UDC 502.55,628.192

ECOLOGICAL EFFECTIVE TREATMENT OF INDUSTRIAL WASTEWATER FORMED IN THE OIL-PRODUCING INDUSTRY BY COAGULATION METHOD

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Received 19.04.2021

Accepted 16.06.2021

Research work has been carried out on deep purification of water samples taken from industrial wastewater formed in the oil-producing industry containing hydrophilic and hydrophobic ("oil-in-water" and "water-in-oil") emulsions from oil and organic suspended substances. Using the coagulation method developed by us, industrial wastewater samples were purified up to 100% from oil and suspended substances under optimal conditions. It has been substantiated that this method is of great economic and environmental importance. The applied coagulant and extractant meet the requirements of environmental safety.

Keywords: oil production, technological processes, production wastewater, coagulation, coagulant, extractant, hydrophobic, hydrophilic, emulsion.

doi.org/10.32737/0005-2531-2021-3-63-66

Introduction

As is known, oil production, which is one of the foundations of the oil industry, naturally generates industrial wastewater (IWW) during the technological processes of extraction oil from the ground, purification of oil from water and mechanical impurities, and final preparation as a commodity raw material. The IWW compositions and characteristics formed during the preparation of oil as a commodity raw material are also different from other IWW.

During the study on coagulation treatment of samples of industrial wastewater (IWW) taken from the production areas of the oil industry of Azerbaijan, it was found that depending on the development of optimal conditions, i.e., depending on the mechanism of using coagulation, solvent, extractant, neutralizer, up to 100% of the ecological purification of these waters from oil and suspended substances can be carried out with a special coagulant. At present, the purification of hydrophobic and hydrophilic oil emulsions, which are part of the IWW in the oil industry and cannot be completely purified in several steps over a long time from the coagulant $\text{Al}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}$ and gasoline fraction with a boiling point of 45–75°C (petroleum ether) is associated with great problems. Their complete pu-

rification (up to 100%) and clarification were achieved using neutralizing solutions of NaHCO_3 or $(\text{CaHCO}_3)_2$ substances. With the developed new coagulation method, it is possible to achieve the purification of IWW formed in the oil industry, not only according to the enterprises' environmental standards but also with a concentration 10 times lower than the sanitary standards.

Thus, in the composition of some extracted oils, water-in-oil, oil-in-water, i.e., "hydrophobic" and "hydrophilic" emulsions can be very durable. During the preparation of such oil, the IWW formed as a raw material cannot be thoroughly purified in all existing multi-stage treatment plants [1–8].

Based on the explanations and information provided in the works [9–12], it can be noted that in some cases, despite the use of special demulsifiers and technological processes to prevent the loss of oil remaining in high-emulsion IWW, a high percentage of IWW treatment is not achieved. Therefore, there are "irreversible oil loss" norms for these production areas. This, in turn, hampers the flora and fauna of basins. Simultaneously, the evaporation of oil and other harmful substances in these waters causes environmental pollution of the atmosphere, soil, and finally, the biosphere and creates environmental problems.

The ecological and economic significance of using our research results to eliminate these environmental problems can be considered scientifically based.

So, the following analysis can be made of the mechanism of the coagulant action used in the treatment of IWW formed in the oil industry by the new coagulation method developed.

As noted in the technical literature, the coagulation method is mainly used to purify natural waters from colloidal and suspended impurities.

To precipitate the impurities by this method, the charges of its particles must be neutralized by the use of electrodes or colloidal particles of coagulants having a charge of the opposite sign. When $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ is used in water treatment as an effective coagulant with qualitative advantages that it is first hydrolyzed. The resulting acid reacts with bicarbonate NaHCO_3 or $\text{Ca}(\text{HCO}_3)_2$ and forms a neutral medium. This happens according to the following mechanism [6]:

Methodical part

Samples for the study were pH=7.2–7.4 neutral. As noted in the technical literature [6], when $\text{Al}_2(\text{SO}_4)_3$ is used as a coagulant by the coagulation method of natural waters, $\text{Al}(\text{OH})_3$ is positively charged at a certain pH in the colloidal state. In contrast, the negatively charged hydroxide in the water collapses due to its weight, mechanically precipitates suspended clay, soil and other such mixed particles.

The study found that the use of high-percentage and large amounts of $\text{Al}_2(\text{SO}_4)_3$ coagulant in the treatment of IWW samples in the oil-producing industry precipitates oil emulsions along with mechanical mixtures. This is not allowed in the cleaning of IWW. Therefore, research's main directions was to determine the optimal conditions for the effective use of this coagulant.

One of the main conditions is the identification of extractants used in the chemical treatment of IWW samples. The study found

that using "petroleum ether" as an extractant is an ecologically and economically important reagent that has a positive effect on oil quality [5].

As noted, the water temperature should be at least 35–40°C [6]. The high temperature in the cleaning process has a positive effect on the rate and quality of the chemical coagulation process. The reagents used in the study meet the modern requirements of ecological safety specified in the technical literature [13–15].

Experimental part

The method developed by us has achieved the transparency of the IWW color even at the lowest temperature of 3 to 5°C, by purification up to 100% from oil and suspended substances.

In long-term experiments with IWW containing 500–2500 mg/l oil, using the prepared solution of coagulant $\text{Al}_2(\text{SO}_4)_3$, as well as a certain amount of petroleum ether, it was purified from oil. It suspended solids to 100%, and their color became lighter.

During the study, it was found that the oil obtained during the initial chemical coagulation treatment of IWW samples formed in the oil-producing industry can be reused as an extractant from a certain part of the extraction mixture. At the same time, it was determined that part of the IWW cleaned by the same method could be used as a coagulant to save the coagulant used.

As is known, every chemical reagent used in different directions in many industrial enterprises in recent years must meet the environmental safety requirements [16]. From this point of view, each of the coagulant, extractant, neutralizing reagents used in our method for deep environmental treatment of IWW samples taken from the oil industry meets all the requirements of modern environmental safety.

According to the technical literature, mainly in ecological scientific and technical production journals [7–12], the oil industry has not yet been able to fully clean up to 100% of the IWW formed during the oil preparation as a raw material in oil production facilities. Therefore, after the treatment of these waters, even though the remaining oil emulsion is in the eco-

logical norms, environmental problems continue to arise due to its discharge into water basins [7–12].

As noted, during the preparation of oil as a commodity raw material, as well as in the technological processes of oil refining, an aqueous oil emulsion is formed, which makes up 0.5–1.8% of the total volume of refined oil, has a stable content and is captured in purification plants [4].

Currently, research is underway on the use of various demulsifying agents for the deep decomposition of "water-in-oil" and "oil-in-water" emulsions, i.e., complete purification of oil from water, as well as the removal of mechanical impurities (salts and other impurities), which is one of the most pressing problems in the oil industry.

However, despite some results, it has not yet been possible to completely separate the persistent "petroleum" emulsions in the IWW. As can be seen from the research results, in laboratory conditions in several stages up to 100% separation of the oil-water emulsion even with optimal technological schemes due to the creation of combined thermochemical deposition, in the final stage by creating an electric field, using various characteristics of demulsifiers and parameters could not be achieved [4]. However, based on the comparative results of research on this problem applying of these developed methods in the industry is not guaranteed. However, each of these types of research is considered one of the main environmental requirements of the time.

Analysis results

Based on the analysis results carried out in the experimental part of our research work on the environmental treatment of industrial wastewater (IWW) generated in the oil industry by the coagulation method, the following information can be summarized.

To increase IWW purification rate (to increase the coagulation rate), a flocculant FK-1 5% H_2SO_4 acid is used in twice the amount of coagulant solutions.

To study the purification of samples of industrial wastewater IWW formed in the oil industry of Azerbaijan by the developed method of coagulation, a 5% solution of the component $Al_2(SO_4)_3 \cdot 18H_2O$ (conventionally designated K-1), an extractant of petroleum ether EK-1 (gasoline fraction 40–70°C), NK (neutralizing component) $Ca(HCO_3)_2$ or 5% $NaHCO_3$ solution was used.

The optimal conditions were determined after long-term experimental work, and the results of the analysis are presented in the Table.

Conclusion

The environmental results of industrial wastewater treatment (IWW) formed in the oil industry, obtained developed by our method in laboratory conditions, have 10 times more environmental and economic advantages than the results of existing scientific research, of which patents for inventions and inventors certificates have been issued.

The obtained data of the carried out experimental work

Conditional number and quantity	Indicators before cleaning			The component used in cleaning			Indicators after cleaning		
	the amount of oil, mq/l	pH environment	color	K-1, mq/l	EK-1	NK-1	the amount of oil, mq/l	pH	color
N-1 1L	500–1000	6.8–7.5	dark cloudy	3–5	2–3	1–2	≤ 0.01	7.0	transparent
N-2 1L	500–1000	6.9–7.6	dark cloudy	3–5	2–3	1–2	≤ 0.01	7.0	transparent
N-3 1L	500–1000	6.7–7.0	dark cloudy	3–5	2–3	1–2	≤ 0.01	7.0	transparent

Note: N-1 Sample of IWW from "Oil Rocks"

N-2 Sample of IWW Surakhani oil production

N-3 Sample of IWWF. Amirov oil production IWW cleaning time: 30 minutes, Temperature: 5 – 20°C.

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NEFT HASILATI SƏNAYESİNDƏ FORMALAŞAN İSTEHSALAT TULLANTI SULARININ KOAQULYASIYA METODU İLƏ EKOLOJİ EFEKTLİ TƏMİZLƏNMƏSİ

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Neft hasilatı sənayesində formalaşan və tərkibində davamlı suda neft, neftdə su hidrofil və hidrofob emulsiyaları olan istehsalat tullantı sularından götürülmüş su nümunələrinin dərinədən neftdən və üzvi asılı maddələrdən təmizlənməsi üzrə tədqiqat işi aparılmışdır. İşlənmiş koagulyasiya metodu ilə optimal şəraitdə nümunələrin tərkibində olan neftin və asılı maddələrin 100%-ə qədər sudan təmizlənməsinə nail olunmuşdur. Bu metodun iqtisadi və ekoloji cəhətdən böyük əhəmiyyətə malik olması əsaslandırılmışdır. İstifadə olunan koagulyant və ekstragent ekoloji təhlükəsizlik tələbatlarına cavab verir.

Açar sözlər: neft hasilatı, texnoloji proseslər, istehsalat tullantı suları, koagulyasiya, koagulyant, ekstragent, hidrofob, hidrofil, emulsiya.

ЭКОЛОГИЧЕСКАЯ ЭФФЕКТИВНАЯ ОЧИСТКА ПРОИЗВОДСТВЕННЫХ СТОЧНЫХ ВОД, ОБРАЗУЮЩИХСЯ В НЕФТЕДОБЫВАЮЩЕЙ ПРОМЫШЛЕННОСТИ, МЕТОДОМ КОАГУЛЯЦИИ

С.Р.Гаджиева, Н.Т.Шамилов, Г.И.Байрамов, Н.М.Ракида

Проведены научно-исследовательские работы по глубокой очистке образцов производственных сточных вод, формирующихся в нефтедобывающей промышленности, содержащих гидрофильные и гидрофобные эмульсии ("нефть в воде" и "вода в нефти"), от нефти и органических взвешенных веществ. С помощью разработанного нами коагуляционного метода в оптимальных условиях образцы до 100% были очищены от нефти и взвешенных веществ. Обосновано, что этот метод имеет большое экономическое и экологическое значение. Используемые коагулянт и экстрагент соответствуют требованиям экологической безопасности.

Ключевые слова: нефтедобыча, технологические процессы, производственные сточные воды, коагуляция, коагулянт, экстрагент, гидрофобный, гидрофильный, эмульсия.