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Research Article

ADSORPTION PROCESSES FOR RESTORING TECHNICAL CHARACTERISTICS AND PROPERTIES OF USED OIL

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ABSTRACT

The work carried out systematic research to create a technology for restoring the original properties of used oils. Adsorption purification of waste oils using the bentonite-vermiculite method was carried out. based on the use of the ability to retain oily contaminants penetrating through the outer surface and internal capillaries - the pores of the sorbent granules.

KEYWORDS

Bentonite, vermiculite, adsorption purification, waste oils, petroleum, pyridine, interlayer structure.

INTRODUCTION

In the processes of oil exploitation, oxidation products and other polluting waste accumulate, which cannot be processed at refineries, since particles added to oil lead to the failure of plant equipment. Currently, only 17-19% of used oils are being restored, accumulated used lubricants lead to contamination of the soil layer, a decrease in the area of land and its useful components. Recycling and reuse of accumulated waste oils is important.

Today, in-depth research is being conducted in the world aimed at the regeneration of contaminated waste oils and their reuse into products that ensure effective use. In this regard, special attention is paid to determining the causes of oil pollution, comparing the chemical composition, physical and operational properties of used oils, accelerating and refining technologies for their regeneration using acid, alkaline and selective, as well as adsorbates.

The purpose of the study is to create a technology for restoring the original properties of used oils.

The discussion of the results. The sources describe physical, physical-mechanical, physical-chemical, adsorption, combined and other methods of regeneration processes [1-4]. Chemical methods of oil purification used in this literature have been viewed as secondary, with recommendations for the use of physical methods based on the final step of the purification process as the primary method of removing contaminants.

In recent years, it can be seen that more and more sources are appearing in the published literature devoted to the study of physical methods for purifying oils. The practical aspect of these methods is mechanical impurities (metal particles, sand, dust, water, heavy asphaltenes, tar, mineral clots, coke, etc.) that are eliminated in the process and are associated with a constant content of hydrocarbons in base oils [5] . Methods of distillation, separation, filtration, evaporation, and transfer of water vapor in physical processes were considered traditional and were introduced into production processes.

Among the physical methods for purifying used motor oils, a number of studies using chemical methods can also be noted [50; P.257]. Methods for chemical purification of used motor oils are based on the interaction of special substances added to the mass and the slag in the composition. Special chemical reagents must form compounds that allow the oil to be easily extracted from the contents when interacting with the suspension. Based on this, chemical methods differ in the interaction of acidic, alkaline, acid-base, hydrogenation, oxidizing, drying components and sludge with metal oxides, carbides and hydrides.

Acid cleaning involves cleaning the oil with sulfuric acid (concentrated). This allows you to eliminate unwanted components - asphalt-resin compounds, oxidation products, as well as unsaturated hydrocarbons and aromatic compounds that contribute to the appearance of heavy products in the oil. Sulfuric acid has the ability to react between contaminants such as resins, asphaltenes, carbonyl compounds, hydroxy acids, phenols, etc. Chemical purification in this case occurs along with physicochemical phenomena, since sulfuric acid is a solvent for certain substances [6].

Alkaline cleaning is also used in industry. In a used engine oil regeneration system, this may be a step after cleaning with sulfuric acid, as well as a separate step. Caustic soda, soda water and trisodium phosphate are used as reagents for alkaline cleaning. The process is carried out in a closed system with high pressure and a temperature of 70-80°C.

Used motor oil, treated with a chemical acid base and solvent, after filtration is sent for adsorption treatment with betnotnite and vermiculite.

In order to increase the efficiency of the adsorption process, bentonite and vermiculite have passed the initial stage of purification and activation. It should be noted that the use of a mixture of bentonite and vermiculite sorbents prevents metal ions from entering the composition of the cleansing oil and ensures that the oil will be transparent, clean and light in color. Purification and activation of bentonite and vermiculite is carried out by acid-base and heat treatment, which leads to an increase in the amount of SiO_2 due to the melting of magnesium, iron, aluminum and bentonite oxides in the composition, which, along with an increase in the absorption activity of the adsorbent, also increases the rate of transition of waste oil.

The adsorption purification of waste oils by the bentonite-vermiculite method is based on the use of the ability to retain oily impurities penetrating through the outer surface and internal capillaries - pores of sorbent granules. Bentonite was obtained at the Navbakhor field in Navoi region, and vermiculite - at the Tebinbulok field in the Republic of Karakalpakstan, which are determined by the relatively low cost, availability of this type of raw material and the ability to better adsorb the products of hydrocarbon oxidation in the oil used - tar, heterocyclic compounds, etc.

In recent years, the bentonite extraction and processing capacities at the Navbakhor deposit in Navoi region have increased several times. This is one of the important properties of bentonite, the presence of alkaline and alkaline earth elements in its composition. Bentonites are known to consist of more than 70% montmorillonites with an aluminosilicate layer. Montmorillonite is a crystallochemical structured mineral that determines its physico-chemical properties, such a structure of which ensures the presence of ionizing cations on the surface.

The negative charge in large quantities at the interlayer spatial boundary of montmorillonite ensures high hydrophilicity of bentonite and is compensated by alternating cathones. When bentonite interacts with water, it penetrates into the interlayer spatial boundary of montmorillonite, hydrates, and swelling is observed. Bentonite has a thixotropic shell when washed with a large amount of water - when mechanically exposed, it forms a stable suspension with reduced viscosity and increased viscosity when infused.

Generalized methods were also used to purify and activate the vermiculite of the Tebinbulak deposit. It is known that during the heat treatment of vermiculite, layering and an increase in volume are observed. Vermiculite does not change with rapid heating to 100 ° C, layering only at 300 ° C, while maximum swelling is observed with a sharp increase in temperature. With slow heating, a sharp increase in the yield of vermiculite plates is not observed, while when it is expanded, a light porous material is formed. The reason for the layering perpendicular to the layering plane can be explained by the sharp separation of water vapor in the layering zones.

Research was carried out to increase sorption activity by chemical treatment of vermiculite from the Tebinbulak deposit. For chemical activation, thermally treated expanded samples were selected. The chemical treatment was carried out with a mixture of nitrate and sulfuric acid, and as a result of analysis of vermiculite samples treated in an acidic environment, the oxides of magnesium, iron, aluminum in the vermiculite indicate a relatively increased content of silicon oxide as they transition to a solution state.

Samples treated with thermal and acid treatment with nitrogen-hetroatomic heterocyclic compounds were studied in order to modify the surfaces of vermiculite from the Tebinbulak deposit by chemical treatment.

Many sources report that a number of scientific attempts have been made to intercalate with organic molecules in the interlayer field of vermiculites [7-9]. As a result of this modification, it was proven that the sorption properties of the mineral composition are improved. Organic components are introduced into the interlayer region in a neutral or cationic state. Considering that the intercalation process is associated with the physicochemical state of the mineral active surfaces, an azoheterocyclic pyridine ring was used.

Previously, in the course of research, the structure of the impact surface of vermiculite from the Tebinbulak deposit was studied, taking into account the fact that adsorption, desorption and intercalation of cations are associated with the physicochemical state of the active surface of the mineral.

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Modification of the surface of the vermiculite sorbent of the Tebinbulak deposit was carried out using a pyridine ring C5H5N, characteristic of tertiary amines, which has aromatic properties.

Modification of verimulite with a pyridine ring is associated with the expansion of its structure in the vertical direction by layers [10], recognizing that with an increase in the number of carbon atoms in an organic molecule, the distance between the layers also increases. The rate of reproduction and intensity will be related to the structure of the organic molecule obtained for the purpose of modification, as well as its location between layers, concentration and duration of the reaction. Taking this into account, the modification was studied for 8, 16, 24 hours at temperatures of 80-100°C in a vermiculite: pyridine ratio of 1:2 ÷ 1:4.

In studies involving pyridine, interlayer masafa with a holding time of 16 hours with vermiculite had maximum values, and nanoparticles of the pyridine molecule were also identified. The shape of the surface of the intermediate layer is influenced by electrons in the nitrogen heteroatom, forming an irreversible chain of different sizes, not completely and uniformly coated on the surface of vermiculite. The surface condition of the multilayer surface can also be explained by the result of partial dehydration of metal cations under the action of temperature.

The adsorption rates of zinc ions by the initial unmodified (A) and modified (b) vermiculite of the Tebinbulak deposit were studied (Fig. 1).

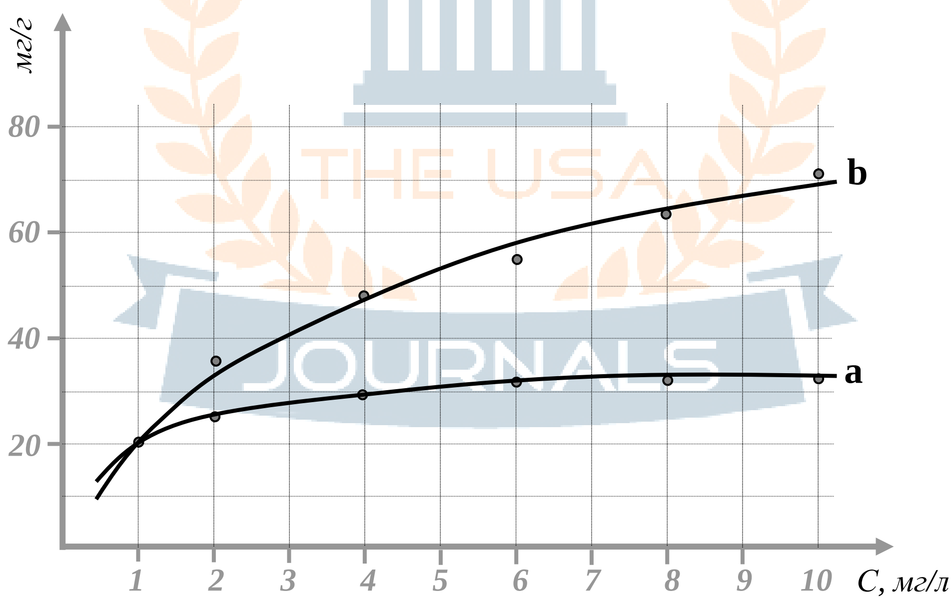

Figure 1. Initial isotherms of zinc ion adsorption on the vermiculite of the Tebinbulak deposit: unmodified (a) and modified (b)

As can be seen from the data obtained, vermiculite modified with pyridine effectively sorbs zinc ions in comparison with its inactivated original analogue. At the same time, the modified composition has a high specific surface area and maximum adsorption

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capacity compared to all purified and activated samples.

As shown above, the high sorption property of the pyridine-modified sorbent does not overlap the vermiculite surface, forming a complete and planarly homogeneous non-layer, forming non-repeating channels that vary in size and shape. The modifier ensures that the shapes formed by pyridine and their arrangement on the surface provide a different distribution of electrons on the surface of the verimulite and that the surface is composed of nanoscale quantities.

It has been proved that vermiculite is dehydrated at low temperatures of 80-90 °C, and this process leads not only to partial destruction of its interlayer structure, but also to a change in the surface structure as the distance between the layers decreases from 15.43 Å to 14.78 Å. If there are not so many convex coins on the surface of the vermiculite, this surface can be evenly coated with pyridine.

In a bentonite-vermiculite combination sorbent, the ion sorting mechanism can be represented in the following two directions: by cation exchange reactions of metal ions on flat surfaces with a negative charge or by the formation of hemispherical complexes with active centers of sorbent particles.

The mechanism of adsorption of pollutants from used motor oils by bentonite-vermiculite sorbent is complex and is determined by the active surface of the composite sorbent, as well as the intermolecular effect between the sorbent composition and the forces of electrostatic action of non-volatile point charges. In the process of adsorption of metals in polarized sorbents with ionic mineral structures, the chemical nature of the sorbent is considered important. On a solid surface, ions are adsorbed if they represent a group of atoms of the same type or an isomer with an interacting surface, while donor-acceptor complexes through chelates are formed in the donor oxygen atom, metal ions in the acceptor state.

Through research and analysis of the results, it can be assumed that the rate of adsorption process of the combined bentonite-vermiculite system is a two-stage process: the second stage of the action of delayed-action activated bentonite, based on the diffusion of ions on the surface of the adsorbent in the oil used and adsorption on the same surface, with vermiculite in waste oils. The quantitative change in the metals entering the sorbent system is determined by the nature and concentration of active centers interacting with metal ions.

Bentonite and the combined bentonite-verimculite sorbent help clean waste oils from metal impurities. The results of purification of used oils from metal impurities are shown in Figure 2.

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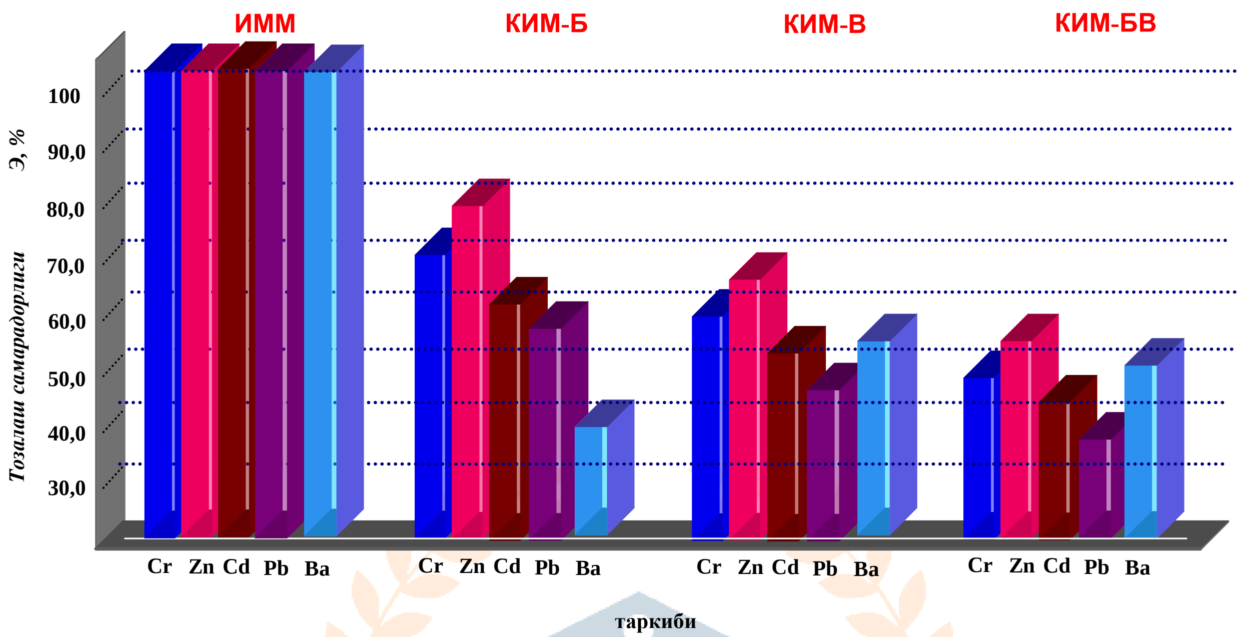

Figure 2. Quantitative indicators of metals in used and regenerated oil

IMM – used motor oils; KIM-B – chemically treated waste motor oils purified with activated bentonite; KIM-V – chemically treated and used motor oils purified with modified vermiculite; KIM-BV - heat-treated waste motor oils, purified with bentonite-vermiculite combined sorbent.

It is known that vermiculite effectively adsorbs organic compounds when used in various ratios, while the permissible proportions of vermiculite for the sorption of organic compounds are 1: 4 ÷ 1:6.

Collected processing data for used motor oils extractively treated in bentonite-vermiculite combination systems and they are shown in Table 1 below.

Table 1

Physico-chemical properties of purified used motor oils

Indicators	Used motor oils		Refined used motor oils		Unused motor oils	
	№1	№2	№1	№2	№1	№2
Viscosity, mm2/s						
- 40 °C	60.59	59.74	69.51	67.27	92.21	90.7
- 100°C	9,52	9.57	12.42	10.98	13.99	14.6

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Amount of mechanical impurities, % no more	0.087	0.072	0.016	0.023		
Amount of water, % no more	0.05	3.45				
Flash point, °C	190	205	205	217	200	208
Pour point, °C no more	-23	-22	-29	-30	-40	-40
Density, kg/m3 no more	880	882	875	877	861.4	863
Composition (mg/kg):						
Sulfur;	0.3238	0.3442	0.2432	0.2156	0.2312	0.2096
Ethylbenzene:	11.8	20.3	0.289	0.345		
Toluene;	136	324				
Xylene;	584	635				
Polyaromatic compounds						
Composition (mg/kg):						
lead	21.16	10.69	0.98	0.89	0.16	0.18
zinc	402.96	387.56	140.99	138.25	139.04	138.18
aluminum	57.94	41.36	12.65	11.03	12.70	10.96
calcium	171.94	203.12	67.54	63.41	65.88	61.54
magnesium	436.12	440.96	124.36	122.15	164.41	120.18
copper	37.85	32.48	3.54	3.03	1.04	1.48
chromium	18.26	7.95	2.89	2.18	2.09	3.31
cadmium	0.51	0.12	0.05			
barium	13.89	3.45	4.91	1.03	0.94	0.87

CONCLUSION

From the results of the study it is clear that purified motor oils meet standard requirements: flash and solidification points do not differ significantly from those of unused motor oils; the number of metal ions in the composition is also close to each other and differs by no more than a maximum of 5%. Comparing the physicochemical indicators of used and unused motor oils, we can conclude that the indicators of GOST requirements have been studied and recommended for reuse after adding the necessary additives.

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