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ANALYSIS OF COMPOSITION AND PROPERTIES OF OIL RESIDUES AND BITUMEN

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Abstract

With the increase in the volume of modern housing and road construction in the world, the demand for construction bitumen obtained from petroleum raw materials is also growing. Because petroleum bitumen has many advantages over bitumen obtained from other raw materials used in construction, has the necessary level of protection and strength in construction, and also has many advantages in terms of operational properties. This article presents an analysis of the main physical and chemical properties of oil residues and bitumen and their composition. The results of this analysis serve as a basis for further improvement of the properties of bitumen obtained from petroleum raw materials.

Keywords: *oil, oil residues, bitumen, tar, distillate, paraffinic hydrocarbons, aromatic hydrocarbons*

Introduction

According to the classification given by Kreutzer (Multykh M. E., Privalova N. M., Ezzhalkin M. M., Milovanova V. S., 2008), petroleum asphalt bitumen is visco – liquid or soft and ductile at normal temperature, or solid and brittle products of oil refining or its derivatives.

Objects and methods of research

From a chemical point of view, heavy petroleum residues (HNO) and bitumen are a complex mixture of high-molecular organic compounds of a hydrocarbon and non-hydrocarbon nature, which, along with carbon and hydrogen, include oxygen, sulfur and nitrogen, as well as a number of metals (Fe, Mg, V, Ni, etc.) (Knyazev Yu. V., Budantsev V. V., Frolov V. A., Merkulov S. A., 2015). The elementary composition of bitumen is as follows, mac. %: carbon 80.0–85.0; hydrogen 8.0–11.5; oxygen 0.2–4.0; sulfur 0.5–7.0; nitrogen 0.2–0.5 (Belyaev, V.P., 2013).

Due to the wide variety of compounds that make up TNF and bitumen, it is impossible to isolate any individual substances from this complex mixture in the current state of science and experimental technology. In addition, the bulk of the compounds that make up its composition are substances of a hybrid nature. The only class of compounds that can be isolated from bitumen in a more or less pure form is paraffins. All this is the reason that the chemical composition of bitumen is

most often evaluated by the quantitative content of group components in it.

Results and their discussion

Currently, there is a certain opinion about the composition of individual bitumen fractions, their behavior during oxidation and their impact on quality.

It is known that petroleum bitumens consist mainly of three groups of substances: oils – compounds that are soluble in alkanes and desorbed by eluents; resins – compounds that are soluble in alkanes and desorbed from the surface of silica gel with benzene or its mixture with alcohol, but are not desorbed by alkanes; and asphaltenes-compounds that are insoluble in алканах C_{C5}–C7 $alkanes_7$ (Belyaev. 2012).

The oils are a mixture of aromatic and paraffin-naphthenic hydrocarbons. It should be noted that such a different content of hydrocarbon groups in oils affects the properties of bitumen in different ways. The very name of the group of paraffin-naphthenic hydrocarbons indicates the mixed nature of this fraction, which, along with paraffins of normal and iso-structure, may include polycyclic naphthenes, the latter usually exceeding 60% by weight. Polycyclic naphthenes are catacondensed naphthenic rings (4–5) that have alkyl substituents (Belyaev P. S., Zabavnikov M. V., Malikov O. G., 2008).

It is not always possible to isolate paraffin-naphthenic hydrocarbons in their pure form. They almost always contain a certain number of molecules, the chains of which include benzene and even naphthalenecycles, and sometimes cycles that include sulfur (Belyaev P. S., 2005). The only hydrocarbons of this bitumen fraction that do not have a hybrid structure aresaturated hydrocarbonsof normal structure (paraffins) and hydrocarbons of iso structure (ceresins).

According to Pajitnova (Amash, A., 2002), paraffin-naphthenic hydrocarbons are plasticizers in bitumen, and their replacement withmonocycloaromatic hydrocarbons cannot compensate for their plasticizing effect. Solid paraffins have a great influence on the properties of bitumen, their content in raw materials should not exceed 3–6%, and anincrease in these values, accordingto the authors (Nefedov B. K., Gorlova E. E., Gorlov E. G., 2008; Solov'ev E. M., Borisov E. M., Solov'ev M. E., 1998), leads to a sharp decrease in the structural and mechanical strength of bitumen. This served as the basis for creating a classification of oils in terms of theirsuitability for bitumen production.

Bitumen aromatic compounds are polycyclic condensed hydrocarbons that include one or two aromatic rings. Monocycloaromatic compounds are mainly represented by five-ring condensed systems with 2–– 4 metal substituents and one long alkyl substituent. The molecules of bicyclo-aromatic compounds consist of both one and two fragments, but the total number of aromatic rings in the molecules of such compounds is two. In addition, the molecules of mono-and bicycloaromatic compounds contain гетероатомы S, N, and O heteroatoms, but their number is relatively small – one atom per 3–5 molecules. S and N atoms belong to cyclic structures such as thiophene, pyrrol, and pyridine, while hydrogen atoms belong to peripheral functional groups.

Polycycloaromatic hydrocarbons are usually found in small amounts in bitumen. The main structural element of this group of hydrocarbons is condensed naphthalene-type systems, which are part of hybrid structures consisting of three or more cycles. In addition, their separation is difficult and most likely they are a transitionfraction from oils to resins.

Resins have a molecular structure similar to oils (Zinov'ev M., Berezhnaya O. N., Kutsenko G. V., Yarushina O. V., 2001), but are characterized by an even higher degree of condensation. The carbon skeleton of resin molecules is a polycyclic system consisting mainly of aromatic rings with a high degree of condensation and aliphatic substituents. At least 78% of the total number of protons in the" medium molecules " of resins are concentrated in saturated structures, and more than half of them belong to H protons that are not part of metal groups and CH2 $groups_2$, CH located in the a-positions of aromatic nuclei and heterones.

The elementary composition of resins is characterized by a high ratio of C and H content (C-79–87%, H– 8,5–9,5%) /36,37/. In addition, resins are characterized by a high content гетероатомов of S, N, and O het-

eroatoms, as well as metals. Most of the resins are made up ofneutral substances, and a smaller –part is made up of acidic substances. Sulfur is mainly a part of cyclic structures, its contentin resins can reach 10%, and the oxygen content is also high. Nitrogen is not always present in resins, although sometimes its content reaches 2% or more.

Most researchers (Milani, M., 2001) believe that nitrogen compounds (mainly cyclic structures) are so stable that even with the most severe heat treatment, they do not break down and pass into coke. In addition, researchers are of the opinion that resins are a genetically intermediate stagebetween oils and asphaltenes.

Asphaltenes – solid amorphous substancescolored in a dark color, from dark brown to black, have a great influence on the properties of bitumen.

Their density is greater than unity. When heated, they decompose without melting. When stored in the air, especially under the influence of sunlight or other types of radiation, asphaltenes pass into an insoluble state.

Asphaltenes –are the most complex components, which are a mixture of non-hydrocarbon high-molecular compounds of oil. Many researchers believe (Shakhovets S. E., 2006) that asphaltenes are a product of compaction of cyclic compounds, up to the creation of a flat spatialstructure.

Conclusions

A wide range of experimental data on the composition and content of various compounds that are part of heavyHO oils and bitumenis due to both the diversity of the composition of various oilsand different approaches to studying the structure of molecules. More recent studies are based on the association of high-molecular-weightoil compounds fromrelatively low-molecular-weight compounds.

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