HED	400	80	10	St DA	32	0.25	99.2	18	22	40.6
DEMTROL-2020 (USA DOW)	VWD	400	80	10	Stable	32	16.4	48.8	0.27	1405	0.64
DEMTROL-2025 (USA DOW)	VWD	400	80	10	Stable	32	17.6	45.0	0.25	1436	0.62
DEMTROL-2030 (USA DOW)	VWD	400	80	10	Stable	32	19.1	40.3	0.23	1490	0.60
DMO-86520 (USA BH)	VWD	400	80	10	Stable	32	9.3	70.9	0.48	1066	0.84
Randem-2208 (USA RN)	WD	400	80	10	ves	32	5.6	82.5	0.80	902	0.99
Randem-2219 (USA RN)	VWD	400	80	10	Stable	32	7.4	76.9	0.61	1112	0.80
Control	-	-	80	10	-	32	28	**12.5**	**0.16**	**1134**	**0.77**
Randem-2208 (BD)	WD	400	80	10	ves	32	**4.5**	**85.9**	-	**894(BD)**	-

Notes: dem. effic—demulsifier efficiency; Sc, g/t—specific consumption of demulsifiers; T_d—demulsification temperature; τ, hours—is the settling time of the bottle tests in a water bath at T_d; Dem. stab—demulsifier stability; Con. of water, %—concentration of water in oil; init-l W_i—initial water; res-l W_r—residual water; D_d—degree of demulsification, $D_d = [(W_i - W_r)/W_i]\cdot 100$, %; DEID—destruction efficiency of inverse emulsions; EDIERBD—the effectiveness of the destruction of inverse emulsions relative to the base demulsifier. EDIERBD = W_{rbd} / W_{rtd}, (at times) W_{rbd}—residual water in the case of base demulsifier, W_{rtd}—residual water in the case of test demulsifier; ROCW—residual oil concentration in water, мг/дм^3; DEDERBD—destruction efficiency of direct emulsions relative to the base demulsifier, DEDERBD = ROCW (BD) / ROCW (TD), BD—base demulsifier, td—test demulsifier; in expl—in exploitation; AOP—annual oil production per field, t; PNS—polynanostructured; St—stable; DA—desuspensifier ability; ρ—oil density, kg/m^3; T_{pp}—pour point of oil; ves-visco—elastic systems; hlws—high level of water solubility; delam—delamination; cmf—a curd mass is formed; SD—super demulsifier: D_d = 99.8–100%; HED—highly effective demulsifier: D_d = 99.0–99.8%; ED—effective demulsifier: D_d = 97.0%–99.0%; WD—weak demulsifier: D_d = 80.0%–97.0%; VWD—very weak demulsifier: D_d = up to 80.0%; BH—Baker Hughes; RN—Rauan-Nalco.

3. Results and discussions

3.1. Requirements for demulsifiers

Building upon the authors' extensive experience in the field of primary oil preparation (PPO)[26] and considering relevant literature sources[27], a comprehensive set of requirements for demulsifiers was developed for the first time at the nanotechnology level.

1) Demulsifiers must be effective, that is, ensure high quality of the resulting oil at minimum specific consumption, minimum settling time and minimum temperature;
2) Demulsifiers must have a higher surface activity in the phase into which they are introduced (dispersion medium);
3) Demulsifiers must have good dispersion properties in a dispersion medium to increase the contact surface with particles of the dispersed phase [water droplets of different sizes with molecular adsorption layers (MAL) around the perimeter];
4) Demulsifier molecules must have sufficient peptization property (sol-gel transition) to ensure its release due to adsorption on the MAL ("protective coating") formed around the particles of the dispersed phase;
5) The demulsifier molecules must have strong wetting properties towards the MAL components;
6) Demulsifier molecules should not form a continuous film around particles of the dispersed phase;
7) Demulsifiers must have low viscosity (no more than 100 mPa·s), not be subject to delamination and hardening at low temperatures for a long time (at least during the warranty period, for example 1–3 years);
8) Demulsifiers must ensure high quality of formation water separated under PPO conditions, which can allow its use in a reservoir pressure maintenance system (RPM) without additional preparation (removal of oil and mechanical impurities);
9) Demulsifiers should not cause corrosion of pipes and equipment and should not have a negative impact on the effectiveness of other reagents used (for example, scale inhibitors, paraffin deposits, corrosion inhibitors, etc.);
10) Demulsifiers should not be subjected to coagulation in formation waters;
11) Demulsifiers must have anti-foam properties;
12) It is desirable that the demulsifiers be oil-soluble nonionic surfactants (NS);
13) Demulsifiers must have a high speed of action;
14) Demulsifiers must exhibit thermodynamic and aggregative stability in various technical, thermal, technological and climat conditions of PPO;
15) Demulsifiers for the destruction of oil emulsions (W/O—reverse emulsion; O/W—direct emulsion; W/O/W—medium emulsion) and other oil nanocolloids under PPO conditions [HDWOE (hard to destroy water-oil emulsions), HDWOS (hard to destroy water-oil suspensions), trap oil, pit oil, bottom sediments of technological and commercial tanks, oil sludge, crude oil with viscoelastic properties or crude oil with structural and rheological properties; demulsifiers used to ensure high disintegration of gas hydrates, etc.] must be nanodemulsifiers with a polynano structure;
16) The surface pressure for a nanodemulsifier must be at least 40–42 mJ/m^2;

17) To ensure maximum efficiency of the thermochemical method in the processes of demulsification of all types of oil emulsions, it is more expedient for nanodemulsifiers to be in a hybrid state of aggregation of the liquid crystalline type (the concept of “hybrid state of aggregation” for organic substances is used for the first time)[26];
18) The components of the active phase of the nanodemulsifier should exhibit a synergistic effect during the breakdown of reverse, direct and medium emulsions;
19) The presence of wetting agents in the composition of a highly effective nanodemulsifier, consisting of n-aliphatic alcohols of the neonogenic surfactants type, oxyethylene esters of acids, creates maximum wetting ($\cos\alpha = 0$ or $\cos\alpha \to 0$) in the molecular adsorption layers around the particles of the dispersed phase. (“protective coating”), and the emulsions undergo complete decomposition;
20) Highly efficient nanodemulsifiers must have minimum values of interfacial tension (σ_M) at the boundaries of the water-oil partition ($\sigma_M = 0$ or $\sigma_M \to 0$);
21) Highly effective nanodemulsifiers should not exhibit emulsifying properties regardless of the specific application of the nanodemulsifier for all types of petroleum emulsions. It is for this reason that the use of demulsifiers with an antagonistic effect in PPO technologies is absolutely unacceptable;
22) It is advisable to replace surfactants injected into wells, used in these fields to increase the oil recovery factor to nanodemulsifiers (or demulsifiers);
23) By switching to full downhole demulsification using nanodemulsifiers in oil fields, it is possible to achieve the maximum elimination of possible negative consequences in primary oil treatment technologies, including the maximum level of purification of oil from formation water and salt, as well as formation water from oil;
24) Critical nanoemulsions that provide a synergistic effect with the active phase are considered one of the most suitable solvents for nanodemulsifiers;
25) The active phase of demulsifiers should not produce viscoelastic systems with a solvent;
26) Molecules of the active phase of demulsifiers should easily overcome polynanostructural barriers existing in the dispersion medium and dispersed phase of crude oil;
27) It is inappropriate to include nanopowders in demulsifiers and nanodemulsifier compositions, which can further increase the stability of oil emulsions;
28) The presence of organochlorine compounds in the composition of the demulsifier is unacceptable;
29) Surfactants with intramolecular surface activity, characterized by complex interactions simultaneously with hydrophobic and hydrophilic phases, can be highly effective demulsifiers of oil emulsions;
30) Demulsifiers may also have depressant, anti-corrosion and bactericidal properties;
31) Demulsifiers can also act as a nanodesuspensifer (the terms “nanodesuspensifer” and “desuspensifer” in general are used for the first time), allowing for the cleaning of bottom sediments of reservoirs consisting of a mixture of HDWOE and HDWOS;
32) Demulsifiers can also perform inhibitory and dissolving functions for viscoelastic systems (VES) under conditions primary preparation of oil;
33) Under conditions of primary preparation of oil, demulsifiers can also perform inhibitory and dissolving functions for gas hydrates;
34) Demulsifiers can also perform a neutralizing function against hydrogen sulfide and iron sulfide contained in oil;
35) Demulsifiers must have high surface activity for the dispersive, dispersed phases of all types of oil emulsions, as well as for the MAT phase (or “protective coating”, MAT is considered for the first time as a separate phase);
36) Demulsifiers must also operate under cold demulsification conditions;
37) The boiling point of demulsifier solvents should not be lower than 50 °C–60 °C;

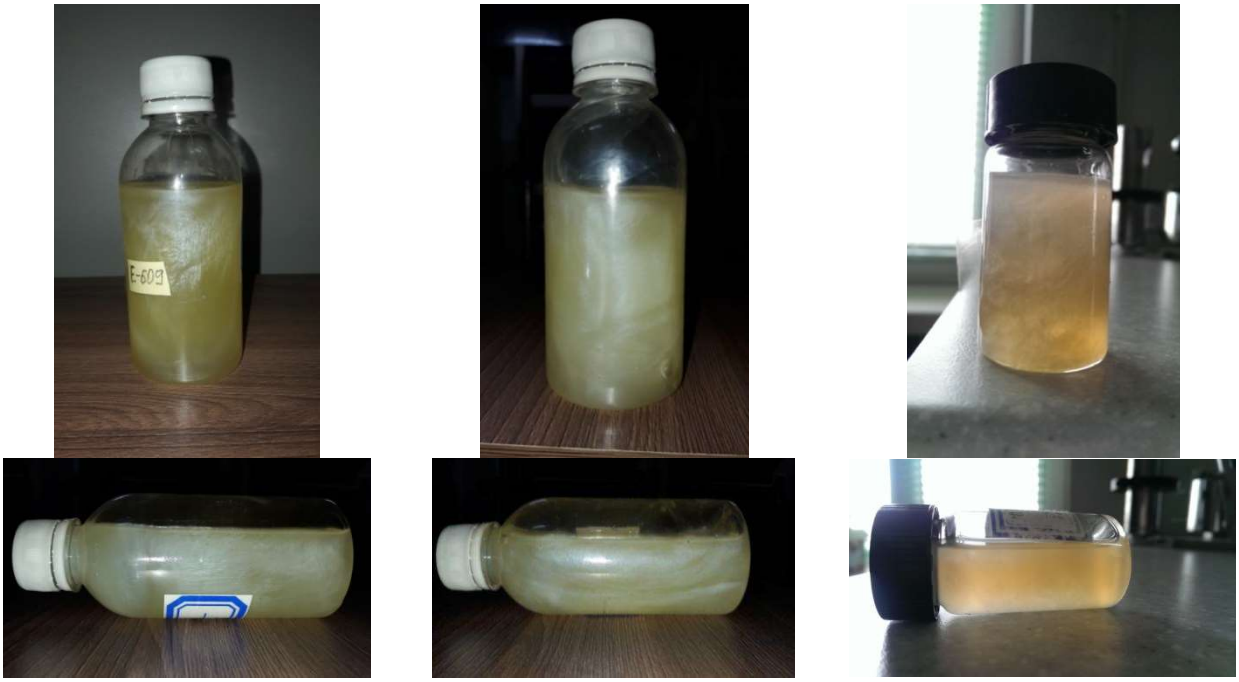
38) Demulsifier solvents should not be carcinogenic;
39) Demulsifiers should not viscoelastic systems create in oil emulsions;
40) The main reason for phase separation in demulsifiers from the point of view of system stability is the thermodynamic incompatibility of the constituent components. Therefore, the thermodynamic compatibility condition must be met for the demulsifier components;
41) Highly effective demulsifiers must have a polynano structure to easily overcome persistent polynano barriers in crude oil at relatively high asphaltene concentrations (≥3%) and relatively high crude oil densities (≥830–840 kg/m^3);
42) Highly effective demulsifiers must have the properties of crystalline liquids;
43) Highly effective demulsifiers should have the properties of eternal intramolecular nanomotors;
44) Highly effective demulsifiers should ensure the simultaneous destruction of oil-water and oil-water emulsions due to the redistribution of oligomer homologues of the most hydrophobic oxyethylene ethers in water-oil emulsions, and the most hydrophilic oligomers in oil-water emulsions with high-strength nanodispersed phases that also have the properties of crystalline liquids. In this case, demulsifiers must provide the necessary qualities of commercial oil (residual water of water no more than 0.5%; chloride salts no more than 100 mg/dm^3; mechanical impurities no more than 0.05%) and produced water (oil no more than 50 mg/dm^3) for reinjection into the reservoir in the reservoir pressure maintenance system (maintaining reservoir pressure);
45) Representatives of the newest generation of highly effective demulsifiers should be nanodemulsifiers with a polynano structure, intramolecular and intermolecular synergy, multifunctional and universal nature.

We formulated requirements 14–45, while the known requirements (1–13) were edited. Therefore, the development and utilization of nanodemulsifiers that effectively meet the demands of PPO conditions is considered a top priority in the field of oilfield nanotechnology.

3.2. Crystalline liquids

In addition to the traditional states of matter (gaseous, liquid, solid), there are also hybrid states of matter. Therefore, liquid crystals can be considered as a hybrid of liquid and solid (crystalline) state of matter. In our perspective, it is crucial to determine which state of aggregation predominantly influences the hybrid version, as this aspect has not been previously addressed[7]. The liquid state of aggregation plays a dominant role in liquid crystalline hybrid states. Therefore, it is necessary to conditionally note the cases of hybrid units. It can be assumed that the first letter represents the dominant role in the hybrid.

The LC (liquid crystal) symbol is suitable for liquid crystal state hybrids. It is known that the solid state of matter can exist in crystalline and amorphous forms. Therefore, in the case of a liquid-amorphous hybrid, if liquid predominates, the corresponding sign will be LA. With this approach, the following possible hybrid aggregated cases can be considered: LC; LA; CL; AL; LG; Gl; CG; AG; GC; GA (where L: liquid, К: crystal, A: amorphous, G: gas). The problem being discussed is highly significant as it represents a novel area in colloidal chemistry, modern molecular physics, petrochemicals, petrochemical physics, oilfield nanotechnologies, and petroleum nanotechnologies. This is because there is a lack of information regarding the hybrid aggregative state of organic substances. Additionally, according to the adsorption theory developed by academician M.M. Dubinin and his students, it is established that the adsorbed gas state in nanoporous adsorbents corresponds to the state of the corresponding liquid[28]. Consequently, the state of absorbed water in the form of interconnected nanoheterogeneous associative colloidal water clusters in the nanodispersed phase of water-oil emulsions will be adequate to a hybrid state such as a crystalline liquid. We were the first to observe this phenomenon in nanosuspensions[18]. Therefore, the investigation of this issue in emulsions is being examined for the first time. Demulsifiers with the visual aggregate state of a crystalline liquid are demonstrated in **Figure 1**:



(a) **(b)** **(c)**

Figure 1. Some samples of nano-demulsifiers "IKHLAS" with visual aggregate states of crystalline liquids (for the first time) in glass bottles in vertical and horizontal positions: **(a)**: "IKHLAS"—6003-20; **(b)**: "IKHLAS"—5003-15; **(c)**: "IKHLAS"—4003-10[29].

3.3. The phenomenon of simultaneous destruction of water-oil and oil-water emulsions

Worth noting that such phenomenon is being explored for the first time. It is known that during the synthesis of ethoxylated esters of n-alcohols, acids and other compounds generally non-colloidal surfactants, a certain mixture of oligomer homologues[30–32], is formed, with a certain pattern in the distribution of monomers in the mixture depending on the number of oxyethylene units (n) in surfactant molecules[30]. Industrial samples of such ethers are characterized by an average number n[33]. Demulsifiers are mainly ester products of block copolymers based on ethylene and propylene oxides[25,34]. Consequently, demulsifiers are also mixtures of homologues of oligomers with certain n values, which are often expressed in terms of the mass fraction of the oxyethylene chain in the demulsifier molecules. When dosing a demulsifier into crude oil, a redistribution of oligomer homologues occurs in oil-water and oil-water emulsions. Monoesters with relatively low n values, i.e., the most hydrophobic components are distributed in water-oil emulsions, and components with relatively high n values, i.e., relatively hydrophilic components pass into the oil-water emulsion[35]. Due to a similar redistribution of oligomer homologues in crude oil, the phenomenon of simultaneous destruction of water-oil and oil-water emulsions occurs and as a result, commercial oil is obtained with a water content of no more than 0.5%, as well as produced water (formation water) with an oil content of no more than 50 mg/dm^3, which comply with current standards[20,21]. Therefore, demulsifiers of the IHLAS (XX) brand with a polynano structure are designed for the simultaneous destruction of oil-water and oil-water emulsions[25]. The polynanostructure of demulsifiers generally contributes to the high intensity of destruction processes of both types of oil emulsions[17]. It should be noted that the results of laboratory tests coincide with the results of pilot industrial tests. As an example, we can show the Karazhanbasmunai field. In both cases, the content of residual water in oil (0.06; 0.17) and the content of oil in wastewater (36 mg/dm^3; 36 mg/dm^3) practically coincide and are confirmation of the discovery in question "The phenomenon of simultaneous destruction of oil-water and oil-water emulsions". Furthermore, the authors of the Karazhanbasmunai field discovery have established an empirical formula $Co = 10.3\ \sigma M + 36.1$ (1) where, Co is the residual concentration of oil in the composition of produced water during oil recovery; σM—interfacial tension at the water-oil interface. For polynanostructured surfactant demulsifiers with the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors such as block copolymers of ethylene and propylene oxides, the values of σM are practically equal to zero. Consequently, at $\sigma M \to 0$ $Co \approx 36.1$ mg/dm^3, which also confirms the reliability of the results of laboratory and industrial tests. Moreover, the co-author of this discovery, T. K. Dashdieva, conducted further extensive research on this topic as part of her dissertation titled “Development and implementation of nanodemulsifiers for the purification of formation waters from oil under conditions of primary oil treatment”. Work performed by polynanostructured surfactants demulsifiers, which have the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors for overcoming polynanobarriers in crude oil, as well as for the simultaneous destruction of water-oil and water-oil emulsions, is determined precisely by ultra-low values ($\sigma M = 0$ or $\sigma M \to 0$) of interfacial tension. This is the eternity of intramolecular nanomotors. Another condition for highly effective nanodemulsifiers is the requirement for surface pressure, which must be at least 40–42 mJ/m^2. Issues with the synthesis of these nanodemulsifiers are given in our paten[25]. The characteristics of the studied nanodemulsifiers meet all the requirements for demulsifiers and are within the listed criteria (See pages 4–6 of the article for details).

3.4. Calculation of the sizes of perpetual nanomotors such as block copolymers of ethylene and propylene oxides

For perpetual nanomotors such as block copolymers of ethylene ($–CH_2CH_2O–$) and propylene ($–CH_2$-$CH_2–CH_2O–$) oxides based on glycerine; the cross section (S) of the molecules is $S = 78 \times 10^{-20}$ m^2[29].

Calculation of the diameter (D) of the cross section or height of the stator (oxypropylene circuit): $S = \pi D^2/4$ $D^2 = 4\ S/\pi = 99.4 \times 10^{-20}$ m^2 $D \approx 10 \times 10^{-10}$ m = 1 nm.

It is known that the cross section (S) of the oxyethylene chain is ~23×10^{-20} m^2[30].

$S = \pi D^2/4$, $D^2 = 4$, $S/\pi = 29.3 \times 10^{-20}$ m^2, $D \approx 5.4 \times 10^{-10}$ m = 0.54 nm. Consequently, the diameter of the rotor (oxyethylene chain) is 1.85 times smaller compared to the stator (oxypropylene chain). The demulsifier surfactant molecule performs the function of a platform for an eternal nanomotor in accordance with the discovery formula. The contact of the rotor at the stator input is determined by the chemical covalent bond of oxygen between the extreme group of the oxyethylene chain and the carbon atom also with the extreme group of the oxypropylene chain, i.e. at the interblock boundary of surfactant demulsifier molecules, i.e., at the interface between the highly hydrophobic oxypropylene chain and the highly hydrophilic oxyethylene chain, due to which there is a rotational movement of the rotor (oxyethylene chain), resulting in interblock activity, which is much stronger than the surface activity of conventional surfactants. It is due to interblock activity that the effect of destruction of oil emulsions is achieved. Therefore, the key distinction between conventional surfactants and surfactant demulsifiers in terms of nanocolloid chemistry lies in the presence of interblock activity in demulsifier surfactant molecules based on oxyalkylene oxides, which is not observed in conventional surfactants. The perpetual nanomotor under consideration according to this discovery, in contrast to the only known perpetual nanomotor (works based on triboelectricity) Zhong[13], works using polynanostructured nanoemulsifiers, which have the properties of crystalline liquids, intramolecular interblock activity and perpetual intramolecular nanomotors. Thus, according to the proposed discovery, the dimensions of perpetual nanomotors are nanosized in all respects:

Stator with a diameter of 1 nm; rotor with a diameter of 0.54 nm; platform with a length of 19.9 nm.

Through our research, we have determined that all existing demulsifiers, including block copolymers of ethylene and propylene oxides, fall into the category of triblock polyols. Within this category, there are two options:

1st option OEB-OPB-OEB water-soluble demulsifiers

2nd option OPB-OEB-OPB oil-soluble demulsifiers

where OEB—oxyethylene block; OPB—oxypropylene block.

In practice primary preparation of oil mainly uses oil-soluble demulsifiers of the OPB-OEB-OPB type. In these three-block demulsifiers, there are 2 interphase boundaries in which, thanks to perpetual nanomotors, there is exists interblock activity of surfactant demulsifiers. It would be reasonable to increase the overall interblock activity and thereby enhance the efficiency of the corresponding demulsifiers with an increase in the number of blocks to a certain value:

OPB–OEB–OPB–OEB–OPB 5-block

OPB–OEB–OPB–OEB–OPB–OEB–OPB 7-block

OPB–OEB–OPB–OEB–OPB–OEB–OPB–OEB–OPB 9-block

OPB–OEB–OEB–OEB–OPB–OEB–OPB–OEB–OPB–OEB–OPB 11-block

The authors conducted tests using bottle tests and found that for crude oil possessing polynanobarrier properties, the most effective demulsifiers in terms of simultaneously breaking water-oil and oil-water emulsions are 7- and 9-block polynanostructured demulsifiers based on monohydric aliphatic alcohols. Worth noting that demulsifiers, such as oxyalkylene block copolymers based on monohydric aliphatic alcohols, are being considered for the first time[7,17].

3.5. Experimental proof of the alleged scientific discovery

We would like to reiterate that this priority article presents the findings of testing oil emulsions from the Uzen, Zhetibay, and Zhalgiztobe fields as the subject of investigation. The highest specific consumption of demulsifier (up to 580 g/t) and the highest oil treatment temperature (up to 114 °C) among the oil fields of Kazakhstan and other regions are characteristic only of the Zhalgiztobe field. Worth noting that highly paraffinic (up to 25%–28%) crude oil from the “Uzen”, “Zhetibai” fields and the highly resinous “Zhalgiztobe” field, which have polynanobarrier properties[7,17] including a nanodispersed medium, a nanodispersed phase and a nano-sized moleculars adsorptions layers with nanoparticle components from organic inorganic origin, are over complex nanoheterogeneous systems in relation to “The phenomenon of simultaneous destruction of water-oil and oil-water emulsions”. The data of the **Tables 1** and **2** are experimentals evidence of the scientific discovery “The phenomenon of simultaneous destruction of water-oil and oil-water emulsions” that occurs with the dosage of polynanostructured surfactants, demulsifiers, which have the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors, unlike all researched known demulsifiers.

3.6. Scientific novelty of the discovery (first achieved by the authors of this discovery)

- The phenomenon of simultaneous destruction of water-oil and oil-water emulsions;
- Polynanostructure of surfactant demulsifiers;
- New hybrid state of aggregation such as crystalline liquids of surfactant demulsifiers;
- Intramolecular interblock activity of surfactant demulsifiers;
- The property of eternal intramolecular nanomotors of surfactants, demulsifiers such as block copolymers of ethylene and propylene oxides;

- The phenomenon of redistribution of oligomer homologs of the most hydrophobic oxyethylene ethers in water-oil emulsions, and the most hydrophilic oligomers in oil-water emulsions;
- New hybrid state of aggregation such as crystalline liquids also for nanodispersed phases of water-oil and oil-water emulsions.

3.7. Area of scientific and practical significance of the proposed scientific discovery

3.7.1. Area of scientific significance of the discovery (ASSSD)

The scientific novelty of the discovery is determined based on individual points of scientific novelty of the proposed discovery:

1) For the first time, a previously unknown phenomenon of simultaneous destruction of oil-water and oil-water emulsions was established, due to the redistribution of oligomer homologues of the most hydrophobic oxyethylene ethers in oil-water emulsions, and the most hydrophilic oligomers in oil-water emulsions with high-strength nanodispersed phases, which also have the properties of crystalline liquids. The authors have also, for the first time, explored the hybrid state of aggregation of substances, specifically in relation to the crystalline liquid state[18]. Future studies of the physicochemical, colloidal chemical and quantum mechanical properties of crystalline liquids are one of the priority areas of modern molecular physics;
2) The polynanostructure of surfactant demulsifiers is presented by the authors as one of the important requirements for demulsifiers: Demulsifiers must have a polynanostructure to easily overcome persistent polynanobarriers in crude oil at a relatively high concentration of asphaltenes (≥3%) and relatively high densities of crude oil (≥830–840 kg/m^3)[17];
3) Intramolecular interblock activity of surfactant demulsifiers. This is a very important property of surfactant demulsifiers, which determines the difference between conventional surfactants and surfactant demulsifiers. This direction will also be a priority for further research;
4) The property of eternal intramolecular nanomotors of surfactants, demulsifiers such as block copolymers of ethylene and propylene oxides and the phenomenon of redistribution of oligomer homologues of the most hydrophobic oxyethylene ethers in water-oil, and the most hydrophilic oligomers in oil-water emulsions are also innovative priority areas in the field of applied nanocolloid chemistry.

3.7.2. The area of the practical significance (APS)

The APS is also determined based on individual points of scientific novelty of the proposed discovery which are closely linked to the name of the discovery itself: “The phenomenon of simultaneous destruction of oil-water and oil-water emulsions”. The practical significance of the discovery is confirmed by the results of pilot testing and the introduction of polynanostructured nanodemulsifiers of the “IKHLAS” brand in rather complex fields of the Republic of Kazakhstan[14–18,25,26,29,34,35]. The annual actual economic efficiency from the implementation of this discovery stands at approximately $10,846,000 and in the period 2021–2023 $32,538,000 (there is an official certificate of economic efficiency from the implementation of the authors’ scientific discoveries in the oil fields of the Republic of Kazakhstan). Furthermore, utilizing the insights provided by this discovery, it is feasible to conduct targeted synthesis of polynanostructured surfactant demulsifiers, such as block copolymers of ethylene and propylene oxides, which possess the characteristics of crystalline liquids, intramolecular interblock activity, and perpetual intramolecular nanomotors. This synthesis can be performed in a specialized installation, employing established technology. The authors of this discovery have strategically set their goal to achieve significant success in the global market for modern demulsifiers by leveraging these unparalleled surfactant demulsifiers, which currently have no alternatives.

4. Conclusion

The presented material is a priority article detailing a scientific discovery regarding “the phenomenon of simultaneous destruction of water-oil and oil-water emulsions”. The authors introduce a corresponding formula that describes this phenomenon. The previously unknown phenomenon of simultaneous destruction of water-oil and oil-water emulsions, which occurs with the dosage of polynanostructured surfactant demulsifiers possessing the properties of crystalline liquids, intramolecular interblock activity and eternal intramolecular nanomotors such as block copolymers of ethylene and propylene oxides (sources of oligomer homologues of oxyethylene ethers) in crude oil under conditions of primary oil preparation, due to the redistribution of oligomer homologues of the most hydrophobic oxyethylene ethers in water-oil, and the most hydrophilic oligomers in oil-water emulsions with high-strength nanodispersed phases, which also have the properties of crystalline liquids.

Author contributions

Conceptualization, DRA and DTK; methodology, DRA; experiments, DRA and DTK; software, DRA; validation, DRA and DTK; formal analysis, DTK; investigation, DRA; resources, DTK; data curation, DRA; writing — original draft preparation, DRA and DTK; writing—review and editing, DRA and DTK; visualization, DTK; supervision, DRA; project administration, DRA. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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