iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53598

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Physico - Chemical Studies of Indian Crude Oil

Kunal Patel[1], Jinal Patel[2], Ashish Nagar[3]
[1]*Student,* [2]*Research Scholar,* [3]*Professor Department of Petrochemical Technology, PIAS, Parul University, Vadodara, Gujarat*

Abstract: ***Crude oil is a complex mixture of non-metallic components like Sulphur, Nitrogen, Oxygen, and other elements with hydrocarbons. Crude oil is distinguished by several chemical and physical features that play an essential role in the oil industry. These qualities are critical in making decisions in the exploration and production of crude oil. Heavy crude oil is highly viscous crude oil with high Asphaltene content and API in the range of 10-25. Especially, transportation of Heavy Crude oil is herculean task for Petroleum industry. As a result, the study of physical and chemical properties becomes crucial for the petroleum industry. The current work deals with the investigation of physico-chemical characteristics of Indian crude oil.***
Keywords: Crude oil, Physico-chemical analysis, Petroleum, Pour point, oil and gas

I. INTRODUCTION

Crude oil is a complicated combination made up of a large variety of hydrocarbon molecules, the majority of which contain carbon (C) and hydrogen (H) (H). Inorganic compounds comprising Sulphur, oxygen, nitrogen, and metals such as Vanadium, nickel, iron, and copper are also present in minor concentrations. Crude oil is a viscous, oily liquid with a strong odour. Depending on where it was obtained and its composition, the colour ranged from greenish brown to black. Crude oil is a mixture of hydrocarbons and other compounds that is difficult to classify. The composition of petroleum varies greatly depending on where and how it was created.

Crude oils contain a variety of hydrocarbon molecules that are divided into three groups which are Paraffins, Naphthenes, and Aromatics. The saturates fraction of crude oil is composed of straight and branched chain hydrocarbons, which are saturated with hydrogen atoms. These hydrocarbons have high boiling points and are generally considered to be the most stable and least reactive components of crude oil. They are soluble in n-pentane and other low-polarity solvents. The aromatics fraction of crude oil is composed of hydrocarbons that contain one or more aromatic rings. These hydrocarbons have lower boiling points than saturates and are more reactive. They are soluble in solvents such as benzene, toluene, and xylenes. The resins fraction of crude oil consists of polar compounds such as acids, phenols, and nitrogen-containing compounds. These compounds have higher boiling points than aromatics and are soluble in solvents such as methanol and ethanol. The asphaltenes fraction of crude oil is composed of high molecular weight, polar compounds that contain heteroatoms such as Sulfur, Nitrogen, and Oxygen. They have the highest boiling points of all the SARA fractions and are insoluble in most solvents, including n-pentane and benzene. SARA analysis is an important tool for the petroleum industry as it provides information about the properties and behaviour of crude oil. Crude oil's physical characteristics, such as viscosity, density, and boiling point range, are determined by the relative proportions of its saturates, aromatics, resins, and asphaltenes. This information is used to determine the appropriate refining process for the crude oil and to develop products with specific properties.

II. MATERIALS AND METHODS

The crude oil utilised was obtained from a single oil field. It was collected from oil field of Western onshore region of India.

A. Water Content Determination

50ml crude oil and 50ml toluene were utilized in this experiment. Toluene is gathered in the trap after 2 hours of heating. Water does not go to the bottom of the trap due to density. The water present in the crude oil will be collected in the trap along with solvent in the form of azeotropic mixture. Further the water content is calculated.

B. Density and API Gravity Determination

1) *Density:* The crude oil mixture is homogenised at 65°C. The contents of the beaker transferred into the 500ml measuring cylinder after removing the sample from the water bath. The hydrometer is dipped into the oil in the measurement cylinder. At the same time, the density and the temperature of the oil is checked. The density obtained at the temperature was converted to the density at 15°C ambient temperature using the Oil Density Table.

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2) *Specific Gravity determination:* For the determination of Specific Gravity (SG), we used the formula: SG = Density of Crude oil at 15°C / Density of water at 15°C
3) *°API Gravity determination:* For °API Gravity we used API gravity formula by knowing Specific gravity.
4) API Gravity = (141.5 / Specific Gravity at 15°C) – 131.5

C. *Pour Point Determination*

Pour point of crude oil or refining product is the lowest temperature at which oil will cease to flow. For the determination of Pour point, the sample of the crude oil is first heated above the cloud point followed by cooling the specimen at about 9°C above the expected Pour point. After every 3°C, the tube was taken out of the bath to check the flow. The temperature at which it ceased to flow for a minimum time of 5 seconds was noted as the cease to flow temperature of the equivalent concentration. Therefore, the equivalent Pour point was noted as the no flow temperature plus (+) 3°C.

D. *ASTM Distillation Of Crude Oil*

Distillation process is simply the separation of this crude oil into different fractions. This method is used for measuring the Initial Boiling point and boiling point of each fraction. The crude oil is assembled in the distillation column and as the temperature column rises, the crude oil separates itself int different components, called “fractions.” The fractions are then captured separately. The temperature at which the first drop of distillate fraction collected is reported as Initial Boiling Point (IBP).



Figure 1: ASTM Distillation

E. *SARA (Saturated Aromatic Resin and Asphaltene) Analysis*

In the round bottom flask, put 1.5gm of 210°C oil residue and 60ml of hexane. To aid asphaltene precipitation, reflux it for about 2 hours and keep it in the dark (overnight). Divide the maltene in two parts. Take one part and continue the procedure. Filter the precipitated asphaltene with Whattman no 41-filter paper. Maltene is the name of the filtrate (used later for Aromatic and Wax determination). Reflux the asphaltene-containing filter paper (wash) with 40ml of hexane. Thimble refers to the filter paper that comes into touch with the asphaltene. In the Soxhlet device, the filter paper (thimble) is washed in hot toluene (25ml). To obtain asphaltene, evaporate the solvent (100mL toluene) via distillation. Filter 50ml of Maltene through the heated silica. Using hexane, wash the filtrate until it is colourless. To precipitate wax, mix the filtrate with acetone and keep it overnight in deep freezer for wax precipitation. Take the other part of maltene and it is subjected to column chromatography for determination of Saturates, Aromatics and Resins. For Saturates, Petroleum ether is used as solvent for elution. For Aromatics and Resins, Toluene and Methanol are taken respectively.

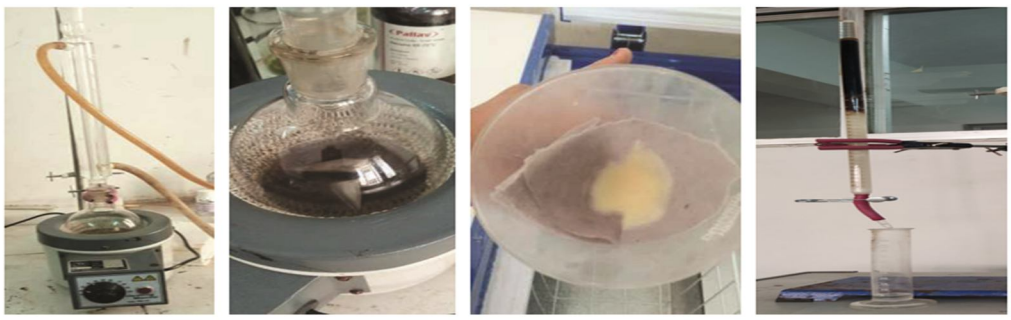


Figure 2: (a) Refluxing in hexane (b) Thimble washing for asphaltene determination (c) Wax determination (d) SARA Analysis through Column chromatography

1) Asphaltene Content

Asphaltene is a heavy fraction of crude oil that has different structure and molecular Makeup which makes it one of the most complex components of the crude oil. To determine the amount of asphaltene, the distillation sample's 210°C residue is refluxed in n-Hexane for around two hours while being left in the dark (overnight). After filtration, the resultant filtrate is known as maltene (kept for wax determination). Further the residue is dissolved in hot Toluene and Asphaltene is obtained.

2) Paraffin Wax Content

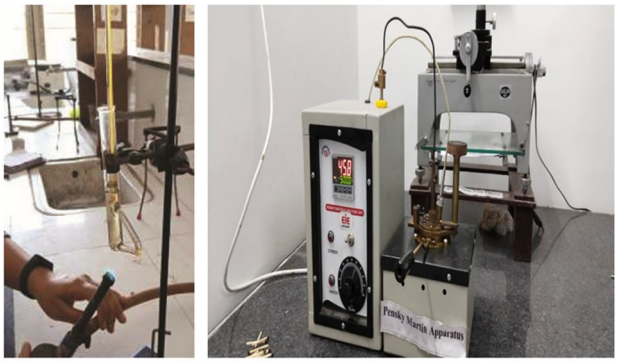
Wax is an organic compound. Paraffin wax consist of straight chain saturated hydrocarbon with carbons ranging from C18 to C36. Together with the wash of hot n-Hexane, maltene is filtered through hot silica. The filtrate collected in kept in deep freezer at - 20^0 C (overnight) after the addition of Acetone for wax precipitation. The filtration collects the wax crystals.

3) Melting And Congealing Point Of Wax

When wax is heated under conventional conditions, the temperature at which a sample drop leaves the thermometer bulb is measured to determine the wax's melting point. The temperature at which molten wax starts to congeal is known as the congealing point. It is a wax property, which is very important to many petroleum wax consumers. By adding a drop of molten wax to a thermometer bulb and measuring the temperature at which it congeals, one can estimate the congealing point of wax in crude oil when the thermometer is rotated under standardized cooling condition.

4) Flash Point & Fire Point

Flash point and Fire point are determined by Pensky Marten apparatus. Flash point is determined experimentally by heating the liquid in a container cup of apparatus and then introducing a small flame just above the liquid surface the temperature at which there is a flash /ignition is recorded as the flash point. The minimum temperature at which a liquid gives off vapor with a test vessel in sufficient concentration to form an ignitable mixture with the air near the surface of the liquid. The fire point of a fuel is the lowest temperature at which the vapour of that fuel will continue to burn for at least second after ignition by an open flame of standard dimension



(a) (b)

Figure 3: (a) Melting point and Congealing point of wax (b) Pensky- Martin apparatus

III. RESULTS

Table 1: Results of physico-chemical analysis of crude oil

S.N	Parameters	Results
1	Water Content	0.2%
2	Density	0.8685g/cc at 15°C
3	°API Gravity	31.27

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4	Pour point	39°C
5	Asphaltene content	2.8%
6	Saturates	38.4%
7	Aromatics	24.6%
8	Resins	34.2%
9	Wax content	8.2%
10	Melting point	54°C
11	Congealing point	52°C
12	Flash point & Fire point	50℃ & 54 ℃

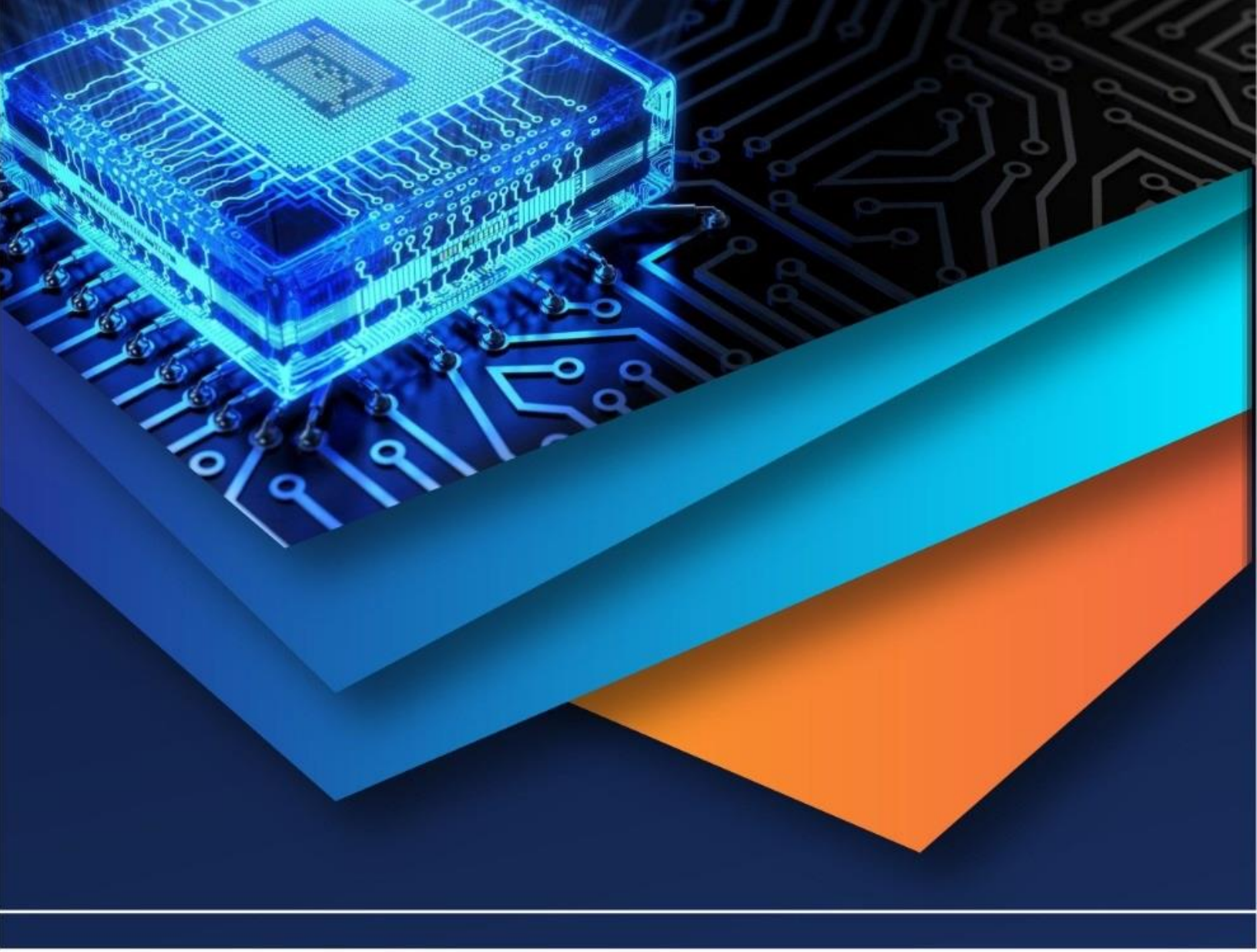
IV. CONCLUSIONS

In the petroleum industry, the physicochemical properties of crude oil are critical. The examination of its parameter's aids decision-making. Water content, density, API Gravity, pour point, distillation, Asphaltene, and Wax content were among the parameters investigated. The density and API gravity were 0.8685g/cc and 31.27 respectively which shows it was medium density crude oil. The Asphaltene content and Wax content present in the crude oil were 2.8% and 8.2% respectively which represent high Asphaltene content in Crude oil. The Pour point of the crude oil was 39^0C. The content of Saturates, Aromatics and Resins were 38.4%, 24.6% and 34.2% respectively. The Melting point and Congealing point of wax were 55^0C and 52^0C respectively.

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