LUPINE PUBLISHERS

An archive of organic and inorganic chemical sciences

DOI: 10.32474/AOICS.2019.04.000181

ISSN: 2637-4609

Short Communication

Separation and Qualitative Characterization of Crude Oil by Conventional Techniques

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Received: May 05, 2019 **Published:** May 10, 2019

Abstract

The objective of this work is to separate and characterize qualitatively unknown crude oil samples by using available equipment and glassware found normally in most chemical laboratories. This approach is neither time-consuming nor expensive. A simple distillation setup was used to prepare the samples, and boiling range apparatus was used to measure the exact boiling points of the samples before the fractional distillation. Selected crude oil fractions obtained from fractional distillation were then characterized by using a refractometer, and a density meter. Obtained results were then compared with available reference values from authentic samples.

Keywords: Crude oil; Chemical laboratory; Laboratory scale; Separation and characterization; Laboratory conventional techniques

Introduction

A very large number of hydrocarbon compounds are found in crude oil, natural gas, and coal. The three major groups of compounds are the alkanes, alkenes, and aromatics [1]. Hydrocarbons are natural organic compounds that have hydrogen, carbon in their structure. They are classified as aliphatic and aromatic and exist as saturated and unsaturated. There are two types of petroleum which come straight from the ground, crude oil and condensate. Crude oil is a dark and viscous liquid while condensate is a clear and volatile liquid. Crude oil is usually black in color but it also appears as other colors like green, red or brown. Crude oil has either light volatile oil or heavy viscous characteristics. This depends on how the crude oil vaporizes when it is heated or is affected by added chemical agents. A major part of the petroleum produced globally is in the form of emulsion [2]. There are many techniques used for crude oil analysis and among them are gas chromatography, gas chromatography–mass spectrometry, and ultra violet spectroscopy [3]. Gas chromatography is very useful technique in the characterization of hydrocarbons and other organic compounds. Using this technique, molecular species present in the samples, and their concentrations can be identified and their composition can be determined [4,5].

It is very crucial to distil the crude oil before carrying GC analysis to avoid column precipitation that is usually encountered during the analysis [6]. Alternatively, heavy fractions of crude oil can be removed from the chromatographic system by back-flush technique [7]. A better analysis of heavy petroleum fractions, that contain hydrocarbons, can be done by using high temperature comprehensive two-dimensional gas chromatography [8]. Among the methods that are used for the analysis and characterization of the crude oil are gas chromatography with flame-ionization or mass spectrometry detection and general gravimetry [9]. The major disadvantage of these techniques is their cost, the time they consume for sample preparation and the use of unsafe extraction solvents [10]. The experimental set-up and procedures presented in this article successfully give a qualitative analysis and characterization of unknown crude oil samples and can be generally used when an instrument such GC is not available or expensive to be purchased.

Analysis and Results

In this work, we present a chemical laboratory scale separation and characterization of Saudi Arabian crude oil by using conventional lab experimental techniques and equipment described in more details in the following procedures. Those separated sample are clean and pure enough and also suitable for further analysis by GC, if desired.

Crude oil separation

Simple distillation

A simple distillation [11] set up was used as shown in Figure 1. The crude oil (about 250ml three batches) was transferred to 500ml round bottom flask. About 120ml of the distillate was collected and used for the following experiments.

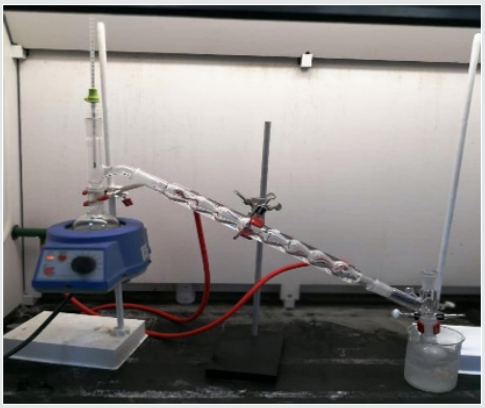

Figure 1: Simple distillation of crude oil in the laboratory.

Boiling range

The boiling range instrument [12] shown in Figure 2 was used to find out the initial boiling points of the samples that were collected from the simple distillation. About 50ml of the sample was placed in a distilling flask. The temperature of the first drop was recorded then after each 5ml collection; the temperature was recorded and tabulated in Table 1.

Table 1: Boiling Range Results.

Volume of sample (ml)	Temperature (°C)
First Drop	160
5	178
10	186
15	193
20	199
25	213
30	227
35	250
40	285

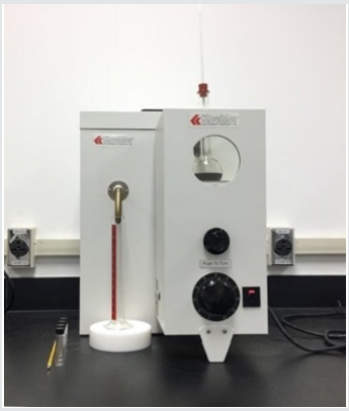

Figure 2: Boiling Range Apparatus

Petroleum oil ASTM color

The ASTM color comparator [13] shown in Figure 3 is normally used for the analysis of different petroleum products and has been adopted for our samples for color measurement and grading. The sample to be tested (about 70ml) was placed in a glass cell contained in the middle field. The color of each tested sample was compared directly with the colored glass standard. The sample was then viewed and adjacent standards were tested until the color of the adjacent was the same or close to the color of the sample. The ASTM color for each distillate sample was determined and it was found to be at ASTM L1.5.

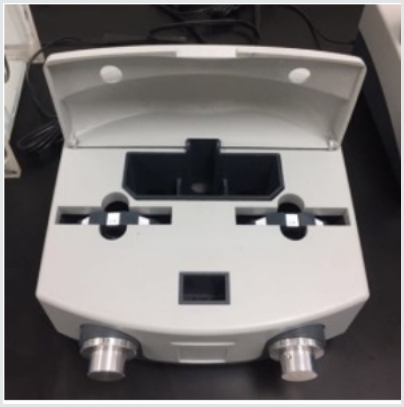

Figure 3: ASTM Color Comparator.

Fractional distillation

This distillation process [14] was used to separate the components of the crude oil on the basis of boiling points as shown in Figure 4. About 300ml sample was transferred to 500ml round bottom flask. The temperature was recorded when the first drop was observed, and then at every 10 °C increment. The distillate was collected within 10 °C range from 90 °C to 220 °C. The collected samples were used following experiments.

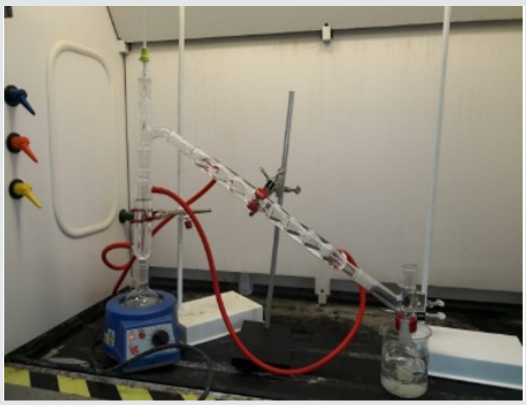

Figure 4: Fractional Distillation Setup.

Crude oil characterization

Refractive Index

This technique is usually used to measure of the bending of a ray of light when passing from one medium into another. The refractive indexes of the selected samples shown in Figure 5 were measured by the refractometer shown in Figure 6 as following: 2-3

drops of each of the previously distilled samples were placed over the measuring prism. Sample cover was placed over the sample prism to block stray light and slow evaporation. Readings for all samples are recorded in Table 2.

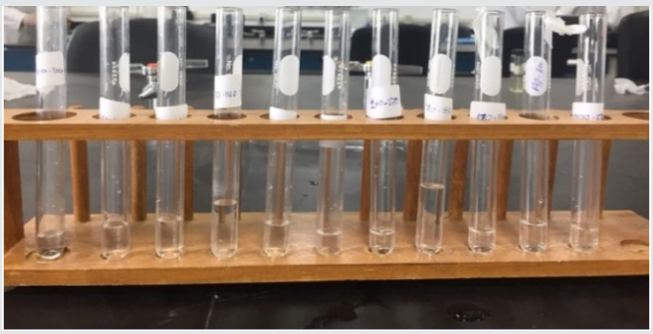

Figure 5: Distilled samples used for refractive index measurements.

Figure 6: Refractometer.

Table 2: Refractometer Readings.

Temperature, °C	Refractive index
90 – 160	1.4365
100 – 110	1.42166
110 – 120	1.42216
120 – 130	1.42461
130 – 140	1.42612
140 – 150	1.42806
150 – 160	1.42929
170 – 190	1.44245
190 – 200	1.44293
200 – 220	1.451

When compared with authentic references samples of gasoline and diesel, it was found that the collected samples may contain mainly gasoline and diesel. Samples with close results (Figure 7) were mixed together and tested again and the obtained results were recorded and presented in Table 3.

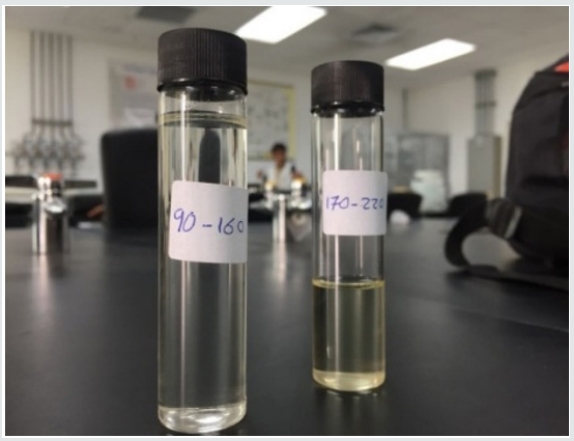

Figure 7: Combined Products.

Table 3: Refractive Index of Gasoline mixed with the 90–160 °C sample and Diesel mixed with the 170–220 °C sample.

Sample	Refractive index	Reference value
90 – 160 °C	1.42525	1.434
170 – 220 °C	1.44801	1.446

Density

In this experiment, we used a density meter shown in Figure 8 to determine the density of our obtained samples (about 5ml each) then we compared them with reference values of authentic samples and the obtained results are shown in Table 4.

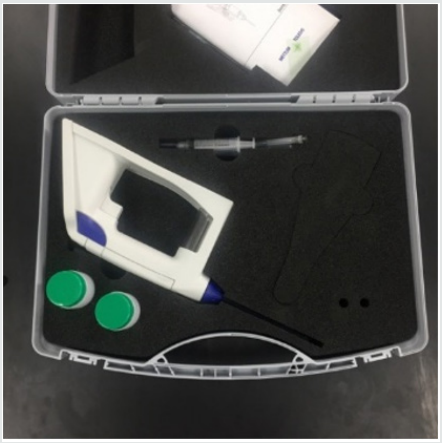

Figure 8: Density meter.

Table 4: Density of Gasoline mixed with the 90– 160 °C sample and Diesel mixed with the 170–220 °C sample.

Name of the sample	Density (g/ml)	Reference value of authentic samples (g/ml)
Gasoline	0.766	0.745
Diesel	0.7998	0.832

Conclusion

Based on the above collected results that were acquired by the techniques that we used for the separation and characterization of the crude oil samples in our laboratory, only two main products (fractions) have existed; diesel as a major product and gasoline as a minor product.

Acknowledgement

Authors of this article thank JIC management team and JIC-RPPAP Team for their continuous help and support.

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DOI: 10.32474/AOICS.2019.04.000180