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Chemical Analysis on Mongolia's Natural Bitumen

Erdenetsogt Bat-Erdene[1], Batdelger Byambagar[1], Erdenee Enkhtsetseg[1], Budeebazar Avid[2]

[1]School of Material Science of the Mongolian University of Science and Technology, Ulaanbaatar, Mongolia
[2]Institute of Chemistry and Chemical Technology, Mongolian Academy of Science, Ulaanbaatar, Mongolia
Email: ico@must.edu.mn, b_byambagar@yahoo.com

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Abstract

To extract pure bitumen, the bitumen from Bayan-Erkhet, Zuunbayan and Ukhaa was prepared into small particles of 0.2 - 0.5 cm and then it was infused with chloroform in the Soxhlet apparatus [1] [2]. The physical-mechanical properties were identified after the solvent was extracted from the chloroform infused bitumen through the vacuum evaporation method. The characteristics of the debris without bitumen or the remains after the infusion were examined in details. The hydrocarbon content of the bitumen was identified with the device: Agilent 7890-5975c Gas chromatography mass spectrometer.

Keywords

Hydrocarbon Dispersal, Tar, Asphalt, Oil

1. Introduction

Our nation imports bitumen that is commonly used for constructions and asphalt concrete road coverings. Within the recent years, the prices of raw oil and its related products have been increasing significantly, and the supply of it has become more limited. Hence, many countries in the world started seeking new materials and sources to substitute and use for road, constructions, fuel, energy and industries, and the researches for these are expanding significantly. It is recorded that our country has substantial amount of bitumen and oil shale, and tentatively there are about 800 million tons of deposits in 60 minefields [3]. Thus, we need to use new technological methods to produce and explore high quality products such as high quality roads, bitumen for raw construction materials and fuels and other related products.

There have been various studies on the bitumen and oil shale minefields, the geological formations and the

deposits. Unfortunately, there have not been sufficient studies on the chemical compositions, structures, and chemical-technologies done.

2. Materials and Methods

2.1. Materials

The materials used for this work include:

1) Bayan-Erkhet deposits of Tuvaimagandsum center, located in the south east, 40 km and 200 km southeast of Ulaanbaatar Railway 14th cross roads 55 kilometers to the northeast. The deposit has reserves of 1.2 million tons of bitumen sands [4].

2) Zuunbayan Dornogovi bitumen sand deposit is located 50 km south across the petroleum deposit consists of a 4.2 km by 2 small deposits and reserves of 330 tons [3] [5].

3) ZuunbayanDornogoviUkhaaofbitumensanddepositsinthecurrentgeologicalexplorationwork.

2.2. Methods

2.2.1. Sample Preparation

Preparing the samples between an area different positions from the supply after to crush 1.25 mm diameter prepared fedsieves.

2.2.2. Bitumen Separation Method

40 times the volume of bitumen dissolved in hexane divided asphaltene. The differentiated asphalt from the Maltese parts were condensed in the Soxhlet apparatus with ASK type activated Silica gel and the butyric compounds with i-hexane, tar-like compounds with 1:1 ratio alcohol:benzol alternatively [6] [7]. Test are shown in **Table 1**.

2.2.3. Mineral Group Methods

Mineral part of the particle module, shares spacing, the actual density parameters such as MNS 392:98, MNS 392:98, MNS 2916:2002 standard specifies methods [6].

2.2.4. Bitumen Hydrocarbon Composition Method Determination

The hydrocarbon content of the bitumen was identified with the device: Agilent 7890-5975c Gas chromatography mass spectrometer

Test conditions: GC: Carrier gas: 99.999% He; Inlet: 300˚C; Transmission line: 280˚C; Column: HP-5MS fused silica capillary column (60 m × 0.25 mm × 0.25 μm); Column temperature: Initial temperature 50˚C, 1 min; 15˚C/min heating to 120˚C, and then to 3˚C/min up to 300˚C to maintain 25 min; Carrier gas flow: 1 mL/min. MS: EI, 70 eV; Full scan [8].

2.2.5. Pure Bitumen Test Methods

Physical and mechanical characteristics of bitument MNS 5109-2001, MNS 5211-2002, MNS 5110-2001, MNS 328-2000, MNS AASHTO T40-2003 standard specifies methods [6].

3. Results and Discussion

The segregated bitumen from the Bayan-Erkhet, Zuunbayan and Ukhaa minefield bitumen's general parameters are shown in **Table 1**.

From the above table, the pure bitumen's yields of the bitumen of Bayan-Erkhet, Zuunbayan and Ukhaa infused with chloroform 14.75%, 15.84%, 10.86%. When the pure bitumen content in natural bitumen is between 10% - 15%, it is considered to be an economically beneficial raw material [11]. Compared to oil bitumen, the natural bitumen has more surface active compositions (tar, asphaltogen acid, and its' anhydride), and they go through adsorption at the mineral parts and the ability to bond with the mineral parts enhances [12]. Some technical properties, like ash-like, humidity, volatile substance contents of the bitumen sand sample and the extracted mineral sample, are identified in **Table 1**. From the table, it can be observed that the humidity content (0.72, 0.64, 0.89 mas.%) is much lower than coal, shale and other hard organic raw materials. This might be due

Table 1. Bitumen's general parameters.

№	Parameters	Bayan-Erkhet [9]		Zuunbayan		Ukhaa [10]	
		Sample	Within the minerals	Sample	Within the minerals	Sample	Within the minerals
1	Bitumen yield, mas. %	14.75	-	15.84	-	10.86	-
2	Humidity, mas. %	0.72	-	0.64	-	0.89	-
3	Volatile substance, mas. %	22.52	0.79	19.84	0.43	16.32	0.64
4	Ash-like, mas. %	73. 41	99.13	79.32	98.51	83.24	99.32

to the bitumen's "hydrophobic" quality, to push water and not dissolve in it. As bitumen is considered to have low organic substance content, it has high ash content (73.41, 79.32, 83.24 mas.%); however, volatile substance content(22.52, 19.84, 16.32 mas.%) indicates that the parts that make up the organic mass has volatile characteristics. Mineral parts are the remains of the chloroform infused bitumen, and the yield of the volatile substance is 0.79, 0.43, 0.64 mas.%, which indicates that the organic parts are almost completely 100% infused with the chloroform. Another proof is the ash-like content of the minerals (99.13, 98.35, 99.32 мas.%).

The following compounds were identified in the natural bitumen that we are studying: (**Table 2**).

The naphtene's total hydrocarbon content in Bayan-Erkhet, Zuunbayan, Ukhaa's natural bitumen is higher than in saturated hydrocarbons. As the bitumen from the above mentioned minefields have high asphalt contents, it is considered to have "Gel" bitumen [12]. Most natural bitumen's tar content is higher and the oil content is lower than oil bitumen, which allows them to be more stable. When tar content is higher, the tar in asphalt's dissolving characteristics "lyophilization" increases, and a stable colloid solution is formed. On the other hand, if the oil content is high, it has negative impact on bitumen quality, as the asphalt's oil does not dissolve "lyophobic" [13]. From the printed materials, it can seen that oil bitumen's main components, high molecular tar, asphalt compounds, ratios are 1:1 and the total content should be close to 50%. However, the remaining 50% consists of oily (fatty) compounds [12].

Important characteristics of the pure bitumen that was separated from the bitumen sand through the standard methods are shown in **Table 3**.

The pure bitumen extracted from the Bayan-Erkhet bitumen sand is in the category of thick bitumen because of the needle sinking depth (48.5 mm at 25˚C), andhydrocarbon content (tar content is relatively high 60 mas.%). From the technical results, it can be seen that majority of the physical-mechanical parameters, including needle sinking depth at 25^0C, temperature to soften, density is within the technical requirements of 40/60 road bitumen. However, the elasticity is lower than the standard, which can be explained by the low asphalt content. On the other hand, the pure bitumen extracted from Zuunbayan bitumen sand is in the category of liquid bitumen due to the needle sinking depth (223 mm at 25˚C) and oil content (42.5 mas.%). The physical-mechanical properties, such the needle sinking depth at 25˚C, temperature to soften anddensity, are within the 200/300 type road bitumen's technical requirements [1]. The pure bitumen extracted from Ukhaa bitumen sand is relatively close to Zuunbayan's bitumen sands properties and it is also within the 200/300 type bitumen.

Table 4 below shows the physical-mechanical properties of the segregated mineral parts of the bitumen sand.

Sand particle modules are categorized into:

- Large particle > 3.1 mm.
- Medium particle 2.1 - 3.1 mm.
- Small particle < 2.1 mm.

From the results, Ukhaa, Bayan-Erkhet's bitumen sand's sand belongs to medium sized particle category, which indicates that these can be used for asphalt concretes, but the dust clay particles in the sand is higher than the accepted technical requirement. On the other hand, Zuunbayan bitumen sand's sand belongs to small sized particle module.

Depending on the strainer diameter size, the samples are called:

- dust, clay for parts that went through 0.075 mm diameter strainers.
- sand for parts that passed through 0.075 - 4.75 mm diameter strainers.
- rock for parts that pass through or bigger strainers with diameters of 4.75 mm [6].

Thus, from the study results, Bayan-Erkhet, Zuunbayan's sands were 8.73, 10.66%, which indicates that the smaller parts were comparatively more.

Table 2. Group compositionofbitumen.

Parameters	Deposits		
	Bayan-Erkhet	Zuunbayan	Ukhaa
Saturated HC:			
– n-Alkane	10.81	11.42	7.38
– Cycloalkane	16.89	20.38	20.49
Total	27.70	31.80	27.87
Aromatic HC:			
– Alkyl aromatic	6.22	6.60	5.85
– Polynuclear aromatic	8.17	11.82	9.48
Total	14.39	18.42	15.33
– *Asphaltene*	28 .42	25 .66	24 .04
– Tar	18 .71	20 .18	18 .12

HC-hydrocarbon.

Table 3. Characteristics of bitumen.

№	Parameters	Bayan-Erkhet	Technical Requirement 40/60	Zuunbayan	Ukhaa [10]	Technical Requirement 200/300
1	Penetration at 25˚C	48.5	41 - 60	223.3	274	201-300
2	Not softening and ring	47.7	40 - 50	34.5	26.2	>35
3	Ductility at 25˚C	36	>100	57.5	-	-
4	Temperature to flame, ˚C	193	> 220	190	210	>200
5	Density, g/cm^3	1.03	0,95-1,15	0.98	0.979	-

Table 4. Bitumen sand minefield's mineral part studies.

№	Parameters	Technical requirement	Ukhaa	Bayan-Erkhet	Zuunbayan
1	Sand particle module	2.1 < 3.1	2.21	3.12	1.6
2	Dust clay content, mas. %	<3	19.97	15.46	20.13
3	Density, g/cm^3	>2.4	1.559	2.58	2.55
4	0.075-antecedent, %	-	1.78	8.73	10.66
5	Organic mix., %	no	no	no	no
6	Flow, flexibility index	unarticulated	unarticulated	unarticulated	unarticulated

The activity levels of natural radioactive isotopes, element contents, and Rad's equivalents of the cenosite ashes of Bayan-Erkhet, Zuunbayan and Ukhaa bitumen sand minefields were identified through gamma spectrometer method (**Table 5**).

The maximum allowed radioactive Radon for construction material production is defined to be 370 Bq/kg. The above mentioned minefield's Radon equivalent dose in cenosite parts of the ashes are almost three times lower than the standard; hence, it can be directly used for road and other construction materials.

4. Conclusions

From the results of this work, the following conclusions can be drawn:

1) The bitumen categories of Bayan-Erkhet, Zuunbayan and Uhaa bitumen sand minefields were identified. For instance: Bayan-Ekhet's bitumen type was thick viscose "asphalt", whereas Zuunbayan and Ukhaa's bitumen was liquid type. According to the results, Bayan-Ekhet, Zuunbayan and Ukhaa's bitumen sand minefields's natural bitumen has high organic mass yields and tar-like asphalt contents.

2) From bitumen mineralogy results of the study minefields, the segregated sands of Ukhaa and Bayan-Erkhet bitumen are categorized into medium particle sized sand, which is suitable to be used for asphalt concretes; however, the dust, alluvium content is higher than the standard. The sand extracted from the Zuunbayan bitumen sand is in the small particle sized category. From the cenosite radioactivity tests of the above mentioned mine-

Table 5. Content of radioactive elements.

№	Sample	Isotopic activity, Bq/kg			Contains elements			Rad's equivalent dose, Bq/kg
		^{226}Ra	^{232}Th	^{232}K	U, g/t	Th, g/t	K, g/t	
1	Bayan-Erkhet	10	10	1080	0.8	2.4	3.2	121.1
2	Zuunbayan	13	11	974	1.0	2.7	3.3	110.4
3	Ukhaa	18	16	956	1.5	4.0	3.6	115.1

fields, it has been identified that it can be used directly towards road and construction materials.

Bayan-Erkhet bitumen has similar physical-mechanical properties as 40/60 type bitumen. This bitumen can be directly used for road coverings. Zuunbayan and Ukhaa's bitumen has similar properties as 200/300 type bitumen for needle sinking depth, temperature to soften and density, and belongs to liquid type bitumen. Hence, these need to be further processed and the structures need to be changed, in order to get high quality bitumen that can be used for roads for the climatic conditions of our country.

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