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Full Length Research Paper

Quality and chemistry of crude oils

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Physico-chemical characteristics such as API (American Petroleum Institute gravity) specific gravity, pour point, Calorific value, Kinematic viscosities, Reid vapour pressure, Copper corrosion, Water and sediments, Total Sulphur, Distillation range (I.B.P.F.B.P., Total recovery), residue and hydrocarbon contents (saturates, aromatics and polar) of crude oils collected from different oil fields of North (Punjab) and South (Sindh) regions of Pakistan have been evaluated using standard ASTM (American Society for Testing and Material) procedures. The results of North Region (Punjab) and South Region (Sindh) crude oils have been compared with each other. Punjab crude oils are better than Sindh crude oils because these have low specific gravity, low sulphur contents, low viscosity and low pour point. All the tested samples are of sweet type on the basis of total sulfur contents except three (L, N, O) samples of south (Sindh) region which are of sour type. All the tested samples belongs to the class light crude oil on the basis of API gravity except one (N) sample which belongs to the medium class.

Key words: Classification, quality, sweet, sour, saturates, aromatics, polars, light, medium, heavy, crude oil.

INTRODUCTION

A crude oil is a naturally occurring mixture, consisting predominantly of hydrocarbons, sulphur, nitrogen and metals. Quality (Bawazeer et al., 1997) of the petroleum products is playing the major role of consumer satisfaction and speaks about the performance of the refineries. To identify and predict the behaviour of the crude oil and finished petroleum products in particular circumstances, it is necessary to measure Physico-chemical properties (Robert et al., 1995) and to compare the measured values with International Standards. The typical nature of crude oil from different sources is different or less identical. The same is true for crude oil also; the individual oil even from the same well at different time of extraction is differing in the characteristics in term of chemical composition (Roussel and Boulet, 1995) and Physico-chemical behaviour though the basic trend is almost same for each type of crude oil. It is known that crude oil, the basic raw material of refining industries is not only unique but the entire organic chemistry can be studied. Crude oil contains almost all known hydrocarbons and non-hydrocarbons. As it is drawn from the earth, it also contains impurities like water, mud and salts during its exploration and transportation.

Crude oils are complex but mainly paraffinic, napthenic and aromatic (Wang et al., 1994). Crude oils contain all normal alkenes from (Khanorkar et al., 1996) C_1 to C_{120}. However, this percentage rises to 35% in highly paraffmic and decreases to zero in highly biograded oils (Ali et al., 1989). Methane is predominant component of natural gas and alkanes ranging from pentane to pentadecane are the chief constituents of straight run (uncrackcd) gasoline or petrol. Above C_{17}, the alkanes are solid wax like substances and crude oils, which contain high concentrations of paraffin wax, will be viscous and have high cloud and pour points. These Paraffins consists of isoalkanes and methyl cycloalkanes. Most commonly found naphthenes are five and six membered rings and occasionally a few rings with seven carbon atoms. Among these, methyl derivatives are the most abundant compounds as compared with the parent bicycle compounds. Crude oils contains up to 50% of such

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naphthenes. Aromatic compounds rarely amount to more than 15% of the crude oils. These are concentrated in heavy fractions such as gas oil, lubricating oils and the residuum. The alkyl derivatives of the benzene namely toluene and xylene are most common aromatic compounds in petroleum. The other derivatives of benzene include fused compounds, the di-aromatics (naphthalene) and tri-aromatics (Phenentherene or anthracene). Naphtheno-aromatic compounds have also been identified in crude oils. These compounds are abundant in shallow and immature oils. Many of these compounds can be related to steroid and triterpennoid structures.

Sulphur compounds (Wang and Huang, 1992) like thiols, sulphides and thiophenes also occur in crude oils. Sulphides (Komine and Tomoike, 1997) are fairly evenly distributed over medium and heavy factions of crude oils. Compounds of nitrogen in crude oils are unwelcomed because of catalyst poisoning and formation of gum in fuel oils. Nitrogen compounds, which can easily separate, include pyridines, quinolines, indoles, pyroles and carazoles. Oxygen compounds in the form of organic acids occur in young and immature crude oils (Verkoczy and Kamal, 1989; Maldonado et al., 2006). These organic acids range in size from C_1 to C_{30} and have isoprenoid structures with members such as carboxylic acids, phenols, cresol anhydride etc. Among the techniques, high-resolution capillary Gas Chromatography (GC) (Wang et al., 1994, 2003; Wang and Fingas, 1997; Dimandja et al., 2003; Vendeuvre et al., 2004; Beens et al., 2001; Colombe et al., 2005; Yasin et al., 2012) equipped with flame-ionization detection (FID) and capillary GC-MS are the most important and most widely used techniques for oil compounds separation, characterization, and identification. Crude oil and oil-spill related samples are extremely complex mixtures in which the boiling points of components can vary over a wide range from a few to several hundred degrees. Complete separation of such complex samples into individual components is difficult or impossible even with high-resolution capillary gas chromatography.

EXPERIMENTAL

Analytical grade chemicals and deionized water was used. Calibrated Pyrex glassware's and equipments such as Viscometer Baths VHC-220 (Giuleukamn, England). Muffle furnace FSE-621 (Gallcnkamp, England) and crude oils were sampled using standard sampling procedure (ASTM D-270) from different oil fields of North region (Punjab, Table 1) and South region (Sindh, Table 2). Physico-chemical characteristics such as API (American Petroleum Institute) gravity, specific gravity, pour point, calorific value, kinematic viscosity, reid vapour pressure, copper corrosion, conradson carbon, water and sediments, total sulphur, and hydrocarbons contents (saturates, aromatics and polar) were determined.

Sampling of crude oils

For the sampling of crude oil ASTM D 4057 method was used. This method provides procedures for manually obtaining samples of petroleum and petroleum products of a liquid and semi liquid. A sampling pot made of copper was used. It was cleaned with detergent and rinsed with distilled water many time to make it contamination free. Sample container (plastic cans) having volume capacity 5 L was used. These cans were also cleaned with detergent and rinsed with distilled water to make these dust free. Three samples top, middle and bottom were taken from storage tank of every well with the help of sampling pot and mixed in 5 L plastic cans. Sample containers were sealed and screwed to make it air tight.

Sulphur analysis

Sulphur was analyzed using sulphur analyzer model Asooma T 2000 following ASTM (American Society for Testing and Material) method 4294. In this analysis X-ray energy dispersive mode was used. The voltage used in X-ray tube was 10 KV, current 400 μA and filter number 5 was used. The instrument was calibrated in the range of 0.001-1.00 wt% by using commercially available standards Analytical Services Incorporation. The repeatability and reproducibility limit ±0.0054 - ±0.0309 and ±0.0089 - ±0.1161 respectively, for the sulfur measurement.

Analysis of hydrocarbons by gas chromatograph

Each crude oil sample was dissolved in pentane and well shacked. 0.2 µl of each crude sample was injected to a Perkin Elmer (PE) 8700 gas chromatograph equipped with a flame-ionization detector (FID) with a 1 min purge-off. A polar capillary column sp-2340 (60 m into 0.25 mm) having stationary phase methyl lignocerate was used. The carrier gas, nitrogen (3.5 ml/min) transport the vaporized sample through the column in which it is partitioned into individual components, which are detected by FID detector. The detector signal was recorded with integrating computer. Each eluting component of each gasoline sample was identified by comparing its retention time with the retention time of reference standards diluted in pentane under identical conditions (Table 3). Following the temperature programme was used: Initial temperature70°C, increased 4°C/min 120°C and then increased by 10 to 220°C, stay time 10 min at 220°C (held for 10 min). The concentration of each component in wt % was determined by measuring the peak area. The components were sum up as saturates, aromatics and polars.

RESULTS AND DISCUSSION

Petroleum crude oils are not uniform materials. Classification on the basis of physical characteristics (Sun et al., 2009; Odebunmi et al., 2002), which are commonly called as "commercial parameters" and has remained with the oil industry for the quality evaluation and pricing purposes of the crude oil. Specific gravity is an important parameter to measure the quality of crude oils. Low specific gravity indicates good quality of crude oil having lighter fractions and vice versa. The specific gravity range of North region (Punjab, Table 4) crude oils is 0.7910–0.8500 (0.8259) and South region (Sindh) crude oils is 0.8088–0.9320 (0.8364). So the North region (Punjab) crude oils are better than South region (Sindh, Table 5). The specific gravity of the crude oil gives a rough measure of the amount of lighter hydrocarbons present. Lower the specific gravity and higher API gravity,

Table 1. Punjab crude oils and well locations.

Crude oil	Well location
A	Toot Crude Oil, Punjab, Pakistan
B	Adhi Crude Oil Punjab, Pakistan
C	Balkassar Crude Oil Well # 2, Punjab, Pakistan
D	Khaur Crude Oil, Punjab, Pakistan
E	Chak Naurang Crude Oil, Punjab, Pakistan.
F	Dakhni Crude Oil, Punjab, Pakistan
G	Sadkal Crude Oil # 2, Punjab, Pakistan

Table 2. Sindh crude oils and well locations.

Crude oil	Well location
H	Tando Adam Crude Oil well#3, Sindh, Pakistan
I	Tando Adam Well # 7 Deep, Sindh, Pakistan.
J	Kunnar Well # 10, Sindh, Pakistan.
K	Dabhi (North), Sindh, Pakistan
L	Dabhi (South), Sindh, Pakistan.
M	Golarchi Well # 8, Sindh, Pakistan.
N	Badin Well#8, Sindh, Pakistan.
O	Umer Well#12, Sindh, Pakistan.
P	Siraj South Well#12, Sindh, Pakistan

Table 3. Retention times of hydrocarbon standards by gas chromatography.

Standard name	Retention time(min.)	Standard name	Retention time(min.)	Standard name	Retention time(min.)
Saturates					
Pentane	3.40	Hexane	3.43	Heptane	3.48
Octane	3.53	Nonane	3.63	Decane	3.89
$C_{14}H_{30}$	8.04	$C_{15}H_{32}$	9.50	N-Hexadecane	11.75
Heptadecane	14.26	$C_{18}H_{38}$	17.75	$C_{20}H_{42}$	19.20
$C_{21}H_{44}$	19.86	$C_{23}H_{48}$	22.09	$C_{24}H_{50}$	22.65
$C_{25}H_5$	23.01	$C_{26}H_{54}$	24.49		
Aromatics					
Toluene	3.79	Benzene	4.1	Ethylene benzene	5.28
Xylene	5.34	Cumene	5.60	ter. Butyl benzene	6.34
Biphenyl	24.53	Naphthalene	32.37	Acenaphthene	33.35
Phenentherene	33.71	Fluranthene	34.11	Fluorene	34.63
Pyrene fluoranthene	34.80	Benz (a) anthracene	35.24	Benzo (b)	35.83
Benzo (a) pyrene fluoranthene	36.63	Benzo (e) pyrene	37.19	Benzo (k)	37.42
Anthracene	37.51				
Polars					
1-propanol	4.19	ter. Butyl alcohol	4.79	Pentanol	7.17
Cyclohexanol	11.09	o-cresol	11.68	p-cresol	27.21
m-cresol	29.08	Phenol	7.17	4-amino phenol	28.07
2, 2, 4-trichlorophenol	30.67	Pyridine	8.50	2,2-bipyridine	29.19
α- naphthol	6.99	Resorcinol	27.45		

Table 4. General Physico-chemical characteristics of North Region (Punjab) crude oils.

Characteristics	Test method (ASTM)	Crude oil								
		A	B	C	D	E	F	G	Range	Mean
SP. Gravity@60/60°F	D-1298	0.8500	0.7910	0.8284	0.8280	0.8283	0.8284	0.8278	0.7910-0.8500	0.8259
API Gravity@60/60°F	D-1298	34.97	47.38	39.31	39.89	39.32	39.31	39.43	34.97-47.38	39.94
Sulfur (wt %)	D-4294	0.2840	0.2090	0.0190	0.0970	0.0190	0.0187	0.0250	0.0187-0.2840	0.0960
Water Contents (Vol %)	D-95	0.85	0.05	0.27	0.25	0.25	0.28	0.25	0.05-0.85	0.314
Kin. Viscosity @ 40°C (cSt)	D-445	7.90	1.95	4.56	4.56	4.50	4.56	4.56	1.95-7.90	2.860
Kin. Viscosity@ 50°C (cSt)	D-445	5.50	1.42	4.00	4.00	3.80	4.00	4.00	1.42-5.50	2.240
Pour Point. (°C)	D-97	+30	+18	+30	+27	+30	+30	+27	+18-+30	27.43
Carbon Residue (wt %)	D-189	0.90	0.65	0.43	0.47	0.45	0.47	0.27	0.27-0.90	0.520
R.V.P.@37.7°C (Psi)	D-323	4.0	6.0	3.8	4.2	3.8	3.9	4.2	3.8-6.0	4.270
Copper Strip Corrosion	D-130	1a	1a	1a	1a	1a	1a	1a	-	1a
Calorific Value (Btu/lb)	D-240	18900	18950	18850	19000	18950	18970	19000	18850-19000	18945.7
Distillation	D-86									
I.B.P. (°C)		65	55	45	55	56	48	55	45-65	54.143
10% Recovery (°C)		144	99	126	120	127	122	120	99-144	122.57
30% Recovery (°C)		292	146	268	257	270	269	257	146-292	251.29
Recovery at 300°C (Vol %)		35	70	35	40	36	36	38	35-70	41.429
Total Saturates (wt %)		18.99	30.69	13.87	21.31	21.34	20.90	8.88	8.88-30.690	19.436
Total poly aromatic hydrocarbons (wt %)		3.358	7.592	5.154	11.861	14.053	14.216	13.335	3.358-14.216	9.938
Total Aromatics (wt %)		14.51	18.35	8.65	20.77	22.95	23.16	15.63	8.65-23.160	17.715
Total Polars (wt %)		16.83	17.30	10.54	27.98	28.39	29.42	25.61	10.54-29.42	22.150

the greater is the yield of light fractions by distillation. Therefore, higher API gravity crude oil have higher price and is of good quality. It means that crude oil samples collected from Punjab are better in quality than Sindh crude oils. On the basis of API gravity, Pakistani crude oils (22.30-47.38) are of better quality international crude oils (30.7-36.5) indicated in Table 6.

Generally speaking, oil with API gravity between 40 and 45 commands the highest prices. Above 45° the molecular chains become shorter and less valuable to refineries (dnr.louisiana.gov, 1989). Crude oil is classified as light, medium or heavy, according to its measured API gravity. Light crude oil is defined as having API gravity higher than 31.1° API. Medium oil is defined as having API gravity between 22.3° API and 31.1° API. Heavy oil is defined as having API gravity below 22.3° API. Heavy crude oil has been defined as any liquid petroleum with API gravity less than 20° (dnr.louisiana.gov, 1989). North region (Punjab) crude oils (Table 4) vary widely in ranging from 34.97-47.37 (39.94) API gravity. Whereas South region (Sindh) crude oils (Table 5) oils have API gravity ranges 22.30-42.54 (38.18). The specific gravity of the crude oil gives a rough measure of the amount of lighter hydrocarbons present. Lower the specific gravity and higher API gravity, the greater is the yield of light fractions by distillation. Therefore, higher API gravity crude oil have higher price and is of good quality. It means that crude oil samples collected from North region (Punjab) are better in quality than South region (Sindh) crude oils. On the basis of API gravity, all the tested samples of North (Punjab) regions belong to the class light crude oil having API gravity greater than 31.1°. All the tested samples of South (Sindh) regions belongs to the class light crude oil one sample N (Badin Well#8, Table 5) having

Table 5. General Physico-chemical characteristics of South Region (Sindh) crude oils.

Characteristics	Test method (ASTM)	Crude oil										
		H	I	J	K	L	M	N	O	P	Range	Mean
SP. Gravity@60/60°F	D-1298	0.8310	0.8360	0.8350	0.8088	0.8135	0.8130	0.9320	0.8453	0.8133	0.8088-0.9320	0.8364
API Gravity@60/60°F	D-1298	38.77	37.75	37.96	43.45	42.43	42.54	22.30	35.90	42.48	22.30-42.54	38.18
Sulfur (wt %)	D-4294	0.018	0.276	0.2360	0.2793	0.8267	0.2630	0.6800	0.9000	0.0300	0.018-0.900	0.390
Water Contents (Vol %.)	D-95	0.05	0.05	0.05	7.0	7.0	6.0	0.05	0.05	0.05	0.05-7.0	2.26
Pour Point												
Kin. Viscosity@40°C (cSt)	D-445	1.99	2.00	1.95	1.29	1.28	1.27	6.70	7.95	1.28	1.27-7.95	2.86
Kin. Viscosity@ 50°C (cSt)	D-445	1.46	1.47	1.42	1.14	1.15	1.14	5.27	6.0	1.15	1.14-6.0	2.24
Pour Point.(°C)	D-97	+18	+18	+21	+6	+12	+12	+12	+36	+12	+12-+36	16.33
Carbon Residue (wt%)	D-189	0.64	0.55	0.62	0.03	0.03	0.03	0.68	0.90	0.03	0.03-0.90	0.39
R.V.P. @37.7°C (Psi)	D-323	6.4	6.6	6.3	4.8	3.0	3.0	4.3	4.0	3.0	3.0-6.6	4.54
Copper Strip Corrosion	D-130	1a	1a	1a	1a	1a	1a	1a	1a	1a	-	1a
Calorific Value (Btu/lb)	D-240	18955	18960	18950	18780	19650	19650	18680	18880	19655	18680-19655	19128.9
Distillation	D-86											
I.B.P.(°C)		52	53	54	50	77	77	65	65	77	52-77	63.33
10% Recovery (°C)		96	97	96	101	122	122	144	144	122	96-144	116.00
30% Recovery (°C)		143	144	143	142	151	151	239	292	151	142-292	172.89
50% Recovery (°C)		212	213	212	188	186	186	289	-	186	186-289	185.78
70% Recovery (°C)		280	283	285	248	239	239	-	-	239	239-285	201.44
Recovery at 300°C (Vol %)		73	70	74	83	86	87	-	-	85	70-86	62.00
Total saturates (wt %)		16.71	22.64	18.54	24.27	17.46	15.97	14.47	8.47	15.85	8.47-24.3	17.15
Total polyaromatic hydrocarbons (wt %)		11.453	7.675	5.478	2.353	5.681	13.279	5.133	14.545	13.146	2.353-14.545	8.749
Total Aromatics (wt %)		17.48	16.92	11.11	6.489	20.10	15.74	12.17	16.72	16.89	6.489-20.1	14.85
Total Polars (wt %)		12.31	14.85	16.26	16.95	22.27	14.86	15.10	10.46	14.83	10.46-22.27	15.34

API gravity 22.30°. Sweet crude oil is considered "sweet" if it contains less than 0.5% sulfur (commodity-trading-today.com). Sour crude oil is that when it contains total sulfur contents greater than 0.5% (commodity-trading-today.com). Sulphur is highly poisonous, cause foul smelling, corrosion and plant rusting. Sulphur is one of the major concerns of refineries. Certain crudes evolve hydrogen sulphide, low boiling sulphur compound and decomposition products of heavy sulphur compounds during processing. However, most of the sulphur compounds concentrate in the distillation residue. Alkali washing and hydro treating remove the sulphur in the distillate. Most of the indigenous crudes are free from dissolved (H_2S) sulphur. South region (Sindh) crude oils have sulphur contents 0.018-0.900 (0.390) wt%. The range of sulphur content in North region (Punjab) crude oils is 0.0187-0.2840 (0.096) wt%, it means that, on the basis of sulphur contents, North region (Punjab) crude oils are of good quality than South region (Sindh) crude oils. All the samples of crude oil of North region (Punjab) are of sweet crude oils having sulfur contents less than 0.5 % while sample L, N, and O (Table 2) South region (Sindh) belong to sour crude oils having total sulfur more than 0.5% and others belong to sweet crude oils having total sulfur contents less than 0.5%. International crude oils have sulphur range 0.14-1.48 wt% and Pakistani

Table 6. Reported values of physical parameters of some international crude oils.

Characteristics	Texas Gulf Coast Mix.	Nigerian (Bonney)	Canada (Red water)	Venezuela (Lagemar)	Pakistan (Min.-Max.)
API Gravity at 60/60 °F	36.5	38.1	34.9	30.7	22.30-47.38
Viscosity SUS at 77 °F	41.0	38.4	47.8	107.0	-
Viscosity SUS at 100°F	37.3	35.7	41.7	64.3	-
Sulphur wt %	0.16	0.14	0.56	1.48	0.018-0.90
Water & Sediments Vol %	0.1	trace	trace	trace	0.018-0.8267
Reid Vapour Pressure at 100°F	3.2	6.9	8.4	2.5	3.0-7.0
Distillation (°F)					
I.B.P.	<50	<50	<50	<50	113-170.6
10% recovery	245	220	230	269	204.8-291.2
30% recovery	398	375	382	422	287.6-557.6
70% recovery	654	684	792	907	462.2-545.0
F.B.P.	1033	1045	1050	1083	-
Total recovery vol %	96	96	92	84	35-86

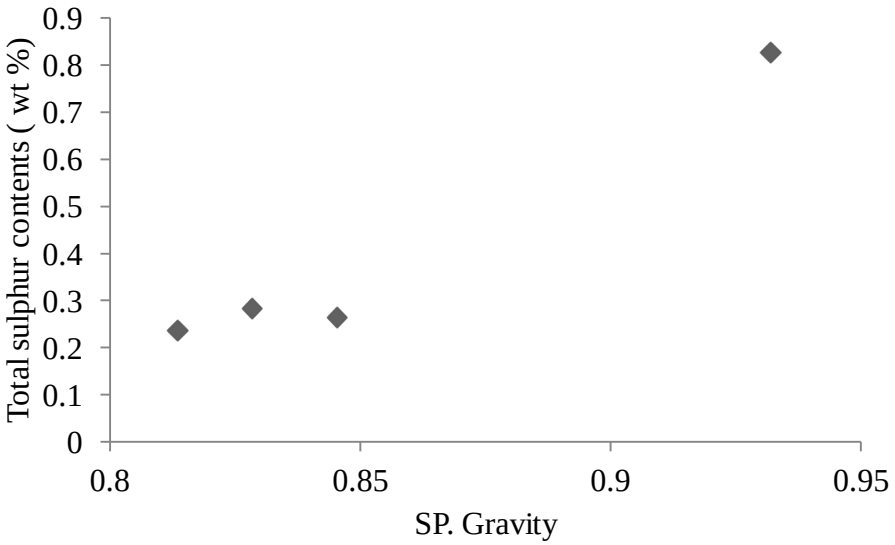

Figure 1. Effect of specific gravity on total sulphur contents.

crudes have lesser sulphur (0.01-0.90). So Pakistani crude oils are better in quality on the basis of sulphur than international crude oils. Generally, there is a direct relationship between the specific gravity and the sulphur. As the specific gravity increases, the sulphur contents also increases and vice versa as shown in Figure 1.

Water in crude oil lead to the corrosion of the plant. Water in crude oil is either in the form of emulsion or in large droplets. Emulsified water in heavy asphaltic crude is difficult to separate. There is a variation from low to high in both Northern (Punjab) and Southern (Sindh) crude oils. North region (Punjab) crude oils have water contents 0.05-0.85 (0.314) Vol%. Whereas South region (Sindh) crude oils have water contents 0.05 -7.0 (2.26) Vol%. So North region (Punjab) crude oil is of better quality on the basis of water contents than South region (Sindh) crude oils. It is clear that Pakistani crude oils have more water (0.05-7.0 Vol%) contents than international crude oils (trace). On the basis of water contents Pakistani crude oils are of poor quality.

Viscosity measurement helps in the pump design. It also gives the rough idea about the different fractions of the crude oils. If viscosity is low then the crude oil sample will have more light fractions. Viscosity data at both temperature at 40 and 50°C indicate variation in North region (Punjab) and South region (Sindh) crudes. Although in South region (Sindh) crude oils viscosity is in between the range of 1.27–7.95 (2.86)/1.14–6.0 (2.24)

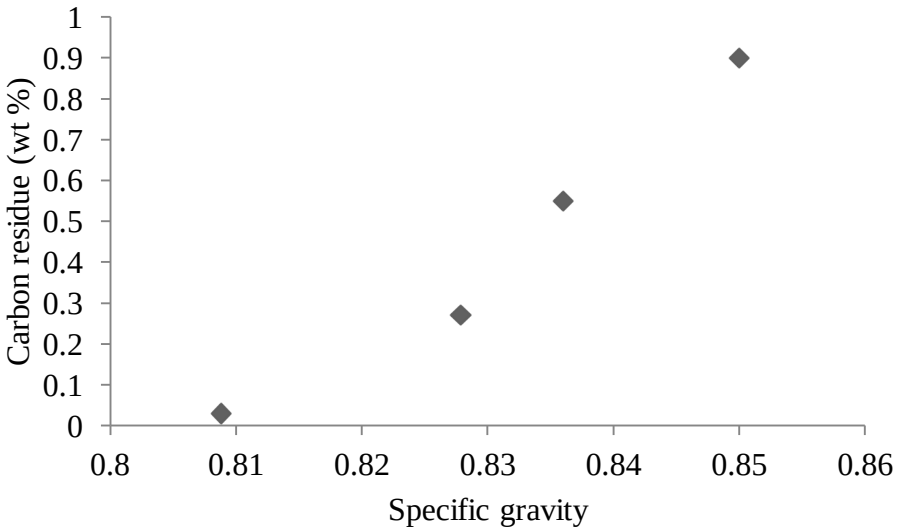

Figure 2. Effect of specific gravity on Carbon contents.

cSt but in North region (Punjab) 1.95-7.90(4.66)/1.42 – 5.50 (3.82) cSt. North region (Punjab) crude oils have low viscosity than South region (Sindh) crude oils. The viscosity data of North region (Punjab) crude oils show that it has lighter contents than South region (Sindh) crude oils. These types of crudes are very good in feedstock for the production of asphalt. So North region (Punjab) crude oils are of better quality than south region (Sindh) crude oils. There is a direct relationship between the specific gravity and the kinematic viscosity, as the specific gravity increases, the kinematic viscosity also increases and vice versa.

Pour point of a petroleum product is used to estimate the paraffinic or waxy contents with respect to quality and transportation and guide for the pumpibility, the relative estimation of paraffinic or waxy content of the crude oil. High values of pour point +12–+36 (16.33)°C indicate waxy nature of the South region (Sindh) crudes; whereas, North region (Punjab) crude oils show extremely low pour point +18–+30 (27.43)°C and indicating intermediate or napthenic nature. Pour point of the crude oil increases as the specific gravity increases.

Conradson carbon test gives an indication of the amount of high molecular or high boiling asphaltic components and coke forming properties of the crude oil. Heating the sample under controlled conditions and estimating the residue perform Conradson carbon residue test. Generally, napthenic crudes have more Conradson carbon residue than the paraffinic crudes. Some crude of North region (Punjab) 0.27-0.90 (0.52) wt% and South region (Sindh) 0.03-0.90 (0.39) wt% and are asphaltic in nature. The carbon residue increases as the specific gravity increases shown in Figure 2.

Reid vapour pressure measurement can be used to estimate the volatile contents and transportation purposes. North region (Punjab) crude oils 3.8-6.00 (4.27) Psi have low volatile contents than South region (Sindh) crude oils 3.0-6.6 (4.54) Psi. As the specific gravity increases the vapour pressure of the crude oils decreases, so the volatility of the crude oil is inversely proportional to the specific gravity shown in Figure 3.

Copper strip corrosion test is the determination of corrosiveness of the sample. Sulphur present in the crude. Non-corrosive nature of all indigenous crude oil and imported crude oils were evident from the results obtained. 1a values of copper strip corrosion of North region (Punjab) and South region (Sindh) crude oils show that all the crude oils are neutral in nature.

Calorific values give the knowledge that how much our sample can produce energy. The estimation of calorific value can be used in power production in thermal units. The range of calorific value of South region (Sindh) crude oils is 18680-19655 (19128.9) Btu/1bs and North region (Punjab) crude oils have calorific value range 18850-19000 (18945.7) Btu/1bs. It means that South region (Sindh) crude oils produce more power than North region (Punjab) crude oils and are of good choice for thermal units.

Distillation gives the idea of the fractions that could be collected bellow 300°C. It is also helpful for the designing of the refinery. Initial boiling point range of North region (Punjab) crude oils is 45- 65(54.143)°C and South region (Sindh) crude oils range is 52-77(63.33)°C. Low initial boiling point range of crude oils indicates that lighter contents will be recovered more quickly than South region (Sindh) crude oils. 10%Recovery range of North region (Punjab) crude oils is 99-144 (122.57)°C and South region (Sindh) crude oils range is 96-144 (116.0)°C.30%Recovery range of North region (Punjab) crude oils is 146-292 (251.29)°C and South region (Sindh) crude oils range is 142–292 (172.89)°C. 50% Recovery range of South region (Sindh) crude oils

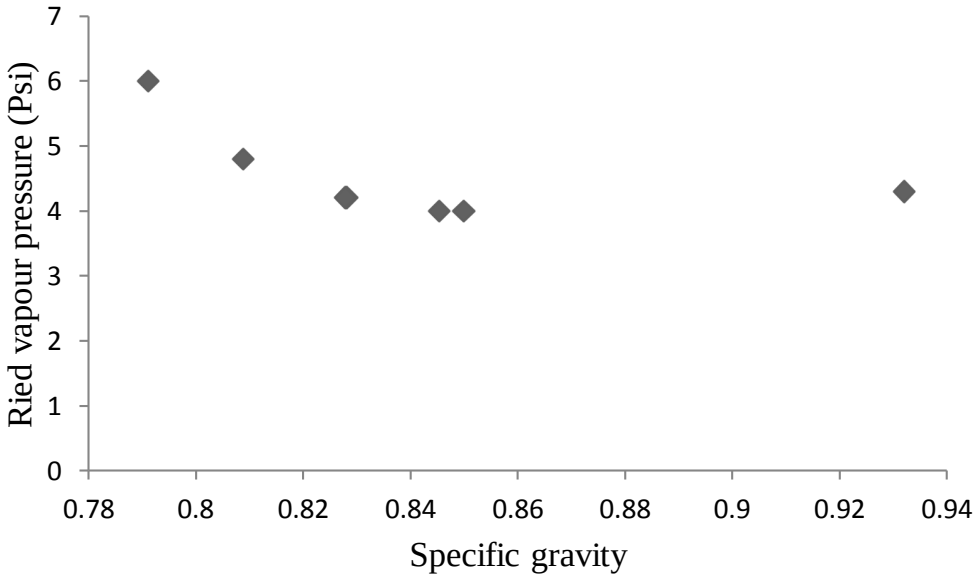

Figure 3. Effect of specific gravity on Reid vapour pressure at 37.7°C.

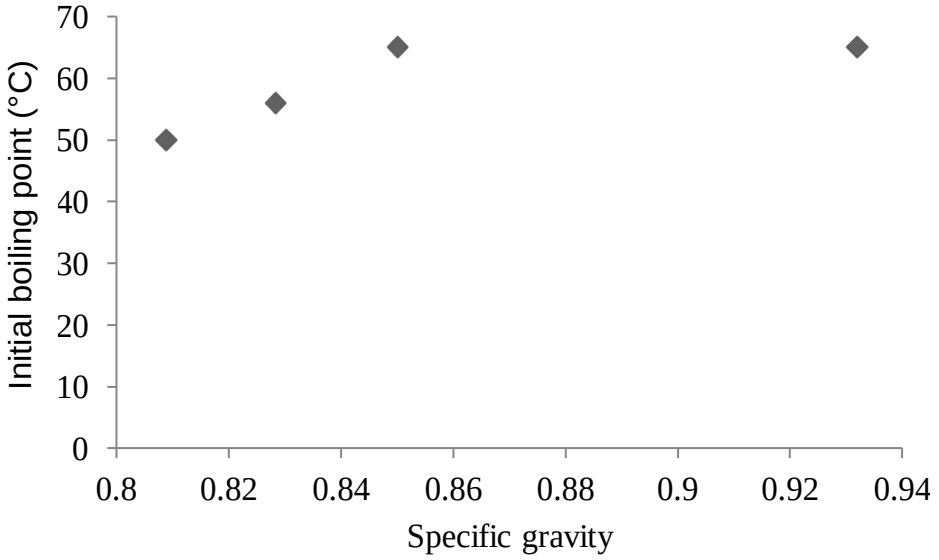

Figure 4. Effect of specific gravity on the initial boiling point of the crude oils.

186-289 (185.78)°C. 70%Recovery range of South region (Sindh) crude oils 239-285 (201.44)°C. Recovery at 300°C of North region (Punjab) crude oils range is 35-70 (41.429) Vol% and South region (Sindh) crude oil range is 70–86(62.00) Vol%. North region (Punjab) crude oils have comparatively larger gasoline range than those collected from the South region (Sindh) whereas larger distillation fractions of kerosene oil, jet fuel, diesel fuel and lube stock have been observed in South region (Sindh) crude oils. The initial boiling point of crude oils and total recovery at 300°C decreases as the specific gravity of the crude oils increases as shown in Figures 4 and 5, respectively.

The North region (Punjab) crude oils have saturates in the range of 8.879-30.691(19.436) wt% and South region (Sindh) crude oils have in the range of 8.47–24.3 (17.15) wt%. The North region (Punjab) crude oils have aromatics in the range of 8.652-23.157 (17.715) wt% and South region (Sindh) crude oils have in the range of 6.489-20.1(14.85) wt%. The North region (Punjab) crude oils have polars in the range of 10.536-29.419 (22.150) wt% and South region (Sindh) crude oils have in the

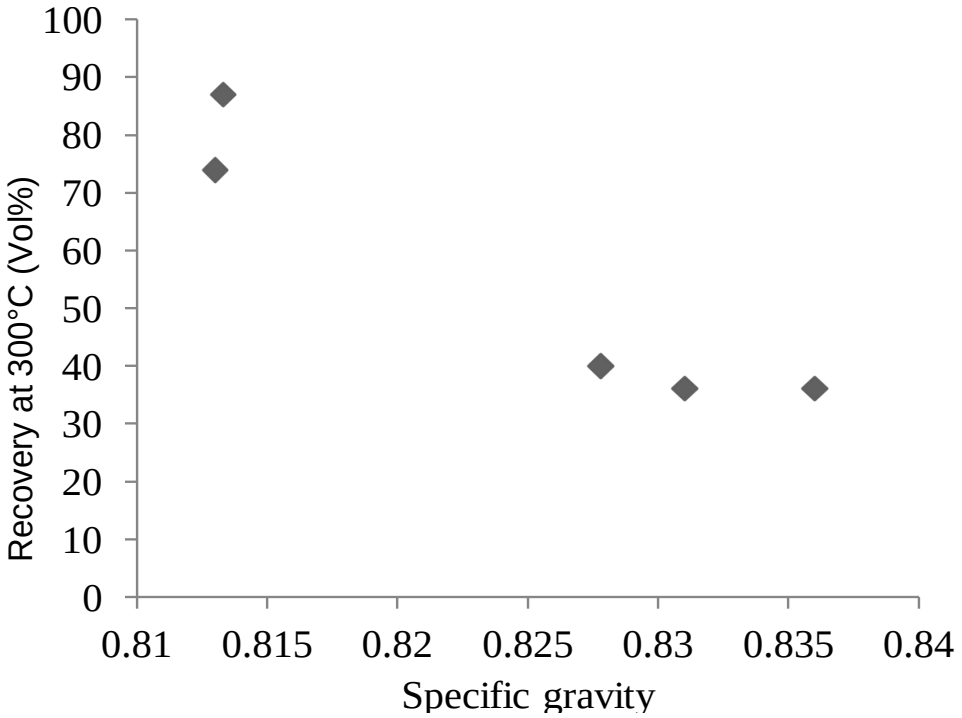

Figure 5. Effect of specific gravity on total recovery at 300°C.

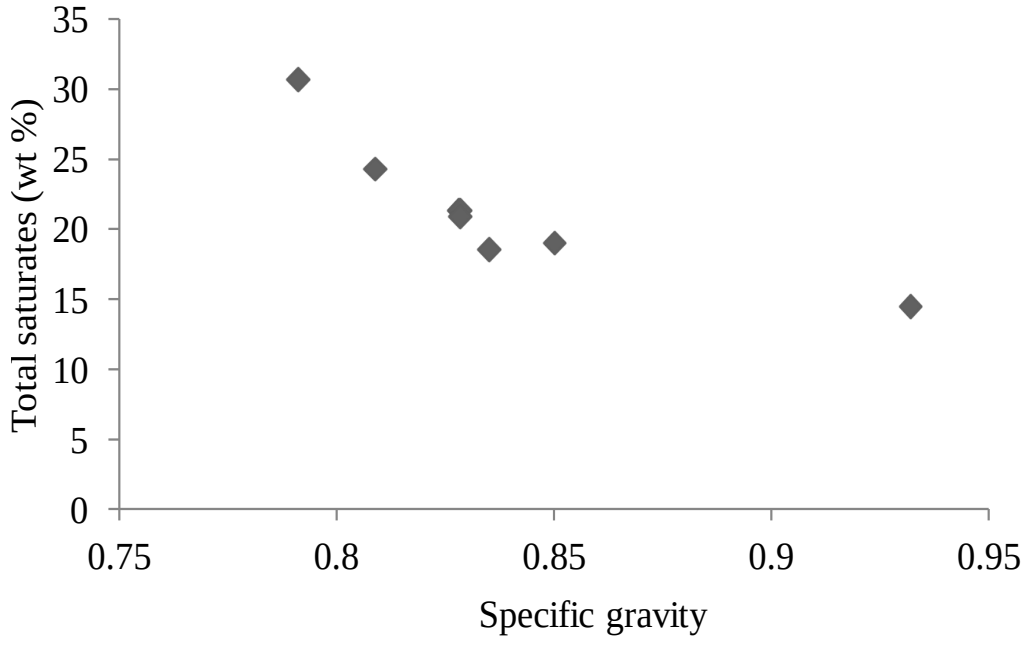

Figure 6. Effect of specific gravity on total saturates concentration.

range 10.46-22.27 (15.34) wt%. From these values, it is clear that North region (Punjab) crude oils have more saturates aromatics and polar contents than South region (Sindh) crude oils. The concentration of total saturates decreases as the specific gravity increases as shown in Figure 6 while total aromatics, polyaromatic and total polars concentration increases as the specific gravity increases as shown in Figures 7, 8 and 9, respectively.

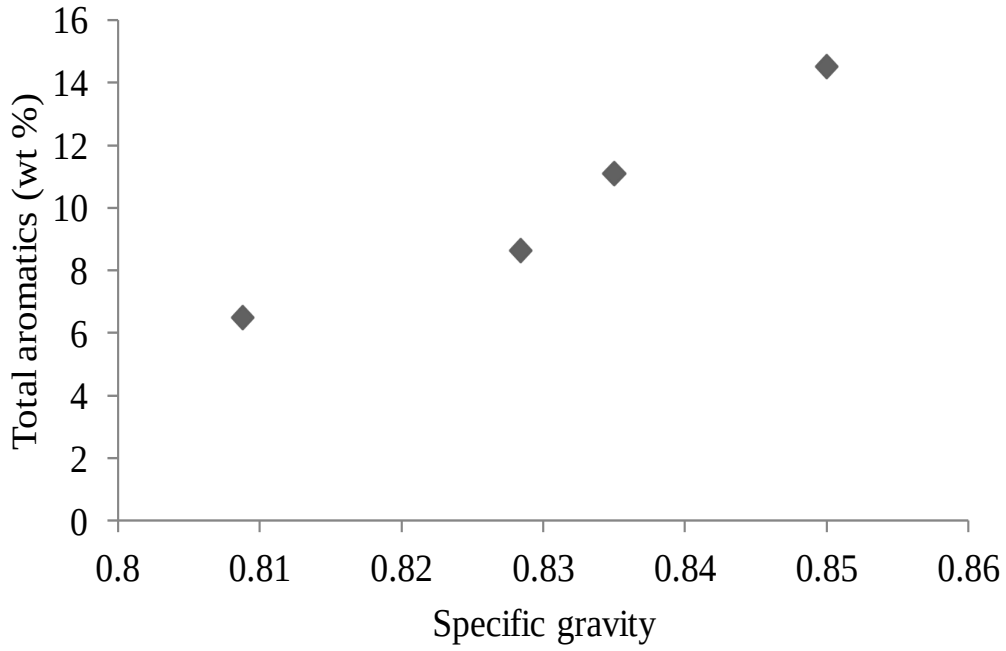

Figure 7. Effect of specific gravity on total aromatics concentration.

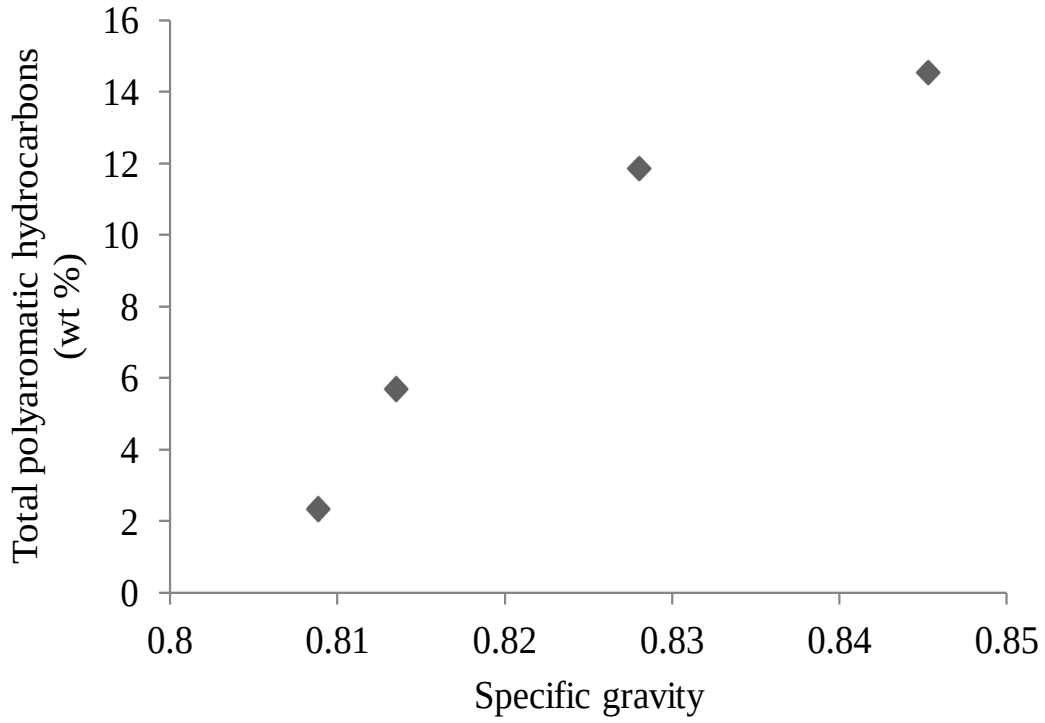

Figure 8. Effect of specific gravity on the concentration of polyaromatic hydrocarbons.

Conclusion

All the tested samples of North region (Punjab) have better quality than the samples of South region (Sindh). North region crude oils are of sweet type while some samples of South region belong to sour type crude oils.

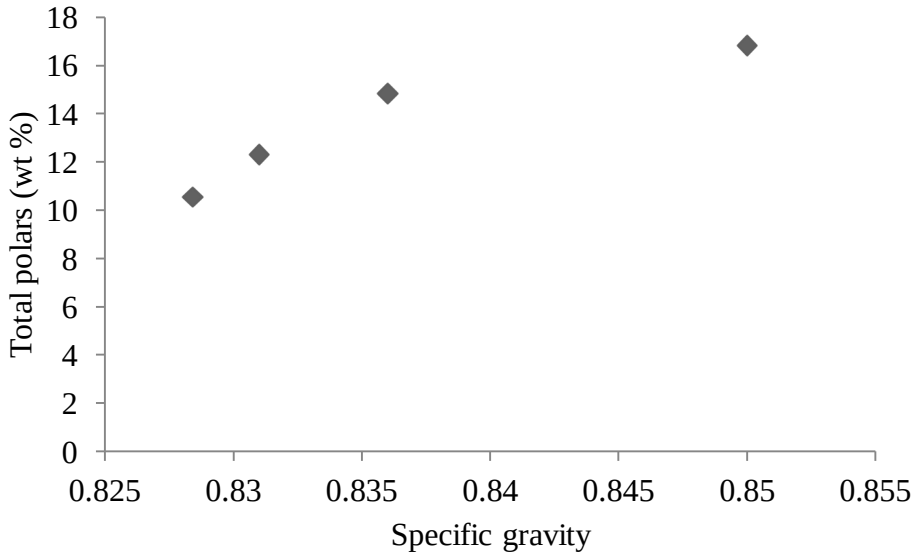

Figure 9. Effect of specific gravity on total polars concentration.

North region crude oils belong to light crude oil class while one sample of South region belongs to medium class crude oils. North region (Punjab) crude oils have more saturates aromatics and polar contents than that of South region (Sindh) crude oils.

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