

Sorption capacity of oil sorbent for the removal of thin films of oil

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The dependence of the sorption capacity of the sorbents on the amount of sorbent, sorption time, thickness of the oil film, as well as the number of cycles of use of the sorbent was investigated. The performed studies in this work demonstrated the potential use of the synthesized sorbents as adsorbents for the removal of thin oil films.

Keywords: oil sorbent, sorption capacity, thin oil film.

INTRODUCTION

At present, the pollution of surface water bodies by petroleum hydrocarbons occurs not only under accident oil spills, but also during routine maintenance. The process of operative removal of oil pollution from the water surface is topical considering the increasing technogenic impact on the ecosystem. It is therefore particularly important to solve this problem. There is search of materials suitable for collecting oil from surface water and sewage industrial water.

Cleaning of the surface of water bodies from contamination involves the removal of the oil film by mechanical and (or) physical and chemical methods. Most promising and environmentally expedient is the method of removing oil film with the help of oil sorbents [1]. The materials used for the collection of oil and petroleum products from water, are commonly called oil sorbents, as well as collectors of oil and oil absorbers. One of the main problems when cleaning the surface of water bodies from pollution is the removal of a thin oil film having the ability to spread in the shortest terms over vast distances, violating the oxygen exchange [2-3].

For the production of oil sorbents various raw materials are applied [4]. By the mechanism of oil removal are distinguished the sorbents, for which physical surface adsorption dominates. Here, the collection of oil occurs due to adhesion to the surface of the sorbent particles. In this case, the amount of oil absorbed is determined by the specific surface area of the material and its properties (hydrophobic and oleophilic). Literature data show that such a mechanism for collecting of oil and petroleum products is realized for oleophilic

powders and granular materials with closed porous structure and materials in which the pores by size are not available for the molecules of the removable substances [5].

EXPERIMENTAL

All experiments were carried out by the methods described in [6-8]. A Petri dish was filled with water and weighed, and then an oil slick was applied to the water surface so that it didn't touch the walls of the cup, followed by the cup reweighed. Then, on the oil slick a sample of sorbent was applied to complete absorption of the oil spill and the cup was reweighed. Gain of oil weight to the weight of the sorbent gave the value of the absorption capacity of the sorbent in water.

Weight of dry cup was 134.15 g and with water - 178.93 g. The weight of the oil slick was 0.4 g and the weight of the cup became 179.33 g. After the total absorption of the oil slick by a modified carbon sorbent with weight of 0.04 grams, the weight of the cup amounted to 179.37 g, and the sorption capacity was 10.0 g/g.

The weight of the cup with water was 173.44 g and 173.90 - with the oil spill, after applying the carbon sorbent of vegetable origin of weight 0.22 g, the oil spill was absorbed by the sorbent. The sorption capacity of the sorbent was 5, i.e. 1 g of sorbent could adsorb 5 g of oil.

After repeating the experiment with stirring of oil and sorbent, the total absorption of the oil slick was achieved with 0.05 g of modified carbon sorbent, i.e. the adsorbent capacity increased to 10.9 g/g.

For creation of an oil film into a Petri dish, about 40 ml of water with a salt concentration of 17-20 g/l (seawater) was poured and a few drops of oil were added. When the oil slick was formed, its diameter and thickness were determined.

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RESULTS AND DISCUSSION

In the laboratory tests the medium viscous oil of Karazhanbas was used (Figure 1).

The dependence of the sorption capacity of the obtained carbonized sorbents based on rice husk (CRH) on the amount of sorbent, the sorption time, the thickness of the oil film, as well as the number of cycles of use of the sorbent was studied.

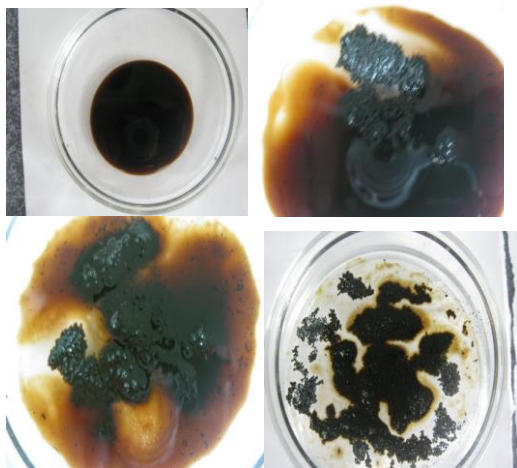


Fig. 1. Sorption of oil of Karazhanbas.

Figure 2 shows the sorption capacity of the sorbents on the sorption time. As can be seen from the presented data, the maximum sorption of oil is in the first minutes (~ 3-4 minutes), after which the sorbent based on foam rubber and sunflower husk carbonizate (FRCSH- 300) is able to retain the sorbed oil for two days, whereas the sorbents on the basis of polystyrene foam and carbonizate of rice husk PFCRH-400 and modified foam rubber (MFR-300) after active sorption gradually began to release it after 4 hours.

Such behavior of the sorbents may be due to the lower level of hydrophobicity and oleophilicity of the sorbents based on PFCRH-400 and MFR-300, and the different structure of the sorbents.

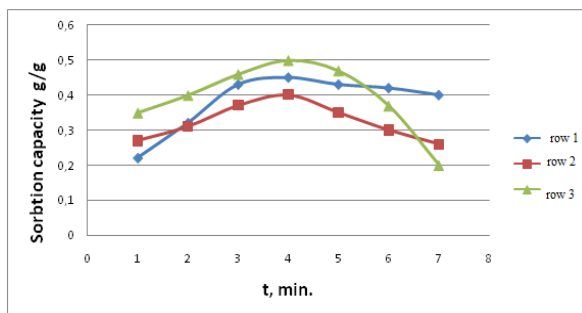


Fig. 2. Dependence of the sorptive capacity of the sorbents on the sorption time: 1 - Foam rubber + carbonizate of sunflower husk (FRCSH- 300) 2 - Foam polystyrene + carbonizate of rice husk (PFCRH-400) 3 - Modified foam rubber (MFR -300)

The sorption capacity of vegetable materials without polymers was studied as well. With the increase in mass of the sorbent amount, the sorbed by it oil gradually increased. After reaching the optimal sorption time (4 hours), the speed of active sorption markedly decreased, which may be explained, apparently, on the one hand by the oil saturation of the sorbents, and on the other hand, by the process of desorption (in the case of CRH-400 and -300).

The dependence of the sorption capacity of the sorbents on the thickness of the oil film was also studied (Fig.3).

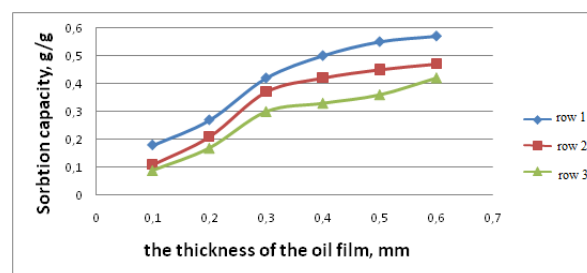


Fig. 3. - Dependence of the sorption capacity of the sorbent on the thickness of the oil film: row 1 - Foam rubber + carbonizate of sunflower husk (FRCRH- 300); row 2- Foam polystyrene + carbonizate of rice husk (PFCRH -400); row-3 modified foam rubber (MFR-300)

It is known that the maximum absorption capacity of the sorbent is exhibited with an excess amount of absorbed oil [9,10]. As seen in Fig.3, the increase in the thickness of oil film increases the oil absorption capacity of the sorbents.

The results of the studies of the dependence of the sorption capacity of the sorbents on the number of cycles used are shown in Table 1.

Regenerability of sorbents in one of the basic performance parameters. The obtained data illustrate the good regenerability of the sorbents and the possibility of their repeated use.

Regeneration of the sorbents was carried out by centrifugation by washing with a hydrocarbon solvent and followed air drying.

The data in Table 1 demonstrate the potential use of the sorbents synthesized by us as adsorbents for the removal of thin oil films.

We have also studied the maximum oil absorption of CKP-400, depending on the viscosity and the physical state of aggregation, i.e. the sorbed oil product was a petroleum oil, oil, gasoline and diesel fuel.

In the cases when the thickness of oil spill layer is less than the thickness of the sorbent the collection of oil from the water surface also occurs beyond the sorbent place. Table 2 shows that the sorbent absorbs oil «Mobil», to a higher extent than

gasoline and diesel. This is probably due to the higher affinity of the sorbent to the sorbed oil.

With increasing film thickness, the oil sorption capacity of the sorbent increases.

From the data of Table 2 it is clear that the collection of relatively low-viscosity products (gasoline and diesel) racking of their excesses and real-absorbing properties of the sorbent are characterized by oil absorption at the level of 30-40 g/g.

This sorbent is easily regenerated by simple squeezing of the absorbed oil. Despite of the high oil absorption of sorbent "CRH- 400" its application in dispersed form is not enough technological due to the significant time consuming

technical difficulties that arise at spraying of the sorbent on the surface oil spills and subsequent collection of the spent sorbent.

Since the performance of the sorbent heavily depends on the ambient temperature, for example, in winter conditions, we also investigated the effect of ambient temperature and volume weight of sorbents based on Apricot stone CAS-400 and rice husk CRH-400.

Table 3 represents the temperature dependence of the sorption capacity of sorbents (CAS - 400 with weight by volume of 50 g/cm³ and CRH- 400 with weight by volume of 150 g/cm³) on oil and petroleum products in the temperature interval 10-50 °C.

Table 1. Dependence of the sorption capacity of the sorbents on the number of cycles used

Number of Cycles	Sorption Capacity, g/g		
	FRCRH-300	FPCRH-400	MFR -300
1	0.45	0.49	0.42
2	0.44	0.40	0.40
3	0.35	0.38	0.40
4	0.33	0.35	0.32

Table 2. Effect of the thickness of oil and oil products on the sorption capacity of the sorbent CRH-400, g/g

Collected oil product	Layer thickness, cm	Amount (g/g) of the sorbent on the collected oil product		Degree of squeezing, %
		absorbed	squeezed	
Oil field "Kumkol"	4.1	38-40	28	86
Oil "Mobil"	1.1	53-60	43	87
Motor car gasoline	3	32-33	25	78
Diesel fuel	4	24-30	19	77

Table 3. Influence of temperature of the medium and bulk density of sorbents on the sorption capacity on oil and petroleum products (g/g).

Weight by volume, g/cm ³	Temperature of medium, °C	Sorption capacity of sorbents, g/g			
		Oil	Fuel oil	Diesel fuel	Gasoline
CAS-400 50 g/cm ³	10	9.3	7.4	1.6	1.4
	15	12.4	11.5	2.4	2.1
	25	15.6	16.2	3.5	3.0
	30	17.4	17.3	3.5	2.4
	35	20.4	21.4	2.4	-
	40	22.5	24.2	1.0	-
CRH-400 150 g/cm ³	10	4.0	2.2	8.3	7.2
	15	5.3	2.5	9.2	8.1
	20	5.4	2.6	10.3	9.1
	25	6.2	3.4	11.4	12.1
	30	8.1	5.2	12.5	12.1
	35	8.8	6.3	12.4	-
	40	10.2	7.2	12.0	-

Analyzing the data of Table 3, we can come to the following regularities: in the case of oil and fuel oil, temperature increase leads to a constant growth of the sorption capacity for oil and fuel oil of the sorbent CAS-400. In this case, the established temperature limit for the sorbents is not the limit of saturation of oil and fuel oil.

The maximum adsorption capacities of these sorbents are 22.5 and 24.2 g/g, respectively. In the case of gasoline and diesel fuel in the sorbent CAS-400 with weight by volume of 50 g/m³ the maximum sorption of diesel fuel was achieved at a temperature of 30°C and was equal to 3.5 g/g. A further increase in the temperature of the medium causes a decrease in the sorption capacity of the sorbent on diesel fuel. This is due to the fact that the sufficiently large mesh size of the sorbent AS - 400 ensures that the forces of attraction between the sorbate molecules are higher than those between the sorbate and sorbent molecules, resulting in a liquid phase portion flowing from the cells of a solid sorbent during weighing [11].

In the same Table 3 the regularities of the changes of the sorption capacity of the sorbent CRH-400 with a bulk density of 150 g/m³ with temperature are given. By analogy, in this case, regardless of the type of the sorbate, a regular increase of the temperature of sorption capacity was observed. This is due to the fact that with increasing temperature, the viscosity of oil and petroleum products is reduced, and thereby, the migration of sorbate to a diffusion region of fine-mesh macrostructure of the sorbents is accelerated. However, here, an opposite picture is observed: the sorption capacity for diesel fuel and gasoline is higher than that of oil and fuel oil. In this case, we are confronted with the specifics of selective sorption of sorbents and their ability to selectively perform the sorption of oil and petroleum products, depending on the size of the cells and bulk density. The studies revealed that the conducted studies allow to speak about potential use of the sorbents synthesized by us as adsorbents for the removal of thin oil films. On the basis of experimental data it was revealed that the maximum absorption of crude

oil is reached at equal proportions of the film thickness of dispersed sorbent and the thickness of layer of an oil spill, i.e. in the case of oil «Mobil» with a layer thickness of 1.1 cm the maximum adsorbed quantity of oil products is 53-60 g.

CONCLUSION

It was found that irrespective of the type of oil and volume weight of the sorbent, with an increase of thickness of layer of oil from 1.0 to 7.0 mm there was a general tendency to increase the sorption capacity. It is interesting to note that the maximum sorption for each type of oil occurred on sorbents with definite values of bulk density.

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СОРБЦИОНЕН КАПАЦИТЕТ НА СОРБЕНТИ ЗА ОТСТРАНЯВАНЕ НА ТЪНКИ СЛОЕВЕ ОТ НЕФТ

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(Резюме)

Изследван е сорбционният капацитет на сорбенти в зависимост от количеството, времето, дебелината на нефтения филм, както и броя на циклите на употреба. Извършените изследвания демонстрират потенциалната полза от синтетични сорбенти за отстраняването на тънки филми от нефт.