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EVALUATION OF THE EFFECTIVENESS OF TREATMENT WATER EMULSIONS FROM OIL BY PHYSICO-CHEMICAL METHODS

In this work the processes of treatment of water emulsions from oil with application of aluminum coagulants and activated carbon as a sorbent-clouding agent were investigated. These were coagulants such as aluminum sulphate $Al_2(SO_4)_3$, aluminum hydroxide $Al(OH)_3$ and aluminum hydroxide $Al(OH)_2Cl$. Treatment of water emulsions was carried out with coagulants separately and in combination with activated carbon, and studies were conducted to determine the effectiveness of their separate and compatible use. It is determined that aluminum coagulants in doses of 2–50 mg/dm³ both separately and in combination with a sorbent provide a high degree of oil removal from emulsions. The level of water treatment reaches 97–99%. The use of activated carbon in doses of 5-100 mg/dm³ causes a linear decrease in the concentration of oil in water with an increase in the dose of the sorbent. Aluminum hydroxide (without sorbent) has the greatest efficiency in oil removal from water, as it ensures maximum reduction of oil concentration in both fresh and mineralized water. At the same time, the compatible application of aluminum coagulants with activated carbon is characterized by efficiency fluidity. This efficiency depends on the type and concentration of coagulant, dosed sorbent, as well as mineralization of the initial water. The greatest stable and linear combined effect is observed with the simultaneous use of aluminum sulfate and activated carbon in the treatment of fresh water, and aluminum hydroxochloride in combination with activated carbon in the treatment of highly mineralized water. The degree of water treatment reaches 98,6 –99,3%, and 99,1–99,8%, respectively. The results of this study show that the use of aluminum coagulants to extract oil from water solutions of various mineralization is appropriate and effective.

Key words: water-oil emulsions, bilge waters, aluminum coagulant, active carbon, emulsion treatment

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ОЦІНКА ЕФЕКТИВНОСТІ ОЧИЩЕННЯ ВОДНИХ ЕМУЛЬСІЙ ВІД НАФТИ ФІЗИКО-ХІМІЧНИМИ МЕТОДАМИ

Дана робота представляє дослідження процесів очищення висококонцентрованих прісних і мінералізованих водних емульсій від нафти із застосуванням алюмовмісних коагулянтів та активованого вугілля. У якості коагулянтів було використано сульфат алюмінію, гідроксид алюмінію та гідроксохлорид алюмінію. Очищення водних емульсій проводили окремо як коагулянтами, так і активованим вугіллям, а також проводили дослідження щодо визначення ефективності їх сумісного застосування. Отримані результати показують, що алюмінієві коагулянти в дозах 2–50 мг/дм³ дозволяють досягти досить високих ступенів очищення висококонцентрованих нафтовмісних вод, що складають 97–99%. Дані значення характерні для процесів очищення як коагулянтами окремого так і сумісно з активованим вугіллям. Експериментально доведено, що найкращу результативність щодо видалення нафти з як з прісної так і з солоної нафтовмісних емульсій показує гідроксид алюмінію без сорбенту. Алюмовмісні коагулянти разом з активованим вугіллям характеризуються нестабільністю значень ефективності. Доведено, що концентрація та тип алюмовмісного коагулянту, солоність води та доза сорбенту мають вплив на ефективність вилучення нафти з водних розчинів.

Ключові слова: нафтовмісні емульсії, ллляльні води, алюмінієвий коагулянт, активоване вугілля, очищення емульсії

Introduction

Water transport is an important trade and transportation and, accordingly, plays a significant role in the country's economy. At the same time, shipping, like other water users, it affects the environment, in particular the hydrosphere.

One of the most dangerous substances, which pollute the hydrosphere, is oil and oil-containing waters.

Despite the fact that according to the statistics of the State Statistics Service of Ukraine the inflow of oil products into the sea and river of Ukraine with return waters (fig. 1) are reduced, their contribution to the pollution of the hydro sphere remains high [1].

The total amount of oil-containing waters coming from vessels into the hydrosphere is

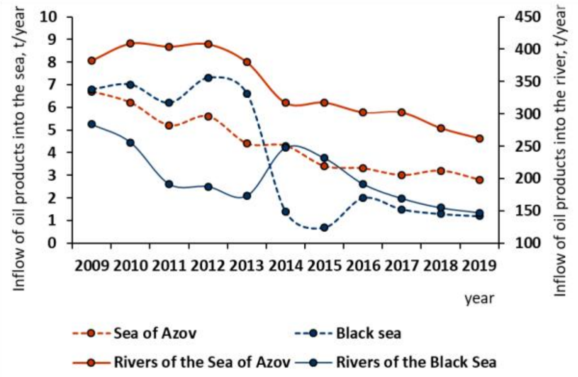

Figure 1. Inflow of oil products into the seas and rivers of Ukraine with return waters (2009-2019)

insignificant in absolute terms than the amount of oil coming from oil tankers. However, the influence of water-oil emulsions on the ecological state of the water environment is significant.

During the operation of water transport in the vessel's machinery departments, flask waters – water-oil emulsions are formed. On sea vessels these waters are called bilge water, and on river vessels – slang water.

The sources of the formation of the bilge water on vessels are vessel engines, generators and other parts of the propulsion systems (pumps, pipes, mechanical and operational components of the machine departments). Basically, bilge waters contain heavy fuel, oil, oil for hydraulic systems, detergents, additives to oils, chemicals.

According to the requirements of national and international regulatory and legal acts, a skip from the vessels of oil, harmful substances, garbage, polluted and regulated waters is forbidden both on internal waterways and in internal sea waters and territorial seas of Ukraine. In addition, bilge waters from vessels should be transferred completely to specialized treatment facilities for further treatment and contamination [2], [3], [4]. The exception is only the overboard (in international waters) of the waters cleaned by ship's installations (separators), which contain oil products in the quantity not more than 15 million^{-1} [5].

Maximum permissible concentration (MPC) of oil products for water of water body of domestic drinking and cultural-domestic use is 0,3 mg/dm^3, and for fishery water body – 0,05 mg/dm^3 [6], [7].

Failure to comply with regulations on the diversion of untreated oil-containing waters in the water body may cause violations of life cycles of all components of the biosphere, which will lead to negative consequences for people, the environment, biota [8].

Based on the initial characteristics of the oil-containing waters, namely: oil concentration in water, morphological composition of the bilge waters, etc., apply the appropriate treatment methods. Physical, physical, chemical, chemical, biological and combined methods of cleaning are often used.

Bilge waters belong to heterogeneous dispersive systems [10] with particles of different size. Normally, the this emulsions contain up to 50% of oil products in sizes up to 10 microns, 25% of particles – up to 30 microns, the rest have sizes from 30 to 200 microns [9].

Systems formed by the admixture of such a group are kinetic unstable, and nonsoluble substances are kept in a dependent state by dynamic forces of the water flow. To remove the impurities of this group apply phenomena and techniques, which are based on physical and chemical processes such as: adgesia on the surface of inert granular loads, sedimentation with the help of reagents. Therefore, basically, use the following methods of water treatment: Drainage, filtration, microfiltration, centrifugation, coagulation, flotation [10].

Wide application of sewage treatment by coagulation method [11], [12], [13]. For coagulation treatment of sewage, as coagulants use salts of aluminum and iron. More often used aluminum sulphate, less often used chloride and hydrochlorides of aluminum, sulfates and iron chloride, sodium aluminum [14].

The purpose of coagulants application is to reduce the aggregate and sedimentation stability of ion-gen, coloid and highly dispersed impurities contained in water.

The efficiency of coagulation and degree of water treatment depends on the nature and dose of coagulant, water composition, pH and temperature. For example, during coagulation treatment of water with aluminum compounds should pay special attention to pH, and, if needed correct it. Thus, due to the amphoteric character of aluminum compounds in both acid and alkaline medium, there is an incomplete hydrolysis of coagulant and it leads to high concentrations of residual aluminum in water [15]. The process of coagulation of oil-containing waters will theoretically have the effect of mineralization, as the content of salts in waters of oceans and some seas reaches 50 g/dm^3 and more [10].

Aluminum sulphate $AL_2(SO_4)_3$ is one of the most common coagulants. Its coagulation properties are caused by the formation of coloid hydroxide aluminum and basic sulphate as a result of hydrolysis [16]. The advantage of aluminum sulphate is its availability and low cost. Among its shortcomings are noted low content of the current component (15% Al_2O_3), low efficiency at low water temperatures, acidification of water with low alkalite content due to hydrolysis of coagulant [17], and high water hardness causes a sedimentation of calcium sulphate.

One of the main aluminum-based coagulants is the freshly-precipated aluminum hydroxide ($Al(OH)_3$), which is easily dissolved in acids and alkalite. The advantages of its use are that it is easily hydrolyzed, contains more active component, acidifies water at hydrolyze, has higher efficiency than aluminum sulphate [16]. However, aluminum hydroxide has a heightened sensitivity to pH and water temperature. The isoelectric area for aluminum hydroxide, wich is characterized by the lowest solubility, corresponds to pH 6,5–7,5. At lower pH values, dissolvable basic salts are formed, at higher pH values – aluminate. At the temperature of the outgoing water below 4°C, the coagulation processes of admixture are slowed down due to the increased of aluminum hydroxide, the residual aluminum gets into the filtrate, and the flakes of hydroxide are formed in water already after treatment [17].

Hydrochlorides of aluminum are considered the most effective among aluminum coagulantsv. The advantages of these coagulants include the fact that they have a high coagulation capacity in a broad range of pH, ensure formation of large flakes, which are quickly precipitate, their consumption is 25–30% lower for aluminum sulphate with the same treatment efficiency [10].

Sorption methods of water treatment with the application of adsorbents are used for wastewater treatment at concentration of organic compounds less than 1 g/dm^3. Even modification of sorbents allows to use them at post-treatmentthe stages to remove residual amounts of dissolved oil products [18].

In order to increase the processes of coagulation water treatment use complex methods. For example, by adding mineral impurities (clay, bentonite, graphite), which act as additional centers of crystallization of products of hydrolysis, there is an increase of effect of sorption of dissolved impurities and thus accelerating coagulation [19].

There are not so much scientific works devoted to coagulation methods of water-oil emulsions treatment [20], [21], [22], [23]. This is explained by the various composition of oil-containing sewage, therefore, there is a need a large number of researches in order to determine optimally effective coagulants and their working concentrations.

Purpose of work

The purpose of the work was to determine the efficiency of treatment of fresh and mineralized water-oil emulsions by using of aluminum coagulants in the presence or absence of absorbent.

To achieve the set goal it was necessary to solve the following scientific tasks:

1. assess the effectiveness of aluminum coagulants depending on their composition and dose, and on the mineralization of water-oil emulsions.

2. determine the degree of effectiveness of using activated charcoal in combination with aluminum coagulants for treatment of fresh and salty oil-containing waters depending on the type and dose of coagulant, the concentration of the sorbent.

An example of the basic material

In the work used model water-oil emulsions with oil concentration of 100 mg/dm^3. There were used emulsions of two compounds: water-based emulsion and emulsion based on mineralized solution with sodium chloride concentration of 30 g/dm^3.

Aluminum sulphate ($AL_2(SO_4)_3$), aluminum hydroxide ($Al(ON)_3$) and aluminum hydroxochloride ($Al(ON)_2Cl$) were used as aluminum coagulants. Working doses of coagulants were changed in the range from 2 mg/dm^3 to 50 mg/dm^3 in the conversion to aluminum oxide (Al_2O_3). Coagulants were used separately or in combination with activated charcoal.

Activated charcoal was used as a sorbent- turbidizer. In case of its separate (single) application, the working concentration were in the range from 5 mg/dm^3 to 100 mg/dm^3. In combined application with coagulants, the working concentrations of activated charcoal corresponded the values of 50 and 100 mg/dm^3.

After the addition of reagents, the pH was adjusted to 7.5. The mixing time was 3 minutes, after which the solutions were allowed to stand for 24 hours. After settling, the samples were filtered with paper filters "blue tape". The residual oil concentrations in filtrates were determined by extraction spectrophotometric method [24].

Based on the obtained experimental data, the degree of oil removal from water (Z, %) was calculated using the formula :

$$Z = \left(1 - \frac{C}{C_0}\right) \cdot 100, \% \qquad (1)$$

where C – the residual concentration of oil in treated water, mg/dm^3;

C_0 – the initial concentration of oil in emulsion, mg/dm^3.

Carbon tetrachloride (CCl_4) was extracted as an extractant. The reference solution was a suitable solvent.

Discussion of results

As mentioned above, oil and oil products are the main component of the bilge waters. Therefore, the first stage of the work was to conduct research on the establishment of the efficiency of oil removal from water-oil emulsions depending on the type and dose of coagulants, and the mineralization of the initial solutions. The results of the studies are shown in Figures 2 and 3.

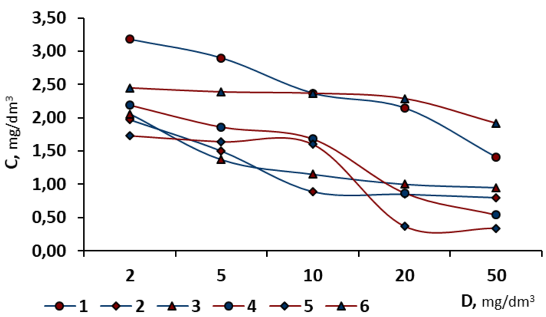

Figure 2. Change in the concentration of oil in fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm^3) depending on the type of coagulant $Al_2(SO_4)_3$ (1, 4), $Al(OH)_3$ (2, 5), $Al(OH)_2Cl$ (3, 6), and their doses (in terms of Al_2O_3)

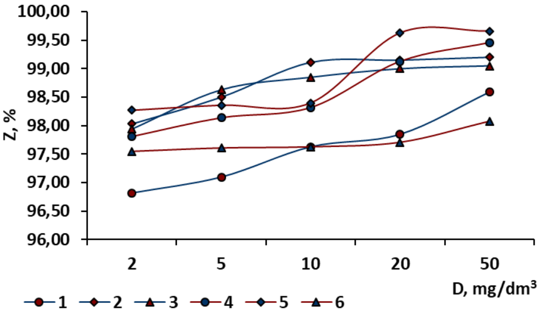

Figure 3. Dependence of oil removal from fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm³) depending on the type of coagulant $Al_2(SO_4)_3$ (1, 4), $Al(OH)_3$ (2, 5), $Al(OH)_2Cl$ (3, 6), and their doses (in terms of Al_2O_3)

As can be seen from Fig. 2, when using aluminum sulphate at doses of 2–50 mg/dm³ in term of Al_2O_3, the concentration of oil in water decreases to 3,18–1,41 mg/dm³, respectively, wich corresponds to the degree of oil extraction 96,82–98,59% (fig. 3). For salty oil-containing waters ([NaCl]=30 g/dm³) under such initial conditions, the residual oil content is in the range of 2,19–0,54 mg/dm³, and the oil extraction from water is 97,81–99,46 %, respectively.

Aluminum hydroxochloride in terms of the efficiency of removing oil from emulsions provides better performance than aluminum sulfate, but less effective than aluminum hydroxide. This coagulant provides a decrease of oil concentration to 2,06–0,95 mg/dm³ (Z = 97,94–99,05 %) in fresh water, and in mineralized water the indicators are slightly worse - at the level of 2,45–1,92 mg/dm³, but the degree of oil extraction is still high - Z = 97,55–98,08%.

Among aluminum coagulants, the effectiveness of which was investigated in this work, aluminum hydroxide demonstrates the best performance in both fresh and salt waters. This coagulant at doses of 2–50 mg/dm³ per Al_2O_3 in fresh water provides a decrease the oil concentration to 1,97–0,8 mg/dm³ and in sea water the oil content decreases to 1,73–0,34 mg/dm³. Accordingly, the degree of water treatment from oil is 98,03–99,20% for fresh water and 98,27–99,66% for sea water.

The second stage of the work was to conduct research to determine the effectiveness of the use of activated charcoal in processes of treatment of the bilge water from oil, depending on the dose of the sorbent and the mineralization of the initial solutions. The results of the studies are shown in Fig. 4.

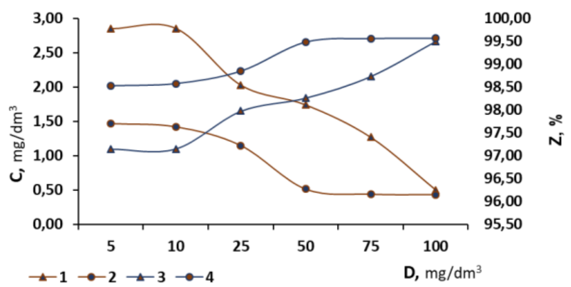

Figure 4. Dependence of residual oil concentration in fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm³ and degree of oil removal from fresh (3) and salt (4) waters on the sorbent dose

As can be seen from Fig. 4, when using activated carbon at doses of 5–100 mg/dm³, the concentration of oil in water decreases linearly with increasing the dose of sorbent. Fresh water treatment ensures reduction of oil concentrations in water to the level of 2,86-0,50 mg/dm³, which corresponds to the degree of oil extraction of 97,14–99,50%. For mineralized solutions ([NaCl]=30 g/dm³) at the same initial conditions, residual oil concentrations are at the level of 1,47–0,43 mg/dm³, and the oil extraction from water is 98,53–99,57%, respectively.

Since the MPC of oil products for water body of domestic drinking and cultural-domestic use is 0,3 mg/dm³, and for fishery water body – 0,05 mg/dm³, the next stage of work was determination of dependence of the degree of efficiency of compatible use of sorbent and aluminum coagulant in the processes of treatment of oily waters from the type and dose of coagulant, concentration sorbent and water mineralization. The results of the studies are shown in Fig. 5–10.

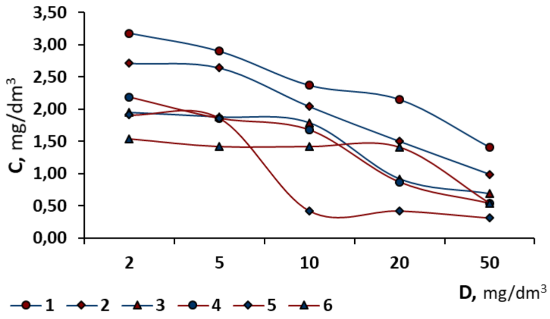

Figure 5. Change in the concentration of oil in fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm^3) depending on the dose of $Al_2(SO_4)_3$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm^3 (1, 4), 50 mg/dm^3 (2,5), 100 mg/dm^3 (3, 6)

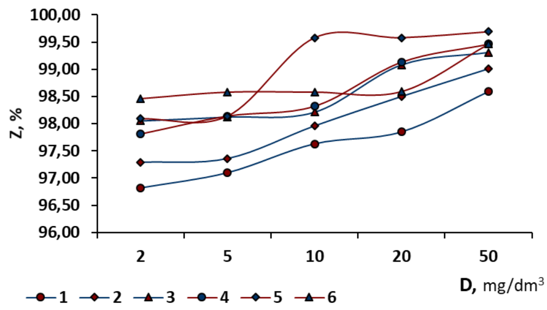

Figure 6. Dependence of oil removal from fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm^3) depending on the dose of $Al_2(SO_4)_3$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm^3 (1, 4), 50 mg/dm^3 (2,5), 100 mg/dm^3 (3, 6)

As can be seen from Fig. 5, with the combined use of aluminum sulfate coagulant at doses of 2–50 mg/dm^3 and activated carbon at doses of 50 mg/dm^3 and 100 mg/dm^3 for the treatment of water-oil emulsions, there is a significant decrease in the remaining oil concentrations. The decrease in oil concentrations is observed both with increased coagulant doses and increased concentrations of activated carbon. The reduction of residual oil concentrations using these compositions is more significant for fresh water than for mineralized. In particular, at combined treatment of oil-containing fresh waters, aluminum sulphate (50 mg/dm^3) and activated carbon, the residual concentration of oil in water decreases from 1,41 mg/dm^3 in the absence of sorbent to 0,99 mg/dm^3 with a sorbent dose of 50 mg/dm^3, and at a sorbent concentration of 100 mg/dm^3 the oil content in water decreases to 0,69 mg/dm^3. The degree of water treatment from oil (fig. 6) is 98,6%, 99,0%, 99,3% respectively.

In case of processing of mineralized solutions (fig. 5) similar patterns are observed, but the decrease in oil concentration is not as linear as in the case of treatment of freshwater solutions. Thus, at complex application of aluminum sulphate (50 mg/dm^3) and activated carbon during salt water treatment, the residual oil concentration decreases from 0,5 mg/dm3 in the absence of a sorbent to 0,3 mg/dm^3 with a sorbent dose of 50 mg/dm^3, and with an activated carbon concentration of 100 mg/dm^3, the oil content in water decreases to 0,54 mg/dm^3. Accordingly, the degree of water treatment from oil (fig. 6) is 99,5%, 99,67%, 99,5%.

Most likely, the additional treatment of the emulsion is facilitated by the enlargement of insoluble particles due to the sorption of insoluble oil on the surface of the sorbent and the subsequent precipitation of agglomerates from solutions.

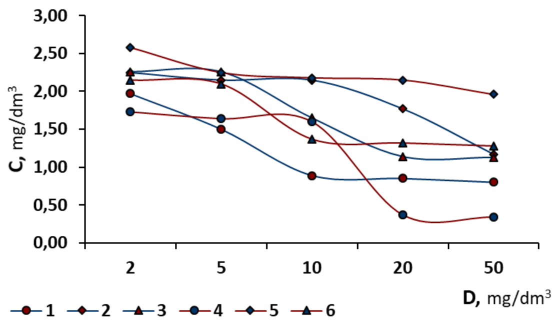

Figure 7. Change in the concentration of oil in fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm^3) depending on the dose of $Al(OH)_3$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm^3 (1, 4), 50 mg/dm^3 (2,5), 100 mg/dm^3 (3, 6)

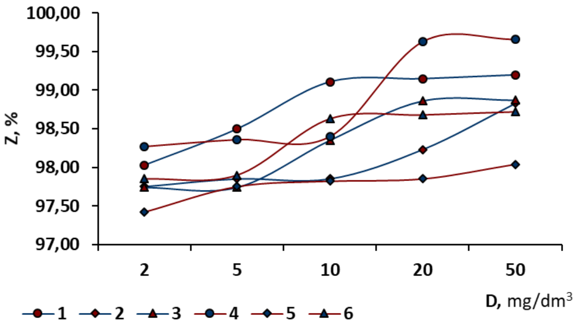

Figure 8. Dependence of oil removal from fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm³) depending on the dose of $Al(OH)_3$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm³ (1, 4), 50 mg/dm³ (2,5), 100 mg/dm³ (3, 6)

The compatible use of aluminum hydroxide and activated carbon does not contribute to the efficiency of the treatment process. On the contrary, it is characterized by a negative character (fig. 7, 8). Individually, aluminum hydroxide the best results in extracting oil from water emulsions (fig. 2, 3) compared to other aluminum coagulants considered. However, the addition of activated carbon significantly impairs the indicators. Thus, the addition of sorbent in concentrations of 50 mg/dm³ and 100 mg/dm³ at a dose of aluminum hydroxide of 50 mg/dm³ leads to an increase in the residual concentrations of oil in water. For example, for low-mineralized water, the residual oil content at the concentration of coagulant 50 mg/dm³ increases from 0,80 mg/dm³ in the absence of sorbent to 1,17 mg/dm³ in the concentration of activated carbon 50 mg/dm³, and at the increased dosages of sorbent to 100 mg/dm³ the oil content in water is also high – 1,13 mg/dm³ (fig. 7). And the degree of water treatment, of course, decreases from 99,2% to 98,9% (fig. 8).

During treatment of highly mineralized water (fig. 7) there is also a negative effect. At the doses of aluminum hydroxide in the range of 2–50 mg/dm³, its individual use is much more effective than at the complex application with a sorbent. Accordingly, the degree of treatment of emulsions also decreases from 99,7% to 98,7% (fig. 8).

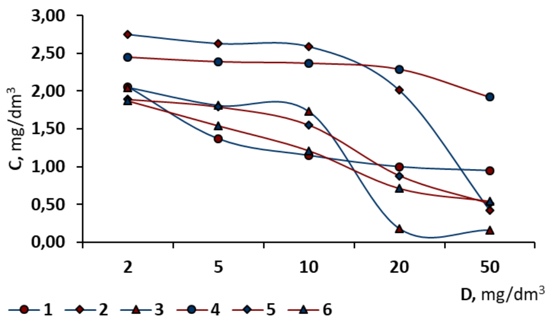

Figure 9. Change in the concentration of oil in fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm³) depending on the dose of $Al(OH)_2Cl$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm³ (1, 4), 50 mg/dm³ (2,5), 100 mg/dm³ (3, 6)

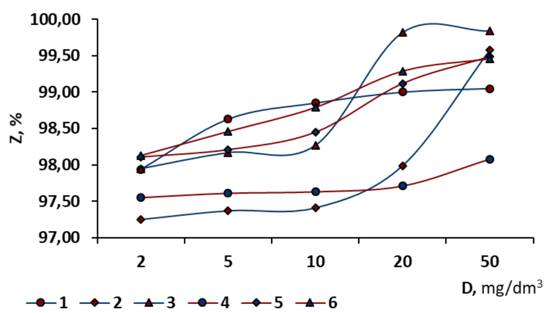

Figure 10. Dependence of oil removal from fresh (1, 2, 3) and salt (4, 5, 6) water ($[H_{initial}]$= 100 mg/dm³) depending on the dose of $Al(OH)_2Cl$ (in terms of Al_2O_3) and the working concentration of the sorbent: 0 mg/dm³ (1, 4), 50 mg/dm³ (2,5), 100 mg/dm³ (3, 6)

The efficiency of the process of complex treatment of water-oil emulsions of aluminum hydroxochloride and activated carbon depends on the initial mineralization of water (fig. 9, 10).

In the case of combined treatment of low-mineralized waters of aluminum hydroxochloride and activated carbon, a stable positive effect is observed at the dose of coagulant of 50 mg/dm³ and sorbent concentrations of 50 mg/dm³ and 100 mg/dm³. At these concentrations, the residual oil decreases from 0,95 mg/dm³ in the absence of a sorbent to 0,42 mg/dm³ in case of sorbent dose 50 mg/dm³ and to 0,16 mg/dm³ in case of sorbent dose

100 mg/dm^3. The water treatment degree correspond to the value 99,05%, 99,58%, 99,84% (fig. 10). At lower doses of aluminum hydrochloride sorbent impairs indicators of water treatment.

In the highly mineralized water, aluminum hydrochloride is the least effective in comparison with hydroxide and aluminum sulphate (fig. 2). However, in combination with activated carbon already at low (5 mg/dm^3) concentrations of coagulant, the efficiency of oil extraction from salty solutions increases significantly (fig. 9). Increasing the sorbent dose from 50 mg/dm^3 to 100 mg/dm^3 practically does not contribute to increase the degree of water treatment from oil (fig. 10). Residual oil concentrations in water at different doses of activated carbon are almost the same.

Summarizing the results, it is possible to say that the efficiency of treatment of fresh water from oil at complex treatment with aluminum coagulants and activated carbon (fig. 5–10) depends on the type of coagulant. The greatest combined effect is observed with simultaneous application of aluminum sulphate and activated carbon – the effect is the most stable and linear. In particular, in case of absence of sorbent at a concentration of coagulant of 50 mg/dm^3 the residual content of oil for aluminum sulfate, aluminum hydroxide, aluminum hydroxochloride in fresh water is 1,41 mg/dm^3, 0,80 mg/dm^3 and 0,95 mg/dm^3, respectively. At addition of activated carbon and coagulants in doses of 50 mg/dm^3, the corresponding values are 0,99 mg/dm^3, 1,17 mg/dm^3 and 0,42 mg/dm^3. In case of further increase of dosages of activated carbon to 100 mg/dm^3 at stable concentration of coagulants (50 mg/dm^3), the residual oil content corresponds to 0,69 mg/dm^3, 1,13 mg/dm^3 and 0,16 mg/dm^3. High efficiency of treatment of low-mineralized water at the complex use of aluminum hydrochloride and sorbent is observed only for high concentrations of reagents. The combined use of aluminum hydroxchloride and activated carbon at low concentrations is inappropriate. To treatment the mineralized water from oil using coagulants and activated carbon (fig. 5–10) it is advisable to use aluminum hydroxochloride in combination with a sorbent. At the same time, there is a stable linear increase in the efficiency of water treatment. And aluminum sulphate or aluminum hydroxide is impractical to use in combination with activated carbon. This is confirmed by the supporting indicators. At the dose of coagulant 50 mg/dm3 in the absence of active carbon, the residual oil content for aluminum hydroxochloride, aluminum hydroxide, aluminum sulfate in salt water corresponds to 1,92 mg/dm3, 0,34 mg/dm^3 and 0,54 mg/dm^3. In the case of active carbon in the dose of 50 mg/dm^3 at the same concentrations of coagulant (50 mg/dm^3), the indicators are 0,51 mg/dm^3, 1,96 mg/dm^3 and 0,31 mg/dm^3. And at increased doses of activated carbon (100 mg/dm^3) at the same doses of coagulants (50 mg/dm^3) the residual concentrations of oil are 0,54 mg/dm^3, 1,28 mg/dm^3 and 0,54 mg/dm^3.

The ambiguity of the obtained results can be explained by the heterogeneity of the initial water-oil emulsions. However, it can certainly be argued that the use of aluminum coagulants to extract oil from water solutions of different mineralization is reasonable and effective.

Conclusions

As a result of the research, it was shown that aluminum sulphate, aluminum hydroxide, aluminum hydroxochloride in concentrations from 2 mg/dm^3 to 50 mg/dm^3 provide a high degree of oil removal from water-oil emulsions. The degree of water treatment is 97–99%.

It is proved that the efficiency of oil removal from water using aluminum coagulants depends depends on the chemical composition of coagulant, as well as on mineralization of the source water. Aluminum hydroxide is the most effective in extracting oil from water, which provides minimal residual concentrations in both fresh and mineralized water.

The compatible use of aluminum coagulants with activated carbon is marked by a fluidity of efficiency, which depends on the type and concentration of coagulant, the dose of sorbent and the mineralization of the source water.

As for the prospects of further research, it is planned to conduct research on the processes of removing oil from water solutions by electrochemical methods, in particular electrocoagulation and electroflotation. In these research it is planned to use iron and aluminum electrodes.

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