



Mongolian Academy of Sciences

# Mongolian Journal of Chemistry

Institute of Chemistry &amp; Chemical Technology

## Investigation on the possibility of obtaining of motor fuels from bituminous sand by heat treatment

D. Jadamba, B. Ulzii, M. Tuya

Institute of Chemistry and Chemical Technology, Mongolian Academy of Science, 13330, Ulan-Bator, Bayanzurkh-51, St.Enkhtaivana, IV. Email: jadamba\_dash@yahoo.com

**Keywords;** bituminous sand, thermal treatment, synthetic fuels

### Introduction

Have been obtained a oil like liquid product with hydrocarbon type from bituminous sand of Bayan-Erkhet deposits by a heat treatment. Main characteristics and chemical composition of the bitumens isolated by extraction various organic solvents from the bituminuos sand of the Bayan-Erhket deposits are determined. Show that they are similar composition and properties there bitumen asphalt or natural bitumens. The possibility of obtaining of synthetic oil by heat treatment of bitumens is estimated up to 600 °C in laboratory conditions. Have been determined the possibility of obtaining high-quality oil from the liquid product from the thermal treated bituminous sands of Bayan Erhet by using of Nb-Zr-aluminosilicate catalyst type ZSM-5, and by varying the temperature of the process. On the basis of this treatment was obtained an additional petroleum products, which are the basic components of motor fuels..

**Key words;** bituminous sand, thermal treatment, synthetic fuels

### Experimental

The object of the study were samples of bituminous sands of the Bayan-Erkhet deposits. Bituminous sands of Bayan-Erhket deposit is located in the of Tuv aimag Bayanjargalan village, 5 km from the river

Herlen, 40 km from the soum centre and 55 km from the Railway station. The Bayan-Erkhet deposits consists of two oil bearing layers area of 0.025 km<sup>2</sup> with a thickness of 0.5-0.6 m and the lower – 0.4 km<sup>2</sup> whit a thickness of 0.1-15.2 m and has supplies 1913.6 thousand tons of estimated resources.

### Results and discussion

#### *Isolation of bitumen from tar sands, the study of physical and chemical properties.*

Results of bituminous sands extraction with various solvents and hot water are shown in Table-1

Table 1. The yields of the bitumens isolated by extraction of various organic solution and hot water from bituminous sand

Deposit name	Yields of bitumen, mass. %					
	Choloro form	Petrolein ether (40-70 °C)	Benzene	Ethanol : benzene (1:1)	Hot water	NaHCO <sub>3</sub> 7 % solution
Bayan-Erkhet	14,75	11,27	0,18	0,15	7,46	9,23

The dates in Table 1 show that the yields of organic matter extracted with chloroform are 14.75 and 20.4 %. The extraction of bitumen from tar sands, the best is with choloroform, which was chosen that more polar character than all other applied solvents.

The content of the bitumen extracted with hot water is 7.5 wt,% in the Bayan-Erhet deposit. Main technical characteristics of the bituminous sand of Bayan-Erkhet deposit are determined and the results are given in Table 2.

Table 2. Main technical characteristics of Bituminous sand, mass. %

Technical characteristics	Deposit of Bayan-erhket	
	Bitumen	Minerals
Moisture, W %	0.72	-
Volatile substance, V <sub>dag</sub>	22.52	0.79
Ashes, A <sup>a</sup> %	73.41	99.13

Moisture of extracted bitumens of Bayan-Erkhet (A<sup>a</sup> - 0.72 %). This moisture is much smaller compared with the moisture of coal, shale and other fossil fuels. This may be due to the hydrophobic property of bitumen.

As a part of natural bitumen tar can be uses as a binder material for asphalt road. The elemental compositions of the studied bitumen extracte from bituminous sands are shown in Table 3.

Table 3. Main technical characteristics of bitumen extracted from bituminous sand

№	Main characteristics:	Bayan-Erhket deposit
1	Group composition of group organic compounds, % mass.	
	- asphalt	6.08
	- resin	60.19
	- oil	31.82
	- n-alkanes	1.15
2	The elemental composition, mass%.	
	C	84.11
	H	11.72
	N	1.13
	O	2.75
3	Specification :	
	The depth of needle penetration, sSt	
	25 °C	48,5
	0 °C,	18
	Softening temperature, °C	47,7
	36	
	Ductile 25 °C, cm	193
	Flash point, °C	1,03
	Density, kg/m <sup>3</sup>	3,83
	Disrepair, %	
Adhesion with marbel		
The index of penetration	-1.7	

Content is four times lower than allowed for materials suitable for the production of

bitumen. According to the standard requirement of BND 40/60 technical characteristics such as penetration, softening temperatures and density of bitumen extracted from bituminous sand deposit are suitable for binding material of asphalt road.

The rentgen flouescens analysis results are presented in Figures 1.

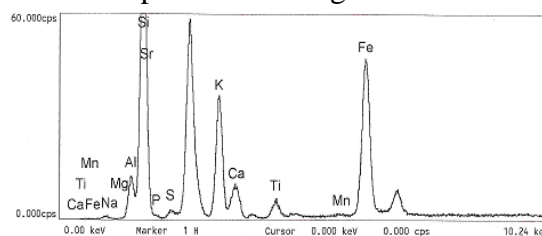


Figure 1 - X-ray spectrum of the mineral part of bituminous sand of the Bayan-Erhet deposits

Table 4. Chemical composition of minerals of bituminous sand

№	Compositi on of minerals	Content , % mass.	№	Composition of minerals	Content , % mass.
1	Na <sub>2</sub> O	1,25	7	K <sub>2</sub> O	3,93
2	MgO	0,19	8	CaO	0,28
3	Al <sub>2</sub> O <sub>3</sub>	9,612	9	TiO <sub>2</sub>	0,11
4	SiO <sub>2</sub>	83,85	10	Mn <sub>2</sub> O <sub>3</sub>	-
5	P <sub>2</sub> O <sub>5</sub>	-	11	Fe <sub>2</sub> O <sub>3</sub>	0,56
6	SiO <sub>3</sub>	0,18	12	SrO	0,001

The results of X-ray analysis sands show that the composition of the mineral components of the bituminous sands of Bayan- Erhet dominated silica 83.85 and alumimium oxid 9.6 %.

**The thermal treatment of bituminous sand**  
Have been carried out heat treatment of bituminous sands of Bayan Erhet deposits at 600 °C temperature and determined physico-chemical characteristics of the obtained liquid products. The data presented in Table 5.

Table 5. The yield of liquid products obtained by heat treatment of bituminous sand of the Bayan-Erhet deposit

Sample	The yield of products, % mass.:		
	Liquid	Gas	Solid
Bayan-Erhket	8.25	1.25	90.5

As can be seen from Table 5, the yield of liquid product after heat treatment is 8.25 wt.% for bituminous sands of the Bayan-Erhet deposit. Liquid products were subjected to fractionation on gasoline (NC-200 °C),

diesel (200-350 °C) and oil (350-450 °C) fraction. The results of atmospheric and vacuum distillation of liquid products of thermal treatment are shown in Table 6.

Table 6. The yield and size distribution of liquid products obtained by heat treatment of bituminous sand of Bayan-Erkhet deposit, mass. %

Sample	Fractions			
	B.p -200 °C	200-350 °C	350-450 °C	yeild >450 °C
Bituminous sand of Bayan-Erkhet deposit	19,5	52,2	19,86	3,98

As seen from the data in Table 6, the output fraction of b,p -200 ° C, obtained from the liquid product after pyrolysis of tar sands deposits of the Bayan-Erhet is 19.5, the diesel fraction - 52.2 and oil fractions - 19.86 wt. To assess the possibility of synthetic oil-saturated sandstone oil from heat treatment, we carried out a comparison of physical and chemical characteristics of the liquid products derived from sandstones of the Bayan-Erhet, with the fractional composition of commodity gasolines A-80.

Table 7. Technical characteristic of the gasoline fraction (b,p-200 °C) of the liquid product after heat treatment

Technical characteristics	The amount of study	
	A-80 gasoline (GOST-2084)	Liquid products
Octan number (no less): -research methods -motor methods	>80 >76	70,5 67,3
Density , 20 °C, g/cm <sup>3</sup>	No rated	0,7659
Fractional composition, driven away at temperature, ° C, distilled:		
10 vol. %	>35	40
50 vol. %	< 70	91,7
90 vol. %	< 115	141,3
End boiling point, ° C, not higher	< 180	205,3
The residue, % volume, max.	205	237,6
Water-soluble acids and alkalis	1,5	1,8
Test on copper plate stand	No	
The color	Stand up	
Water content (volume. %),	Yellow	
Content of mechanical impurities, % wt.	No	

The eight fraction (b.p -200 °C) of the liquid products after heat treatment of bituminous sand can be a useful raw material for preparation of commercial gasoline in the refining equipments for oil by using catalitic process.

The determined characteristics of a diesel fraction (200-350 °C) of bituminous sand of Bayan-Erhet deposit compared with commercial diesel fuel and demonstrated in Table 8.

Table 8. Characteristics of the diesel fraction (200 - 350 ° C) of liquid products of thermal processing of bituminous sand.

Characteristics	Values	
	Flight of diesel fuel, GOST-305-82	"Bayan-Erkhet" fraction of diesel
Cetan number, (no less)	45	42
Kinematic viscosity at 20 ° C, mm <sup>2</sup> / s (cSt)	3.0-6.0	6.87
Kinematic viscosity at 50 ° C, mm <sup>2</sup> / s (cSt)	1.3-2.4	3.23
Flash point in a closed crucible, ° C, below:	40	62
Pour point, ° C, max	- 10	-1.5
Density 20 <sup>0</sup> C , g/cm <sup>3</sup>	0,860	0,862
Fractional composition, °C:		
50% vol. distils at a temperature, ° C, max	280	268
96% vol. distils at a temperature, ° C, max	340-360	350,1
Content of sulfur, mass. %	0,2-0,5	0,33

In the one hand the value of viscosity, density at 20 ° C and the sulfur content of diesel fractions are close to the standard indicators of summer diesel fuel. In the other hand such as pour point and cetane number are different then the characteristic of commercial diesel fuel.

Thus, the results of technical performance of various fractions of liquid products of thermal treatment of bituminous sand of the Bayan-Erhet deposits and indicate the possibility of their successful preparation the combined fuel-oil version, which includes the processes of catalytic refining, hydrotreating, and dewaxing.

***Catalytic refining synthetic crude oil obtained from bituminous sandstone field Bayan- Erhet using zeolite catalysts.***

Table-9 presents the most important products, yield, and octane number of gasoline obtained by using of 0.5% Nb-2.5% Zr/AS catalyst at different temperatures ( $W=2 \text{ h}^{-1}$ ,  $P=0.1 \text{ MPa}$ ) The results of feedstock are shown in Table-9.

Table 9. Content of product, yield, and octane number of gasoline obtained over 0.5% Nb-2.5% Zr/AS catalyst at different temperatures ( $W=2 \text{ h}^{-1}$ ,  $P=0.1 \text{ MPa}$ )

Products, wt. %	Temperatures, °C						
	320	340	360	380	400	420	440
N-alkanes	20.4	19.2	17.7	9.2	7.7	6.1	4.2
Iso-alkanes	22.3	22.5	22.9	19.4	20.8	19.2	16.5
Alkenes	18.0	15.6	14.9	11.7	11.1	5.3	1.5
Naphthenes	19.1	20.4	20.6	17.3	13.2	15.6	11.9
Aromatic hydrocarbons	20.3	22.4	24.0	42.4	47.3	53.9	66.0
Benzene	1.1	1.1	1.1	1.5	2.1	3.2	4.3
Yield of gasoline, %	99.8	98.0	97.5	94.0	87.0	77.0	54.0
Octane number	68	69	70	85	88	92	102
Index of refraction, $n_D^{20}$	1.4324	1.4332	1.4338	1.4476	1.4592	1.4616	1.4682

It is evident from the data shown in the Table-9, that gasolines with high octane number are produced over the investigated catalyst at higher 380 °C and at 440 °C. An increase in reaction of temperatures results in an increase in the concentration of aromatic hydrocarbons and a decrease in the content of normal alkanes, alkenes and cycloalkanes in the gasoline obtained over the catalyst studied.

Component of alkene's hydrocarbons (19.0 %) of gasoline fraction from bituminous sand show that with the increase of temperature there was an increase in the degree of conversion of aromatics hydrocarbons. A gasoline fraction with yield 94-77% and with octane number 85-92 was obtained in the presence of zeolite catalyst from bituminous sand of temperatures 380-420 °C. The yields of gas phase increased in the temperature of 440 °C, because of intensification of cracking process of bituminous sand. Table 10. Characteristics of diesel fraction (180-360 ° C) after termolysis and catalytic processing of bituminous sand have been determined and presented in Table 10.

Table 10. Characteristics of diesel fraction (180-360 ° C) after termolysis and catalytic processing of bituminous sand.

Characterization	Diesel fraction of feedstock	Diesel fraction after of conversion
Density 20 °C, g/sm <sup>3</sup>	0,860	0,872
Index of refraction, $n_D^{20}$	1,4732	1,4820
Viscosity 20 °C, MM <sup>2</sup> /c (cCT)	4,3	3,9
Viscosity 50 °C, MM <sup>2</sup> /c (cCT)	2,5	2,3
Cloud tempetrature, °C,	- 8	- 21
Pour point °C,	- 20	- 37
Index of cetane	42	38
Yield of products, %	-	90

The processing of bituminous sand such thermolysis and catalytic cracking lead to improvement of its low temperature performance, reduce viscosity, increase the density and refractive index (Table 6) that due to with cracking of normal paraffins and the formation of aromatic compounds.

Gasoline fraction (b.p -180 ° C), isolated from the diesel fraction catalyte processing of termolysis of bituminous sand contained 7.6% alkanes, isoparaffins 20.3%, 13.9% naphthenes, 9.1% alkenes, 49, 1% aromatic hydrocarbons, and had octane number 88 points.

## Conclusions

- Bituminous sand of Bayan-Erhet deposit belongs to natural bitumen with high content of organic matters, especially resin-asphalt components. On a data set about composition and properties the type of bitumens is established: bitumen from bituminous sands of a deposit the Bayan-Erhet concerns to asphalt, natural bitumens.
- Have been estimated the possibility of obtaining of synthetic oil from the bituminous sand of Bayan-Erkhet deposit by heat treatment at 600 °C in the laboratory conditions and the obtained liquid products were similar with the appropriating fractions of oil.
- Established the possibility of obtaining high-quality oil from the liquid product after thermal treatment of bituminous sand Bayan Erhet deposit with Nb-Zr-aluminosilicate catalyst (structure type ZSM-5) obtained an additional quantity of

petroleum products, which are the basic components of motor fuels.

## References

1. С. Пател. Канадские битуминозные пески: благоприятные возможности, технологии и проблемы // Нефтегазовые технологии. 2007. №6. с. 87-93.
2. Х. Болормаа, Ө. Энхтөгс, Н. Чимид. Отчёт об исследовании горючих ископаемых из бассейнов центральной части Монголии. Улан-Батор. 1997. с. 107-110.
3. Т. Арвижих, С. Очирбат, Д. Дашзэвэг, Ч. Лхагважав. Исследование дорожно-строительных материалов. Улан-Батор.- 2005, с.331-397.
4. Б.М. Рыбак. Анализ нефти и нефтепродуктов. Гостоптехизда, 1962. с.888.
5. А.И. Богомолова, М.Б. Темялко, Л.И. Хотынцева. Современные методы анализа нефтей. -Л. - Недра. - 1984. - с.432.
6. Л. Мөнхтоогоо, Б. Чулуун, Ж. Дашдондов. Отчёт геолого-разведочной экспедиции об исследовании бассейна Баян-Эрхэт, Монголия. ТГЭ, Улан-Батор, 1986.
7. А.С. Колбанов, В.В. Михайлов. Дорожные битумы. - М. - Транспорт. - 1973.-с.261.