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FULL PAPER

Physico-Chemical Properties of Yemeni Crude Oil of Alif –Mareb, Masilla and Jardan – Shabwa Fields

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ABSTRACT:

Given the immense importance of crude oil to contemporary civilization as a raw material for several chemical and petrochemical businesses as well as a source of energy, in this study we assess the properties of specific Yemeni crude, and fuel oils, in particular, Masila crude oil and Mareb crude oil.
These crudes' and fuel oils' general requirements are established.
And contrasted utilizing the available data in the specialist literature with a few other regional and global kinds, such as Brent and West Texas benchmark crudes. It is discovered that the lightest and sweetest crude oil is Mareb crude oil blend. The aforementioned samples contained eleven metals and heavy metals, of which the most prominent ones were identified by atomic absorption spectroscopy and the ICP technique as (Na, K, Mg) and (V, Co, Ni). Figures depict the sequence in which the metal concentrations in Yemeni crude oils were found:
Due to the high significance of crude oil to modern society as a source of energy and as raw material for a wide chemical and petrochemical industries; in this study, we evaluate the characteristics of certain Yemeni crude, and fuel oils specifically Mareb crude oil blend, Masila crude oil . The general specifications of these crudes and fuel oils are determined and compared with some other regional and international types including Brent and West Texas benchmark crudes using the published data in the specialized literature. It is revealed that Mareb crude oil blend is the lightest and sweetest crude oil followed. the levels of heavy metals present in the crude oil For heavy metals, the range of values were Ag (0.003- 0.0614), Ca (3.24-1876), Cd (<0.001-0.0195), Co (<0.0018-0.1615), Cr (<0.0018-1.776), Fe (1.684 -94.3), K (0.0320-12.59), Na (0.04 -31.94), Ni (0.1894-1.60), Pb (0.0534-1.31), V (0.0667- 0.45) . In many nations, the quantities of metals in the investigated sample were generally lower than those in crude oil and fuel oil. This indicates that Yemeni fuel oil and petroleum are of the highest caliber. In general, the analyzed sample's metal contents were lower than those of crude oil and fuel oil in many different nations. This indicates that Yemeni fuel oil and petroleum are of the highest caliber.

Keywords: Yemeni crude oil, Alif, Masilah, Eyad-Jardan, TBP, Physico-chemical

1. Introduction

The demand for petroleum, a non-renewable energy source, is high worldwide. petroleum industry depletion; heating systems; transportation industries; and domains Petroleum is an intricate blend of many organic materials.

Hydrocarbons are the main component of petroleum and are typically combined with other minor components including oxygen, nitrogen, and sulfur. Petroleum is typically found in land solids. Hydrocarbons are the main component of petroleum and are typically combined with other minor components including oxygen, nitrogen, and sulfur. Petroleum is typically found in land solids.

Measuring the physical-chemical parameters of crude oil and finished petroleum products is required to identify and predict their behavior under specific conditions [17]. additionally to contrast the measured values with global norms.

Crude oil typically has a varied or nearly identical character depending on its source. Crude oils are mostly aromatic, paraffinic, and naphthenic, however they can be complex. [22]. From C1 to C120, all common alkenes are present in crude oils[12].

A small error in the prediction of any property can make big changes in design and operation specifications of units, which in turn effects on the plant cost, production cost, plant life, desire product specifications, and finally on the profit.

Therefore, a significant amount of the additional cost can be avoided by using an adequate characterization approach to accurately forecast the attributes of petroleum fractions. The data indicates that West Texas Intermediate crude oil (WTI), one of the world's market crudes used as a benchmark for pricing other US crudes, is produced in Texas and southern Oklahoma in the United States.

The hydrocarbon combination is extremely intricate. The different ratios of the components that make up crude oils cause noticeable changes in their properties. For refiners handling crudes from various sources, a straightforward standard may be devised to classify crudes with comparable attributes.

Relative to the hydrocarbon classes that predominate in the mixture, crude oils can be arbitrarily divided into three or four groupings.

The main distinctions between crude oil from various sources can be attributed to the hydrogen and heteroatom concentrations, although the carbon component of crude oil remains largely unchanged.

Certain crude oils are mostly composed of hydrocarbons since they contain only trace amounts of nitrogen, oxygen, and sulfur. However, if the constituents have at least one atom of nitrogen, oxygen, or sulfur in their molecular structures, then a crude oil with 9.5% (w/w) heteroatoms may not actually have any true hydrocarbon ingredients.

Three categories of crudes are described as follows: 1. Paraffinic: Compared to aromatic and naphthenic hydrocarbons, the ratio of paraffinic hydrocarbons is higher. 2. Naphthenic: Compared to paraffinic crudes, the percentages of naphthenic and aromatic hydrocarbons are comparatively higher. 3. Asphaltic: have a higher asphalting content, a greater proportion of polynuclear aromatics, and a lower paraffin percentage than paraffinic crudes.

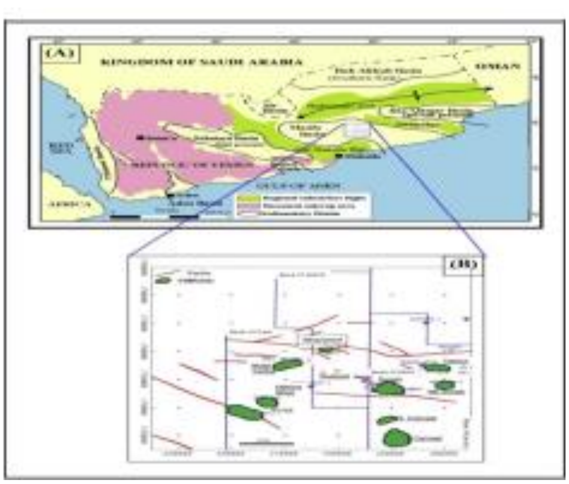
olefins Unsaturated hydrocarbons, such as ethylene and propylene, that have a double carbon bond, with the molecular formula CnH2n.

paraffins Saturated aliphatic hydrocarbons with the molecular formula CnH2n+2. Reforming A process for the transformation of naphthenic to products with higher octane number. Reforming Comprises isomerization, cracking, polymerization, and dehydrogenation.

visbreaking A low-temperature cracking process used to reduce the viscosity or pour point of straight-run residues.

2. Site Description

One of Yemen's onshore basins, the Masila Basin is situated in the country's east (Fig. 1). A few significant hydrocarbon oilfields may be found in the Masila Basin, which is one of Yemen's largest hydrocarbon basins (Fig. 1A). However, the Shabwa oilfield's Masila, Mareb Alif-field, and Jardan Eyda are the study's areas of interest (Fig. 1A, 1B, IC).



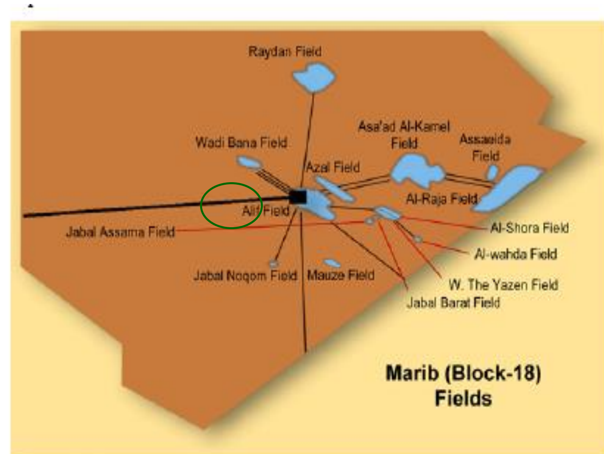


Figure (1A) location map of some Masila. Basin's. Blocks including Sharyoof oilfield (Block 53), Hadramout region of the Republic of Yemen [4]

Figure (1B) Mareb field (block 18)

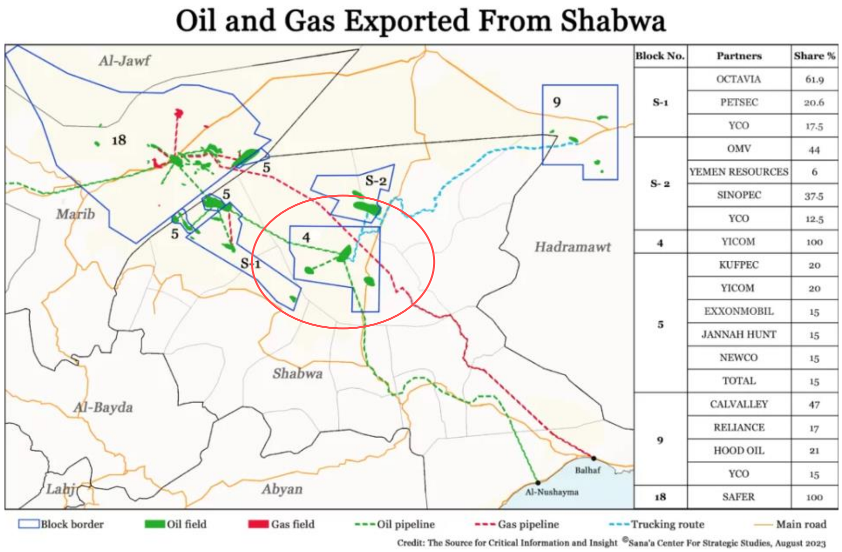


Figure (1C) Block 4 of the Eyad area in Jardan district

Horst, tilted fault blocks that originated in the Late Jurassic–Early Cretaceous and developed in the Oligocene–Middle Miocene period as a result of the Red Sea and the Gulf of Aden opening during the Tertiary rifting tectonic event characterize the main structures in these oilfields [4, 5, 8, 9, 18].

The least productive block in Shabwa, Block 4, is entirely owned and run by YICOM. Block 4 contains three oil fields. It is located in the Jardan district's Eyad sector, north of Ataq, the capital of the governorate.[45] Although it has not been thoroughly investigated, seasoned specialists in the area speculate that it may have sizable unexplored deposits that, if properly utilized, may surpass other blocks in the governorate Figure (1C).

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3. Objectives

examining the characteristics of the crude oils from the Shabwa Jardan-Eyad field, Masila, Mareb-Alif field, and comparison with other crude oils in Yemen and worldwide.

4. Material and Method

From each field, crude oils from Masila, Mareb-Shabwa were gathered and removed. and ready for examination, like the crude oil characterization.

Characterization of crude oils.

1) Density and Specific Gravity: utilizing a hydrometer cylinder, hydrometer, and glass stirring in accordance with the (ASTM D-1298) method.

2) According to the (ASTM D-445) technique, kinetic viscosity was measured at 40 ° C using an electric furnace at 100 ° C and a viscometer measuring (5/4685, 5/61315, 5/4686, 5/4688), Kv-55, and kinetic bath developed by Tanaka Scientific Limited Company.
3) Using the Conductivity Method, determine the total salt content of crude oil (IP 265)
4) Utilizing a conductivity cell, meter, thermometer, and cylinder.
5) We used an auto vapor pressure tester model AVP-30 D, a manometer, and a vapor pressure bomb to determine the vapor pressure of crude oil in accordance with the Reid method (ASTM D-323).
6) Using toluene, an Oil Test Centrifuge Model Set A made in Germany, centrifuge tubes, an Interdit Pour TouteMettler PE 600 Transaction, and a heating bath, the Centrifuge Method is used to extract water and sediment from crude oil in accordance with (ASTM D-4007).

7) Sulfur in oil as determined by IP 336, with the Horiba Company model SLFA-2800 Sulfur in Oil Analyzer.
8) ICP: The Optical Emission Spectroscopy Principle. One technique for optical emission spectrometry is called inductively coupled plasma, or ICP. The component constituents (atoms) of the sample under analysis are energized when external plasma energy is directed towards it. Emission radiation, or spectrum rays, are emitted as the excited atoms settle back to a low energy state. The emission radiation wavelength of the photon is determined by measuring this emission radiation.
The location of the photon rays determines the type of element, and the intensity of the rays determines the content of each element. Argon gas is fed into the torch coil first, followed by the feeding of high-frequency electric current into the working coil at the end of the torch tube to produce plasma. Plasma is produced by ionizing argon gas using the electromagnetic field produced by the high-frequency current burner inside the tube.
9) **Differential Scanning Calorimetry for Determining Wax Appearance Temperature.**

As a function of temperature, the difference in heat flow between the sample and a reference at the same temperature is measured. DSC is frequently used in wax system investigations to calculate the amount of crystallized wax under quiescent conditions and the temperature at which wax crystallization begins.

- The sample and reference temperatures in this system are managed by the same furnace.
- The system keeps track of the sample and reference temperatures.
- A temperature differential between the sample and the reference arises from variations in the sample's enthalpy or heat capacity.
- Using calibration, the temperature difference is noted and connected to the sample's enthalpy change.
- A little metal pan is filled with a 1–10 mg sample that is sealed.
- Usually, an empty pan and cover serve as the reference.
- A nitrogen gas flow is maintained above the samples in order to establish a dry and repeatable environment.
- A typical heat flow plot showing the temperature at which wax crystallizes. Wax begins to crystallize at the onset temperature (T1) and produces two peaks; the end point occurs at T2. This process occurs when a sample cools. A baseline, often known as a dot line, connects the onset and finish points

Infrared Spectroscopy (IR / FTIR)

FTIR and Infrared Spectroscopy

Chemical substances can be identified and examined using infrared spectroscopy. A sample is exposed to an infrared beam, and the sorts of molecules present in the sample can be determined by measuring the amount of radiation absorbed by the sample at various frequencies.

The most popular kind of infrared spectrometer is the Fourier transform infrared (FTIR) spectrometer. It logs the information gathered and converts it into a spectrum. The spectrum is shown with a graph that indicates the frequency and amount of absorption that took place. The spectrum can be used to identify the sample at the molecular level because various molecules absorb the radiation at different frequencies in known proportions.

(TBP) distillation is a popular batch distillation method that is often utilized primarily for marketing and refining purposes when characterizing crude oils. Plotting the cumulative mass or volume distillation fraction with rising temperature yields the TBP curve. The True Boiling Point (TBP) distillation analysis is used to determine the qualities of natural petroleum and petroleum products. It has been shown to be highly helpful in the design and operation of refinery units as well as the characterization of petroleum.

5. Results

The physicochemical properties of the crude oils are shown in Table (1), which also compares the sulfur content and API gravity of Yemeni crude oil to the API (2005) standard. The physicochemical characteristics obtained for the oil samples ranged in value as follows, according to the results: specific gravity (0.8010-0.916), API gravity (25.72-44.99), and sulfur content (0.1270 –0.859), water content (0.00-4.9),TAN (0.00-0.54); pour point (-33-18), density at 150C (0.8010-0.8598), wax content (30.95-45.25),R.V.P (12.5-45), Asphalten content (0.00-0.8), Kinematic viscosity at 50^{o}C (1.632-106.67), density at 150C (0.8010-0.8598), wax content (30.95-45.25), R.V.P (12.5-45), asphalten content (0.00-0.8), water content (0.00-4.9), TAN (0.00-0.54), pour point (-33-18), and kinematic viscosity at 50oC (1.632-106.67) are among the values to consider.

The amounts of heavy metals found in crude oil are displayed in Table 2. Ag (0.003-0.0614), Ca (3.24-1876), Cd (<0.001-0.0195), Co (<0.0018-0.1615), Cr (<0.0018-1.776), Fe (1.684 -94.3), K (0.0320-12.59), Na (0.04 -31.94), Ni (0.1894-1.60), Pb (0.0534-1.31), and V (0.0667-0.45) were the range of values for heavy metals.

The physico-chemical parameters of Yemeni crude oils are presented in Table 1.

Density at150°C	0.8010	0.8296	0.899
API	44.99	38.90	25.72
S.G	0.8010	0.8304	0.916
TAN	0.02	0.00	0.54
Pour point	-33	-24	-18
Water content	0.00	4.9	0.00
Wax content	39.67	45.25	30.95

Sulfur content	0.1270	0.1371	0.8598
R.V.P	45	27.7	12.5
Asphalten cont.	0.00	0.11	0.80
Kinematic viscosity at50^{0}C	1.632	2.724	106.67

Table 2: The concentrations of heavy metals found in the Yemeni crude oils under study

	Alif field	Almasillah field	Jardan Eyad field
Ag	0.003	<0.003	0.0614
Ca	6.900	83.41	18.6+76
Cd	0.001	<0.001	0.0195
Co	0.067	<0.002	0.1615
Cr	0.008	0.0018	1.776
Fe	1.684	18.50	94.3
K	0.320	12.59	4.169
Na	0.04	31.94	19.67
Ni	1.60	0.1894	0.3915
Pb	1.31	0.0534	0.3915
V	0.45	0.0667	0.2073

Table 3: Temperature of Wax Appearance of Yemeni Crude Oils

	WAT$^{\circ}$C	Wt-mg
Alif (Mareb)	12.32	6.4
Almasillah	39.50	8.4
Jardan (Eyad field)	-8.90	10.8

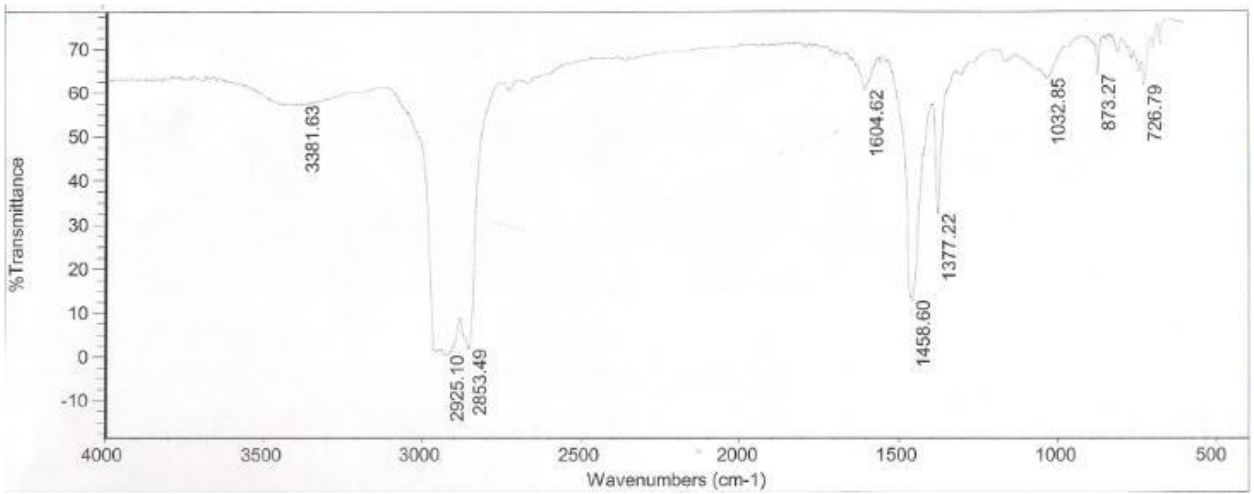


Figure (2): Almasilah crude oil's infrared spectrum

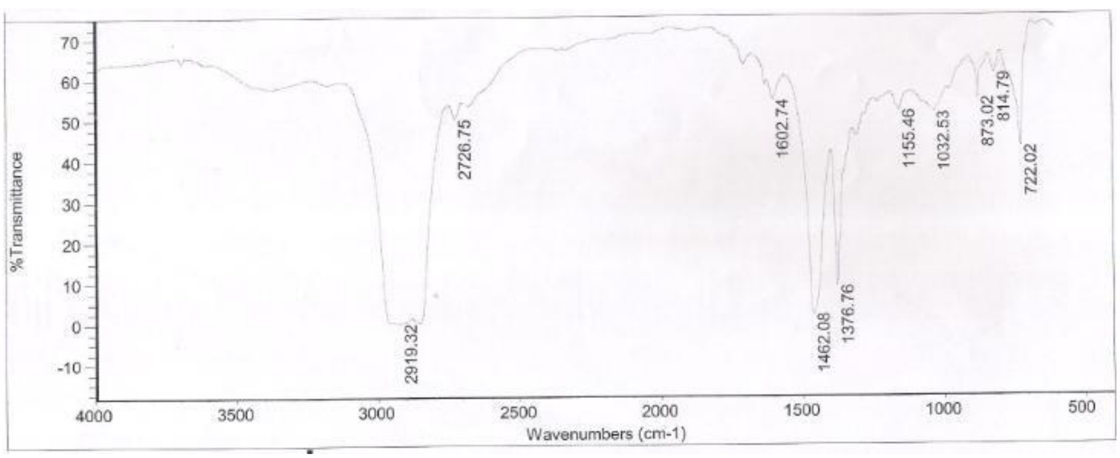


Figure 3 shows the Eyad (Jardan) Shabwa crude oil's infrared spectrum.

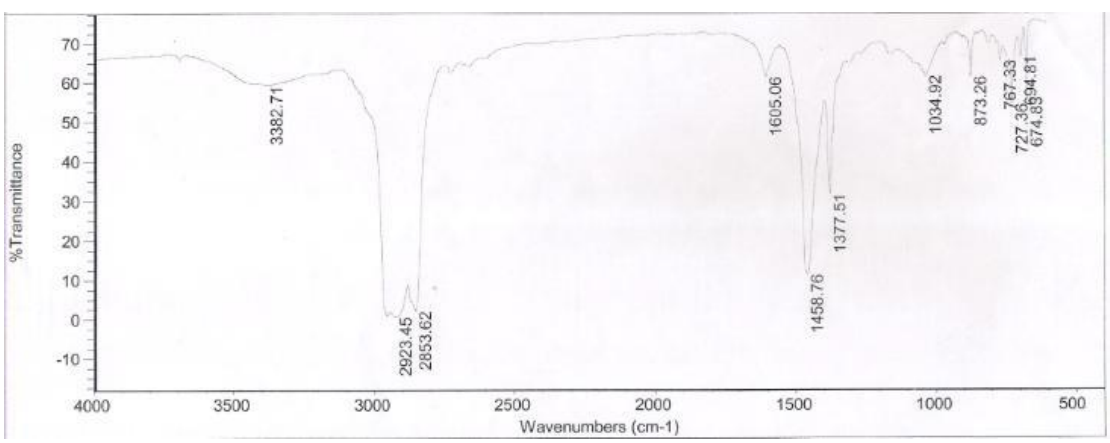


Figure 4: Alif (Mareb) crude oil's infrared spectrum.

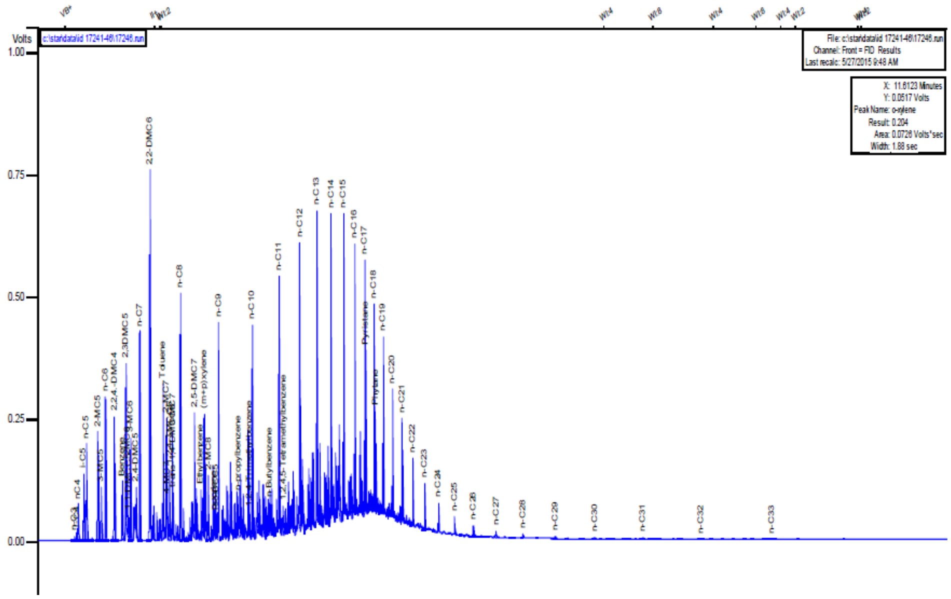


Figure 5: A representative entire oil sample for Eyad (Jardan) Shabwa crude oil utilizing GC-FID fingerprint.

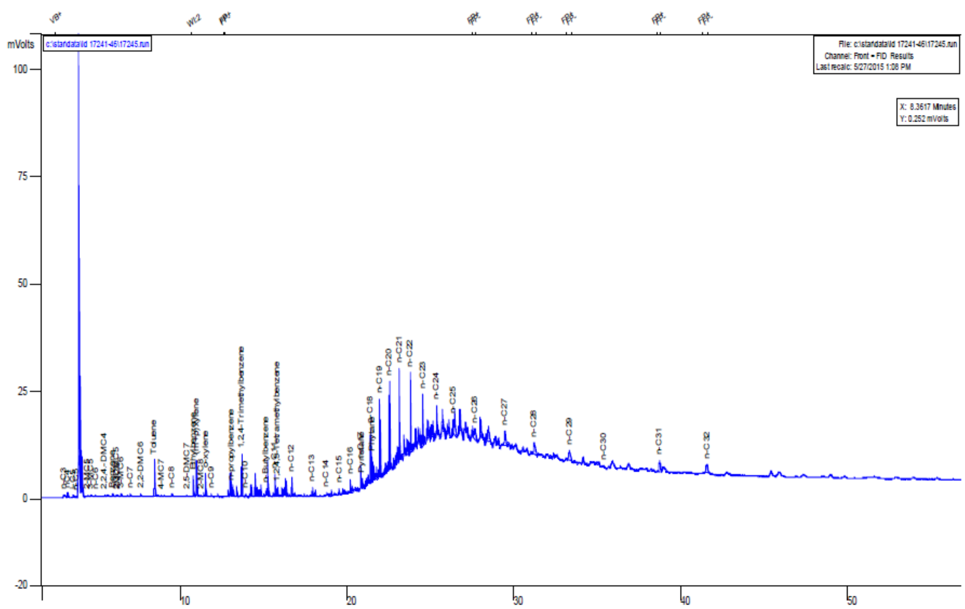


Figure (6): GC-FID fingerprint of a representative whole oil sample from AL-Masilah crude oil sample.

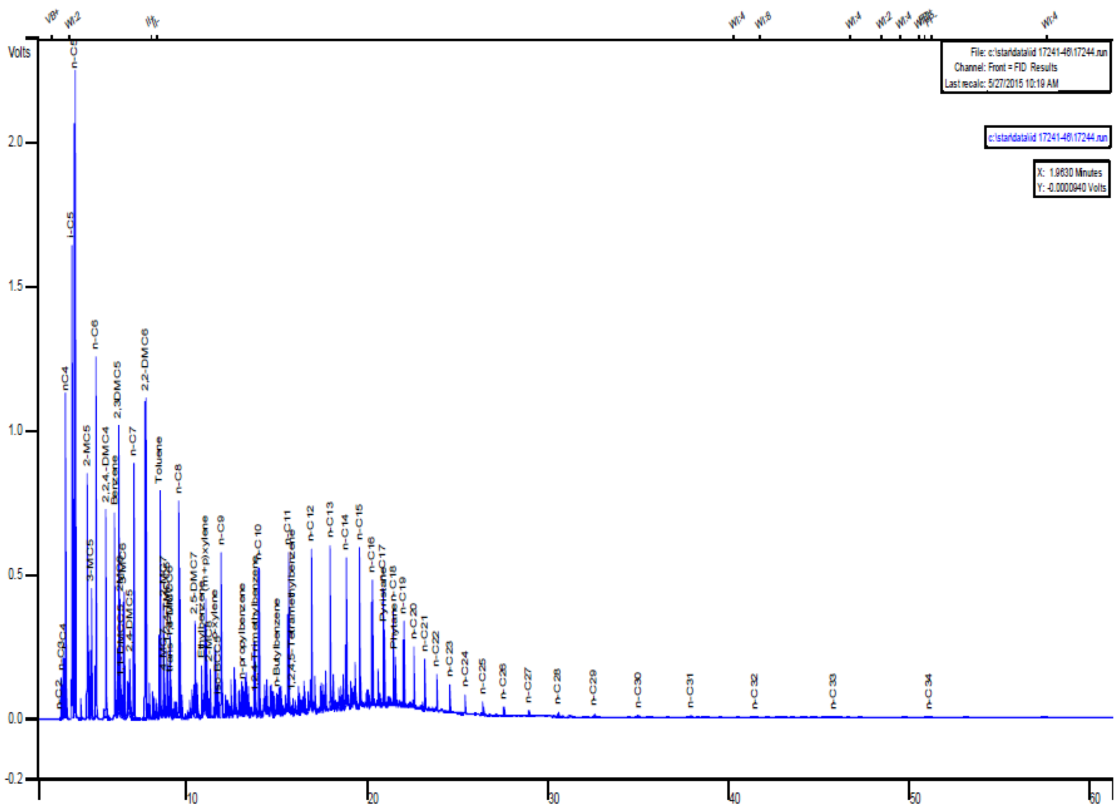


Figure (7): Alif crude oil sample representative whole oil utilizing GC-FID fingerprint.

Table 4: Yemeni crude oil's properties: mean and standard deviation

Field / Parameter	Alif field (Mean ± SD*)	Almasillah field (Mean ± SD*)	JardanEyad field (Mean ± SD*)
Density at150° C	0.846^{a}± 0.0925	0.830^{a}± 0.0711	0.931^{a}±0.0278
API	44.66^{a} ± 0.592	38.27^{b} ± 1.020	25.48^{c} ± 0.496
S.G	0.8126^{a} ± 0.0105	0.8684^{a,b} ± 0.0493	0.8938^{b} ± 0.0201
TAN	0.013^{a} ± 0.0058	0.007^{a} ± 0.0058	0.537^{b} ± 0.0152
Pour point	-33^{a} ± 1	-24^{b} ± 1	-18^{c} ± 1
Water content	0.030^{a} ± 0.058	4.901^{b} ± 0.200	0.003^{a} ± 0.006
Wax content	39.49^{a} ± 0.439	44.95^{b} ± 0.327	31.22^{c} ± 0.584
Sulfur content	0.1483^{a} ± 0.0449	0.1485^{a} ± 0.0471	0.8735^{b} ± 0.0369
R.V.P	44.67^{a} ± 1.528	28.03^{b} ± 0.757	12.80^{c} ± 0.265
Asphalten content	0.003^{a} ± 0.006	0.120^{b} ± 0.010	0.860^{c} ± 0.053
Kinamatic viscosity at500C	1.658^{a} ± 0.075	2.776^{a} ± 1.002	106.737^{b} ± 1.002

SD*: Standard deviation (N = 3), at the 0.05 level.

Table 5: Yemeni crude oil's heavy metal mean and standard deviation

Field / Parameter	Alif field (Mean ± SD*)	Almasillah field (Mean ± SD*)	Jardan Eyad field (Mean ± SD*)
Ag	0.003^{a} ± 0.001	0.003^{a} ± 0.001	0.061^{b} ± 1E-4
Ca	6.90^{a} ± 1E-3	83.42^{b} ± 0.015	18.67^{c} ± 0.025
Cd	0.0013^{a} ± 5.77E-4	0.0013^{a} ± 6.08E-4	0.0192^{b} ± 3.79E-4
Co	0.066^{a} ± 0.0061	0.002^{b} ± 0.0011	0.162^{c} ± 1.528E-4
Cr	0.008^{a} ± 0.001	0.002^{a} ± 1E-4	1.774^{b} ± 0.004
Fe	1.686^{a} ± 0.0032	18.467^{b} ± 0.1528	94.200^{c} ± 0.2646
K	0.32^{a}± 0.002	12.59^{b} ± 0.035	4.17^{c} ± 0.003
Na	0.04^{a} ± 0.01	31.94^{b} ± 0.02	19.67^{c} ± 0.02
Ni	1.61^{a} ± 0.01	0.19^{b} ± 5.03E-4	0.39^{c} ± 0.01
Pb	1.310^{a} ± 0.020	0.057^{b} ± 0.006	0.386^{c} ± 0.005
V	0.453^{a} ± 0.0153	0.067^{b} ± 0.0012	0.205^{c} ± 0.0055

SD*: Standard deviation (N = 3), at the 0.05 level.

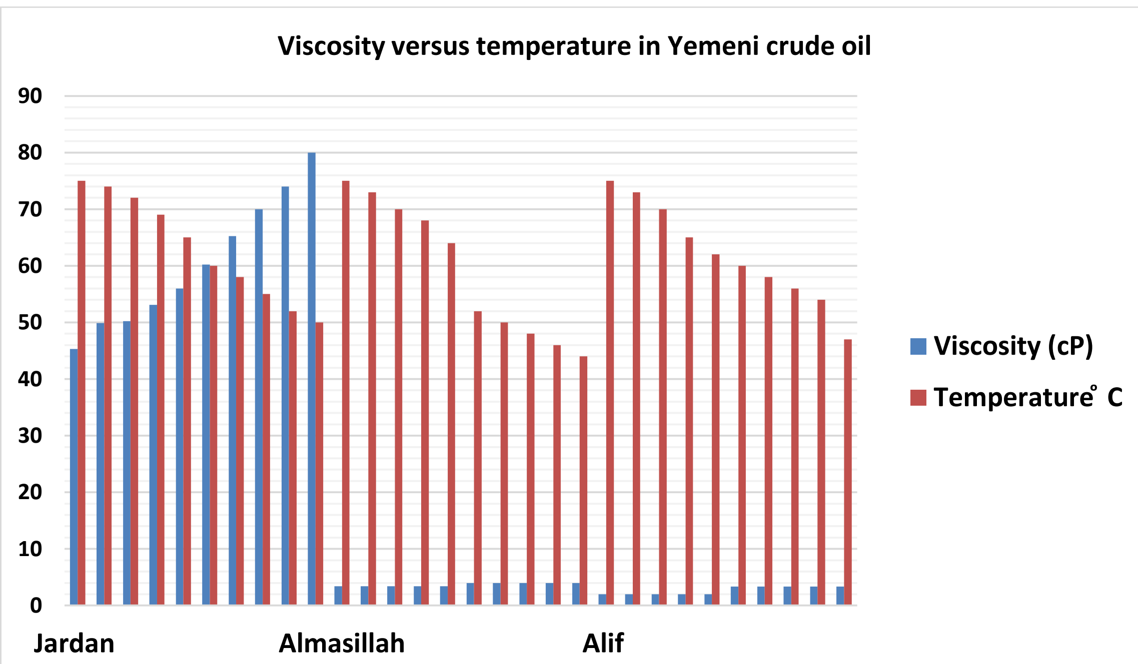


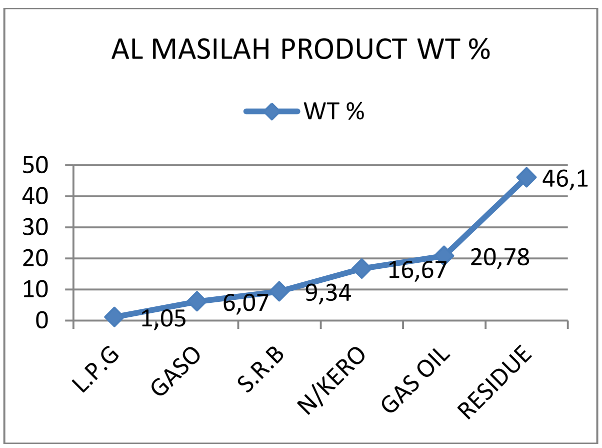
Figure 8: Viscosity of Yemeni crude oil as a function of temperature

TBP was investigated for the Mareb-Alif and Almasillah fields. During the distillation process, the temperature corresponding to the volumetric percentage distilled was recorded. The results were recorded in Table (6), and based on it, the correct distillation curve was drawn by representing the temperature versus the volumetric percentages distilled as in the figures (10a,b).

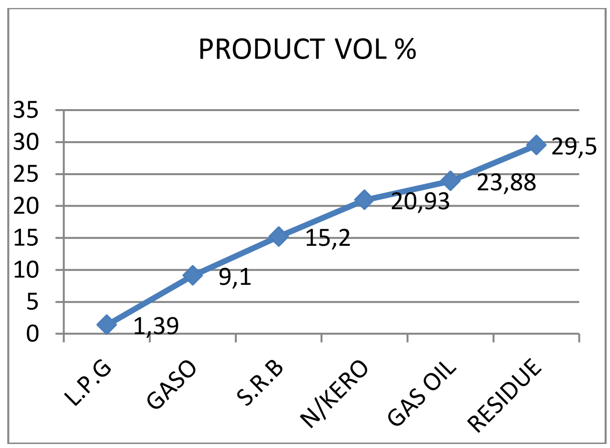
Table (6) Temperature corresponding to the volumetric percentage

Vol.%	0	5	10	15	20	25	30	35	40	45	50
Temp. °C	29	74	94	109	127	145	171	188	212	238	259
Vol.%	55	60	65	70	75	80	85	89			
Temp. °C	289	314	340	367	388	409	434	496			

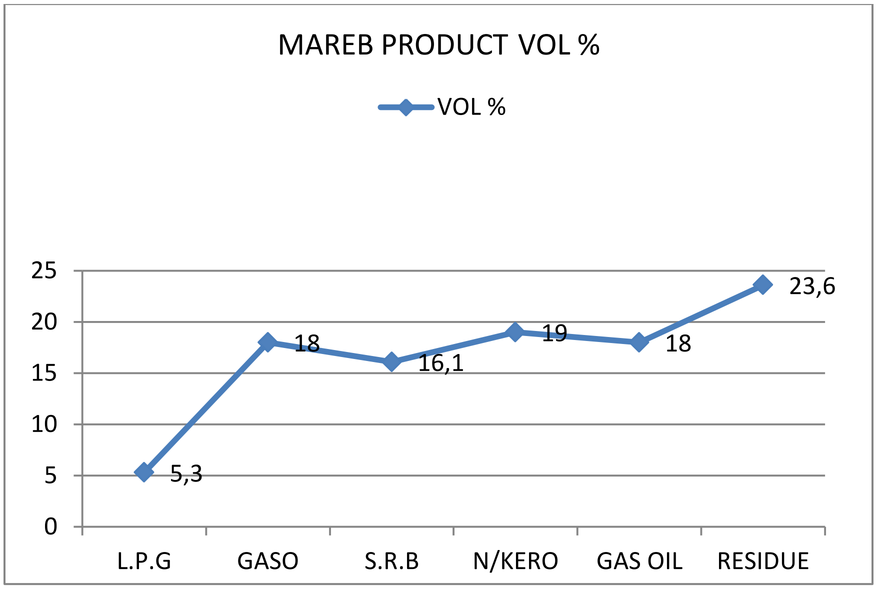
Figures (9) Different fractions of studied Yemeni crude oils



Different fractions distillation of Al-Masillah crude oil (9-a)



Different fractions distillation of Jardan crude oil (9-b)



Different fractions distillation of Mareb Alif crude oil (9-c)

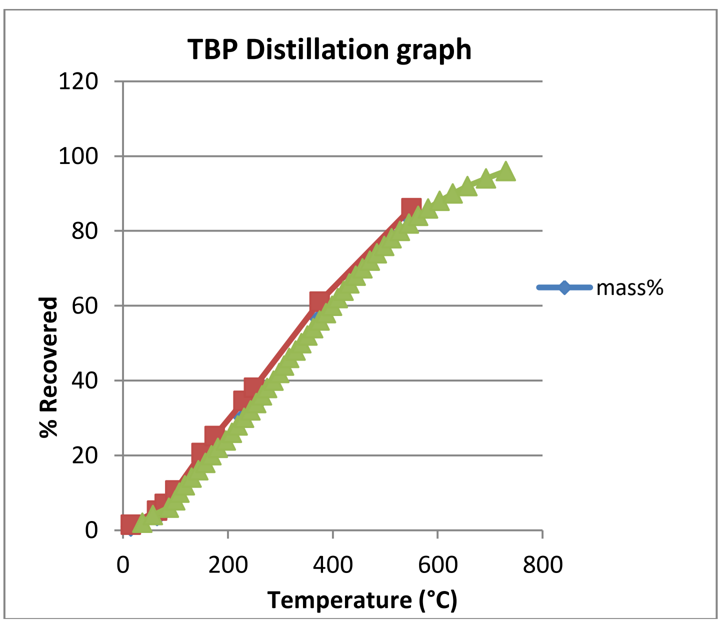


Figure (10-a) TBP for Almasillah crude oil

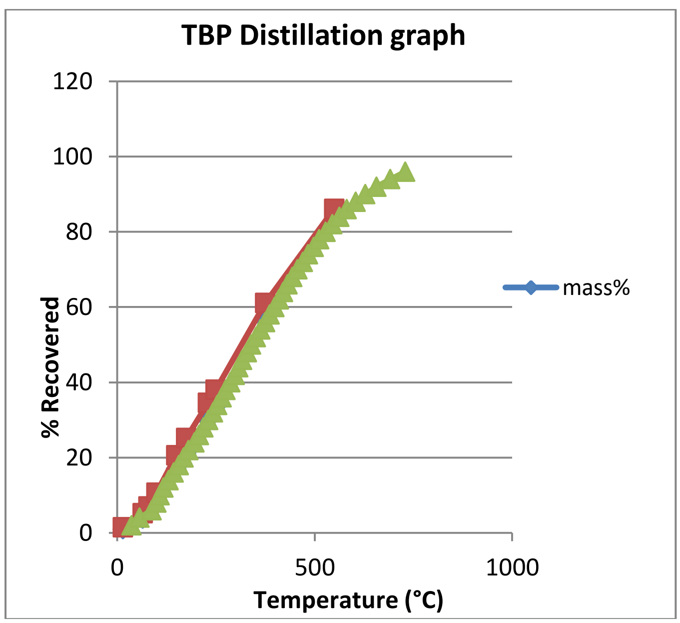


Figure 10-b) TBP for Mareb- Alif crude oil

6. Discussion

Properties and characteristics of Yemeni crude oils.

According to Tables (1), the crude oils are classified as light crude type, with an API weight of around 44.99 (sp.gr. 0.8010) Alif 41.15 (sp.gr. 08188). in comparison to 34,38.90 (sp. gr. 0.8296) AL Masilah and 25,72 (sp. gr. 0,8992) Jardan (Eyad field).

All of the samples' low pour point results are compatible with GC-FID analysis rather than a high wax content. The samples' high wax and low asphaltenes content readings suggest that the crude oils from Yemen are paraffinic in nature. With the exception of Jardan (Eyad field), where the sulfur percentage is (0.8598), most oil samples have low sulfur content (>0.5), indicating sweet type and light oil.

All samples have low TAN values (0.00-0.54), indicating that Yemeni crude oil does not have a tendency to corrode.

With the exception of AL Masilah (4.9) and water content (0.00-0.90), Ca, K, and Na increased in this sample. Since crude oil has a very low kinematic viscosity at 500 °C, the low viscosity obtained for crude oil suggests that it can go through pipes with ease. This has the unintended consequence of making it easy for oil to flow to extremely low temperatures during transit, features that guarantee Yemeni crude oil's purity.

Heavy metals of Yemeni crude oils

Oil samples frequently include heavy metals. Potential origins of trace metals in petroleum include the following: adding biological materials from the source rocks, or clay minerals or interstitial aqueous solution through the aqueous phase during primary and secondary migration;

diagnosing the presence of metal complexes from the original biological materials; and obtaining trace metals from formation waters or reservoir rock minerals.[21].

Table (2) makes clear that the majority of the trace elements found in this investigation were found at usually low levels. This was in line with studies indicating, in comparison to heavy oils, light oil samples typically have lower quantities of trace metals. [17]

The findings of Ni, V, and Fe are predicted as these elements are frequently found in oil samples.

Sulfur content, specific gravity, and API gravity are significant factors

It is well known that when the specific gravity of crude oil lowers, the API weight of the oil increases [20]. Additionally, it has been noted that the % sulfur concentration in petroleum blends and API gravity have an inverse connection [6]. The majority of light oil samples are discovered in regions with less sulfur rock concentrations.

Moreover, sulfur raises the specific gravity of oil samples because it is a relatively heavy ingredient. Additionally, this explains why samples of low sulfur oil have low specific gravities and vice versa. Research like [15] and (Joel et al., 2009) have already demonstrated the inverse relationship between API gravity and specific gravity, as well as percentage sulfur concentration. API should ascertain the crude oil's grade or quality in this investigation.

Oil samples are commonly categorized as light oils if their API gravity is greater than 31; medium crude oils are defined as having an API weight between 22 and 31; and heavy crude oils are defined as having an API weight of 20 or less (AP1, 2011). This API study demonstrates that light oil makes up the majority of the oil extracted from certain Yemeni fields. The medium-sized Jardan (Eyad field) sample is the exception.

Because heavy oil is more expensive to convert into more valuable oil, more difficult to process, and too thick to be easily piped through pipelines without being diluted, light oil samples are highly sought for and have a high market value. petroleum products, including fuel oil, diesel, and gasoline. It is well recognized that the heavier the oil, the more challenging the refining process is, as beneficial products in the oil refining process [2]. A crude oil's sulfur content influences whether it is sweet or sour.

All crude oils used in this study were found to be low sulfur based on their sulfur content based on API standards. Yemeni oil samples can therefore be classified as sweet (0.0846-0.488). Petroleum samples are classified as sweet if their sulfur content is less than 0.5%. Anything over 0.5% is called acidic.

A fluid's internal friction, or its reluctance to flowing, is measured by its viscosity. As a result, it illustrates oil's capacity to move across locations [11]. According to the study's findings, Yemeni crude oils can swiftly drain following spills because of their comparatively low viscosity.

Viscosity is a measure of a fluid's internal friction, or resistance to flowing. It therefore demonstrates the ability of oil to travel across regions [11]. The study's conclusions indicate that Yemeni crude oils' relatively low viscosity allows them to drain quickly after spills.

In the investigation of energy loss during production, oil viscosity plays a crucial role. To maximize transportation, oil viscosity is a necessary understanding for all engineering processes,

including pipeline building. Additionally, reservoir simulations and fluid structure identification depend heavily on viscosity [1].

Because crude oil has a low viscosity, it may flow through pipes more easily during transportation, simplifying the process. But it also implies that, in the case of oil theft leading to contamination, oil samples from some Yemeni fields might readily find their way into the environment. Figure (8) illustrates the observed inverse relationship between viscosity and temperature.

Crude oil's low pour point ratings suggest that it is suitable for use at low temperatures. Acidity and salinity are crucial processing operating indicators.

Elevated levels of these characteristics suggest that crude oil has a strong propensity to corrode [7].

These parameters' values were found in a few Yemeni oil fields. With the exception of AL-masilah oil (4.9), which has a very low potential for corrosion, the table (3.4) demonstrates how very low the water content (0.00-0.90) is. With the exception of Jardan (Eyad field), where TAN is not present in any sample (0.54), Yemeni crude oil's low pour point readings suggest that it can be used at low temperatures and is not prone to corrosion.

Compositional analysis using GC-FID.

The gas chromatograms of three Yemeni oil samples, as shown in figures (5-7), demonstrated a high degree of similarity between the rich hydrocarbons in the Alif and Jardan (Eyad field oil samples) and the lighter hydrocarbons in the Alif oil sample and the poorer hydrocarbons in the Al-Masilah oil sample. It can also be used to determine the source, as the CPI values for petroleum contaminants are typically close to one (Bray, 1961). Source differences can be determined by comparing the relative concentrations of steranes and C27-C29 (Hunt, 1996).

Oils with slightly lower contents of C28 and C29 and relatively higher concentrations of C27 steranes indicate greater input from an organic source in the sea, whereas oils with a predominance of C28, C29, and C30 steranes indicate the origin of oils derived primarily from mixed terrestrial and marine organic sources. The analysis indicates that there may be an increase in the marine organic source due to the slightly lower abundance of C28 and C29 and the significantly larger concentration of C27 steranes.

analysis difference (Co, Cr, Fe , Ni, Pb, V). Table (5) shows that the P-value of t-test (0.006) is less than the significant level (0.05), which means that there is a statistical difference between Yemeni crude oils.

Wax Characteristics.

The generated wax is controlled to be somewhat greasy under working conditions with a solvent composition of 75% MEK, a solvent to oil ratio of 20:1, a mixing temperature of 50°C, and a 20-minute residence time at a filtration temperature of -22°C. to come into contact Moreover, it has been discovered to be soluble in carbon tetrachloride, petroleum, toluene, xylene, kerosene, benzene, ethyl alcohol, and hot acetone.

Figures (5-7) illustrate the GC result. About 37.8405% of light hydrocarbons (n-C10-n-C16) and 6.6057% of C36+ are present. Oil that remains in the wax can produce light paraffins. This study is more in accordance with (Amel A. Nimer et al., 2010). The results revealed that at a maximum temperature of 50 ˀC, with a residence period of 20 minutes and a solvent to oil ratio of 20:1, 92% of the raw product wax could be extracted using a 75% volume MEK combination at a filtration.

The resultant wax feels a little oily to the touch and dissolves in acetone, petroleum, toluene, xylene, kerosene, benzene, ethyl alcohol, and carbon tetrachloride. According to gas chromatographic research, light products (C10–C16) make up 6% of the wax produced, whereas C45+ makes up 10%. Furthermore, As'ad et al. (2015) found that this study

effectively used pure methyl ethyl ketone solvent to demonstrate the impact of parametric adjustments on the wax treatment of Australian heavy crude oil.

It was discovered that the wax yield rose when the cooling temperature dropped, the solvent-to-oil ratio increased, and the mixing temperature increased. Based on the experimental findings, it was determined that a solvent to oil ratio of 15:1, a mixing temperature of 50°C, and a cooling temperature of -20°C produced the best wax yield of 27.9% by weight.

Table(8) Reported value of physical parameters of some crude oil [23].

Characteristic	Texas Gulf	Nigerian (Bonney)	Canada	Venzuela (Lagemar)	Syrian	Alif Mareb	Al-Masillah	Eyad-Jardan
API Gravity	36.5	38.1	34.9	30.7	0.9094	44.99	38.90	25.72
Viscosity	41.0	38.4	47.8	107.0	31.6	1.632	2.724	106.67
Sulphur wt%	0.16	0.14.	0.56	1.48	4.08	0.1270	0.1371	0.8598
Water & sediments vol %	0.1	Trace	Trace	Trace	4.08	0.00	4.9	0.00
Reid vapor pressure	32	6.9	8.4	2.5	5.8	45	27.7	12.5

Table (9) lists the metal and heavy metal contents in Yemeni and some foreign crude oil as reported by [21]

Crude oil Metal ppm	Alif field	Jardan (Eyad field)	Hijah [ ]	Sounah [ ]	Syria	Kuwait	Morocco	West Texas
Na	0.04	19.67	7.23	5.20	5.67	-	-	-
Mg	-	-	3.398	4.387		-	-	-
Al	-	-	0.082	0.095	0.285	-	-	-
K	0.320	4.169	5.55	2.83	0.51	-	-	-
Ca	6.900	18.76	1.72		0.97			
V	0.45	0.2073	4.127	0.398	15.04	22.5	0.6	7.9
Cr	0.008	1.776	0.24	0.26	48.43	-	-	-
Mn	-	-	0.22	0.20	38.46	-	-	-
Fe	1.684	94.3	0.43	0.54	0.79	0.7	-	5.1
Co	0.067	0.1615	6.82	7.79	0.36	-	-	-
Ni	1.60	0.3915	2.54	3.20	6.67	6.00	0.8	4.8
Cu	-	-	0.21	0.19	26.90	0.1	0.1	0.4
Cd	0.001	0.0195	0.717	0.69	29.49	-	-	-
Zn	-	-	-	-	-	-	-	-
Pb	1.31	0.3915	0.23	0.27	1.53	-	-	-

Alif – Mareb crude oil had the lowest concentration of magnesium, while Sounah crude oil had the highest concentration. Crude oil from Kuwait has the highest content of (V), whereas Alif field had the lowest. Alif field has the lowest concentration of (Cd) and Syrian crude oil had the highest. While Kuwaiti crude oil had the lowest quantity of iron (Fe) and Jardan crude oil had the greatest concentration.

Table (10) comparison between three studied crude oils

CRUDE OIL YIELD % vol						
	LPG	**GASO**	**SRB.**	**N/KERO**	**LGO**	**AR**
TBP CUT POINT 0C	0-20	20-95	95-149	149-250	250-369	369
Alif- Mareb	5.3	18.0	16.1	19.0	18.4	23.6
Jardan-Eyad	1.39	9.10	15.20	20.93	23.88	29.50
Almasillah	1.57	7.48	10.70	17.86	20.85	41.64

Derive the equilibrium evaporation curve from the integer distillation curve:
We assume that the part between the two volume percentage is 20, 75% on the correct distillation curve is straight line, then slop of correct distillation will be :

$$\text{Slop} = \frac{730.4 - 260.6}{75 - 20} = 8.54\,^{\circ}F / \%$$

Where :
$T_{75\%} = 388\,^{\circ}C = 730.4\,^{\circ}F$, $T_{20\%} = 127\,^{\circ}C = 260.6\,^{\circ}F$
So we will have slop of equilibrium evaporation = $5.73\,^{\circ}F / \%$

The degree of distillation is halved mathematically :
$730.4 - 25 \times 8.54 = 517\,^{\circ}F = 269\,^{\circ}C$
The half degree over actual distillation slop $498\,^{\circ}F = 259\,^{\circ}C$
Hence : degree of distillation 50%volume average :

$$T_{50\%} = \frac{517 + 498}{2} = 508\,^{\circ}F$$

We calculate the degree of equilibrium evaporation 50 %
TBP 50% - EFV50 = $68\,^{\circ}F$
$EFV_{50\%} = 440\,^{\circ}F$
Then degree of evaporation 0 % over equilibrium evaporation is:

$$EFV_{0\%} = EFV\ 50\% - 5.73 \times 50 = 154\,^{\circ}F$$

In order not to neglect the curvature that actually exists in the correct distillation curve and thus The curvature in the balanced evaporation curve between several points based on the following equation:

The slope of the equilibrium evaporation curve is from 20 to 75%.

——————————————————————— =

The slope of the equilibrium distillation curve is from 20 to 75%.

The slope of the equilibrium evaporation curve of studied part

——————————————————————— =

Slop of distillation at the same part

Then the slop evaporation at the studied part =

$$\frac{5.73}{8.54} \times \text{slop distillation at the studied part}$$

Slop equilibrium evaporation between 50 , 60 %

$$\text{Slop} \quad \frac{597 - 498}{10} = 9.9\,^{\circ}F/\%$$

Slop of equilibrium evaporation between 50 , 60

$$\text{Slop} = \frac{5.73}{3.54} \times 9.9 = 6.64\,^{\circ}F/\%$$

Hence degree of evaporation on equilibrium is

$$EFV\ 60\ \% = EFV\ 50\% + 6.64 \times 10 = 440 + 6.64 \times 10 = 506\,^{\circ}F$$

The temperature corresponding to the volume percentages was calculated and the results were recorded in the table ( )

Two points calculated ºC		Two points calculated ºF		Slope of the equilibrium evaporation curve	Slope of the equilibrium distillation curve	Percentage %
72	116	162	241	7.86	11.72	0 – 10
116	138	241	281	3.99	5.94	10 – 20
138	168	281	334	5.31	7.92	20 – 30
168	195	334	383	4.95	7.38	30 – 40
195	227	383	440	5.66	8.44	40 – 50
227	263	440	506	6.64	9.90	50 – 60
263	299	506	570	6.40	9.54	60 – 70
299	227	570	621	5.07	7.56	70 – 80
327	392	621	738	11.67	17.4	80 – 89

7. Conclusion:

Crude oil extraction activity brings serious heavy metal contamination of soil. The heavy metals accumulation in the soil is due to various factors such as: the nature of soils, the relief, and the litology, the hydrology, the climate, the dominant winds, the soil reaction, the cathionic exchange capacity, the use of the land, and not least the source of contamination, which is various depending by oil extraction, The risk associated with the presence of metals in soil depends by their ability to transfer in water or plants

Yemeni crude oils are the best according to their properties, this study allow us to implement the new study for Syrian crude oil and it's derivatives as heavy Naphtha and Kerosene. In cooperation with Homs Refinery Company.

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