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Laboratory Evaluation of Fractional Distillation Productsof Sudanese Crude Oils

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Abstract: *Sudanese crude oil considered as one of the sweet types of crude in the world, but it contains some undesirable materials that need to be removed. Sulphur compounds are not required in petroleum because they damage the catalyst throughout the refining processes, and they are the main cause of acid rains and environmental pollution since it includes significant amounts of acids and salts which is negatively impacts the refiningprocess. The need to address the chemical and physical properties for crude oil types before used in the manufacturing are very important because production facilities and transportation lines struggle with these corrosive materials. However, it suffers other issues in flow properties included the high viscosity and high wax percentage. The samples were collected after the initial and final treatment at Central Processing Facility (CPF) and tested for chemical and physical properties, ASTM's petroleum standards are used in the evaluation and the assessment of the physicaland chemical properties of crude oils. The samples were tested for density, kinematic viscosity, specific gravity, Total acid number (TAN), Pour point, asphalting content, Sulphur content and wax content. Results found that blend of fulla and staroil crude oil was the optimum type used.*
Key words: *Sudanese crude oil, properties, evaluation*

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I. Introduction

Although of the fact that Sudanese crude oils is considered as sweet crude oilstypes, theycontain specific amounts of compounds that should be removed before the refiningand transporting in the production lines[1]. Sulphur, wax, asphaltene etc.… components are not preferred in the production because they are negatively affect the catalyst during the refining processes also, they causethe acids and the environmental pollution because they contains large amounts of salts and acids which is negatively impacts the petroleum processes[1, 2].

ASTM's petroleum standards are helpfulproceduresin evaluating and assessingdifferent crude oils properties (physical, mechanical[3], thermal, rheological, and chemical properties), oiling grease, vehicle and aeronautics gasoline, hydrocarbons, and other naturally occurring energy resources utilized for numerousmanufacturing applications[4]. These fuels are examined forthe composition, density, purity, miscibility, compatibility with other fluids and materials, toxicity, and thermal stability between others[5]. These petroleum standards help petroleum refineries, automotive and aeronautics companies, and other chemical and geological processing plants to suitablystudy these fuel oils and guarantee their quality near safe and effectiveusage[6, 7].

Determining the physical and chemical properties for crude oils is an important step to reduce the risk before using them in the industry[4].For example, defining the density, water content, viscosity, the un desirablematerials (wax, asphaltene, sulphur) in crude oil, refined petroleum products, fuels, biofuels, lubricants, chemicals, and other products help in preservingthe quality control, meeting trade specifications, protecting financial value, and increasing the process optimization[8].Measuring these propertiesaidsin decreasingthe risks from corrosion, safety problems, and infrastructure damage which can be caused from undesirablelevels of their content.

The need to address these chemical and physical properties for crude oil types before used in the manufacturing are very important because production facilities and transportation lines suffer from with these

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acidic materials[9], besidethe other problems in flow properties such as the high viscosity and high wax percentage[10].

In this study ASTM's and UOP petroleum standards are used in the assessment and evaluation of the chemical and physicalproperties of crude oils. The samples were tested for (density, kinematic viscosity, specific gravity, Total acid number (TAN), Pour point, asphalting content, Sulphur content and wax content) using different techniques, depending on the measurements of these properties the proper crude oil type was selected to use for the refinery.

II. Material and methods

The samples of crude oil are tested for properties; study was supplied by Greater Nile Petroleum company(GNPOC) Petroleum Operating Company and Petroleum Training and Research Centre. The main sources wereNile blend, Full a light, Sargas and Star oil fields. The samples were tested for density, kinematic viscosity,specific gravity, Total acid number (TAN), pour point, asphalting content, Sulphur content and wax content.

Density and specific gravity were measured by the density meter analyzer (DMA) according to (ASTMD5002),the density was determined by inserting a sample into the digital densitometer analyzer Anton Paar model DMA 5002. It was measured at 50 °C then estimated at 20 °C for determining the API gravity using the specific gravity from (API gravity = 141.5/SG – 131.5)[11].

Total acid number (TAN) was tested using TAN titrationequipment according to ASTMD664 method while ASTM D97-04 was used for Pour point measurements.

Water content was determined using Karl Fischer (KF) reagent technique, accordingto ASTM D 4377 standard procedures[12].The solvent used throughout the analysis was a mixture of chloroform and dry methanol (20% vol/vol).

Kinematic viscosity was analyzed by insertingthe sample into the numerical automatic viscometer analyzer (Anton PaarStabinger SVM 3000). It was measured at different temperatures (50 °C, 60 °C and then assessed at 70°C)[13].

Asphaltene content was analyzed according to IP143 methodusing asphaltene content analyzer (Model APD-600A), device measuring Range of the asphaltene from 0.5 to 15 wt%.Wax content is measured using wax content analyzer according to UOP46 method. Paraffin wax content is theprecipitated masspercentage of material when thefree solution of wax in methylene chloride is cooled to -30 °C[14] andthe lower limit of detection is 5 mass%[15].

III. Results and discussions

True Boiling Point (TBP) distillation gives an almost exact picture of a crude petroleum by measuring the boiling points of the compounds created the crude[16]. The TBP (True Boiling Point) distillation gives an nearlypreciseimage of a crude petroleum by measuring the boiling points of the crude oil compounds[17]. Table 1 showed the values of TBP measured for each crude oil fraction. It is observed that light fractions (liquified petroleum gas fractions) have lower boiling points less than 100 °C.For the heaviest fractions the range is increased to 70-180 °C, 160- 260°C, 260-370 °C and T > 370 for Light debutanized, heavy gasoline, kerosene and residue respectively.

Table (1) True boiling points (TBP) of the components

component	Boiling point range °C
Liquefied petroleum Gas	C3-C4 C5 -70 C6-80 C7-100
Light debutanizedgasoline	70 -140 80 -180 100 -180
Heavy gasoline	160 -260 180 -260
kerosene	260 -325 325 -360 360 -370
Residue	T > 325 T > 360 T > 370

Wax contents of five crude oils types are determined using wax content analyzer according to UOP46 standard method. The results figure 2 showed that the values determined according toUOP46standard method. The concentration of wax reaches its maximum value in Nile blend crude oil type (36.88%) and has lower value in fulla and Staroil blend which indicate that give ideal crude for refining with law wax content.

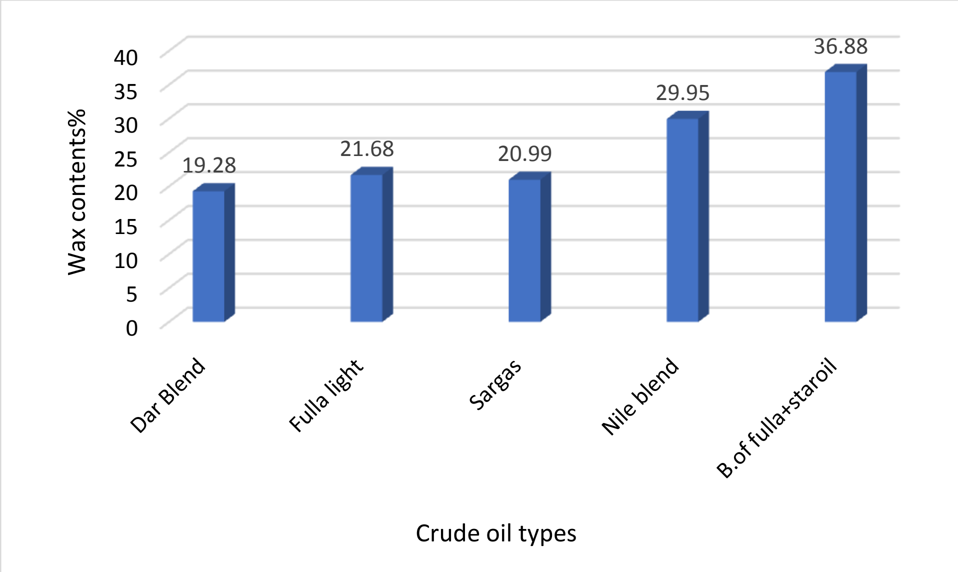

Figure 1: Wax content in crude oil types

Sulfur content is expressed as weight percent of sulfur in oil and it varies in the range from 0.0745 to 0.1272%wt. The standard method that used to measure the sulfur content is ASTM D129, depending on the sulfur level. Results showed that crude oils with more than 0.1%wt sulfur need to be treated extensively during petroleum refining. Using the sulfur content, crude oils was classified as sweet (<0.1%wt) and sour (>0.1% %wt.). It's found that the distillation process separates sulfur species in higher concentrations into the higher-boiling fractions and distillation residue. Results approved that blend of fulla and staroilis the proper crude oil type due to its low Sulphur content (0.0745).

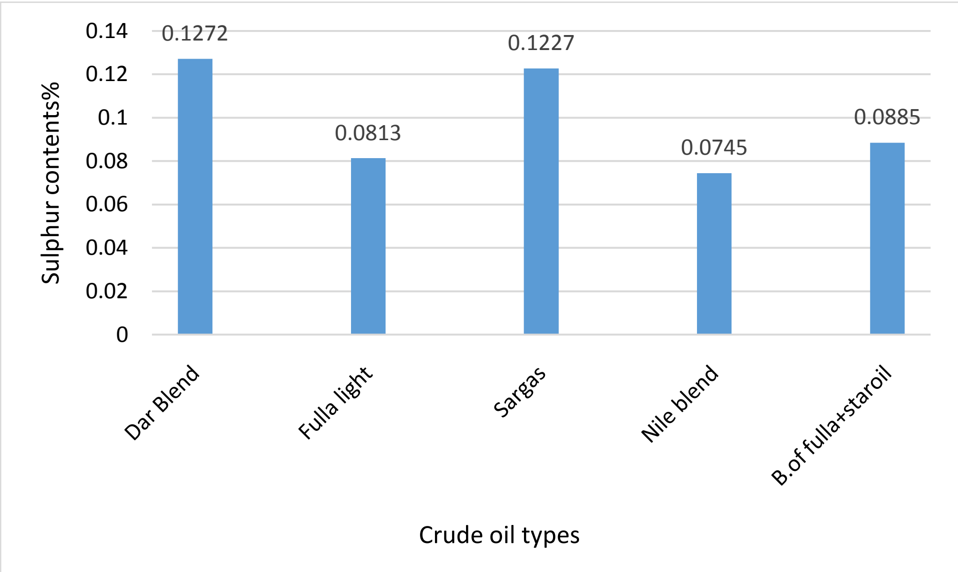

Figure 2: Sulphur content in crude oil types

The experimental data were correlated as a function of crude oil types fractionsusing anexperimental linear equation. These equationsfoundfrom the regression analysis using the measured values to estimate the density[18]. The estimated densities and calculated values for each crude oil type are observed in Tables 2. The general form of the equation as a function of the crude oil is given by: D = ax where D represent the density (kg/m^3) a, b are coefficients and x represent the crude oils fractions[19]. As seen in the Tables, it is noted thatfulla and staroil crude is the best type due to its lower density while the other types considered as heavy types which is more than the value of the acceptable range (greater than 870 kg/m^3) (Table 2).

Specific gravity values were determined from the density values,where the specific gravity is the density of the crude oil [kg/m^3]divided by the density of water at temperature of 4^{o}C[8].As shown in table 1 blend of fulla and star oil has acceptable value of SG (863.9 kg/m^3) which make it the suitable type used in the production (Table 2).

Pour point results agreed that all crude types have values in the standard pour point range (-60-30°C), it is observed that light crude oils (Dar blend, Fulla light, Sargas, Nile blend, blend of fulla and staroil) have lower pour points(20, 12, 13, 10, 29°C) respectively, andcrude oils still be liquidand pour very slowly because they consist of various hydrocarbons compoundswhich limited their use as an indicator of oil state. Therefore, in case of pour point property measurements blend of fulla and staroil is alsoappropriateto use due to its high pour point value equal 29 °C (Table 2).

The concept ofTAN measurementit is directly determined the level of acid in the sample, which related to the KOH required to neutralize the acid[20, 21]. Results ofthe TAN measurements from the direct analysis of the samples are summarized in Table 2. The samples have a range of TAN from 0.12 to 4.47 mg KOH/g, the oils having a TAN value>0.5 mg KOH/g represented high TAN samples[21]. Thus, depending on that all crude oils types considered as they have a higher TAN contents except the blend of fulla and staroil has a lower value which make it the optimum crude oil type used.

Direct determination of entrained water in crude oil using Coulometric Karl Fischer Titration in the range from 0.02 to 5 mass or volume % water in crude oils[22]. Results showed that blend of fulla and staroil crude type has the lowest water content values equal to 0.05 wt% which make it the best type selected.

A method for estimating the asphalts content of petroleum called IP143 methodwas used. Asphaltene content is an empirical value reliant on the conditions ofseparated asphalts from the original material[23].The attempts were made to get complete flocculation of asphaltenes and effective filtration with filters paper, the separation of asphaltene from the products was made using porosity Millipore filters. Measurements of Asphaltenecontents according to IP 143 methods are analyzed byspectrophotometric determinations for asphaltene concentrations in the range from 1 to 40wt. % (Table I). The experimental resultsgive values of 0.04, 0.14, 0.0.8,0.1 and 0.12 % for blend of fulla and star oil, Nile blend, Sargas,fulla light, and Dar blend respectively.It’s observed that blend of fulla and staroil crude type has the lowest asphaltenecontent and these results confirmed other analysis which indicatesthat this crude oil type is the proper type selected for the production. (Table 2)

Table 2: Other measured properties for crude oil types

Crude oil types	Density @15°C (kg/m3)	Specific Gravity (SG)	Pour point °C	TAN (mg KoH/g)	Water content wt%	Asphalting content wt%
Dar blend	913.6	914.5	20	4.47	0.44	0.12
Fulla light	881.3	882.1	12	0.35	3.0	0.10
Sargas	927.8	928.6	13	1.64	2.8	0.08
Nile blend	878.4	872.9	10	0.66	0.20	0.14
B.offulla+star oil	836.3	836.9	29	0.12	0.05	0.04

The kinematic viscosity of the five crude oils types was estimated at different temperatures 50°C, 60°C, 70°Cusing400 and 450 universal viscometers. This technique does not measurethe non-Newtonian crude oils behavior, so it is assumed that all the oil types tested were Newtonian[24]. Results showed that for Dar blend and Sargas (heavy oils) the kinematic viscosity hasvalues of 440.5, 233.4, 139.8, 499.4, 278.7and 170.6 for both crude oil types at70°C 60°C and 50°Crespectively. Results showed that blend of fulla and staroil have the lowest viscosity values at each temperature which make it the best type used in refining process.

Figure .3 shows the volume percentages of light products in each type of crude oils. Analysis showed that Blend of fulla light with staroil crude gives the highest light components content and less residue products, which makes it the best candidate for refinery process

Table (3) Kinematic viscosity at different temperatures

Sample type	k. Viscosity @70°C	k. Viscosity @60°C	k. Viscosity @50 °C
Dar blend	440.5	233.4	139.8
Fulla light	32.54	21.34	16.06

Sargas	499.4	278.7	170.6
Nile blend	39.03	25.06	17.88
B.offulla+staroil	12.97	7.761	6.696

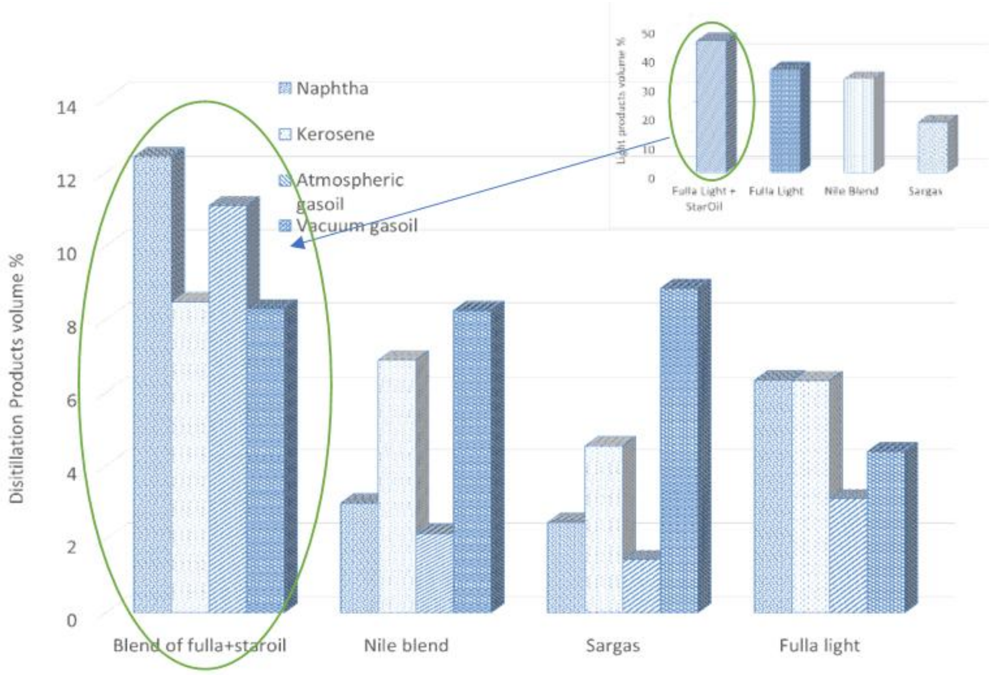

Figure 3: The Percentages and the products yield of crude oil.

IV. Conclusion

Analysis concluded that Dar blend oil is a heavy crude oil with low API, high asphalting content (more than 0.12%) and high TAN high density, specific gravity and wax contents. The most promising type is fulla crude and star oil blend due to the law viscosity, law total acid number (TAN), law pour point, and law sulfur content, law asphalting content, law wax content and high API. The high API help inproducing light products more than heavy products, therefore, Star oil and fulla blend give ideal crude for refining with low total acid number and pour point.

In the other hand, the blend of fulla and staroil crudes law sulfur and wax contents is the main properties that indicate the higher percentage of light components which is an important characteristic needed in the crude oil.

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