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Study of the composition of petroleum products extracted from oil-contaminated soil using the spectrometric method.

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Abstract

Oil-contaminated soils undergo various transformations, depending on the composition and duration of exposure to the pollutant, which leads to changes in the soil structure and even the component composition of the oil. This paper presents the results of a study of soil samples with a high content of oil fractions. From the results, it follows that oil-contaminated soils under the influence of the environment undergo significant structural changes, namely, agglomeration, with the formation of long hydrocarbon chains and indestructible complexes. This must be considered when developing methods for cleaning soils from oil pollution.

Key words: oil-contaminated soil, petroleum hydrocarbons, volatile components, spectrum, chromatography

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1.Introduction

The reason for separating oil pollution into separate types is the complex composition of oil (hundreds of different hydrocarbon compounds and heterocyclic compounds containing nitrogen, oxygen, sulphur, and trace elements) and its simultaneous entry into the environment. Strong toxicants to vegetation are volatile aromatic hydrocarbons contained in oil and some water-soluble fractions of oil. Oil and oil products in direct contact with plants act mainly as powerful herbicides [1]. In soils, oil and oil products exist in several forms: in pores, gas and liquid in a state of high mobility, free or dissolved in aqueous or aqueous emulsion phase; in pores and cracks, in a free, stationary state, acting as a viscous or solid binder between soil particles and aggregates; in a sorbed state, bound on soil particles, including soil humus compounds; in the surface layer of soil or soil in the form of a dense organomineral mass. The qualitative and quantitative changes that occur during the long-term presence of foreign organic compounds in the soil and the mechanisms of their redistribution have not yet been fully studied.

When oil comes to the surface of the earth, it finds itself in qualitatively new existing conditions. Geochemical processes penetrate a well-aerated environment from anaerobic conditions, where it undergo various physical and chemical changes [2]. Oil components can rearrange under the influence of diffusion and capillary forces through saturation, hydrogenation, or dissolution of soil pores in water. Crude oil can be transported and transformed by evaporation, adsorption, and sedimentation. Under the influence of various atmospheric influences and chemical transformations, various hydrocarbon fractions of oil and petroleum products can be converted into asphaltenes. In this case, oil and its derivatives acquire a bituminous structure, which is difficult to decompose.

Asphaltenes and high molecular weight polycyclic aromatic hydrocarbons tend to accumulate in soil. Due to the absence of polar groups on the molecules, these substances are extremely hydrophobic. They can be absorbed by organic matter, trapped in micropores, and form

stable compounds in the soil, which contributes to their low biodegradability [3]. As a result of oil pollution, intrasoil heterogeneity in the distribution of pollutants occurs.

Soil contamination with oil leads to a sharp change in its properties: the soil becomes hydrophobic, and therefore its agrophysical and especially water-physical properties change dramatically. Light fractions of oil have a particularly strong phytotoxic effect [4].

The effect of oil on living soil organisms is largely determined by its concentration. In low concentrations, oil has a stimulating effect on soil biota since it is an energy substrate for a large group of microorganisms and contains substances that stimulate plant growth and development. Severe soil contamination with oil is accompanied by an acute toxic effect of oil on living organisms, especially in the initial period after contamination [5].

As a result, when choosing a solvent, it is necessary to take into account the complex chemical composition of both the substance being determined—the petroleum product—and the object being studied—the soil. Impregnation of soil mass with oil leads to changes in the chemical composition, properties, and structure of soils. First of all, this affects the humus horizon; the amount of carbon in it increases sharply, but the properties of soils as nutrient substrates for plants deteriorate. Petroleum products cause the formation of a stable hydrophobic film, thereby disrupting the recycling and exchange of nutrients through the soil. In the soil profile, it is possible to change redox conditions and increase the mobility of humus components and several microelements [6].

4. Research method

To study the negative impact of long-term oil pollution on the soil cover, we conducted laboratory studies of a certain composition and concentration of oil products. These studies were based on chemical methods: extraction using organic solvents, calcination to determine volatile components, and gas-liquid chromatography [7]. We took two samples of oil-contaminated soils of varying degrees from the Balakhanyeft field. Samples were taken from the well area at two different locations from the well, with a sample collection date of April 4, 2023. We studied the processes of extracting petroleum products from samples using different solvents: benzene, n-hexane, toluene, and chloroform.

We examined the resulting samples of petroleum products after extraction using gas-liquid chromatography, since it is the most promising, with simultaneous decoding of the chemical composition, which allows us to determine the individual components in a mixture of petroleum products. Therefore, we examined samples of extracted petroleum products using a gas chromatograph with a flame ionization detector, and the separation efficiency of the mixture components was high [8].

5. Results and discussion

For the most complete information about the isolated petroleum products, we carried out additional research on the analysis of petroleum products using a modern physical and chemical method, such as nuclear magnetic resonance. The NMR spectra of the samples we prepared, presented below, were taken to obtain approximate information about the composition of petroleum products extracted from the soil and more precisely, to assess the integral intensity of the signals to obtain the number of protons belonging to various functional groups.

To do this, we prepared two samples of petroleum products extracted from contaminated soil using chloroform as a solvent. The first sample was obtained by the long-term stirring of this soil in chloroform, with further evaporation of the solvent by heating. We obtained a second similar

sample with minimal stirring and evaporation without heating. Based on the NMR spectra of these samples, it can be concluded that the aliphatic part of the mixture is many times greater in composition than the aromatic compounds.



Figure 1. NMR spectrum of the first sample

The broadened signals in the spectrum of the first sample in the region of 0.74–1.1 ppm relate to the signals of the methyl, methylene, and methine groups of alkanes and cycloalkanes. The broadened signals in the region of 2.12–2.5 ppm refer to the signals of methyl, methylene, and methine groups associated with the benzene ring. The broadened signals in the region of 6.85–7.2 ppm belong to the signals of aromatic protons.

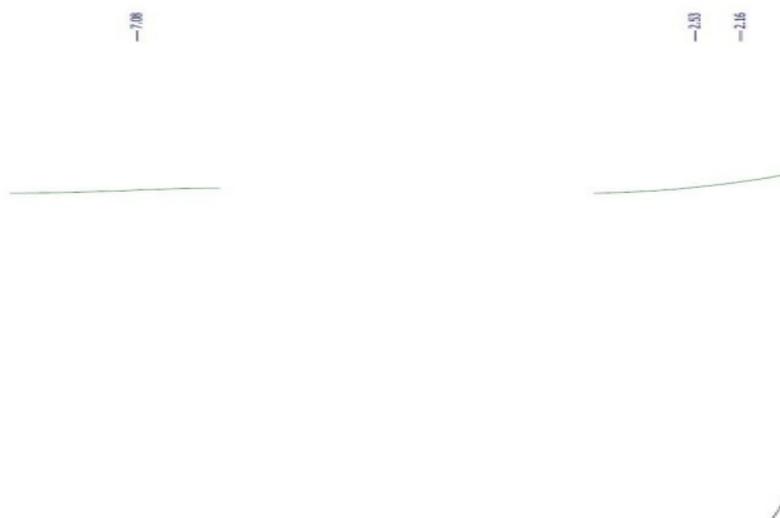


Figure 2. NMR spectrum of the second sample.

As can be seen from the spectrum of the second sample, the broadened signals in the region of 0.89–1.21 ppm relate to the signals of the methyl, methylene, and methine groups of alkanes and cycloalkanes. The broadened signals in the region of 2.16–2.53 ppm refer to the signals of methyl, methylene, and methine groups associated with the benzene ring. The broadened signal at 7.08 ppm refers to the signal of aromatic protons.

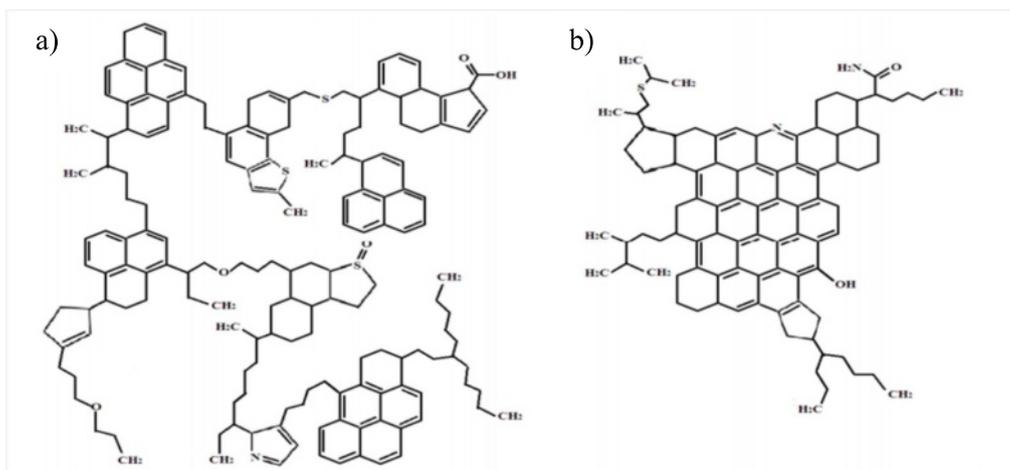


Figure 3. Asphaltenes structures

Considering the above examples, it can be assumed that different asphaltenes may be present in the mixture. However, more accurate information about the composition of the mixture can be obtained from mass spectroscopic analysis data.

6. Conclusion

A study of petroleum products extracted from oil-contaminated soil was carried out using the nuclear magnetic resonance method. The obtained spectra confirm that the composition of oil absorbed into the soil undergoes strong changes over a long period of time. The aliphatic part of the petroleum product mixture is many times greater than the aromatic components. The results obtained confirm the data of the gas-liquid chromatography study with flame ionization.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research.

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Novel adsorbents on the bases of functionalized chitosan and magnetite nanoparticles for removal of organic pollutants and heavy metal ions from water

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Abstract

This paper reports about the successful functionalization of low molecular weight chitosan with 2,2-(ethane-1,2-diylbis(oxy))dibenzaldehyde and further conjugation of obtained gel with Fe₃O₄ nanoparticles. The functionalization of chitosan with dialdehyde occur through condensation reaction of chitosan amino group with carbonyl groups of dialdehyde that brings to the imine linkage that tithing the chitosan chains. The structure of prepared gel have been proved by NMR and FTIR spectroscopies. The morphology and composition of prepared conjugated gel@Fe₃O₄ have been studied by XRD and TEM analysis methods.

Keywords: Chitosan, 2,2-(ethane-1,2-diylbis(oxy))dibenzaldehyde, adsorption, Fe₃O₄, nanostructure, gel.

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1. Introduction

The development of oil and petrochemical industry moving to the next level however exerts serious influence on the environment, pollution of water basins and greenhouse effect. One of the global problems at the moment is the leakage of oil and oil products leading to serious environmental problems. Enterprises aimed at oil transportation and oil and gas complexes are the most frequent water polluters [1]. As a result of poisoning by organic compounds and heavy metals, abiotic components including marine life and plants are killed, leading to the destruction of the ecosystem [2].

Currently, various methods of water purification have been developed and successfully applied. Among them there are such methods as: gravity sedimentation [3] and corrugated plate interceptors