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Possibilities of preparation asphalt concrete by oil sands of Kazakhstan

Abstract. In the paper physicochemical properties of oil sands of Munayli-Mola deposits and efficient ways to use them for preparing asphalt concrete were represented. For determination of organic part of oil sands the extraction methods were used in Soxhlet apparatus by variety of solvents. It has been established 16 wt.% content of natural bitumen in oil sands, which compared with results of ash content determination. According to results of experiment, the natural bitumen is heavy oil and its characteristics close to characteristics of paving bitumen. The optimum content of oil sands in asphalt mix are 28 and 47 mass %, the mixes prepared under these conditions satisfy standard requirements of the Republic of Kazakhstan on the asphalt mixture ST RK 1225-2003.
Keywords: petroleum, oil sands, natural bitumen, extraction, solvents, heavy oil, asphalt-concrete, elemental composition.

Introduction

Petroleum products play an important role in economic development of any nation. At present oil producing sector takes a leading position in the structure of national economy of Kazakhstan. However, the energy demand of the world is increasing while conventional oil reserves are declining. The shortage of oil of known petroleum serves will make less attended energy resources more attractive[1, 2].

Many countries in the world have large deposits of bituminous sands, commonly referred to as oil sands, including America and Russia. However, the largest deposits of theworld oil sandsare located in Canada and Venezuela. Over 50 fields of oil sands (oil-bituminous sands, tar sands, extra heavy oil) have been discovered in Kazakhstan. Most deposits of oil sands contain mixtures of bitumen, sand, water, small amounts of heavy metals and other contaminants. In its natural state, bitumen is suitable only for paving roads. Compared to conventional crude oil, bitumen contains too much carbon and too little hydrogen. In making synthetic crude oil, special refining processes are used to remove impurities and correct the carbon-hydrogen imbalance [3-4].

Bitumen becomes gradually more important as a refinery feedstock. In recent years, technological advancements in bitumen and heavy oil processing and the stabilization of crude oil prices have made production of synthetic crude oil from these resources attractive and economical. With the goal of processing heavy oil, bitumen, and residue to obtain gasoline and other liquid fuels, an in-depth knowledge of the constituents of these heavy feeds tocks is an essential first step for any technological advancement. Synthetic crude oil produced from bitumen accounts for about 28% of Canada's total oil production. Compared to conventional oil (obtained from traditional, easily accessible sources), however, synthetic crude from bitumen is expensive and complicated to produce [5].

Oil bitumen are widely used in many industries. Therefore their production is the important economic problem and requires constant perfection. The main problem with road building is the poor quality of bitumen used in asphalt-concrete pavements. Characteristic of bitumen completely mismatch climatic conditions of our State, i.e. do not maintain sharp differences of temperatures from -40 up to 40 °C. In our country the satisfaction of need for a bitumen material occurs due to its import from Russia and Iran. So the problem upgrading of domestic raw materials is actuality [6].

The main purpose of this investigation is to use the extracted and upgraded bitumen as a raw material for road construction.

Materials and methods

The object of research in the article was oil sands of deposits Munayli-Mola (at figure 1). For extraction of organic part from oil sands the extraction method was used. The hexane, toluene, ethanol and benzene mixture (the ratio of ethanol: benzene was equal to 1:4) was used as a solvent. Extraction was carried out in Soxhlet apparatus till termination of solvent coloring.

Figure 1 – Oil sands of deposits Munayli-Mola

Physicochemical characteristics of natural bitumen are established by standard methods: density was determinated by pycnometer, heating value determinated by "Calorimeter", ash content determinated by "Nabertherm" apparatus. Content of C, H, N, O in bitumen from oil sands defined at the analyzer «Vario EL III». These analyses were determined in Berlin Technical University.

Physical and mechanical characteristics of the samples were determined in the testing laboratory of LLP «Asphaltbeton-1" according to the standard requirements of the Republic of Kazakhstan on the asphalt mixture ST RK 1225-2003, "Mixtures of road asphalt-concrete, airport, asphalt mix, technical conditions (specifications)". Analyses were carried out under the following conditions: temperature at 22°C, humidity (water content) 69%, the pressure of 93.3 kPa.

Results and discussion

Physicochemical characteristics and potential of the organic content in the oil sands were studied by standard methods of analysis. Extraction of organic species from oil sand was carried out by extraction method. For the extraction process variety of solvent was used, which boiling points are showing in Table 1.

Table 1 – Boiling point of solvents

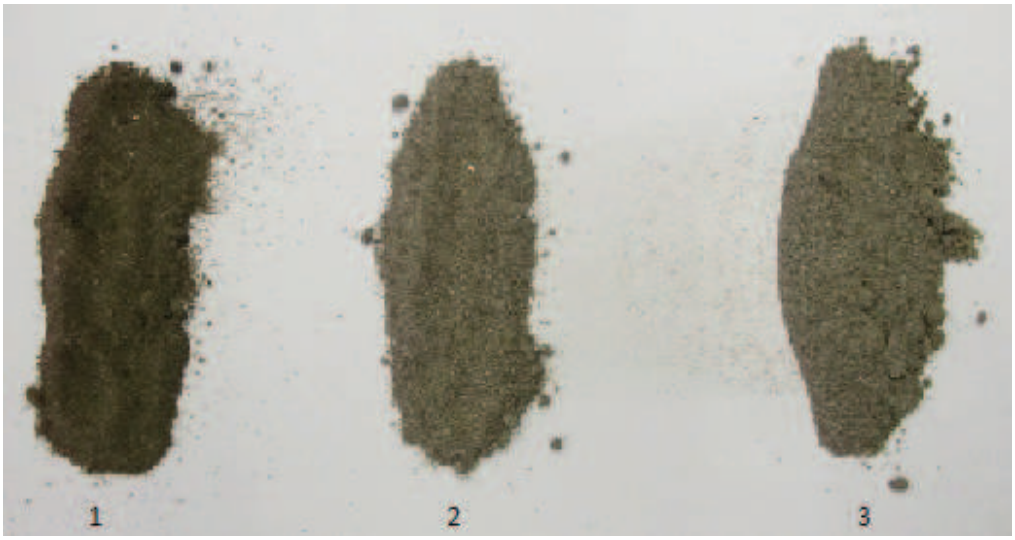
Solvents / characteristics	Hexane	Toluene	The ethanol and benzene mixture
boiling point of solvents, °C	69	111	80.1 and 78.37

As showing table, hexane has lower boiling point (69 °C) and toluene has higher boiling point (69 °C). The equal of ethanol and benzene mixture was 1:4 and their boiling points closest each other (80.1 and 78.37 °C). Extraction and some analyses' results are presented in table 2.

Table 2 – Physical and chemical properties of natural bitumen deposits Munayli-Mola

Solvents / characteristics	Hexane	Toluene	The ethanol and benzene mixture
content of organic part, wt. %	15.5	16.5	15.9
heating value, j/g	-	42464	41857
density, g/cm^3	0.997	-	0.987

Including three kind of samples, natural bitumen extracted by toluene has higher content. The medium content of organic part in oil sands are 16 wt.%. Other parts are consists solid and sand mixture, which presented at figure 2. Heating value of natural bitumen produced by toluene was 42464 j/g and produced by ethanol/benzene 41857 j/g. Results of density presented the object of research is heavy oil. Because of density of heavy oil produced by hexane 0.997 g/cm^3 and by the ethanol and benzene mixture is 0.987 g/cm^3.



1 – extracted by Hexane; 2 – extracted by Toluene; 3 – extracted by ethanol/benzene

Figure 2 – Image of after extracted sands of oil sands

The results of extraction were compared with results of ash content determination (in table 3). As the table, ash content of oil sands was 83.3 wt.%, so its organic part is 16.7 wt.%. and extraction results close to it. In general, same organic content in oil sands by determined two methods.

Table 3 – Comparison results of determination ash content and extraction

Research object	Determined method	Contents	
Munayli-Mola oil sands	extraction method	extracted oil, wt. %	after extracted sands, wt. %
		16	84
	determination of ash content	ash content, wt. %	organic part, wt. %
		83.3	16.7

The elemental composition of natural bitumen from the oil sands in comparison with the elemental composition of petroleum bitumen BND 60/90 is shown in Table 4.

Table 4 – Elemental composition of bitumen

Type of bitumen	Ash content. wt. %	Content, wt. %				
		C	H	S	N	O
natural bitumen extracted by hexane	0.082	84.36	12.16	1.294	0.29	1.814
natural bitumen extracted by toluene	1.3	85.00	12.34	1.010	0.30	0.15
natural bitumen extracted by ethanol/ benzene	0.13	84.69	11.39	1.292	0.38	2.118
standard paving bitumen BND 60/90	0.167	84.91	11.01	3.050	0.52	0.343

A distinctive feature of the natural bitumen is almost the same content of carbon (between the 84 and 85), hydrogen (11-12) and lower content of sulfur, nitrogen.

Samples were prepared by hot asphalt mixes with the addition of oil sands deposits Munayli-Mola and studied their properties. All of the samples prepared without adding petroleum bitumen. The physicochemical characteristics of samples tabulated in table 5.

Table 5 – The physicochemical characteristics of samples.

Name of indicators	Asphalt mix with oil sands			Basic requirements for the ST RK 1225-2003
	28 %	47 %	60 %	
medium density, g/cm^3	2,29	2,30	2,22	not rated
water saturation, %	6,1	2,4	2,6	for the dense type of B, V, G from 1,5 to 4,0 for the porous type from 5to 10
compression strength, MPa, at 20 °C	8,7	4,6	4,2	not less than 2,5 for M1 not less than 2,2 for M2 not less than 2,0 for M3
compression strength, MPa, at 20 °C water-saturated	6,5	4,7	4,8	not rated
compression strength, MPa, at50 °C	2,1	1,1	0,6	not less than 1,3 for B M1 not less than 1,2 for B M2 not less than 1,1 for B M3 not less than 0,7 For the porous M1 not less than 0,5 For the porous M2
compression strength, MPa, at 0 °C	14,9	13,0	5,1	no more than 13,0 fortheporousnot rated
water resistance	1,0	0,75	0,64	not less than 0,85 For the dense M1 not less than 0,80 For the dense M2 not less than 0,7 For the dense M1 not less than 0,6 For the dense M2
water resistance with prolonged water saturation	0,55	0,78	0,43	not less than 0,75 For the dense M1 not less than 0,7 For the dense M2 not less than 0,6 For the porous M1 not less than 0,5 For the porous M2
adhesion of binder to the mineral portion of the mixture	braves	braves	braves	braves (at least ¾ surface of the mixture covered with foil binder)

Sample number 1 - a mixture containing 4 wt.% of bitumen. Mineral part of asphalt mix consists 2.45 kg of sands, 0.49 kg of mineral powder, 2.3 kg of screening. 2 kg of oil sands are used, in the composition of them 0.3 kg of natural bitumen and 1.7 kg of mineral parts. The content of oil sands in the initial mixture was 28wt.%.

Sample number 2- a mixture containing 7 wt.% of bitumen. For the preparation of the samples were mixed in 2.45 kg of sands, 0.49 kg of mineral powder and 1 kg of screening. 3.5 kg of oil sands are added. In this material consists of 0.5 kg of natural bitumen and 3 kg of mineral parts. The content of the oil sands in the initial mixture was 47wt.%.

Sample number 3- a mixture containing 10 wt.% of bitumen. This sample prepared by 2.45 kg of sands, 0.49 kg of mineral powder and without screening. In the asphalt mix 4.7 kg of oil sands were used. As parts of the organic species are 0.7 kg, the amounts of the mineral part are 4 kg. The content of the oil sands were – 60wt.%.

Conclusion

For the extraction of natural bitumen (organic part) from oil sands the extraction method was used. It was carried out in Soxhlet apparatus and discovered 16 wt. % of organic part in oil sands. It was determined natural bitumen is heavy oil and its elemental composition close to standard paving bitumen BND 60/90. The composition of oil sands of the Munaily-Mola deposit and opportunity of its use

in composition of asphalt concrete mixes are shown in work. The optimum content of the oil sands are 28 and 47 mass %, the mixes prepared under these conditions satisfy requirements of the standard.

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Қазақстанның мұнайбитумды жыныстарынан асфальтбетон қоспасын дайындау мүмкіндігі

Бұл жұмыста Мұнайлы-Мола кен орнының мұнайбитумды жыныстарының физика-химиялық қасиеттерін анықтап, оны асфальтбетон қоспасын алуға пайдалану мүмкіндіктері қарастырылған. Мұнайлы шикізаттың органикалық бөлігінің мөлшері Сокслет аппаратында әртүрлі еріткіштерді пайдалану арқылы анықталды. Нәтижеде, ол 16 мас.%-ды құрайтындығы белгілі болды және бұл көрсеткіш күлділігін анықтау әдісі арқылы алынған нәтижемен салыстырылып көрсетілді. Тәжірибе нәтижелері бойынша табиғи битумның сипаттамалары жол битумының қасиеттеріне өте жақын келетіндігі анықталды. Мұнайбитумды жыныстардан асфальтбетон қоспасын дайындауда ең тиімді мөлшері 28 және 47 мас % болды және олар Қазақстан Республикасының асфальтбетон қоспасына қойылатын СТ 1225-2003 тиісті стандарт талаптарына сай келетіндігі анықталды.

Түйін сөздер: мұнай, мұнайбитумды жыныстар, табиғи битум, шаймалау, еріткіштер, ауыр мұнай, асфальт жабындылар, элементтік құрамы.

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Возможности подготовки асфальтобетонной смеси из нефтебитуминозных пород Казахстана

В работе были исследованы физико-химические свойства нефтяных пород месторождения Мунайлы-Мола и эффективные пути использования их для приготовления асфальтобетона. Извлечение органической части нефтебитуминозных пород осуществлялось экстракционным способом. Содержание органической части в породах месторождения Мунайлы-Мола составляет 16 мас. %. Результаты эксперимента показали, что органическая часть природных битумов по физико-химическим свойствам близка к битумам. Оптимальным содержанием породы для получения асфальтобетона является 28 и 47 мас.%, при этих условиях асфальтобетонные смеси соответствуют требованиям государственного стандарта Республики Казахстан СТ 1225-2003.

Ключевые слова: нефть, нефтебитуминозная порода, природный битум, эстракция, растворители, тяжелые нефти, асфальтобетон, элементный состав.