ЕҢБЕК ҚЫЗЫЛ ТУ ОРДЕНДІ
«Ә. Б. БЕКТҰРОВ АТЫНДАҒЫ
ХИМИЯ ҒЫЛЫМДАРЫ ИНСТИТУТЫ»
АКЦИОНЕРЛІК ҚОҒАМЫ

ҚАЗАҚСТАННЫҢ ХИМИЯ ЖУРНАЛЫ

ХИМИЧЕСКИЙ ЖУРНАЛ КАЗАХСТАНА

CHEMICAL JOURNAL of KAZAKHSTAN

АКЦИОНЕРНОЕ ОБЩЕСТВО
ОРДЕНА ТРУДОВОГО КРАСНОГО ЗНАМЕНИ
«ИНСТИТУТ ХИМИЧЕСКИХ НАУК
им. А. Б. БЕКТУРОВА»

2 (70)

АПРЕЛЬ – ИЮНЬ 2020 г.

ИЗДАЕТСЯ С ОКТЯБРЯ 2003 ГОДА

ВЫХОДИТ 4 РАЗА В ГОД

АЛМАТЫ
2020

UDC 54.056

A. N. SABITOVA, B.B.BAYAKHMETOVA

Shakarim State University of Semey, Semey, Republic of Kazakhstan

EXTRACTION AND COMPONENT COMPOSITION OF COAL FROM MAIKUBEN DEPOSIT

Abstract. This article discusses the production of important organic compounds by extracting coal from the Maikuben deposit using various solvents such as benzene and hexane. For the first time, the composition of extracts was studied by IR spectroscopic method. As a result of IR spectroscopic study of hexane and benzene extracts, saturated, unsaturated, aromatic compounds, and amines were determined. A comparative analysis of benzene and hexane extract was made.

Keyword: coal, extraction, extractable substances, coal quality, solvent, IR spectroscopy.

Introduction. One of the properties of coals that determine the molecular structure is their effect on various types of solvents. Since coals of various types and degrees of metamorphism swell at low temperatures, various products can be extracted from them.

By nature, the swelling and dissolution of coal is a process very close to each other. Due to the dissolution of the solvent in the coal, coal edema occurs. The results of the experiment show that the process of coal edema is a reversible process. The process of edema occurs due to the formation of intermolecular bonds between the solvent molecule and the organic mass of coal (OMC) [1, 2].

Solvent extraction at boiling point is performed to produce rock wax, lignite, and peat. To do this, we studied the kinetics of the extraction process at the boiling point of the solvent and a certain pressure, grinding coal to a certain amount (0.5–6 mm), mixing coal and solvent with a mass ratio of 1:3 [3].

In milder conditions, it is possible to extract organic substances from coal to several tens of percent. For example, 24% of the organic mass of coal was extracted with a yield of 42% volatiles.

The composition and content of the extract depend on the structural and chemical parameters of the coal and the physical and chemical properties of the solvent used. For example, 40 solvents were studied and the maximum yield of the extract was observed when using anthracene oil as a solvent, when using quinoline and paraffins of low origin [4].

One of the parameters that are important for the output of the extract is the temperature. The extraction mechanism in a softer position differs from the extraction mechanism at a high temperature (t = 400÷450 °C). When extracted under mild conditions, the solvent can only dissolve part of the organic mass of coal bound between the molecules. During high-temperature extraction, destructive processes occur, and the resulting products are stabilized by hydrogen released due

to the disproportion of the organic mass of coal, or by hydrogen released from the solvent, if the solvent is a hydrogen donor [5].

It follows that the coal molecule is considered as an agglomerate of various compounds with different structures and properties, and it should be considered that the dissolution mechanism is more complex than individual compounds.

The study of coal dissolution conditions is one of the most important sections of organic chemistry, including coal chemistry.

At atmospheric pressure, solid combustible ores can be partially dissolved by exposure to various organic solvents. When the temperature increases, the amount of soluble substances increases and shows the maximum dose of the solvent when the boiling point is reached [6].

The study of the influence of various solvents on solid combustible ores shows that the amount of dissolved substances that pass into the solvent depends on the composition, physical and chemical properties of the solvent and solid fuel, the dissolution conditions and the degree of carbon dioxide of the solid fuel [7].

Research materials and methods. This article presents for the first time the results of research on the physical and chemical characteristics and extraction of coal in the Maikuben deposit.

Brown coal from the Maikuben Deposit was used for experimental research. Maikuben is a quarry located 160 km southwest of Pavlodar and 110 km from the power plant. The estimated life of the section is more than 30 years, which is a reliable base for the supply of raw materials. The coal extracted here is brown and belongs to the group of 3 B coals in terms of humidity. Its production is carried out in an open way. It is supplied to Ekibastuz GRES-1, as well as to other thermal power plants and industrial enterprises, as well as for domestic use in Kazakhstan and other countries.

Extraction of coal with organic solvents under normal conditions is carried out on the soxlet apparatus. The soxlet device consists of four parts: a flask heater, a flask, a soxlet extractor, and a reverse refrigerator. The parts of the device are connected to each other via a slot.

The main part of the device is the soxlet extractor . The top and bottom of the extractor are connected by two tubes. One of the two tubes is much wider than the other, it passes steam from the round bottom flask into the extractor. The second, thin, siphon tube again removes the condensed solvent collected in the extractor.

The filter paper cartridges are loaded with carbon weighting (65g of coal : 500 ml of solvent). The cartridge is placed in the extractor and the solvent is poured into the extractor by bending the siphon tube. The extractor is connected to the refrigerator, and the flask turns on the heater.

The physical and chemical characteristics of the brown coal of the Maikuben deposit were determined for the first time using the LabsysEvo analyzer.

The IR spectrum of coal products was taken on a Spektrum 65 IR Fourier spectrophotometer (Perkin Elemer company) in the range of 4000–450 cm^{-1}. KBr with a diameter of 3 mm was used as tablets. The ratio of coal and CBD is 1: 200.

RESULTS AND DISCUSSIONS

The results of technical analysis of the Maikuben coal deposit are presented in table 1.

Table 1 – Physical and chemical characteristics of Maikuben coal deposit

№	Characteristic	Unit	Index	Average value
1	Humidity	%	W	18,0
2	Ash content	%	A	19,8
3	Volatiles output	%	V	42,9
4	Sulfur	%	S	0,8
5	Carbon	%	C	73,5
6	Hydrogen	%	H	4,83
7	Nitrogen	%	N	0,93
8	Oxygen	%	O	19,25
9	Phosphorus	%	P	0,04

Table 1 shows, that the studied coal of the Maikuben deposit is characterized by low ash content and humidity. The analysis of coal showed that the content of elements, in particular carbon and hydrogen, oxygen, the coals of the Maikuben deposit are brown and belong to the humus coals of the technological brand 3B.

The study of the qualitative composition of coal samples from the Maikuben deposit was determined from the group bands in the IR spectra obtained using the Cary 660 FTIR IR-Fourier spectrophotometer (figure 1).

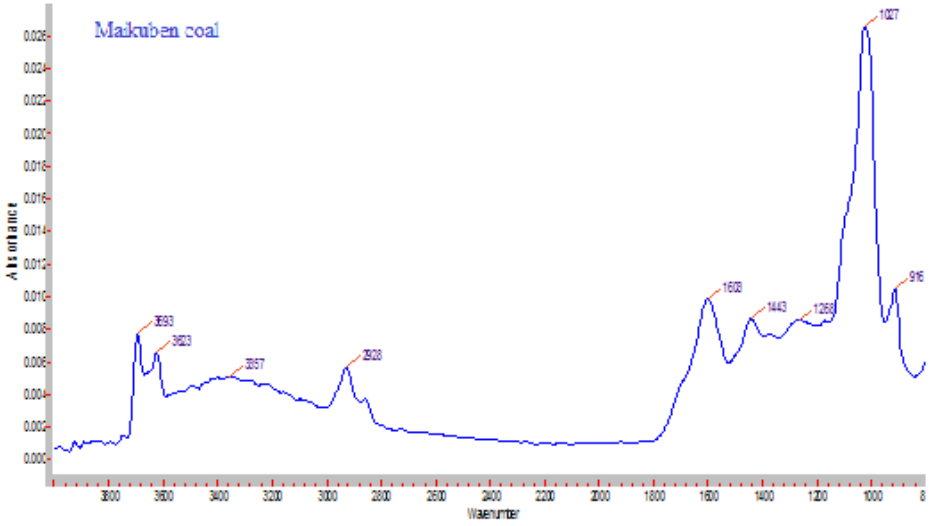

Figure 1 – Graph of the IR spectrum of coals

Absorption bands characteristic of valence vibrations of amides, aromatic hydrocarbons, aromatic and arylalkyl esters, and alcohol hydroxyl were identified in the IR spectra of the studied coal (table 2).

Table 2 – Characteristics of IR spectra in the Maikuben deposit

Fluctuation	Type of compound	Frequency, cm^{-1}
ν_{OH}	Hydroxyl group	3693(av.), 3623(av.), 3357 (str.)
$\nu_{OH\ (bond)}$	Alcohols	–
ν_{CH}	Methylene groups in the benzene ring	2928 (str.)
$\nu_{C=C}$	Double carbon bonds of primary amides	1603 (av.)
ν_{HC-CH}	Arenas	916 (av.)
ν_{COC}	Aromatic and arylalkyl esters	1268 (wk.)
$\nu_{C-O-;\ -OH-}$	Primary alcohols	1027 (str.)
ν_{CH2}	Methylene group	1443 (av.)
$\nu_{OH\ (bond)}$	Phenols	–
$\nu_{C=O}$	Ester	–
Note: 1 str. – strong; 2 av. – average; 3 wk. – weak.		

In the process of coal extraction on the Soxhlet apparatus, the following solvents were obtained: benzene, n-hexane. The conditions of the extraction process are shown in table 3. The ratio of the coal and the solvent taken for the study is 1:5. The extraction was carried out at the boiling point of the solvents for a week.

The composition of liquid extraction products was studied by physical and chemical analysis methods.

Table 3 – Parameters of the Maikuben coal extraction process in the Soxlet apparatus

Solvent	Carbon mass, g	Volume of solvent, ml	Temperature,°C
Benzene	70,0	400,0	80,1
Hexane	80,0	600,0	68,0

The study of the extract content after extraction in the Soxhlet apparatus of the Maikuben deposit was made using IR spectroscopy.

The results of IR spectroscopy of benzene extract obtained from the extraction of coal from the Maikuben deposit in the Soxhlet apparatus are shown in table 4.

The content of n-hexane extract obtained as a result of extraction of coal from the Maikuben deposit in the Soxhlet apparatus, according to IR spectroscopy, is shown in table 5.

In the IR spectroscopy data shown in figure 3, absorption bands of aliphate compounds, olefins and naphthenes and saturated compounds were detected in the composition of n-hexane extract.

Table 4 – Composition of benzene extract of coal deposit using IR spectroscopy

Fluctuation	Type of compound	Frequency, cm^{-1}	Intensity
ν_{NH_2} ν_{NH_2} δ_{NH}	Primary amines	3443,03 3641,92-3610,64 1248,89-1176,89	Weak Weak Weak
$\nu_{C_{Ar}-H}$ $\nu_{c=c}$ $\nu_{c=c}$ $\nu_{=c-H}$	Aromatic compounds (-C=C-C=C-) (=C-H)	3090,56 3035,74 3071,03 1670,92 849,88 774,18	Average Average Strong Average Weak Weak
ν_{CH} δ_{c-c}	Alkanes, $(-CH_2-)$ $-C(-CH_3)_2$	2906,12 2887,19 2818,80 1478,68 1393,32	Weak Strong Strong Strong Average
$\nu_{c=o}$	Ketones	1754,09 1719,51	Weak Strong
ν_{c-o}	Ethers	1178,64	Weak
ν_{HC-CH}	Saturated compounds	728 464,12	Strong

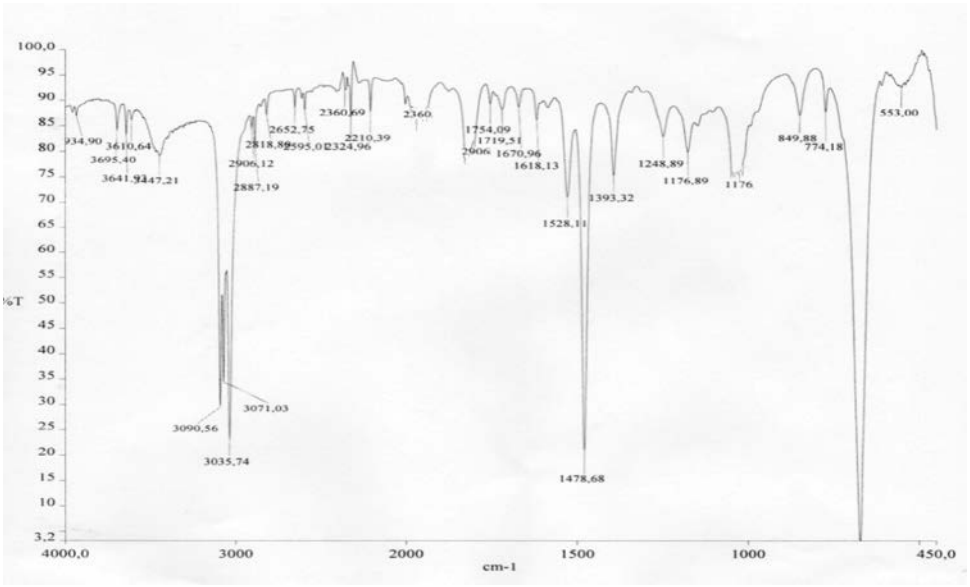

Figure 2 – IR spectrum of benzene extract obtained from the extraction of coal from the Maikuben deposit in the Soxhlet apparatus

Table 5 – Composition of n-hexane coal extract from the Maikuben Deposit using IR spectroscopy

Fluctuation	Type of compound	Frequency, cm^{-1}	Intensity
ν_{NH_2} δ_{NH} δ_{NH2}	Primary amines	3437,09 1248,81-1210,06 1619,62	Weak Weak Strong
ν_{CH} δ_{C-C}	Alkanes $(-CH_2-)$ $-C(-CH_3)_2$	2927,21 2874,43 1466,87 1378,88	Strong Strong Average
$\nu_{C=C}$ $\nu_{C=C}$	Alkenes	1958,74 1854,84	Weak Weak
ν_{CH}	Aldehydes ((typical only for aldehydes)	2734,09 883,80	Weak Average
ν_{C-O}	Ethers	1219,33 1136,02	Weak Weak
ν_{OH}	Alkohols	1065,23 1018,56	Average Average
ν_{HC-CH}	Saturated compounds	905,43 603,46	Strong

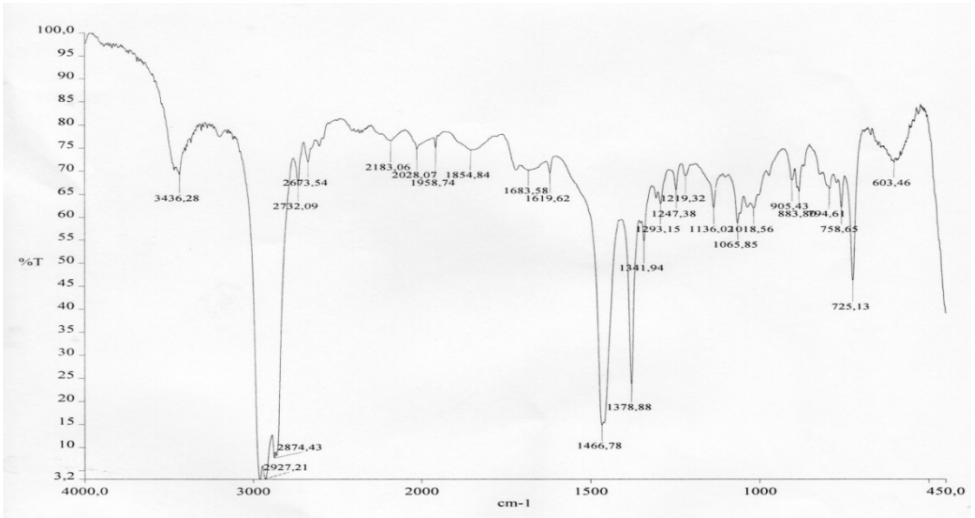

Figure 3 – The IR spectrum of the hexane extract obtained
from extraction of coal deposits Maikuben in Soxhlet apparatus

The study of the IR spectra of benzene extract obtained from extraction revealed absorption bands characteristic of aromatic, aliphatic compounds, amines, esters, ketones and saturated compounds.

Conclusions. Thus, as a result of the study of the IR spectra of benzene extract obtained from the extraction of coal from the Maikuben deposit in the Soxhlet apparatus, absorption bands were determined and they are typical for aromatic, aliphatic compounds.

The study of IR spectra of n-hexane extracts obtained from the extraction of coal from the Maikuben deposit in the Soxhlet apparatus revealed absorption bands of caliphate compounds, olefins, naphthenes and saturated compounds.

The process of coal extraction can distinguish valuable organic substances:

a) alkanes,including nonadecane, and naphthalenes are obtained from coal using a benzene solvent;

b) using a hexane solvent from among the aliphate hydrocarbons, decane, undecane, from the aromatic hydrocarbons of benzene are obtained.

REFERENCES

[1] Makitra R.G., Midyana G.G., Alchikova E.Ya. Influencing properties of solvents on the yield of the extract from coal // Chemistry of solid fuel. 2013. N 4. P. 12-15.

[2] Kairbekov Zh.K., Jeldybayeva I.M., Yermoldina Ye.T., Maloletnev A.S. Thermal cracking of fuel Oil in slate mixture // The Bulletin of the National academy of sciences of the Republic of Kazakhstan. ISSN 1991-3494. 2018. P. 42-47. https://doi.org/10.32014/2018.2518-1467.5

[3] Gulmaliev A.M., Kairbekov Zh.K., Maloletnev A.S., Emelyanova V.S., Myttykbaeva Zh.K. Thermodynamic analysis of the gasification of the Kenderlikskoye oil shale // Chemistry of Solid Fuel. 2013. N 6. P. 49-53.

[4] Zherebtsov S.A. Extraction and component composition of bitumoids of solid fuels // KSTU Bulletin. 2018. N 1. P. 169-179.

[5] Analysis of the liquid products obtained by extraction processing of brown coal Kairbekov Zh.K., Yershova J.T., Akbaeva D.N. // Beremzansky VIII international congress of chemistry and chemical technology. Almaty, 2014. P. 245-248.

[6] Makitra R.G., Bryk D.V. Influence of the nature of solvents on coal swelling // Chemistry of solid fuel. 2010. N 3. P. 26-30.

[7] Makitra R.G., Pristansky Z.E. Dependence of the degree of coal swelling on the physical and chemical properties of solvents // Chemistry of solid fuel. 2001. N 5. P. 3-7.

Резюме

А. Н. Сабитова, Б. Б. Баяхметова

МАЙКӨБЕ КЕН ОРНЫ КӨМІРІНІҢ ЭКСТРАКЦИЯСЫ ЖӘНЕ КОМПОНЕНТТІК ҚҰРАМЫ

Мақалада Майқұбен кен орнынан бензол және гексан сияқты әртүрлі еріткіштерді пайдалана отырып көмірден маңызды органикалық қосылыстарды алу қарастырылады. Алғашқы рет сығындылардың құрамы ИК-спектроскопиялық әдіспен зерттелді. Гександы және бензолды сығындыларды ИК-спектроскопиялық зерттеу нәтижесінде қаныққан, қанықпаған, ароматты қосылыстар мен аминдер анықталды. Бензол және гексан сығындыларына салыстырмалы талдау жүргізілді.

Түйін сөздер: көмір, экстракция, экстрагирленетін заттар, көмір сапасы, еріткіш, ИК-спектроскопия.

Резюме

А. Н. Сабитова, Б. Б. Баяхметова

ЭКСТРАКЦИЯ И КОМПОНЕНТНЫЙ СОСТАВ УГЛЯ
ИЗ МЕСТОРОЖДЕНИЯ МАЙКУБЕН

В статье рассматривается получение важных органических соединений путем извлечения угля из месторождения Майкубен с использованием различных растворителей, таких как бензол и гексан. Впервые состав экстрактов был изучен ИК-спектроскопическим методом. В результате ИК-спектроскопического исследования гексановых и бензольных экстрактов были определены насыщенные, ненасыщенные, ароматические соединения и амины. Проведен сравнительный анализ бензольного и гексанового экстрактов.

Ключевые слова: уголь, экстракция, экстрагируемые вещества, качество угля, растворитель, ИК-спектроскопия.