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Impact of Asphaltene Presence in Heavy Crude Oil and Its Separation Technique

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Abstract*: Heavy crude oil is the crude oil with no gas composition and major constituents are asphaltene, resins, saturates and aromatics. Heavy crude oil is capable of producing a low high valued products and high low valued products. Asphaltene is a molecular substance that acts as a binding molecule to help in the recovery of heavy crude oil. On the contrary, an asphaltene deposition becomes troublesome in the heavy crude oil transportation through pipelines. In this research article, the heavy crude oil was collected from the western part of Indian oilfield and subjected to the separation of asphaltene content by the addition of aliphatic solvent. The results of separation of asphaltene from the heavy crude oil by the addition of n-heptane and n-hexane were found to be 15 wt. % and 17 wt. %. The asphaltene will cause moderate deposition problem during the production and transportation of investigated heavy crude oil.

***Keywords:* Aromatics, Asphaltene, Heavy Crude Oil, n-heptane, n-hexane and Resins**

I. INTRODUCTION

Asphaltene is a high molecular weight aromatic compound and alkyl side chain along with presence of heterogeneous atoms namely nitrogen, sulphur, oxygen and halogens. In addition to the compounds mentioned, a small amount of Nickel and Vanadium is present in it. Asphaltene is a sticky substance that acts as a binder with the addition of surfactant on the crude oil. Asphaltene is insoluble in the alkanes says n-heptane while soluble in the aromatic solvents namely toluene and benzene [5].

Asphaltene is a molecular substance which helps in the recovery of crude oil on the addition of surfactant. It has the ability to acts as a binding molecule between crude oil and added surfactant. Asphaltene binding performance is limited to Critical Micelle Concentration (CMC). The CMC value gives the specific concentration of asphaltene at which the individual asphaltene reacts with the solution without aggregation and above the value makes the asphaltene to form aggregation in the solution [1].

Asphaltene is a restraining parameter in the transportation of crude oil through pipelines and trucks. Asphaltene tends to deposits on the pipelines during the transportation process due to its sticky nature.

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The deposition of asphaltene can be reduced by the addition of heat or solvents [2, 3]. Asphaltene in heavy crude oil have both pros and cons namely the binding action between crude oil and chemical surfactants, pure solution in low CMC as their advantages; while the deposition, precipitation and adhesiveness are the disadvantages.

Origin of Asphaltene

Origin of Asphaltene is mainly related to the crude oil formation. The crude oil formed in the terrestrial and marine environment various by the living and dead in the specific region. In the terrestrial, living organisms and plants plays key role in the diagenesis process while in the marine, small and large fishes and sea microorganisms involve in the diagenesis process. Diagenesis process gives rise to the kerogen which is insoluble in organic solvent and a starting point for the creation of petroleum hydrocarbons [1]. Formations of crude oil have the composition of asphaltene, resins, aromatics and saturates. Asphaltene have more aromatic compounds than saturates.

Various Asphaltene Compositions in Various Crude Oil

The composition of asphaltene is varied in each regions depending upon the environment. Table 1. gives the different asphaltene composition on various heavy crude oil field. The composition of the asphaltene varies on region besides the types of crude oil namely light, medium, heavy and extra-heavy crude oil [5, 10].

Table 1. Composition of crude oil in various heavy oil fields [5, 10]

Name of the heavy crude oil field	°API	Asphaltene Composition (wt. %)
Lloydminster (Sparky J)	16.9	6.3
Wildmere (Sparky)	16.0	13.8
Lloydminster (Blairmore)	16.5	12.9
Chauvin (Mannville A)	21.8	10.9
Wabasca	12.4	10.6
Cold Lake	9.7	16.3
Peace River	8.0	13.6

Structure of Asphaltene

Asphaltene is a macromolecule made up of many aromatic compounds. Asphaltene is a black or brown colour in nature. The structure of asphaltene to be precise fused aromatic ring is always compared with the Human Hand or Archipelago. Yen model gives the hierarchical structure of asphaltene. The constituents of asphaltene are carbon, hydrogen, oxygen, nitrogen and sulphur with trace amount of nickel and vanadium. Crude Asphaltene was found to have a molecular weight ranging from 500 to 1000 g/mol by fluorescence depolarization method [1, 4]. The molecular diameter of the crude asphaltene was in the range of 10 to 20 ˚A [1]. The structure of asphaltene which seemed to have a numerous aromatic rings with alkyl side chains.

Petroleum Asphaltene VS Coal Asphaltene

Petroleum and coal asphaltene differs mainly by their molecular weight, colour, nature of state and origin. Petroleum asphaltene have high molecular weight compared to coal asphaltene. Colour of the coal asphaltene is light black compared to the dark brown or black petroleum asphaltene. The states of nature of petroleum asphaltene are dark or semi-solid while the coal asphaltene is rock solid in nature. Petroleum asphaltene are produced from the crude oil during catagenesis process, where kerogen undergoes thermal degradation by the action of heat and microbes under the earth surface. In the formation of coal asphaltene, the catagenesis process in which kerogen undergoes a high temperature and pressure in deeper depth modification where the action of microorganism is impossible [1].

Asphaltene VS Asphalt

Asphaltene is the chemical proportion of crude oil whereas asphalt is the distillation product of crude oil. Asphaltene is a high molecular aromatic fused ring while asphalt is the bottom product of crude oil separation in the distillation process and made up of hydrogen and carbon alone. Asphaltene is a compound separated from the crude oil through SARA analysis [4]. Asphalt is obtained from the separation of crude oil at various temperatures in the distillation column. Asphalt produced from the crude oil are thermoplastic in nature to be exact it soften on heating and harden on cooling. Asphaltene is useful in the recovery of crude oil by acting as binding compound. On the other hand, asphalt is applied in the road construction, roofing, cable coating and waterproofing [9].

Separation of Asphaltene from Heavy Crude Oil

Heavy crude oil contain four major fractions namely asphaltene, resins, aromatics and saturates. Fig. 1. shows the separation of crude oil feedstock. Asphaltene was separated by the solvents namely the insoluble of n-heptane, n-hexane and n-pentane [6]. After the separation of asphaltene, remaining portion of crude oil is called Deasphalted oil or Maltene fraction [4]. Maltene fractions are separated into resins and oil fractions, when passed through the clay column the resins are restrained in the column while saturates and aromatics are filtered. The remaining oil fraction is separated in the silica column to filter saturates and restrain aromatics [5].

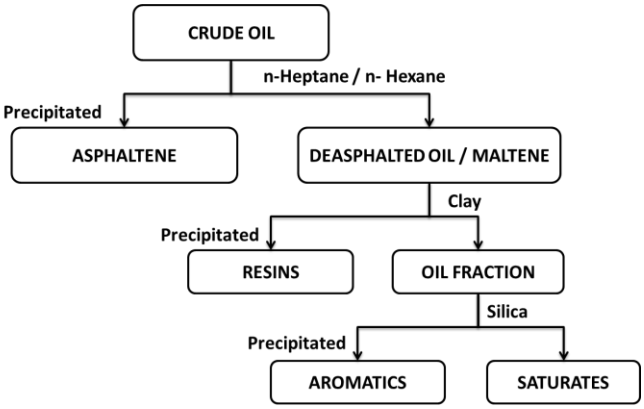

Fig. 1. Separation of heavy crude oil feedstock

II. MATERIALS AND METHODS

Materials Required

Heavy crude oil was collected from the western part of Indian oil field for the investigation of asphaltene content. The required solvent for the investigation are n-heptane, n-hexane, clay, activated silica gel and toluene.

Methodology

A. Determination of ˚API

˚API (American Petroleum Institute) is the standard class for the crude oil classification in worldwide petroleum industries. ˚API is given by the formula shown below. It is the inversely proportional to the density and viscosity that is if the density and viscosity are higher for the crude oil, then the ˚API is lower. It has no units.

˚API = (141.5 / Specific gravity @ (15.5 ˚C)) – 131.5

B. Determination of Asphaltene Content

The separation of asphaltene from the crude oil was carried by the solvent separation process. Two types of aliphatic solvents namely n-heptane and n-hexane were used in the analysis. The collected crude oil sample was taken in the conical flask with the mouth closed and mixed with 40 times of the chosen solvent. The mixture was shaken vigorously for the complete mixing and left for 2 days in which the conical flask was shaken twice a day. After the second day, the mixture was filtered in the standard filter paper and left the asphaltene for solvent evaporation. The formula used for the calculations was given below [6].

Asphaltene content (g/g) = (Weight of dried asphaltene (g)/ Weight of the crude oil taken (g)) × 100

C. Determination of Resin, Aromatics and Saturates

A glass column was taken and uniformly filled with activated clay for resin adsorption. The deasphalted oil obtained after the asphaltene filtration was poured into the glass column through reservoir. Resins were adsorbed in the clay whereas oil fractions were eluted. Soxhlation was carried out with toluene for the resins separation from the clay and left for solvent evaporation. The dry weight of resins to the weight of crude oil taken gives the resin content. The same glass column was cleaned and filled with activated silica gel for the adsorption of aromatics.

The oil fraction collected during the resin separation was sent into the glass column for saturates elution. The aromatics adsorbed silica gel was subjected to soxhlation with toluene and kept for solvent evaporation. The percentage of saturates and aromatics were calculated in the same way as asphaltene content [6].

D. Determination of Colloidal Instability Index (CII)

Colloidal Instability Index was calculated for determining the stability and deposition of asphaltene in heavy crude oil. The formula for calculating CII was given below.

CII = [(Saturates + Asphaltene) / (Aromatics + Resins)]

Fig. 2. shows that the calculated CII value is less than 0.7, then there will be no asphaltene deposition problem. If the calculated CII value is above 0.9, then there will be a severe asphaltene deposition problem during transportation. The stability of asphaltene in the heavy crude oil will be high above 0.9 CII value.

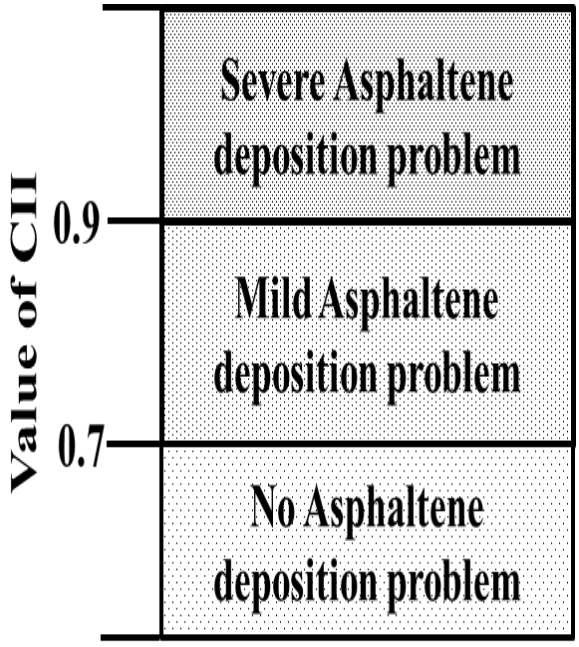

Fig. 2. Asphaltene deposition problem with respect to the CII values

III. RESULTS AND DISCUSSION

Heavy crude oil was investigated for the weight percentage of asphaltene by the solvent separation process. Asphaltene content provides certain data regarding the properties of crude oil. The first investigation of asphaltene content was carried out with the n-heptane solvent and the asphaltene content was found to be 15 wt. %. Second investigation of asphaltene was accomplished by the n-hexane separation solvent and heavy crude oil was detected to have 17 wt. % of asphaltene content. Resins, aromatics and saturates were determined and shown in the table 2.

Table 1 and 2 can be compared and it is observed that the heavy crude oil contains a high asphaltene content compared to other light and medium oil [1, 5]. It is clearly seen that the asphaltene content increase, when the ˚API decreases due to the asphaltene structure holding sulphur, nitrogen and oxygen. Similar results were found in various crude oil investigations by the researchers and industrialists in the petroleum field of applications [7, 8].

Table 2. Specification of heavy crude oil

Heavy crude oil					
˚API	Asphaltene content (wt. %)		Resins (wt. %)	Aromatics (wt. %)	Saturates (wt. %)
	n-heptane insoluble	n-hexane insoluble			
16.5 ˚	15 %	17 %	24 %	30 %	29 %

The ratio of resin to asphaltene was found to be 1.4 which is greater than 1 and that causes less asphaltene deposition problem. The CII value of heavy crude oil was calculated to be 0.85 which will have moderate asphaltene deposition problem. The CII value calculated using the values obtained from SARA is more appropriate than the ratio of resin to asphaltene.

IV. CONCLUSION

Asphaltene content in the heavy crude oil was found to be 15 wt. % and 17 wt. % by the addition of n-heptane and n-hexane. Heavy crude oil was observed to have high resins and aromatics content. More valuable products are obtained from saturates which was found to be less in the tested heavy crude oil. Colloidal instability index shows that the asphaltene will have a moderate stability in heavy crude oil and mild deposition problem while transportation. The results give the impression that the asphaltene content in heavy oil will create some problems at the time of production and transportation. Asphaltene in crude oil has to be treated with chemical or thermal methods for better production and transportation of heavy crude oil.

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