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STUDY OF SORPTION PROPERTIES OF VARIOUS MATERIALS FOR COLLECTING OF OIL AND OIL PRODUCTS

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ABSTRACT

The properties of natural organic, synthetic organic and inorganic materials used for picking-up oil spillages, such as oil absorption, water uptake and squeezing degree, were studied. The main methods of water purification from oil and oil products, the main types of oil sorbents, their advantages and disadvantages were considered.

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1. INTRODUCTION.

Currently, a huge number of industrial enterprises using various petroleum products pour out tons of untreated or insufficiently treated industrial, surface and storm wastewaters into lakes, rivers and seas. Such discharges cause irreparable damage to the environment. Accidental spills of oil and oil products also pose a great danger. Due to the fact that oil products form a thin film on the water

surface, and in depth they are in an emulsified and dissolved form, this causes great harm to hydro- and biosphere objects. Therefore, this problem becomes more and more urgent [3, 4].

To date, there are various methods for elimination of this type pollution of the environment: mechanical, biological and physicochemical. The most important from them is sorption purification of water from oil and oil products [3, 4, 7, 15].

Sorbents must have a number of specific characteristics: significant adsorption capacity, hydrophobicity, chemical and thermal stability, floatability, and the possibility of regeneration. Also important are indicators such as environmental harmlessness and cost [4].

The efficiency of oil absorption depends on the chemical affinity of the sorbent material and the absorbed liquid, and on the structure of the material. Oil absorption occurs as a result of rapid wetting of the sorbent surface with oil or oil product, then oil or oil product penetrates into the porous structure of the material filling all voids under the action of certain forces [1, 3, 12, 13, 17].

Synthetic sorbents are widely used. They have good absorption capacity, but they are more expensive and difficult to dispose of due to the high toxicity of combustion products. A feature of synthetic polymeric materials is the ability to change their porous structure in a very wide range retaining of their chemical structure. By varying the initial components in the synthesis of porous materials, it is possible to obtain adsorbents with predetermined hydrophobic or hydrophilic properties [13, 15, 16].

The term "biosorbent" refers to sorbents that are immobilized by cultures of microorganisms ensuring the biological decomposition of oil and oil products. A significant number of biosorbents have been developed, the distinguishing feature of which is the variety of carriers (sorbents) used and cultures of microorganisms immobilized on them [4, 11].

Natural materials and sorbents based on them have a number of advantages – low cost, availability of sufficient amounts of raw materials, low toxicity.

For wastewaters polluted with oil and oil products a number of minerals are used as raw materials for obtaining of sorbents. These are aleurite, apatite, argillite, asbestos, vermiculites, combustible shale, graphite, kaolin (kaolinite), carbonates, perlite, chain silicates (wollastonite), layered silicates (clayite), frame silicates (clinoptilolite and mordenite), and also ore mining wastes [1, 3, 4, 7, 12, 13, 17, 18].

Sorbents based on wood wastes are products obtained directly from the wood itself – wastes from the processing of greenery, sawdust [2, 6, 9].

A number of oil capacity sorbents have been created on the basis of technical residues from the production of cotton wool, low-grade industrial cotton, and waste from textile production. They are called sorbents based on cellulose-containing materials[4].

Exist sorbents based on raw materials of plant and animal origin.

Sorbents based on vegetable raw materials: the most promising are organic sorbents obtained from renewable plant material. They are an organic part of the ecosystem and meet international environmental requirements to the greatest extent. Examples of such sorbents with high adsorption properties and hydrophobicity are crop wastes, sphagnum mosses [3-5, 7, 10].

Sorbents based on animal raw materials: as a hydrophobic adsorbent for cleaning warehouses from oil and oil products during well drilling, as well as for cleaning of oil traps at industrial service bases, at technological transport departments, and at oil refineries, leather dust and chippings are used. [4, 7].

Carbon-containing granular sorbents, depending on the pore size, can be successfully used to extract impurities of various molecular sizes, large impurities and mixtures of polydisperse composition (domestic wastewater) from water [1, 3].

It should be especially noted that when evaluating the effectiveness of various natural sorbents, it is necessary to take into account not one characteristic, but their complex and the nature of the material. Despite the fact that there is a huge range of sorbents for purification of water from oil and oil products, the limiting factor for their usage is their relatively high cost. The manufacturer should be also taken into account. As a rule oil sorbents of foreign production are chosen. In our country, of course, there are technologies for production of oil sorbents both from natural raw materials and synthetic ones. At the same time, the cost of these products is an order of magnitude lower, and the properties sometimes surpass foreign analogues, but the implementation of domestic

sorbents and the technology for their production is confronting by great difficulties, despite the fact that there is an acute problem of oil spills [4, 6, 8, 11].

Materials used to collect oil and oil products from the surface of water bodies are commonly called oil sorbents, as well as oil collectors and oil absorbers. To determine the quality of oil sorbents, three main indicators are used: oil absorption, water absorption, floatability. The effectiveness of sorbents for collecting oil is evaluated primarily by the value of oil capacity. High water absorption can be eliminated for almost all materials by additional hydrophobization.

At present, a wide range of sorbents for water purification from organic pollutants is known in the world and a variety of raw materials are used for the production of oil sorbents [12-18].

2. EXPERIMENTAL METHODS, MATERIALS, RESULTS AND DISCUSSION.

As an object to be studied we have chosen natural, synthetic and inorganic sorbent materials. As an oil product the motor oil was chosen. Oil capacity and water capacity were measured, which are of great importance when choosing a sorbent. Water capacity is characteristic of the material to absorb and retain water in its pores. To measure the water capacity, sorbents with a mass of m = 4 g were put into a glass of water. After 10 min, the sorbents were removed and their mass was measured again. Water capacity was calculated using the formula $B = (m_1-m_2)100/m$, where m_1 is the mass of dry sorbent, m_2 is the mass of sorbent saturated with water. According to the data obtained, water absorption was calculated, the results are shown in the following table.

Oil capacity is an ability of a material to absorb and retain oil and oil products in its pores. This is also an important criterion when choosing one or another sorbent, because its effectiveness depends on it for the most part. For the experiment, the density of engine oil was previously measured (ρ=0.9 g/cm³). In order to measure the oil capacity of the selected materials experimentally, the motor oil was poured into a measuring cup, its volume was measured (50 ml), and the mass of dry sorbents used was measured. The sorbents were placed in measuring cups containing the oil product. After 20 minutes, they were removed and the mass of the sorbent saturated with the oil product was measured again. The oil capacity M was calculated using the formula $M = (m_1-m_2)100/m$, where m_1 is the mass of the dry sorbent, m_2 is the mass of the sorbent saturated with oil. According to the data obtained, oil absorption was calculated, the results are shown in the following table.

Table. Properties of several products for collecting of oil and oil products.

Material	Oil absorption, g/g	Water absorption, g/g	Oil wringing, %
1	2	3	4
Natural organic materials			
Wheat straw (chopped)	4	4.5	35
Buckwheat husk	3 – 3.7	2.1	45
Sawdust	1.8	4.5	10 – 25
Waste of cotton production	8.1	0.25	66
Wool	8 – 10	5	89
Macroporous technical carbon	4 – 4.5	0 – 1.5	10 – 85
Synthetic organic materials			
Polystyrene foam: fiber	5	6-11	85-92
Polypropylene: fiber	15 – 40	1 – 8	40 –85
Carbamide-formaldehyde resin: powder	40	0.1	65
Phenolphormaldehyde resin: powder	4.5	15	0.2
Foam-rubber laminated	14.5 – 35	1.5 – 26	75 – 90
Sintepon	46	40 – 50	95
Lavsan: fiber	4.7 – 14	3 – 14	60 – 85

Table. Continuation.

1	2	3	4
Inorganic materials			
Glass fiber	5.5	2.1	65
Praphite, modified	40 – 60	0.5-10	10 – 65
Perlite	8 – 17	0.5	15
Diatomite	20-35	40	60
Zeolite	10-30	25	10-50
Basalt fiber, modified	37	0.5	27

3. CONCLUSION.

During the experiment with water, the following features of the action of sorbents were revealed: various materials quickly became saturated with water, but retained it poorly. Others slowly saturated with water and at the seventh minute began to crumble into small particles so it was not possible to measure their water capacity. Some materials slowly absorbed water, but retained it well, while others quickly absorbed water and, under its weight, partially sank to the bottom of the glass.

As it was noted above, motor oil was used for the experiment. After placing some materials in engine oil, they quickly began to absorb oil products. Most of the oil products were consumed. They had a high oil capacity. Some of them slowly absorbed oil and absorbed a small amount of oil products. Few units of sorption did not show abilities, while others quickly absorbed oil. The mass of absorbed oil was more than 2 times higher than the initial mass of dry sorbent.

Исследовали кинетику сорбции паров жидких сред на весах Мак-Бона с кварциевой спиралью и определяли молекулярные массы полимеров вискозиметрическим методом.

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