*International Journal of Engineering Inventions*
*e-ISSN: 2278-7461, p-ISSN: 2319-6491*
*Volume 12, Issue 10 [October. 2023] PP: 88-101*

# Investigation On Characterization Of Liquid Products Obtained By Pyrolysis And Hydrogenation Of Coal From Tevshiin Govi Deposit

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***SUMMARY***
*Through this research, we established the composition and characteristics of coal from the Tevshiin Govi deposit and pyrolysisis and hydrogenation tests to ascertain the process's products output. In a retort, experiments for coal pyrolysis was conducted at 600 $^0C$ for 80 minutes, and in an autoclave, experiments for hydrogenation were conducted at 435 $^0C$ for 120 minutes at a hydrogen pressure of 30 mPa.The yield of liquid products from hydrogenation was determined to be 59.97%, whereas the yield of liquid products from pyrolysis was determined to be 30.28%.In the vacuum distillation of the liquid product of hydrogenation, the light fraction is 29.26%, the middle fraction is 51.52 %, the heavy fraction is 19.22%, and the neutral oil is 85 % of the pyrolysis tar group.*
*The neutral oil of the pyrolysis tar was dissolved in a hexane, toluene, and 1:1 mixture of methylene chloride methanol, and each component was evaluated with a GC/MS analysis. In addition, hydrogenated phenanthrene (obtained from the middle fraction of petroleum products) as a donor solvent and the liquid by-product of hydrogenation carried out in the presence of hydrogen was fractionally distilled, dissolved in a of hexane, toluene, 1x1 mixture methylene chloride, methanol, and analyzed using a GC/MS instrument.In determining the technical and elemental composition of coal in the Tevshiin Gobi deposit, ash yield Ad=21.7%, volatile matter yield 49.69%, carbon content 60.89%, hydrogen content 3.26 %, H/C atomic ratio 0.64, and the composition of coal ash is AlPO4(OH)3 were discovered, as well as minerals including SiO2, CaSO4, and NaAlSiO8.*
***Keywords:****aliphatic, aromatic,tar, polar components, distillate fraction*

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Date of Submission: 03-10-2023 Date of acceptance: 15-10-2023

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## I. INTRODUCTION

Mongolia is among the top 10 coal-rich countries in the world, with 175 billion tons of geological resources, but has few oil and natural gas reserves. 70% of total coal reserves are comprised of brown coal [1].Mongolia's coal is primarily used for energy production, so it is crucial to refine and obtain products that can replace imported oil. In recent years, we have concentrated on producing metallurgical coke, petroleum, petroleum products, and fuel oil by processing coal with deep coal processing technologies (coking, gasification, liquefaction, etc.) [1-4]. There are hundreds of different organic compounds with various functional groups in the liquid products extracted from coal. In the chemical industry, these compounds are used to produce antioxidants, synthetic materials, drugs, paints, and fragrances [5,6]. When liquid products of coal introduced, there is growing concern to the availability of polyaromatic chemicals for manufacturing various carbon materials [7-9]. Additionally, paraffin and olefin compounds are used as liquid fuel's raw materials [10]. The researchers studied the dissolution of different coals intetralin and in anthracene oil at 380°C. Subbituminous coals were found to show maximum reactivity in the tetralin medium, however, bituminous coals were the most reactive in the anthracene oil [11-13]. The dissolution of bituminous coal using various industrial hydrocarbon fractions of coal and petroleum origins as solvents was also studied [14-16]. In general, from the analysis of the results published, it follows that coal dissolution at mild temperatures is in a complex dependence on the properties of both coals and solvents. This may be due to a difference in the reaction conditions, to the limited number of coal samples used, to different methods for determining the process indexes, and to the specificity of interactions of the poly functional fragments of coal with solvent molecules [17-18].

Our research utilizes browm coal, a large deposit with a 923,2million-ton reserve located in the central region of Mongolia, which is relatively advantageous in terms of infrastructure and economy. According to previous research, not only has the yield of pyrolysis liquid products of this deposit's coal been determined, but the chemical composition of the liquid products, as well as the composition and properties of the hydrocarbon group, have not been studied in great detail.A chromatographic analysis of coal liquid products provides much information on the content of various chemical compounds in coals [18]. Therefore, we used a chromatographic analysis in study of coal liquid products.As a result, we sought to determine the chemical composition and hydrocarbon group composition of the neutral oil and hydrogenated liquid products of coal pyrolysis tar from the Tevshiin Gobi deposit in order to increase the likelihood of its use.

## II. EXPERIMENTAL

### 2.1. Sample Preparation

The coal samples used in this study were received from the Tevshiin Gobi deposit of Mongolia. A sample with a particle size of 0.2 mm was selected as an analytical sample [7].Technical analysis were performed by using standard methods for determination of the moisture and ash contents, the volatile matter, and elemental compositions of coal. For example: The sample analytical sample preparation MNS 2719-2001, was determined moisture content-MNS 656-79, volatile matter yield-MNS 654-79, ash yield-MNS 652-79, calorie-MNS 669-87, sulfur content in according with the MNS 895-79 standard method [7].

### 2.2. Hydrogenation

The autoclave was used to perform the hydrogenation experiments. In the experiment, 4 gr of coal were combined with 6 gr of solvent (hydrogenated phenanthrene) and placed in an autoclave. Thirty millibars of pressure were applied to 1340 ml of hydrogen injected at ambient temperature in a single experiment. After 2 hours in a preheated oven at $435^0$C, remove the finished autoclave and, once it has cooled, remove the lid so that you may measure its capacity. Finally, the autoclave was broken open, and the solid and liquid components were isolated.Then it was distilled under the reduced vacuum pressure into the following threemain distillate fractions: light (190°C), middle (350°C) and heavy (≥ 350°C, residue) by Sibata GTR-350 glass tube vacuum distillation apparatus.The coal liquid product is reacted with hydrogen to produce C1-C3 hydrocarbon gases, as well as water, hydrogen sulphide, and ammonia (NH3) in the process of producing hydrogenated oil.

### 2.3Pyrolysis

The vertical cylindrical retort is made of stainless steel was used to perform the pyrolized. In the experiment, 500 gr samples of coal with size 1.5-3.0 mm placed in retort. The retort was placed in an electric furnace (model SNOL) and heat to 550-6000C slowly (at a rate of 20 0C/min) for 80 minutes. The retort was connected with an water-cooled iron tube and a collection vessel for the condensate of liquid product (tar and pyrolysis water). After, non-condensable gases by water-cooled condenser were left the system through a thin glass tube. The yields of water, tar and solid residue were calculated by using their weight also yield of the gaseous product was calculated from its weight loss.

The tar produced by pyrolysis was separated from water and dried with anhydrous CaCI2.

By identifying the chemical family of each substance, group analysis can be performed (carboxylic acids, phenols, organic bases, neutral compounds, etc).

### 2.4.Analysis

The elemental compositions of the coal were determined using the Thermo Scientific FLASH 2000 CHNS analyzer and the oxygen content was obtained by difference. In addition, minerals of sample were determined by Horiba ME 500W spectroscope (XRD) analysis after calcination at 850°C and the structure of the coal functional group was determined with an FTIR Alpha II spectrometer.

The compositions of individual hydrocarbons and hetero atomic compounds in the light, middle and tar distillates were determined by gas chromatography-mass spectrometry (GC/MS) on Agilent 7890A Agilent 5975C quadrupole instrument using column. The neutral sub-fraction (2 g) of the tar was separated into aliphatic (paraffin-naphthene), aromatic and polar components by using column chromatography (CC). A column with a diameter of 10 mm and a height of 200 mm filled with silica gel (ACK) was used in the CC separation. The chromatographic peaks were identified by comparing the retention times of individual compounds.

Additionally, macro-elements and microelements were determined in the ash of coal sample by the ICAP 7000 PLUS SERIES ICP-OES analysis. It is prepared for analysis after dissolving the ash in concentrated nitric acid, diluting to 0.02%

## III. RESULTS AND DISCUSSION

### 3.1. Technical and chemical properties of coal

The technical characteristics and ultimate analysis of the sample determined by standard methods are summarized in Table 1.

Table 1. Proximate and ultimate analyses of the Tevshiin Gobi coal, %

| № | Technical characteristics, wt% | | | | Elemental composition, wt% on a dry basis | | | | | H/C a.r |
|---|---|---|---|---|---|---|---|---|---|---|
| | $W^a$ | $A^d$ | $V^{daf}$ | $Q^d$ ккал/кг | C | H | N | S | O | |
| 1 | 10.33 | 21.72 | 50.91 | 4575.67 | 60.23 | 3.11 | 1.09 | 0.5 | 35.07 | 0.62 |
| 2 | 10.37 | 21.68 | 49.18 | 4604.81 | 61.45 | 3.77 | 1.06 | 0.8 | 32.92 | 0.73 |
| 3 | 10.34 | 21.69 | 48.97 | 4414.59 | 60.92 | 2.95 | 1.04 | 0.6 | 34.49 | 0.58 |
| Average | 10.35 | 21.70 | 49.69 | 4531.69 | 60.86 | 3.26 | 1.06 | 0.6 | 34.22 | 0.64 |

The Tevshiin Gobi deposit coal is difference from other Mongolian brown coal deposits and it is a high ash content and low calorific value. Furthermore, the Tevshiin Gobi coal was determined to have a relatively low content of carbons (60.86%) and a high content of heteroatomic compounds containing. Also, a sulfur content of less than 1.5% is considered low-sulfur coal.

### 3.2. Composition of coal and coal ash

The functional group of coal and the mineral composition of coal ash were studied by FTIR and XRD spectrometers and figure 1shows the FTIR spectrum.

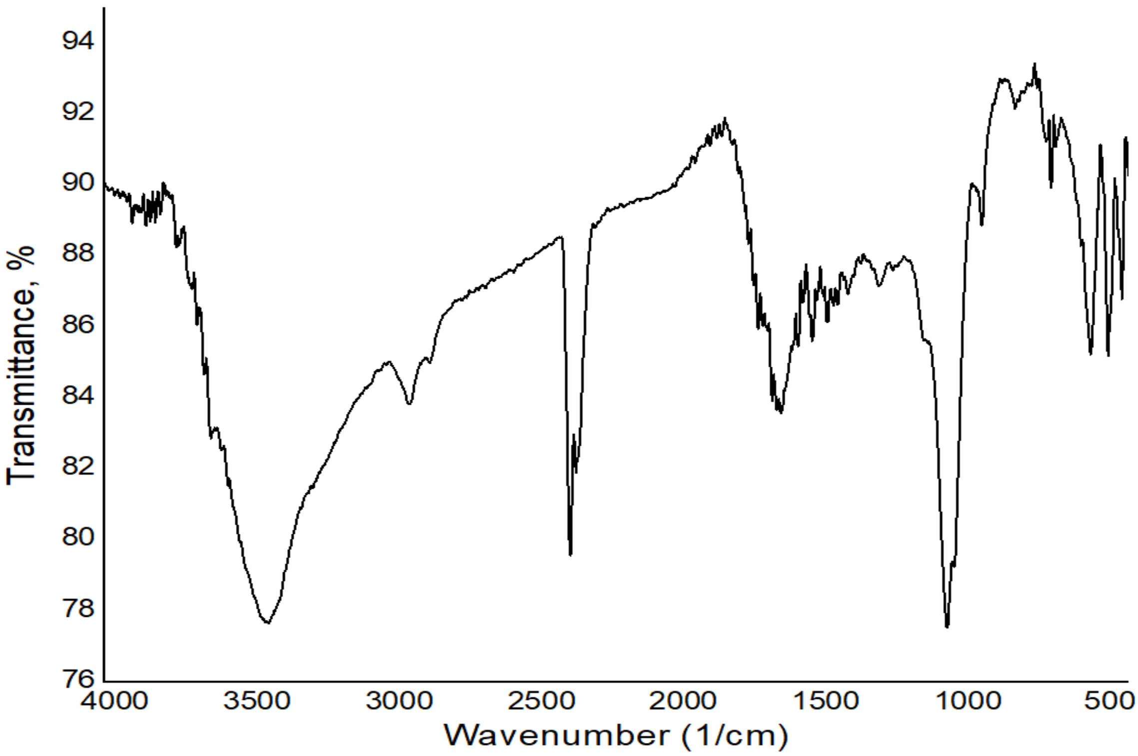


Figure 1. The FTIR spectrum of Tevshiin Gobi coal

The most intensity bonds at 913 $cm^{-1}$ and 796$cm^{-1}$attributed to aromatic structures with 1-2 rings. The analysis reveals the presence of bonds at approximately 1618 -1634 $cm^{-1}$ and 1700 $cm^{-1}$ attributed to phenolic esters (RCOO-Ar), carboxylic acids and ketones respectively. The aromatic C=C stretching bonds from 1519 $cm^{-1}$ and 1559 $cm^{-1}$ was observed. In arylether structures 1275 $cm^{-1}$ the contribution of the bonds at 1035 $cm^{-1}$ was C-O stretching and O-H bonding of carboxylic acids. Also, peaks could be observed at 2930 $cm^{-1}$ and 1458 $cm^{-1}$ (asymmetric-CH3 stretching), and 2868 $cm^{-1}$ and 1384 $cm^{-1}$ (methine C-H stretching) for the sample. The presence of weak absorption bands in the region of 3431 $cm^{-1}$ and in the region of 3625 $cm^{-1}$indicates in coal of an insignificant amount of compounds with hydroxyl groups, as well as nitrogen containing compounds with N-H bonds [9].

The mineral composition of coal ash is shown in Figure 2 and Table 2.

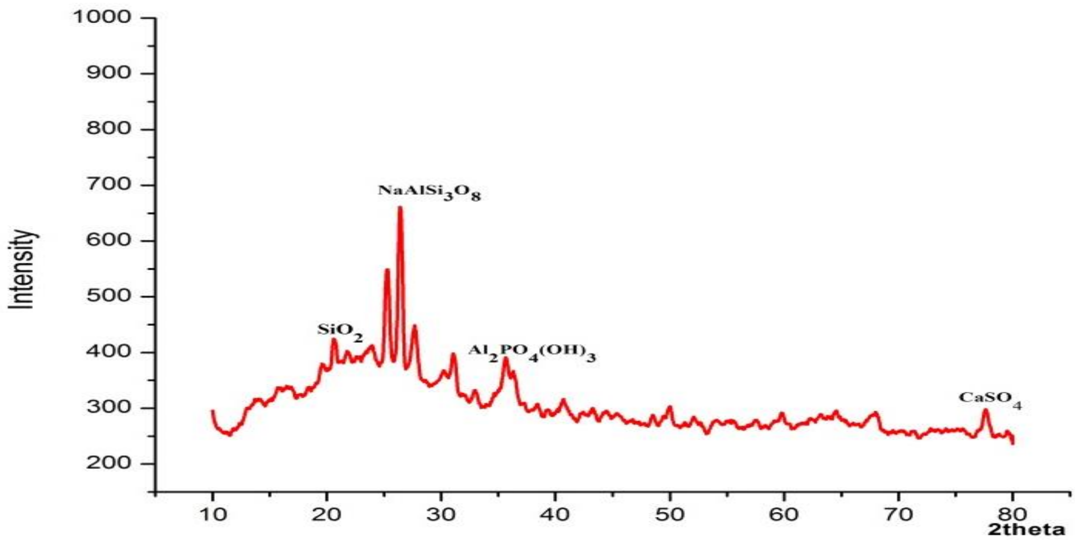


Figure 2. The XRD spectrum of coal ash

Table 2. Minerals in coal ash

| | |
|---|---|
| $Al_2PO_4(OH)_3$ | Aluminum phosphate hydroxide |
| $SiO_2$ | Silicon oxide |
| $CaSO_4$ | Calcium sulfate |
| $NaAlSi_3O_8$ | Albit |

As shown in Figure 2 and Table 2, X-ray analysis of coal ash from the Tevshiin Gobi deposit shows that aluminum phosphate hydroxide-$Al_2PO_4$ $(OH)_3$ has the highest content as well as minerals such as silicon oxide-SiO2, calcium sulfate -CaSO4 and albite-NaAlSi3O8 has been detected other minerals. In addition, macro-elements and micro-elements are detected in the coal ash sample by the ICAP 7000 PLUS SERIES ICP-OES analysis.

Table 3. Micro and macro-elements composition of the ash of the studied coal sample, wt%

| AI | Li | Si | Ca | K | Na | Ba | Hg | Ag | P | Ce | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.89 | 0.09 | 26.78 | 24.89 | 0.08 | 0.10 | 0.01 | 0.50 | 0.001 | 0.43 | 1.05 | 0.14 |
| **Ti** | **Se** | **Ni** | **Mn** | **Cu** | **Sr** | **V** | **Cd** | **Pb** | **Fe** | **Co** | **Cr** |
| 0.07 | 0.03 | 0.09 | 0.21 | 0.72 | 0.01 | 0.14 | 0.01 | 0.01 | 1.42 | 0.01 | 0.02 |

The contents of macro-elements in the sample, high amounts are (AI-9.89, Ca-24.89, Si-26.78, Fe-1.41). On the other hand, it contained a total of heavy (Ni, V, Se, Mn, Cd, Pb) and toxic metals (Sr, Hg, Mo, Ce, Be,) etc. According to results, we suggest that we should focus on reducing the toxicity of heavy and toxic chemical material when mining, processing and using the Tevshiin Gobi coal and its hydrogenation liquid products.

**3.3. Hydrogenation and analysis of liquid products fractions**

The coal sample was hydrogenated to $425^0$C in an autoclave-type assay retort under pressure hydrogen. The results of the hydrogenation experiments of coal performed are shown in Table 4.

Table 4.The yields of hydrogenation products of Tevshiin Gobi coal,%

| | Heating temperatures,°C | Solid residue | Condensed liquid | Gas |
|---|---|---|---|---|
| The Tevshiin Gobi coal | 435 $^0$C | 40.0 | 59.97 | 0.03 |

The hydrogenation converted the organic mass of coal into liquid products 59.97% and solid residue 40.0, and gases including losses (0.03%).

The liquid products produced were separated into light, middle and heavy fractions by distillation (Table 6). The distillate was distilled for 30 min at 190°C at 450 hPa and 30 min at 350°C for 20hPa. In order to increase the yield of light and medium fractions, vacuum pumps were used to adjust the pressure to 450 hPa and 20 hPa respectively.

Table 5. Fractional composition of liquid product, wt%

| Fractions of hydrogenation liquid products | Temperature$^0$C, pressure hPa | Yields |
|---|---|---|
| Light fraction | 190, 450 | 29.26 |
| Middle fraction | 350, 20 | 51.52 |
| Heavy fraction | >350 | 19.22 |

Considering that the yield of the middle fraction is twice that of the light fraction, it is clear that the middlefraction should be recycled and converted into the light fraction, as shown by the findings of the liquid product classification.

### 3.4. Hydrocarbon group composition of the ligh distillatesfractions

Using silica gel column chromatography, we separated the name into aliphatic, aromatic, and polar components before dissolving it in hexane, toluene, and a 1x1 mixture of methylene chloride methanol for GC/MS analysis (Agilent 7890A Agilent 5975 C GC/MS). Table 6-11, showed in Figure 3-8.

Table 6. Aliphatic hydrocarbons of the light distillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 1.57 | 10.44 | Pentane, 3-methyl- | $C_6H_{14}$ |
| 1.61 | 41.92 | Hexane, 2methyl- | $C_8H_{18}$ |
| 1.82 | 4.39 | Hexane, 3 methyl- | $C_8H_{18}$ |
| 1.87 | 22.77 | Cyclopentane, methyl- | $C_6H_{12}$ |
| 2.08 | 10.28 | Octane | $C_8H_{18}$ |
| 2.24 | 8.21 | Octane, 3,5-dimethyl- | $C_{10}H_{22}$ |
| | Total content:28.93(alkanes), Total content:22.77(alkenes) | | |

*RT – retention time; TC – total content*

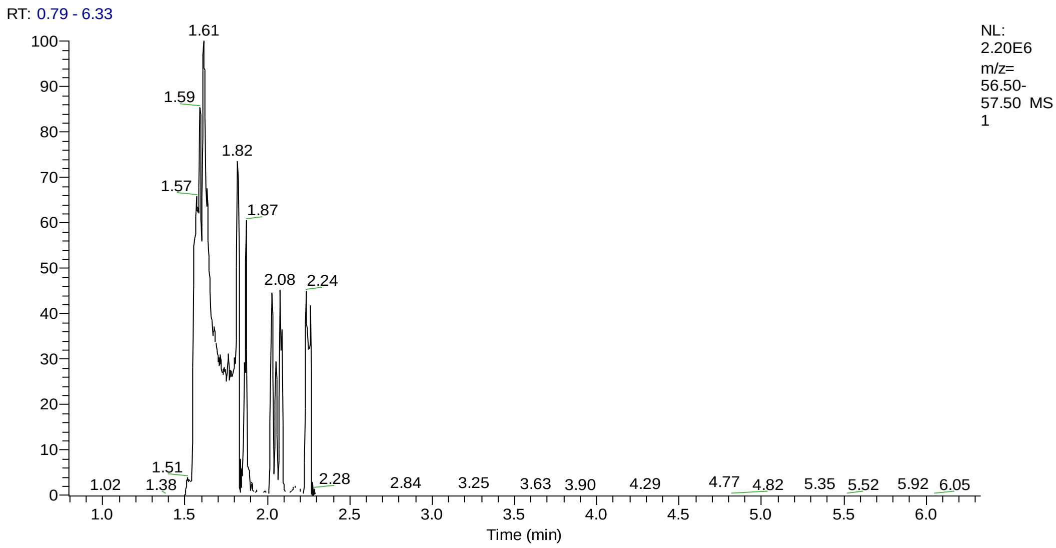


Figure 3. GC/MS-chromatogram of the light fraction of hexane dissolved in the distillate of the liquid product of hydrogenation of coal in the TG deposit

Among all the identified compounds, C6–C10 alkanes were the largest. More than 50% of these hydrocarbons are saturated hydrocarbons which allows to be suitable to use the light distillate as fuel material.

Table 7. Aromatic hydrocarbons of the light distillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 3.39 | 86.07 | Toluene | $C_7H_8$ |
| 4.69 | 0.82 | Ethylbenzene | $C_8H_{10}$ |
| 4.79 | 1.07 | o-Xylene | $C_8H_{10}$ |

| | | | |
|---|---|---|---|
| 5.1 | 3.98 | Benzene, 1,3-dimethyl- | $C_8H_{10}$ |
| 17.08 | 1.64 | Naphthalene, 1-methyl- | $C_{11}H_{10}$ |
| 19.38 | 1.56 | Naphthalene, 1-(2-propenyl)- | $C_{13}H_{12}$ |
| 19.83 | 4.86 | Phenanthrene | $C_{14}H_{10}$ |
| | Total content:13.93 | | |

*RT – retention time; TC – total content*

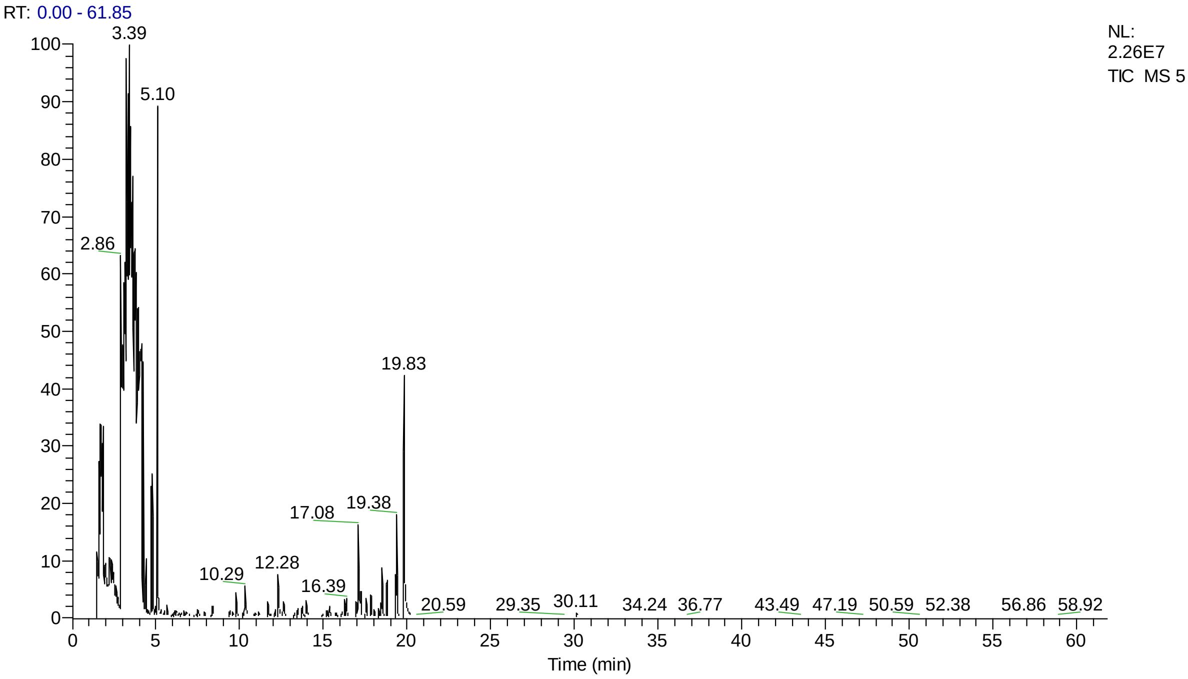


Figure 4. GC/MS-chromatogram of the light fraction of toluene dissolved in the distillate of the liquid product of hydrogenation of coal in the TG deposit

Compounds with C8-C14 aromatic rings were found in the light fraction dissolved in toluene of the liquid product of coal hydrogenation from the Teshvin Gobi deposit, and derivatives of benzene, naphthalene, and phenanthrene are prevalent, as shown by GC/MS analysis.

Table 8. GC-MS results of the with polar compounds of the light distillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 2.98 | 8.4 | Toluene | $C_7H_8$ |
| 3.29 | 77.15 | Methylene Chloride | $CH_2Cl_2$ |
| 4.62 | 1.23 | Ethylbenzene | $C_8H_{10}$ |
| 5.04 | 4.93 | o-Xylene | $C_8H_{10}$ |
| 9.77 | 0.45 | Phenol | $C_6H_6O$ |
| 12.28 | 0.26 | Phenol, 3-methyl | $C_7H_8O$ |
| 19.37 | 0.90 | Phenol, 2,4-dimethyl | $C_7H_8O$ |
| 19.81 | 0.63 | Phenol, 3-ethyl | $C_8H_{10}O$ |
| | Total content:8.40 | | |

*RT – retention time; TC – total content*

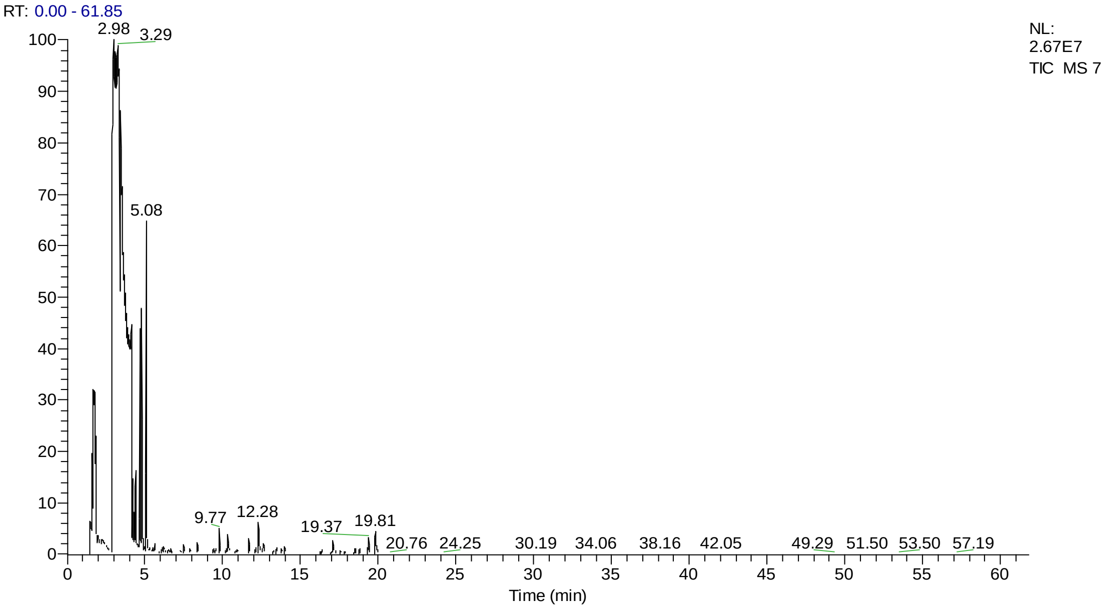


Figure 5. GC/MS -chromatogram of polar compounds in the light fraction of coal hydrogenation liquid products

In the light fraction dissolved in 1x1 mixture of methylene chloride methanol of the liquid product of coal hydrogenation from the Teshvin Gobi deposit, and phenol, its derivatives and o-xylene are prevalent, as shown by GC/MS analysis.Aliphatic compounds are the most abundant in the light fraction of the liquid product of hydrogenation.

**3.5. Hydrocarbon group composition of the middle distillatefractions**

Table 9. Aliphatic hydrocarbons of the middledistillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 1.46 | 18.78 | Hexane, 2,4-dimethyl- | $C_8H_{18}$ |
| 1.62 | 7.11 | Methylheptan 2 | $C_8H_{18}$ |
| 1.87 | 18.26 | Methylundecane,2 | $C_{12}H_{26}$ |
| 2.08 | 13.92 | Trimethyldecane | $C_{13}H_{28}$ |
| 2.24 | 11.94 | Trimethyldecane 2,2,3 | $C_{13}H_{28}$ |
| 15.20 | 9.58 | Tetradecen-1 | $C_{14}H_{28}$ |
| 15.39 | 12.75 | Tetradecane | $C_{14}H_{30}$ |
| 15.77 | 5.07 | Pentadecen-1 | $C_{15}H_{30}$ |
| 16.16 | 3.03 | Pentadecane | $C_{15}H_{32}$ |
| | Total content:67.01(alkanes), Total content:14.65(alkenes) | | |

*RT – retention time; TC – total content*

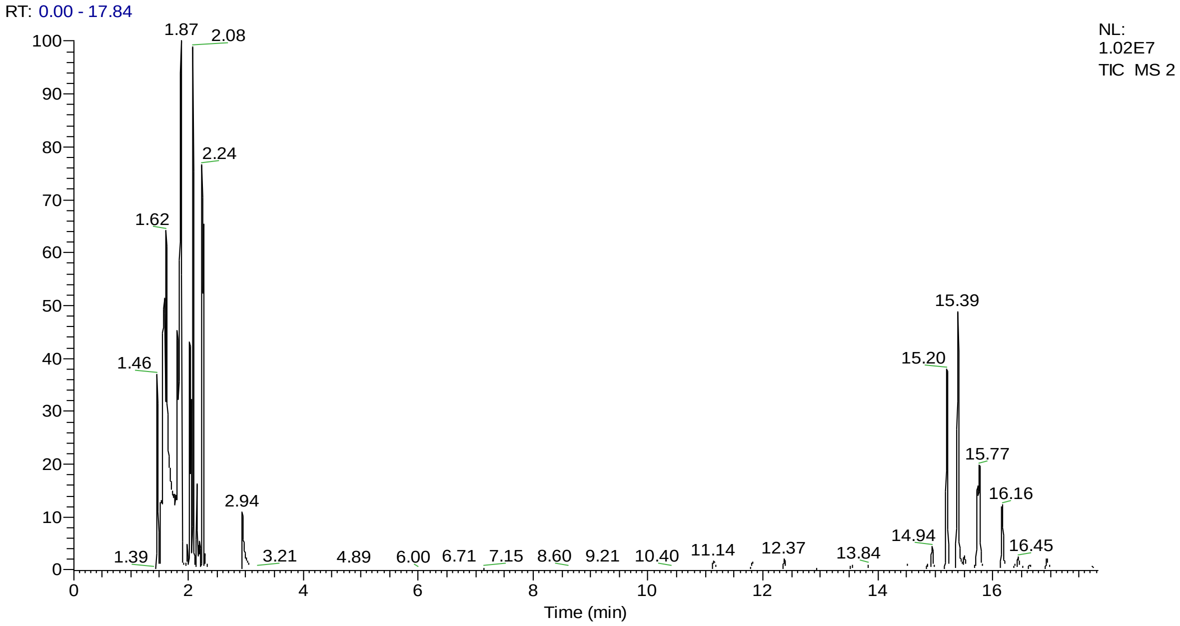


Figure 6. GC/MS-chromatogram of the middle fraction of hexane dissolved in the distillate of the liquid product of hydrogenation of coal in the TG deposit

Of all the identified compounds, C8-C15 alkanes and C14-C15 alkenes were the largest. We calculated of67.01 % alkanes and 14.65% alkenes as shown by GC/MS analysis.As shown in Table 9, stable alkanes are highly abundant in the middle distillate, showing that the hydrogenation the results.

Table 10. Aromatic hydrocarbons of the middledistillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 3.12 | 23.13 | Toluene | $C_7H_8$ |
| 3.33 | 8.20 | Toluene | $C_7H_8$ |
| 3.89 | 11.05 | Tetrahydronaphthalena | $C_{10}H_{12}$ |
| 4.96 | 7.22 | 2,3 dihydro-1 naphthalena | $C_{10}H_{11}$ |
| 12.28 | 2.85 | Naphthalene, 1-methyl- | $C_{11}H_{10}$ |
| 17.83 | 7.58 | diphenylmethane | $C_{13}H_{12}$ |
| 19.47 | 8.68 | Naphthalene, 1-(2-propenyl)- | $C_{13}H_{12}$ |
| 18.53 | 9.83 | Anthracene | $C_{14}H_{10}$ |
| 19.89 | 24.29 | Phenanthrene | $C_{14}H_{10}$ |
| | Total content:71.68 | | |

*RT – retention time; TC – total content*

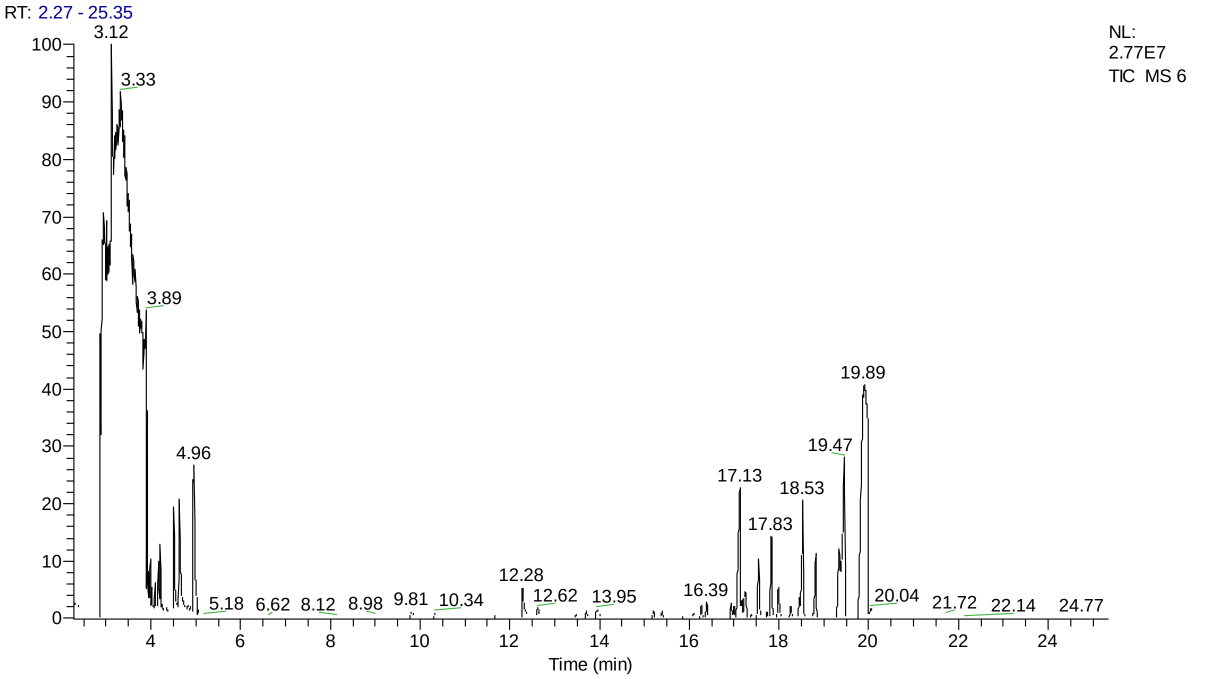


Figure 7. GC/MS-chromatogram of themiddle fraction of toluene dissolved in the distillate of the liquid product of hydrogenation of coal in the TG deposit

Compounds with C10-C14 aromatic rings were found in the middle fraction dissolved in toluene of the liquid product of coal hydrogenation from the Teshvin Gobi deposit, and derivatives of naphthalene, and phenanthrene, anthracene are prevalent, as shown by GC/MS analysis.

Table 11. GC-MS results of the with polar compounds of themiddle distillate

| RT, min | TC, % | Identified compound | Chemical formula |
|---|---|---|---|
| 1.62 | 9.65 | Methylene Chloride | $CH_2Cl_{l2}$ |
| 2.92 | 11.06 | Methylene Chloride | $CH_2C_{l2}$ |
| 3.54 | 58.79 | Benzeneacetamide | $C_8H_9NO$ |
| 4.08 | 8.73 | Phenylmethylether | $C_8H_9O$ |
| 5.11 | 4.84 | Dimethyl phenol-2,3 | $C_8H_{10}O$ |
| 13.12 | 2.44 | Benzoic acid, 3,4-dimethyl | $C_9H_{10}O_2$ |
| 13.91 | 1.48 | Phenol, 2-methyl-6-(2-propenyl) | $C_{10}H_{12}O$ |
| 18.37 | 1.47 | Phenol, 3-phenoxy | $C_{12}H_{10}O_2$ |
| 19.80 | 10.59 | Dibutyl phthalate | $C_{16}H_{22}O_4$ |
| | Total content:88.34 | | |

*RT – retention time; TC – total content*

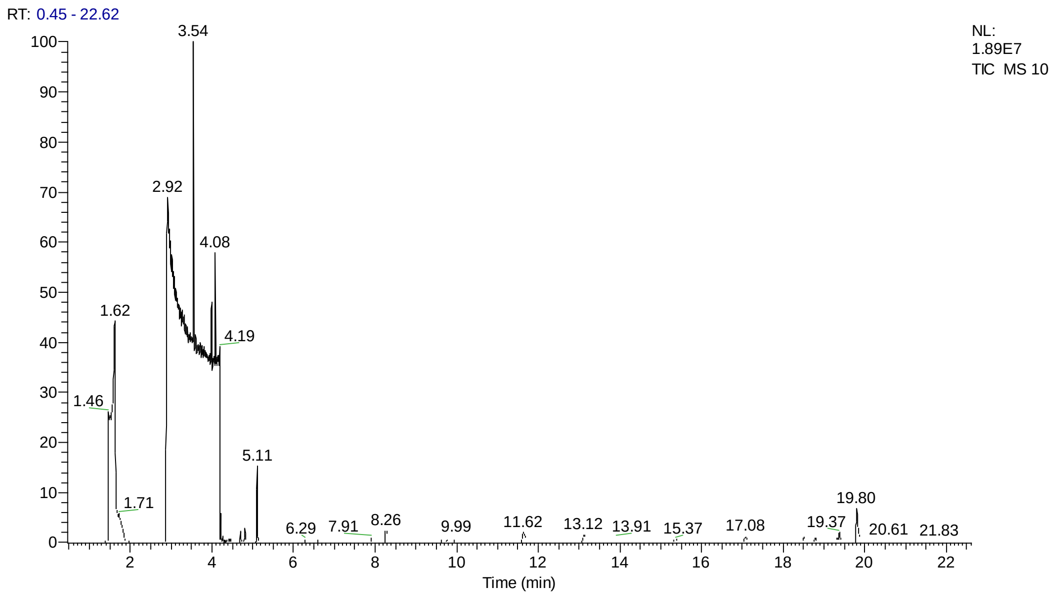


Figure 8. GC/MS -chromatogram of polar compounds in the middle fraction of coal hydrogenation liquid products

In the light fraction dissolved in 1x1 mixture of methylene chloride methanol of the liquid product of coal hydrogenation from the Teshvin Gobi deposit, and phenol, its derivatives benzoic acid, and benzeneacetamide are prevalent, were detected by GC/MS analysis.

**3.6. Pyrolysis and group organic compounds of the pyrolysis tar**

Table 12 shows the test results of the coal pyrolysis and the in table 13 composition of the tar group is shown respectively of Tevshyn Gobi deposit.

Table 12.The yields of pyrolysis productsof Tevshiin Gobi coal,%

| | Heating temperatures,°C | Tar +Pyrolysis water | Solid residue | Gas and loss |
|---|---|---|---|---|
| The Tevshiin Govi coal | 550-600 | 29.64<br>32.28<br>28.94 | 52.80<br>52.15<br>51.58 | 17.56<br>15.67<br>19.48 |
| | **averge** | **30.28** | **52.18** | **17.57** |

Thermal decomposition of coal from the TevshiinGovi deposit results in a yield of liquid and gas products greater than 50% (tar + water 30.28%, gas 17.57%), indicating that the organic mass of the coal has been degraded relatively intensely.

Table 13. The group organic compounds of the pyrolysis tar,%

| Sample | Free carbons | Organic bases | Organic acids | Phenols | Asphalteins | Neutral oils |
|---|---|---|---|---|---|---|
| The pyrolysis tarof the Tevshiin Govi coal | 2.98 | 0.25 | 0.33 | 5.15 | 6.00 | 85.10 |

As a result of the high yield of neutral oil during coal pyrolysis, the Teshvin Gobi deposit had a pitch of 85.10 percent. Aromatics, naphthalene, and methyl-naphthalene are all common in neutral compounds, as are n-alkanes with alkyl substituents.

**3.7.The hydrocarbon group composition of the neutral oil**

The neutral oil was dissolved it in a of hexane, toluene, and 1x1 mixture methylene chloride methanol using silica gel column chromatography, we separated the name into aliphatic, aromatic, and polar compounds and the composition was determined by GC/MS. The results are shown in Table 14-16 and Figure 11-13.

Table 14.Aliphatic hydrocarbons of the neutral oil

| RT, min | TC,% | Identified compound | Chemical formula |
|---|---|---|---|
| 10.3 | 1.79 | Undecane | $C_{11}H_{24}$ |
| 15.14 | 5.28 | Decene, 4-methyl | $C_{11}H_{22}$ |
| 15.28 | 3.5 | 7-Tetradecene, | $C_{14}H_{28}$ |
| 16.81 | 2.86 | 3-Tetradecene, | $C_{14}H_{28}$ |
| 16.92 | 12.09 | Tetradecane | $C_{14}H_{30}$ |
| 17.55 | 5.24 | Decane, 2,3,5,8-tetramethyl | $C_{14}H_{30}$ |
| 18.26 | 5.34 | 7-Tetradecene, | $C_{14}H_{28}$ |
| 19.73 | 3.23 | Nonadecane | $C_{19}H_{40}$ |
| 21.03 | 8.14 | Nonadecene3-methyl | $C_{20}H_{40}$ |
| 22.19 | 2.89 | 3-Eicosene, | $C_{20}H_{40}$ |
| 23.38 | 8.31 | 10-Heneicosene | $C_{21}H_{42}$ |
| 24.51 | 1.23 | 1-Docosene | $C_{22}H_{44}$ |
| 28.74 | 6.61 | Tetracosane, 3-ethyl | $C_{26}H_{54}$ |
| 29.64 | 8.65 | Tetratetracontane | $C_{44}H_{90}$ |
| | Total content:20.28(alkanes), Total content:54.88(alkenes) | | |

*RT – retention time; TC – total content*

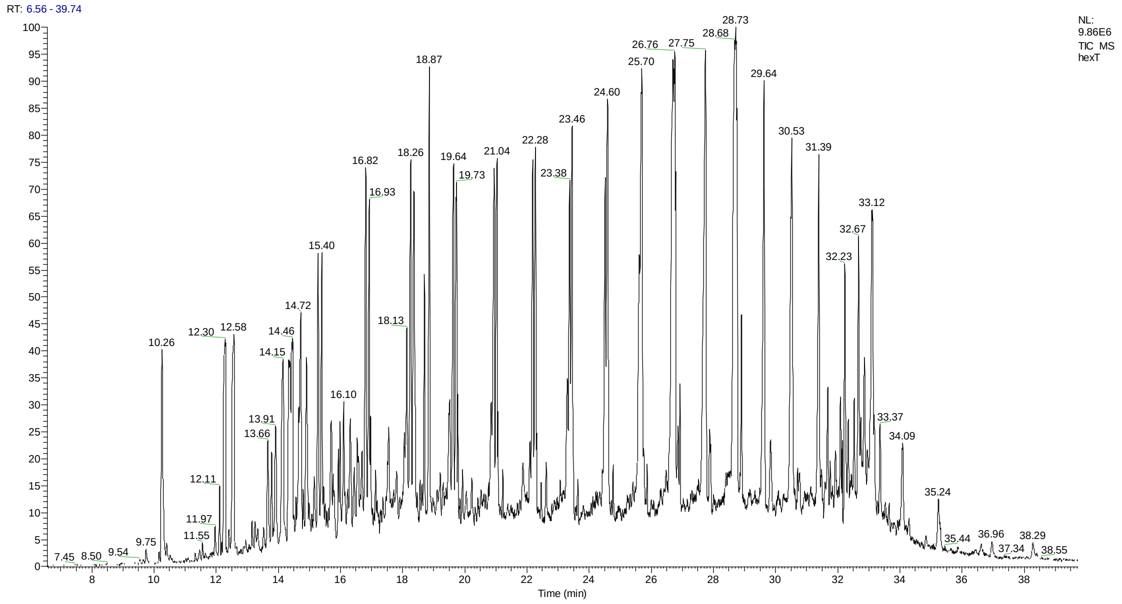


Figure 11. GC/MS-chromatogram of neutral oil dissolved in hexane of the liquid product of pyrolysis of coal from TG deposit

Compounds with C11-C44 alkanes(20.28) and alkenes(54.88) were determined in the neutral oil dissolved in hexane of the pyrolysis tar from the Teshvin Gobi coal deposit, as shown by GC/MS analysis. A higher proportion of alkenes is produced during pyrolysis condensation because of coal's relatively low hydrogen concentration. Thus, GC/MS analysis confirms the need for reprocessing in order to shorten the carbon chain and boost the percentage of saturated carbon.

Table 15.Aromatic hydrocarbons of the neutral oil

| RT, min | TC,% | Identified compound | Chemical formula |
|---|---|---|---|
| 6.31 | 2.60 | Benzene, 1-ethyl-3-methyl | $C_9H_{12}$ |
| 6.84 | 1.16 | 1,3,5-Cycloheptatriene, 7-ethyl | $C_9H_{12}$ |
| 13.64 | 6.08 | Biphenyl | $C_{12}H_{10}$ |

| | | | |
|---|---|---|---|
| 15.33 | 8.90 | 1,1'-Biphenyl, 4-methyl | $C_{13}H_{12}$ |
| 18.57 | 10.51 | 9H-Fluorene, 2-methyl | $C_{14}H_{12}$ |
| 21.36 | 23.27 | Phenanthrene, 4-methyl | $C_{15}H_{12}$ |
| 24.03 | 19.78 | Pyrene | $C_{16}H_{10}$ |
| | Total content:73.30 | | |

*RT – retention time; TC – total content*

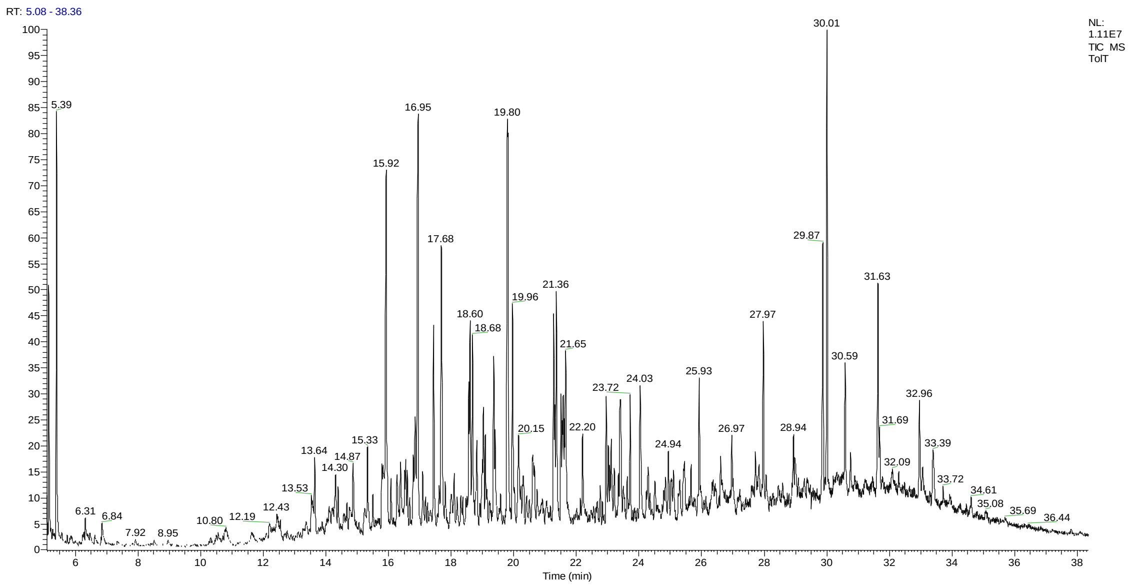


Figure 12. GC/MS-chromatogram of neutral oil dissolved in toluene of the liquid product of pyrolysis of coal from TG deposit

The GC-MS analysis detected with ring C9-C16 hydrocarbons dissolvedin toluene of neutral oil of the pyrolysis tar of coal from Teshvin Gobi deposit. Example: benzene, biphenyl, phenanthrene, fluorene, pyrene and its derivatives

Table 16. GC-MS results of the with polar compounds of theneutral oil

| RT, min | TC,% | Identified compound | Chemical formula |
|---|---|---|---|
| 3.05 | 10.74 | Methylene Chloride | $CH_2Cl_{l2}$ |
| 11.17 | 13.34 | 3,4-Dimethoxytoluene | $C_9H_{12}O_2$ |
| 12.62 | 7.90 | Benzenemethanol, 2-nitro | $C_7H_7NO_3$ |
| 12.74 | 6.92 | Benz[c]pyran-1,3-dione, 4,4-dimethyl | $C_{11}H_{10}O_3$ |
| 14.01 | 3.93 | Norpseudoephedrine | $C_9H_{13}NO$ |
| 19.31 | 8.18 | Propanal, 2,3-dichloro-2-methyl | $C_4H_6Cl_2O$ |
| 20.94 | 5.04 | 3-Cyclopropylcarbonyloxytetradecane | $C_{18}H_{34}O_2$ |
| 25.76 | 5.29 | 2-Nonadecanone | $C_{19}H_{38}O$ |
| 28.41 | 6.93 | [5-(3-Nitro-phenyl)-furan-2-methylene]-p-tolyl-amine | $C_{18}H_{14}N_2O_3$ |
| 30.06 | 27.37 | Terephthalic acid, 2-ethylhexyl octyl ester | $C_{24}H_{38}O_4$ |
| | Total content:84.90 | | |

*RT – retention time; TC – total content*

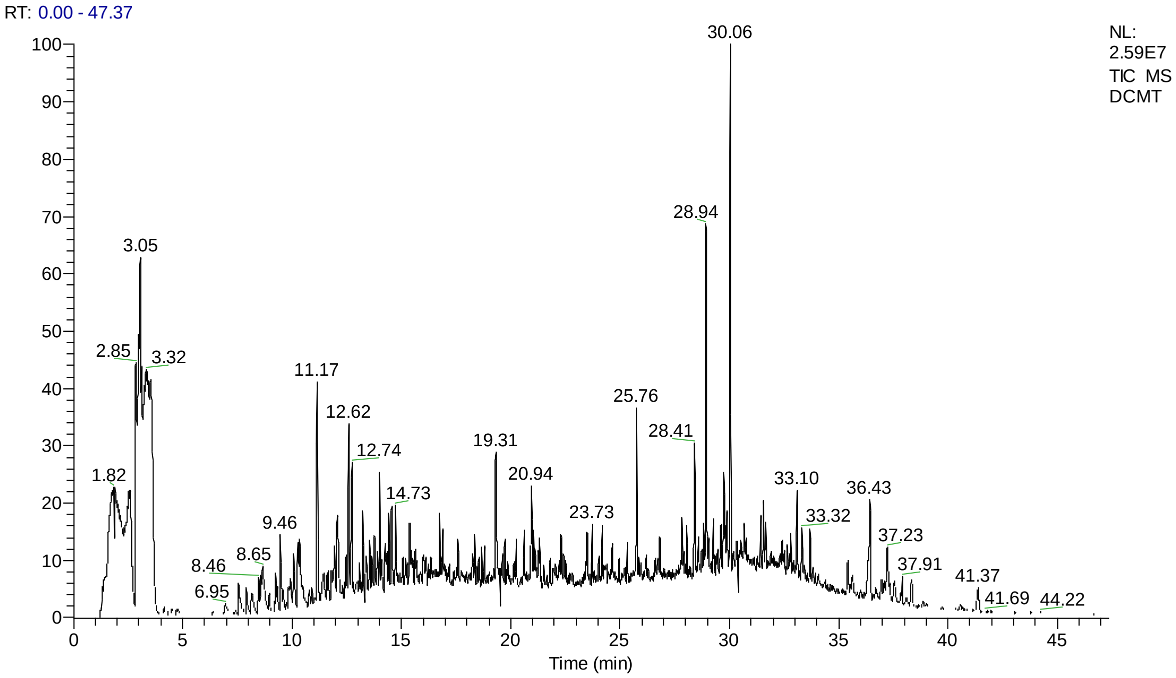


Figure 13.GC-MS chromatogram of the polar component of the neutral oil.

The most large compounds identified were oxygen-containing acidic compounds (84.90), including C7-C24organic nitriles and ketones, alcohol, aldehyde such as.

The pyrolysis liquid products are found to be rich in unsaturated chemicals (alkenes) and oxygenic compounds, while the hydrogenation liquid products are found to be rich in saturated aliphatic compounds, as determined by GC/MS. The hydrogenation procedure has been successful because the oxygenic compounds have been reduced.When coal is pyrolyzed into a liquid, various oxygenated and unsaturated compounds are most created because of its low hydrogen content.

## IV. CONCLUSION

The results of technical analysis of coal the Tevshiingovi deposit show that the content of ash is higher (21.70%), the carbon content (60.86%)and caloric value are lower and the contents of heteroatomic (N, S, O)compounds are also higher.The ash of coal was dominated by Albit, Silicon oxide, Aluminum phosphate hydroxide containing more than 20 heavy and toxic elements.

Have been determined the yields of liquid product (tar and pyrolysis water 30.28%), gases and loss 17.57% and solid residue 52.18% of pyrolysis of coal from Tevshiingovi deposit during pyrolysis experimens at 550-600°C heating temperatures.On the bases of GC-MS analysis in the hexan soluble fraction of the neutral oil pyrolysis tar of coal from Tevshiingovi deposit have been determined that this fraction mainly consists of 20.28% alkans and 54.88% alkens with C11 –C44.

The hydrogenate is carried out under the pressure of hydrogen at 425 °C producing liquid at 59.97%, gas including losses at 0.03%, and solid residue (40.0%). By doing GC-MS analysis, (in the light fraction, mainly C6–C10 alkanes 28.93 and alkenes, 22.77 % and in the middle fraction, mainly C8–C15 alkanes 67.01 % and alkenes, 14.65 %) were identified of hydrogenation liquid product of coal from Tevshiingovi deposit.

The results of hydrogenation of coal from Tevshiingovi deposit show that the most important distillation product is the middle fraction with highest content (67.01%) of alkans and could be produced a diesel fuel after removing of acidic and basic organic components in this fraction.

**Acknowledgments**

This research was financially supported by Mongolian Foundation for Science and Technology (Project 20BB12 CC315 and 2020/12

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