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Enhancing some properties of local Iraqi crude oil using solvent deasphalting process

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Abstract

Asphaltene precipitation is one of the main hitches in the oil sector through the production and refining stages that causes real damages every year. The object of the present work is to study the effect of the deasphalting process of crude oils using different concentrations (5, 10, and 15 wt.%) of n-heptane as a solvent, the experiments were done at a laboratory scale. The deasphalting process quality was based on the sulfur content, conradson carbon residue, density, API, and kinematic viscosity. The results have been shown that the deasphalting process quality was enhanced by increasing the weight fraction of added n-heptane, the API value and kinematic viscosity were increased by about 37 and 19.5% respectively, while the density, conradson carbon residue, and sulfur content were decreased by about 5, 17 and 26.8% respectively when 15 wt.% of n-heptane was used.

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1. Introduction

Oil is still one of the world's most important resources, accounting for more than 30% of global energy consumption. The world's known oil reserves fell by 0.1 percent in 2019 by comparison with 2018 [1]. The necessary expansion of alternative energy sources generated from nontraditional hydrocarbon natural resources is perhaps the most essential strategy to overcome a drop in demand for energy caused by the depletion of conventional hydrocarbon sources [2, 3]. Because of the increased amount of resin and asphaltene constituents in the nontraditional resources of hydrocarbon, they have a higher viscosity, density, water-in-crude-oil emulsions' stability, and coking capacity than light oils. Simultaneously, they represent enormous potential sources for the energy and fuel complex [4-6]. Asphaltenes are an insoluble precipitate formed when oils and bitumens are dissolved in organic solvents (such as pentane, hexane, or heptane), but they are soluble in toluene [7].

Extraction asphaltenes from crude oil by deasphalting methods is a straightforward technique to reduce viscosity and disrupt the emulsions [8]. At the same time, these approaches should attempt to increase the production of light fractions as a possible oil refining input. Solvent treatment, also known as deasphalting by extraction, is one of the most effective applications further for the treatment and transportation of natural bitumen [9]. Nevertheless, it should be noted that using of different solvents, results in a variety of compounds with different structures and physicochemical characteristics [10]. Many physicochemical characteristics of crude oil must be determined in order to maximize exploitation and assist management decisions across the process of production [11].

Kinematic viscosity and API gravity are critical parameters for scaling pipelines, valves, storage tanks, pumps, compressors, and oil measurement equipment in the early stages of production. Carbon residue is an additional measure in crude oil appraisal because it indicates the quantity of asphalt or lubricating oils that can be created during the refining process [11, 12]. Furthermore, large quantities of asphaltenes in heavy oil have high sulfur contents, and strong C-S and C=S bonds dramatically increase viscosity [13]. Therefore, the evaluation of physicochemical parameters aids in the understanding of crude oil's rheological behavior and chemical content [14]. To extract petroleum residue into distinct solubility fractions, heptane, toluene, and pyridine were utilized as solvents [15]. Asphaltenes' tendency to precipitate in the presence of n-heptane is commonly used to investigate crude oil stability in various conditions, such as dilution or blending, temperature or pressure variations [16].

The influence of the process sequence, solvent deasphalting followed by visbreaking vs visbreaking followed by solvent deasphalting, was explored by Zachariah and Klerk, 2017. The solvent deasphalting was done with n-pentane. They discovered that solvent deasphalting followed by visbreaking yielded a 2 wt.% greater liquid yield than the other way [17]. Altoé et al., 2014, reported that the deasphaltation using n-heptane decreases crude oil viscosity from 30,320 to 2510 cP in the extract, then the re-extraction with n-propane further reduces viscosity to 720 cP [18]. Ilyin et al., 2022, presented that, the extracted asphaltenic and their composition increase with increasing hexamethyldisiloxane concentration as a solvent, reaching a maximum when the solvent to oil ratio reaches 15 [19].

However, literature interested in a study of the deasphalting process for heavy oil from the East Baghdad field seems to be rare. Consequently, in this study, the different fraction of n-heptane (5, 10, and 15 wt.%) as a solvent was used to investigate the quality of deasphalting process based on the sulfur content, conradson carbon residue, density, API, and kinematic viscosity for heavy oil obtained from East Baghdad field.

2. Experimental Procedure

2.1. Material

The heavy crude oil used in this study was obtained from East Baghdad oil field as main characteristics shown in Table(1), and n-heptane (purity ≥ 99 %) used as solvent was purchased from a local market supplied by Sigma-Aldrich as shown properties in Table (2).

Table 1: Main characteristics of the used crude oil

Characteristics	Values
Density at 15° C (gm/cm^{3})	0.9231
API gravity	21.7
Asphaltene content (wt. %)	6.412
Sulfur content (wt. %)	4.31
Conradson carbon residue wt.%	9.947
Kinematic viscosity(C.st.) at 37.8°C	48.7121

Table 2: The physical properties of the used solvent

Properties	n-Heptane
Vapor pressure (mmHg) at 20 °C	40
Density at 25º C (gm/ cm^3)	0.684
Phase	Liquid
Solubility (g/L)	0.05
Molecular Weight	100.20
Boiling point (ºC)	98
Autoignition temperature. (ºC)	222.778

2.2. Methodology

In the present experiments, the paired mixtures of heavy crude oil and different fractions of n-heptane (5, 10, and 15 %) were mixed in a conical flask size 150ml under continuous mixing for about an hour to assert a homogenous mixing [20]. After appropriate mixing, the filtration process was done with Whatman filter paper (pore size 11 µm) to extract the asphaltene according to the procedure described by E. Rogel et al., 2016 [21]. The dynamic viscosity of heavy crude oil was measured using Brookfield viscometer (USA) model DV-11, the density of crude oil was measured using a pycnometer at ambient temperature and atmospheric pressure [22]. The kinematic viscosity and API gravity of crude oil were calculated using equations 1 and 2 respectively [23].

$$\boldsymbol{v = \frac{\mu}{\rho}} \qquad \textbf{(1)}$$

Where: v is kinematic viscosity of crude oil (cSt.).
μ is dynamic viscosity of crude oil (cP).
ρ is density of crude oil (gm/cm^3).

$$\boldsymbol{API = \frac{141.5}{sp.gr.} - 131.5} \qquad \textbf{(2)}$$

Where: $sp.gr.$ is the specific gravity of crude oil ($\frac{Desity\ of\ crude\ oil ({gm}/{cm^3})}{Density\ of\ water\ ({gm}/{cm^3})}$).

The sulfur content and Conradson carbon residue of crude oil were measured by following the methods described by ASTM D2622 and ASTM D4530 respectively[24].

3. Results and Discussion

3.1. Effect of Solvent Concentration on Sulfur content and Conradson Carbon Residue.

To clarify the effect of blending heavy crude oil with solvent, the quality of the deasphalting process for heavy crude oil using different solvent concentrations on the conradson carbon residue and sulfur content are presented in Figures 1 and 2. From the relevant results, we have noted an increased n-heptane concentration from 5 to 15 wt. % would decrease the conradson carbon residue and sulfur content by about 17 and 26.8% respectively.
The obtained data attributed to the increase in asphaltene precipitation due to reducing its solubility with increasing solvent concentration leads to decrease in conradson carbon residue [25]. Furthermore, the results in Figure 2 show that, the sulfur content is related directly to asphaltene content [26], it was decreased with the decreasing asphaltene

content, accordingly, in this study, the quality of deasphalting methods was enhanced by increasing solvent concentrations. These results agree with previous studies done by J. M. Lee et al., 2014 and R. Kumar et al., 2022 [27, 28].

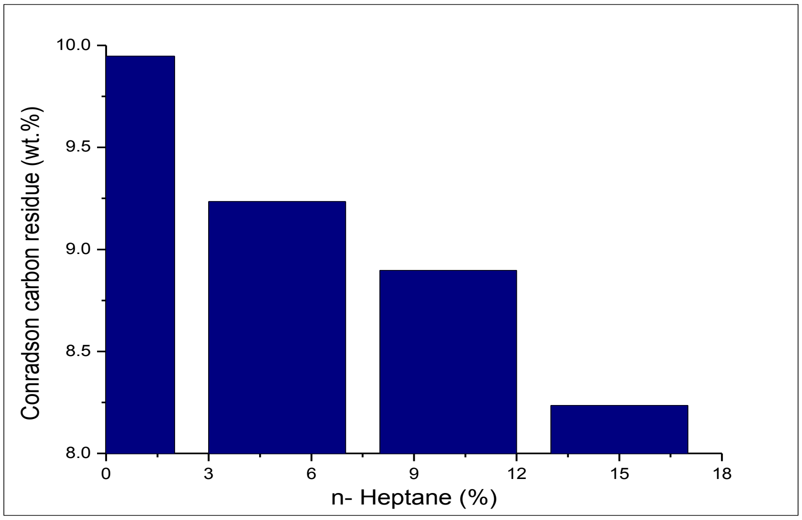

Figure 1. Effect of solvent concentration on conradson carbon residue.

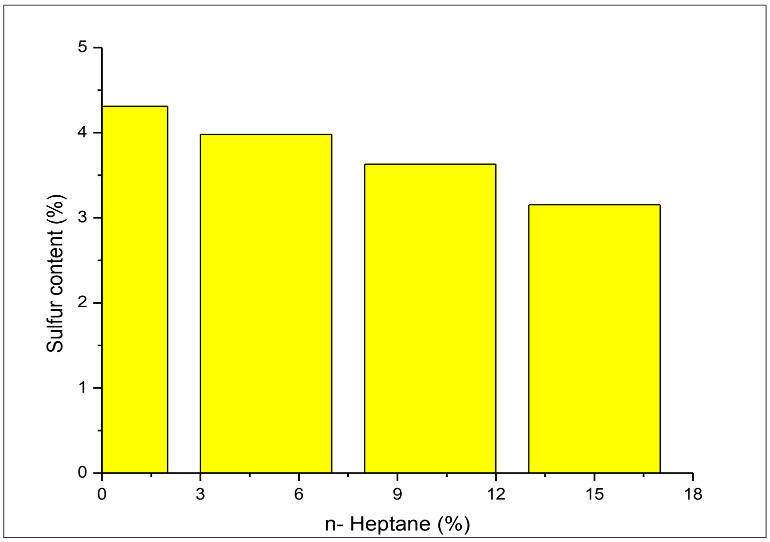

Figure 2. Effect of solvent concentration on sulfur content.

3.2. Effect of Solvent Concentration on Density, API and Kinematic Viscosity.

In this part, we explore the fineness of the deasphalting process using different solvent concentrations. The results are presented in Figures (3,4 and 5) indicating that the properties of heavy crude oils (density, API, and kinematic viscosity) were enhanced with increasing n-heptane concentration, which yields a decrease in the density reaching to about 5%. On the other hand, the API value and kinematic viscosity were increased by about 37 and 19.5% respectively when 15wt. % of the solvent was added. The lowering in specific gravity and increasing the API value of crude oil leading to produce higher light hydrocarbons fractions of during refinery process. For this reason, the price and quality of crude oil are increased with increasing in API value [29].

The obtained results attributed to the breakdown of asphalt conglomerate, moreover, lowering in the existence of micelle-like clusters that cause increasing the API value, furthermore, the scattered occurs to asphaltene molecules by solvent leading to a reduction in the size of asphaltene molecular, as well as decreases in the amount of asphaltene that causing an improvement in the API value [30].

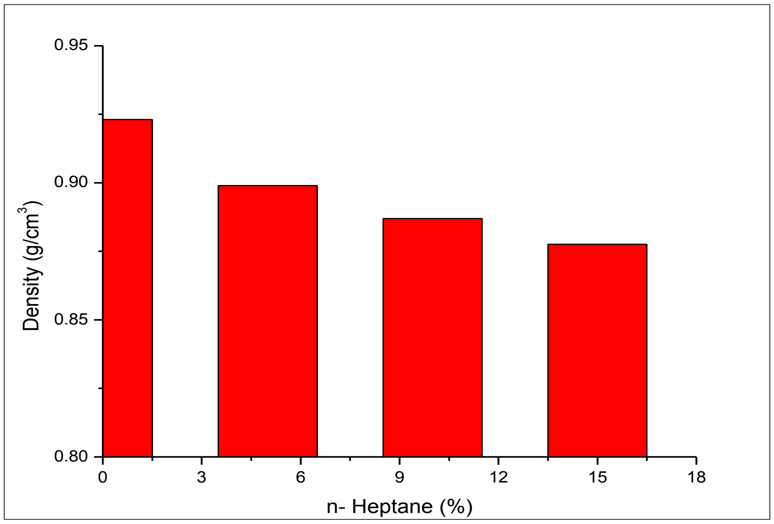

Figure 3. Effect of solvent concentration on density.

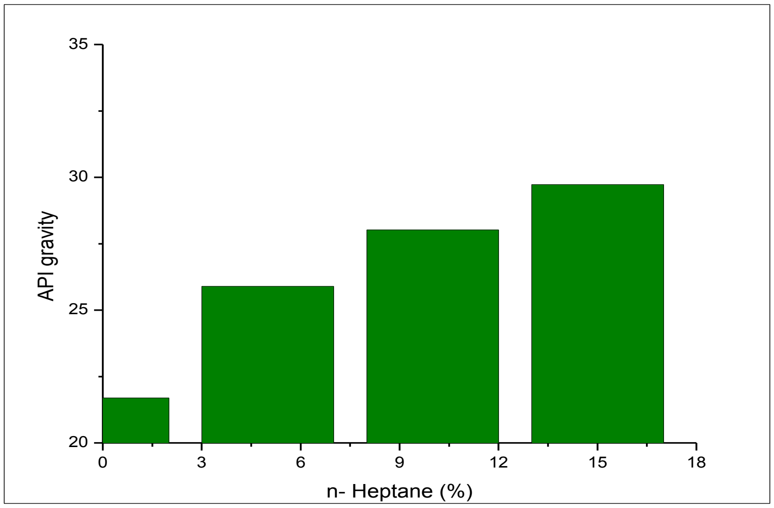

Figure 4. Effect of solvent concentration on API gravity.

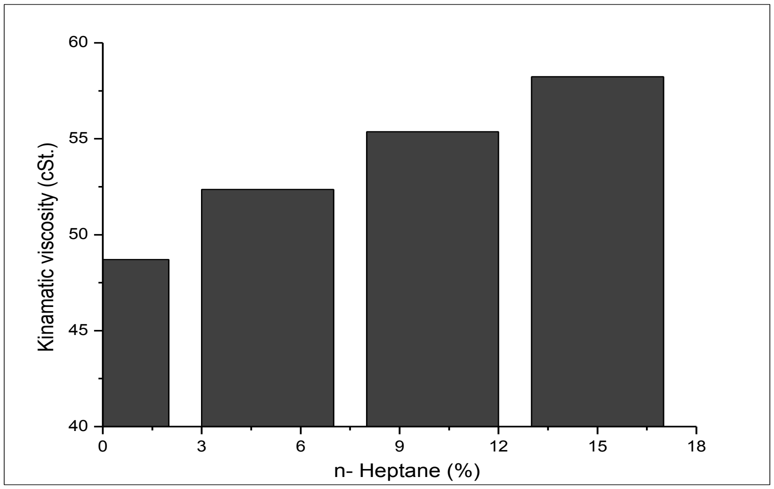

Figure 5. Effect of solvent concentration on kinematic viscosity.

4. Conclusions

The advantageous aspect of the deasphalting process in the oil industry sector is to reduce the viscosity of heavy crude oil and decrease the sulfur content. The attained results show that the quality of the deasphalting process has been effectively increased by the increase in the solvent concentration. It was found that the use of n-heptane as a solvent reduced the density of heavy crude oil, conradson carbon residue, and sulfur content, whereas the API value and kinematic viscosity were increased. The enhancement of the crude properties and lowering the sulfur content is a required issue due to savings of energy, transportation efforts, and equipment corrosion problems at all production and refinery processes.

Conflict of Interest: The authors declare that they have no conflict of interest.

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