Supplementary Materials

Application of Intercriteria and Regression Analyses and Artificial Neural Network to Investigate the Relation of Crude Oil Assay Data to Oil Compatibility

Ivelina Shiskova [1], Dicho Stratiev [1,2,*], Mariana Tavlieva [1], Angel Nedelchev [1], Rosen Dinkov [1], Iliyan Kolev [1], Frans van den Berg [3], Simeon Ribagin [2,4], Sotir Sotirov [5], Radoslava Nikolova [6], Anife Veli [6], Georgi Georgiev [1] and Krassimir Atanassov [2]

[1] LUKOIL Neftohim Burgas, 8104 Burgas, Bulgaria; shishkova.ivelina.k@neftochim.bg (I.S.); tavlieva.mariana.p@neftochim.bg (M.T.); kolev.iliyan.v@neftochim.bg (I.K.)
[2] Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Georgi Bonchev 105, 1113 Sofia, Bulgaria
[3] Black Oil Solutions, 2401 Alphen aan den Rijn, The Netherlands; bergberg134@gmail.com
[4] Department of Health and Pharmaceutical Care, University Prof. Dr. Assen Zlatarov, Professor Yakimov 1, 8010 Burgas, Bulgaria
[5] Laboratory of Intelligent Systems, University Prof. Dr. Assen Zlatarov, Professor Yakimov 1, 8010 Burgas, Bulgaria; ssotirov@btu.bg
[6] Central Research Laboratory, University Prof. Dr. Assen Zlatarov, Professor Yakimov 1, 8010 Burgas, Bulgaria
* Correspondence: stratiev.dicho@neftochim.bg

Table S1. Data of HTSD, and density of both samples of crude oil Helm, and their mixtures with n-heptane at the point of asphaltene precipipitation onset, along with Kw-characterization factor, and Sp, and Sp critical

Parameter	Helm 1.2022	Helm 1.2022 /n-heptane	Parameter	Helm 1.2024	Helm 1.2024 /n-heptane
Density 15 °C, g/cm3	0.9350	0.7960	Density 15 °C, g/cm3	0.9348	0.7726
Distillation ASTM D -7169, % mass	°C	°C	Distillation ASTM D -7169, % mass	°C	°C
0.5	106	87	0.5	82	87
5	197	91	5	155	95
10	244	93	10	211	97
15	280	99	15	251	98
20	310	99	20	283	99
25	339	100	25	312	99
30	364	105	30	339	99
35	392	132	35	367	100
40	415	199	40	393	100
45	436	274	45	418	100
50	459	327	50	441	101
55	484	369	55	465	101
60	511	410	60	493	181

65	540	443	65	521	273
70	570	482	70	552	337
75	601	524	75	584	399
80	632	568	80	614	454
85	657	614	85	639	518
90	682	656	90	661	591
95	710	696	95	692	652
99.5	867	856	99.5	755	728
Taverage, ° C	464	333	Taverage, ° C	441	245
Kw	11.41	11.94	Kw	11.25	11.69
	Sp	**SP critical**		**Sp**	**SP critical**
	53.2	**32.4**		**59.4**	**42.3**

Table S2. True boiling point wide fraction yields of investigated crude oil samples

No	Crude oil sample name	IBP-110°C, wt.%	110-180°C, wt.%	180-240°C, wt.%	240-360°C, wt.%	360-540°C, wt.%	>540°C, wt.%
1	Albanian 2015	2.7	4.2	4.5	14.8	27.2	46.2
2	Arabian Light_25.12.2019	10.0	11.7	9.1	21.4	25.2	21.7
3	Arabian medium_2019	8.9	12.0	8.7	20.0	25.2	24.3
4	Arabian Heavy - November 2015	6.9	8.9	8.1	19.9	25.9	29.1
5	Aseng oil 2014	6.9	9.1	9.5	23.7	39.7	12.2
6	Azery Light 2019	9.1	12.2	10.4	25.9	27.6	13.8
7	Basrah light May 2019	9.0	10.4	7.7	18.5	25.4	27.9
8	Basrah Medium_05.02.2022	8.4	9.5	8.5	18.7	25.6	28.4
9	Basrah heavy_October 2015	6.0	8.3	8.4	17.6	25.6	33.2
10	Boscan-06.2014	1.2	1.9	2.5	12.8	30.1	50.2
11	BUZACHI_10.08.15	2.4	4.0	6.8	18.7	36.3	30.8
12	CHELEKEN_06.05.15	5.5	10.0	11.3	28.4	28.2	15.6
13	CPC_January 2018	17.8	19.5	12.7	24.1	18.8	6.1
14	CPC_24.06.2020	16.6	20.2	13.9	24.6	18.5	5.2
15	El Bouri -2015	5.4	8.9	8.2	18.8	32.4	25.4
16	El Sharara_12.11.2021	16.0	17.4	13.5	24.2	20.3	7.5
17	Forties Blend_22.08.2020	18.1	15.8	10.4	20.3	23.9	10.6
18	Helm C.O._11.01.2022	2.2	5.5	6.4	20.6	30.3	34.1

19	Helm C.O._27.12.2023	2.5	5.3	6.3	20.3	31.1	33.5
20	Johan Sverdrup_09.06.2023	7.4	7.7	8.5	22.8	29.3	23.3
21	Kazakh 11.05.2015	5.8	6.0	5.8	19.0	40.6	21.8
22	Kirkuk _2015	11.2	12.9	10.3	20.3	25.2	19.2
23	Kuwait Export 06.2017	8.2	10.1	8.4	20.0	25.3	27.0
24	OKWVIBOME CO_23.12.14	7.2	10.6	11.2	34.9	29.3	12.2
25	ORYX_2014	5.6	8.9	7.5	16.2	24.5	36.2
26	PRINOS-stabilized - 06.2019	10.1	11.6	8.6	22.4	27.4	18.9
27	Ras Gharib_17.05.2015	4.0	6.5	7.3	14.4	28.3	38.6
28	REBCO_April 2019	7.2	9.6	8.3	21.3	28.8	23.8
29	Rhemoura Melange_11.05.19	9.4	12.6	9.2	21.6	27.4	18.8
30	Sepia_13.12.2023	7.1	8.0	7.4	17.5	29.5	29.5
31	Siberian Light_December 2018	8.6	11.4	9.1	23.1	29.6	17.3
32	SOUTHERN GREEN CANYON 04.07.19	11.5	9.0	6.0	18.1	25.7	28.7
33	Tartaruga Verde C.O._08.12.2023	7.6	8.0	7.5	18.9	29.8	27.2
34	Tempa Rossa_21.05.2020	7.2	8.6	7.2	15.7	24.6	35.8
35	VAL D"AGRI - Юли 2015	14.2	15.6	12.4	22.7	21.6	12.5
36	Varandey blend_17.11.12	10.3	10.8	12.8	21.0	30.4	13.7
37	Western Desert 19.07.2023	16.8	15.5	10.4	23.6	23.2	9.6
38	Es Sider	6.9	12.7	11.1	22.1	27.0	17.5
39	Payara Gold	3.9	8.7	8.8	23.8	33.5	20.1
40	KEBCO	7.8	9.3	9.1	21.7	27.3	23.9
	Min	1.2	1.9	2.5	12.8	18.5	5.2
	Max	18.1	20.2	13.9	34.9	40.6	50.2

Table S3. μ-values obtained from ICrA evaluation of fraction yields obtained during vacuum residue hydrocracking (vacuum reidue hydrocracking data taken from ref. [66]. This data is related to a single crude oil source).

μ	Gas yield	Naphtha yield	Kerosene yield	Diesel yield	VGO yield	Vacuum residue (unconverted)
Gas yield	1.00	0.93	0.95	0.95	0.47	0.05
Naphtha yield	0.93	1.00	0.96	0.95	0.47	0.02
Kerosene yield	0.95	0.96	1.00	0.96	0.45	0.00
Diesel yield	0.95	0.95	0.96	1.00	0.49	0.04
VGO yield	0.47	0.47	0.45	0.49	1.00	0.55
Vacuum residue (unconverted)	0.05	0.02	0.00	0.04	0.55	1.00

Note: Green color means statistically meaningful positive relation; Red color implies statistically meaningful negative relation. The intensity of the color designates the strength of the relation. The higher the color intensity, the higher the strength of the relation is. Yellow color denotes dissonance.

Table S4. υ-values obtained from ICrA evaluation of fraction yields obtained during vacuum residue hydrocracking (vacuum reidue hydrocracking data taken from ref. [66]. This data is related to a single crude oil source).

ν	Gas yield	Naphtha yield	Kerosene yield	Diesel yield	VGO yield	Vacuum residue (unconverted)
Gas yield	0.00	0.07	0.04	0.05	0.53	0.95
Naphtha yield	0.07	0.00	0.02	0.05	0.53	0.98
Kerosene yield	0.04	0.02	0.00	0.02	0.53	0.98
Diesel yield	0.05	0.05	0.02	0.00	0.51	0.96
VGO yield	0.53	0.53	0.53	0.51	0.00	0.45
Vacuum residue (unconverted)	0.95	0.98	0.98	0.96	0.45	0.00

Note: Green color means statistically meaningful positive relation; Red color implies statistically meaningful negative relation. The intensity of the color designates the strength of the relation. The higher the color intensity, the higher the strength of the relation is. Yellow color denotes dissonance.

Table S5. μ-values obtained from ICrA evaluation of Kw-characterization factors of crude oil fractions

μ	50	120	140	160	175	190	210	230	250	270	290	310	330	350	385	410	450	480	515	545	>550°C
50	1.00	0.73	0.69	0.69	0.73	0.73	0.70	0.66	0.58	0.63	0.46	0.48	0.52	0.47	0.46	0.48	0.48	0.44	0.42	0.42	0.47
120	0.73	1.00	0.91	0.88	0.87	0.81	0.82	0.78	0.63	0.66	0.48	0.48	0.51	0.46	0.45	0.46	0.44	0.40	0.40	0.38	0.46
140	0.69	0.91	1.00	0.87	0.86	0.81	0.82	0.81	0.66	0.67	0.50	0.48	0.50	0.45	0.45	0.46	0.43	0.39	0.39	0.38	0.47
160	0.69	0.88	0.87	1.00	0.91	0.84	0.79	0.78	0.63	0.68	0.49	0.48	0.51	0.45	0.45	0.45	0.43	0.40	0.40	0.39	0.46
175	0.73	0.87	0.86	0.91	1.00	0.90	0.82	0.80	0.67	0.69	0.50	0.50	0.53	0.48	0.47	0.46	0.46	0.42	0.40	0.39	0.49

190	0.73	0.81	0.81	0.84	0.90	1.00	0.86	0.84	0.72	0.74	0.55	0.55	0.57	0.53	0.50	0.50	0.48	0.45	0.43	0.42	0.51
210	0.70	0.82	0.82	0.79	0.82	0.86	1.00	0.92	0.76	0.76	0.61	0.59	0.61	0.55	0.54	0.54	0.51	0.48	0.46	0.44	0.50
230	0.66	0.78	0.81	0.78	0.80	0.84	0.92	1.00	0.82	0.79	0.66	0.64	0.62	0.57	0.56	0.56	0.54	0.50	0.48	0.47	0.54
250	0.58	0.63	0.66	0.63	0.67	0.72	0.76	0.82	1.00	0.79	0.67	0.69	0.63	0.59	0.57	0.56	0.55	0.50	0.49	0.48	0.55
270	0.63	0.66	0.67	0.68	0.69	0.74	0.76	0.79	0.79	1.00	0.74	0.73	0.76	0.70	0.67	0.67	0.67	0.64	0.62	0.60	0.69
290	0.46	0.48	0.50	0.49	0.50	0.55	0.61	0.66	0.67	0.74	1.00	0.84	0.78	0.80	0.81	0.80	0.80	0.78	0.76	0.74	0.74
310	0.48	0.48	0.48	0.48	0.50	0.55	0.59	0.64	0.69	0.73	0.84	1.00	0.87	0.84	0.78	0.76	0.78	0.74	0.72	0.70	0.70
330	0.52	0.51	0.50	0.51	0.53	0.57	0.61	0.62	0.63	0.76	0.78	0.87	1.00	0.89	0.83	0.81	0.83	0.80	0.77	0.76	0.71
350	0.47	0.46	0.45	0.45	0.48	0.53	0.55	0.57	0.59	0.70	0.80	0.84	0.89	1.00	0.90	0.88	0.89	0.88	0.84	0.82	0.75
385	0.46	0.45	0.45	0.45	0.47	0.50	0.54	0.56	0.57	0.67	0.81	0.78	0.83	0.90	1.00	0.93	0.91	0.88	0.87	0.84	0.73
410	0.48	0.46	0.46	0.45	0.46	0.50	0.54	0.56	0.56	0.67	0.80	0.76	0.81	0.88	0.93	1.00	0.93	0.88	0.87	0.86	0.72
450	0.48	0.44	0.43	0.43	0.46	0.48	0.51	0.54	0.55	0.67	0.80	0.78	0.83	0.89	0.91	0.93	1.00	0.92	0.90	0.88	0.77
480	0.44	0.40	0.39	0.40	0.42	0.45	0.48	0.50	0.50	0.64	0.78	0.74	0.80	0.88	0.88	0.88	0.92	1.00	0.94	0.91	0.77
515	0.42	0.40	0.39	0.40	0.40	0.43	0.46	0.48	0.49	0.62	0.76	0.72	0.77	0.84	0.87	0.87	0.90	0.94	1.00	0.94	0.77
545	0.42	0.38	0.38	0.39	0.39	0.42	0.44	0.47	0.48	0.60	0.74	0.70	0.76	0.82	0.84	0.86	0.88	0.91	0.94	1.00	0.78
>550°C	0.47	0.46	0.47	0.46	0.49	0.51	0.50	0.54	0.55	0.69	0.74	0.70	0.71	0.75	0.73	0.72	0.77	0.77	0.77	0.78	1.00

Table S6. υ-values obtained from ICrA evaluation of Kw-characterization factors of crude oil fractions

ν	**50**	**120**	**140**	**160**	**175**	**190**	**210**	**230**	**250**	**270**	**290**	**310**	**330**	**350**	**385**	**410**	**450**	**480**	**515**	**545**	**>550°C**
50	0.00	0.24	0.28	0.27	0.24	0.24	0.27	0.30	0.36	0.34	0.50	0.47	0.45	0.49	0.51	0.48	0.48	0.51	0.54	0.54	0.48
120	0.24	0.00	0.07	0.09	0.11	0.17	0.16	0.20	0.32	0.32	0.49	0.49	0.47	0.52	0.53	0.52	0.54	0.56	0.58	0.59	0.51
140	0.28	0.07	0.00	0.10	0.12	0.16	0.16	0.17	0.29	0.30	0.47	0.48	0.47	0.53	0.53	0.52	0.55	0.57	0.58	0.59	0.50
160	0.27	0.09	0.10	0.00	0.06	0.13	0.18	0.19	0.31	0.30	0.48	0.49	0.46	0.52	0.53	0.52	0.54	0.55	0.57	0.58	0.50
175	0.24	0.11	0.12	0.06	0.00	0.08	0.16	0.17	0.29	0.29	0.47	0.47	0.45	0.50	0.52	0.51	0.52	0.54	0.56	0.58	0.48
190	0.24	0.17	0.16	0.13	0.08	0.00	0.12	0.13	0.23	0.24	0.42	0.41	0.40	0.45	0.48	0.48	0.49	0.51	0.54	0.55	0.46
210	0.27	0.16	0.16	0.18	0.16	0.12	0.00	0.05	0.19	0.21	0.36	0.38	0.37	0.43	0.44	0.44	0.47	0.48	0.51	0.53	0.47
230	0.30	0.20	0.17	0.19	0.17	0.13	0.05	0.00	0.13	0.19	0.32	0.33	0.35	0.41	0.42	0.42	0.44	0.47	0.49	0.51	0.44
250	0.36	0.32	0.29	0.31	0.29	0.23	0.19	0.13	0.00	0.17	0.27	0.26	0.33	0.37	0.39	0.39	0.41	0.43	0.45	0.47	0.40
270	0.34	0.32	0.30	0.30	0.29	0.24	0.21	0.19	0.17	0.00	0.23	0.24	0.22	0.28	0.32	0.31	0.30	0.32	0.36	0.37	0.28
290	0.50	0.49	0.47	0.48	0.47	0.42	0.36	0.32	0.27	0.23	0.00	0.13	0.19	0.18	0.16	0.17	0.17	0.18	0.20	0.23	0.23
310	0.47	0.49	0.48	0.49	0.47	0.41	0.38	0.33	0.26	0.24	0.13	0.00	0.09	0.14	0.19	0.20	0.19	0.21	0.24	0.26	0.27
330	0.45	0.47	0.47	0.46	0.45	0.40	0.37	0.35	0.33	0.22	0.19	0.09	0.00	0.09	0.16	0.17	0.15	0.16	0.20	0.21	0.26
350	0.49	0.52	0.53	0.52	0.50	0.45	0.43	0.41	0.37	0.28	0.18	0.14	0.09	0.00	0.09	0.10	0.09	0.09	0.13	0.15	0.22
385	0.51	0.53	0.53	0.53	0.52	0.48	0.44	0.42	0.39	0.32	0.16	0.19	0.16	0.09	0.00	0.05	0.07	0.09	0.11	0.14	0.25
410	0.48	0.52	0.52	0.52	0.51	0.48	0.44	0.42	0.39	0.31	0.17	0.20	0.17	0.10	0.05	0.00	0.05	0.08	0.10	0.12	0.25
450	0.48	0.54	0.55	0.54	0.52	0.49	0.47	0.44	0.41	0.30	0.17	0.19	0.15	0.09	0.07	0.05	0.00	0.04	0.07	0.09	0.20
480	0.51	0.56	0.57	0.55	0.54	0.51	0.48	0.47	0.43	0.32	0.18	0.21	0.16	0.09	0.09	0.08	0.04	0.00	0.03	0.05	0.19
515	0.54	0.58	0.58	0.57	0.56	0.54	0.51	0.49	0.45	0.36	0.20	0.24	0.20	0.13	0.11	0.10	0.07	0.03	0.00	0.03	0.19
545	0.54	0.59	0.59	0.58	0.58	0.55	0.53	0.51	0.47	0.37	0.23	0.26	0.21	0.15	0.14	0.12	0.09	0.05	0.03	0.00	0.18
>550°C	0.48	0.51	0.50	0.50	0.48	0.46	0.47	0.44	0.40	0.28	0.23	0.27	0.26	0.22	0.25	0.25	0.20	0.19	0.19	0.18	0.00

Table S7. μ-values obtained from ICrA evaluation of Kw-characterization factors of vacuum residue hydrocracking fractions (data taken from ref. [66])

μ	VTB Kw	Kw-naphtha	Kw-diesel	Kw-HAGO	Kw-LVGO	Kw-HVGO
VTB Kw	1.00	0.49	0.74	0.91	0.88	0.86
Kw-naphtha	0.49	1.00	0.58	0.50	0.52	0.47
Kw-diesel	0.74	0.58	1.00	0.80	0.81	0.80
Kw-HAGO	0.91	0.50	0.80	1.00	0.94	0.91
Kw-LVGO	0.88	0.52	0.81	0.94	1.00	0.92
Kw-HVGO	0.86	0.47	0.80	0.91	0.92	1.00

Table S8. υ-values obtained from ICrA evaluation of Kw-characterization factors of vacuum residue hydrocracking fractions (data taken from ref. [66])

ν	VTB Kw	Kw-naphtha	Kw-diesel	Kw-HAGO	Kw-LVGO	Kw-HVGO
VTB Kw	0.00	0.49	0.23	0.06	0.09	0.12
Kw-naphtha	0.49	0.00	0.40	0.47	0.46	0.51
Kw-diesel	0.23	0.40	0.00	0.18	0.18	0.19
Kw-HAGO	0.06	0.47	0.18	0.00	0.04	0.08
Kw-LVGO	0.09	0.46	0.18	0.04	0.00	0.08
Kw-HVGO	0.12	0.51	0.19	0.08	0.08	0.00

Table S9. μ-values obtained from ICrA evaluation of fraction yields obtained during hydrocracking of vacuum residues originated from 13 crude oils

μ	Naphtha	Diesel	VGO	VTB
Naphtha	1.00	0.76	0.18	0.14
Diesel	0.76	1.00	0.36	0.18
VGO	0.18	0.36	1.00	0.67
VTB	0.14	0.18	0.67	1.00

Table S10. υ-values obtained from ICrA evaluation of fraction yields obtained during hydrocracking of vacuum residues originated from 13 crude oils

ν	Naphtha	Diesel	VGO	VTB
Naphtha	0.00	0.24	0.81	0.85
Diesel	0.24	0.00	0.63	0.81
VGO	0.81	0.63	0.00	0.31
VTB	0.85	0.81	0.31	0.00

Table S11. Bulk properties of studied crude oils, and some characteristics of their vacuum residue fractions

Nr		Crude D15	Crude S	> 540	VR SG	VR CCR	VR S	VR C7asp	VR C5asp	CO_C7 asp	CO_C5 asp	VR Kw	T50	Kw
1	**Albania**	1.001	5.64	48.2	1.094	31.4	8.7	37.7	49.7	30.8	36.5	10.8	442	10.9
2	**Arab Light**	0.858	1.89	22.9	1.029	18.7	4.9	12.1	18.8	4.7	7.6	11.42	353	12.1
3	**Arab Med.**	0.872	2.48	25.2	1.031	20.7	5.4	14.6	25.5	5.6	8.9	11.40	366	12.1
4	**Arab Heavy**	0.889	2.91	32	1.04	23.6	5.8	21.3	32.9	3.3	5.7	11.40	408	12.0
5	**Aseng**	0.874	0.26	13.8	0.984	14.2	0.6	3.7	10	3.0	4.7	12.05	358	11.9
6	**Azeri Light**	0.848	0.2	14.8	0.967	9.5	0.5	1.4	5.4	1.1	1.7	11.21	323	12.1
7	**Basrah L**	0.878	2.85	28.3	1.052	23.8	5.9	18	27.7	9.0	11.1	11.21	390	12.0
8	**Basrah Medium**	0.8836	3.1	28.35	1.0574	24.2	6.78	22.3	30.2	6.3	10.2	11.15	389	12.0
9	**Basrah H**	0.905	3.86	33.8	1.071	28.9	7.1	27.7	37	9.7	14.8	11.10	433	11.8
10	**Boscan**	1.002	5.5	63.1	1.078	27.8	6	35.2	41	27.5	37.0	10.96	558	11.5
11	**Buzachi**	0.907	1.57	32.7	1.007	16	3.1	1.8	6.1	5.1	8.6	11.74	450	12.0
12	**Cheleken**	0.847	0.4	16.6	0.974	12.3	1.2	5.8	12.5	2.3	3.2	12.08	345	12.2
13	**CPC**	0.805	0.63	9.3	0.981	16	2.1	3.4	11	0.1	2.0	11.78	237	12.2
14	**CPC-Jan. 2024**	0.7982	0.59	6.25	0.9477	8.4	1.46	2.6	11.8	0.2	0.7	12.19	238	12.1
15	**El Bouri**	0.891	1.76	26.2	1.05	25.5	3.3	17.5	27.3	8.2	11.9	11.12	403	12.0
16	**El Sharara**	0.814	0.08	8.7	0.976	13.1	0.39	10.1	17.0	2.2	2.5	11.92	253	12.1
17	**Forties**	0.817	0.68	11.9	0.99	14.8	2.5	7.2	9.8	3.2	4.8	11.89	264	12.1
18	**Helm**	0.935	1.71	35.6	1.054	23.28	3.013	10.1	18.5	11.8	19.6	11.17	448	11.7
19	**Helm (Jan. 2024)**	0.9348	1.63	35.12	1.0540	23.3	2.70	27.0	41.3	10.2	15.1	11.17	455	11.7
20	**Johan Sverdrup**	0.8867	0.82	24.62	1.0225	19	1.77	16.4	27.4	4.2	8.3	11.89	390	12.0
21	**Kazakh H**	0.858	0.81	23.7	0.99	17.1	1.7	11.1	17.8	3.1	5.8	11.22	426	12.3
22	**Kirkuk**	0.873	2.65	24.6	1.054	25.2	5.9	24.3	33.1	7.0	11.2	11.41	332	12.0
23	**KEB**	0.876	2.64	27.7	1.037	23.3	5.7	16.6	25.7	7.7	11.7	11.41	390	12.1
24	**Okwuibome**	0.868	0.2	6.9	0.975	12.9	0.5	1.7	8.2	1.4	1.9	12.00	309	11.7
25	**Oryx**	0.9156	4.209	37.4	1.089	29.4	8.01	30.9	39.6	16.5	23.7	10.91	448	11.9
26	**Prinos**	0.875	3.71	20.3	1.108	32.8	9.14	30	38.8	9.1	14.7	10.55	345	11.8

27	**RasGharib**	0.926	3.44	40.2	1.059	25.1	5.6	26	34.9	17.8	25.5	11.14	486	12.0
28	**Urals**	0.877	1.53	25.2	0.997	17.5	3	14.1	17.6	3.8	6.3	11.82	386	12.1
29	**Rhemoura**	0.865	0.75	20.2	1.041	23.7	1.8	23.2	31.3	6.2	10.3	11.24	342	12.0
30	**Sepia**	0.8883	0.41	30.68	0.9984	13.8	0.75	8.5	17.1	3.5	7.3	11.82	430	12.2
31	**LSCO**	0.854	0.57	18.7	0.993	14	1.58	7.8	15.5	3.2	6.3	11.84	348	12.1
32	**SGC**	0.883	2.26	30.1	1.05	22.9	5.09	21.8	28.4	7.9	13.3	11.19	406	12.1
33	**Tartaruga**	0.895	0.77	28.47	1.0081	16.3	1.35	14.3	22.4	4.3	7.7	11.68	415	12.0
34	**Tempa rossa**	0.94	5.35	37.6	1.12	34.3	9.3	36.8	46.8	15.6	20.5	10.61	455	11.6
35	**Val'Dagri**	0.832	1.97	14.6	1.052	21.4	6	8.5	19.5	1.9	3.6	11.18	280	12.0
36	**Varandey**	0.85	0.63	14.9	0.990	15.1	1.7	7.6	13.5	1.1	2.0	11.90	336	12.1
37	**Western Desert**	0.8208	0.26	10.33	1.0524	24	1.31	17.9	24.7	2.0	3.8	11.14	266	12.0
	Min	0.7982	0.08	6.25	0.95	8.38	0.39	1.40	5.40	0.05	0.74	10.55	237	10.85
	Max	1.002	5.64	63.10	1.12	34.30	9.30	37.70	49.70	30.84	37.03	12.19	558	12.29

Table S12. μ-values obtained from ICrA evaluation of crude bulk properties and some characteristics of their vacuum residue fractions, and oil compatibility parameters.

μ	Crude D15	Crude S	> 540	VR SG	VR CCR	VR S	VR C7asp	VR C5asp	CO_C7 asp	CO_C5 asp	VR Kw	T50	Kw	SP (mod.)	SP cr. (mod.)	RCI (md.)	N-Heptane, wt.%	SBN/IN	SBN	IN	δCO
Crude D15	1.00	0.74	0.89	0.75	0.72	0.68	0.73	0.74	0.82	0.82	0.28	0.89	0.24	0.72	0.58	0.53	0.53	0.59	0.96	0.66	0.96
Crude S	0.74	1.00	0.79	0.84	0.85	0.92	0.82	0.82	0.81	0.81	0.19	0.71	0.30	0.67	0.61	0.42	0.42	0.47	0.73	0.68	0.73
> 540	0.89	0.79	1.00	0.76	0.73	0.72	0.76	0.75	0.84	0.84	0.25	0.89	0.31	0.65	0.53	0.54	0.53	0.59	0.89	0.64	0.89
VR SG	0.75	0.84	0.76	1.00	0.91	0.83	0.87	0.85	0.84	0.85	0.10	0.70	0.23	0.73	0.65	0.41	0.40	0.46	0.73	0.72	0.73
VR CCR	0.72	0.85	0.73	0.91	1.00	0.84	0.86	0.86	0.80	0.81	0.11	0.67	0.26	0.71	0.68	0.36	0.36	0.41	0.70	0.76	0.70
VR S	0.68	0.92	0.72	0.83	0.84	1.00	0.78	0.78	0.76	0.76	0.20	0.64	0.32	0.65	0.61	0.41	0.41	0.45	0.66	0.67	0.66
VR C7asp	0.73	0.82	0.76	0.87	0.86	0.78	1.00	0.95	0.82	0.83	0.18	0.69	0.26	0.70	0.65	0.41	0.41	0.46	0.72	0.70	0.72

VR C5asp	0.74	0.82	0.75	0.85	0.86	0.78	0.95	1.00	0.81	0.82	0.19	0.70	0.26	0.71	0.64	0.42	0.42	0.47	0.73	0.69	0.73
CO_C7 asp	0.82	0.81	0.84	0.84	0.80	0.76	0.82	0.81	1.00	0.96	0.19	0.78	0.24	0.71	0.62	0.46	0.45	0.51	0.80	0.71	0.80
CO_C5 asp	0.82	0.81	0.84	0.85	0.81	0.76	0.83	0.82	0.96	1.00	0.19	0.79	0.26	0.71	0.61	0.46	0.45	0.50	0.80	0.71	0.80
VR Kw	0.28	0.19	0.25	0.10	0.11	0.20	0.18	0.19	0.19	0.19	1.00	0.29	0.69	0.27	0.31	0.54	0.54	0.55	0.27	0.24	0.27
T50	0.89	0.71	0.89	0.70	0.67	0.64	0.69	0.70	0.78	0.79	0.29	1.00	0.32	0.64	0.50	0.55	0.54	0.60	0.91	0.63	0.91
Kw	0.24	0.30	0.31	0.23	0.26	0.32	0.26	0.26	0.24	0.26	0.69	0.32	1.00	0.03	0.28	0.43	0.43	0.44	0.24	0.34	0.24
SP (mod.)	0.72	0.67	0.65	0.73	0.71	0.65	0.70	0.71	0.71	0.71	0.27	0.64	0.03	1.00	0.68	0.48	0.47	0.51	0.72	0.63	0.72
SP cr. (mod.)	0.58	0.61	0.53	0.65	0.68	0.61	0.65	0.64	0.62	0.61	0.31	0.50	0.28	0.68	1.00	0.18	0.18	0.22	0.56	0.79	0.57
RCI (md.)	0.53	0.42	0.54	0.41	0.36	0.41	0.41	0.42	0.46	0.46	0.54	0.55	0.43	0.48	0.18	1.00	0.99	0.93	0.53	0.20	0.53
N-Heptane, wt.%	0.53	0.42	0.53	0.40	0.36	0.41	0.41	0.42	0.45	0.45	0.54	0.54	0.43	0.47	0.18	0.99	1.00	0.94	0.53	0.20	0.53
SBN/IN	0.59	0.47	0.59	0.46	0.41	0.45	0.46	0.47	0.51	0.50	0.55	0.60	0.44	0.51	0.22	0.93	0.94	1.00	0.59	0.26	0.59
SBN	0.96	0.73	0.89	0.73	0.70	0.66	0.72	0.73	0.80	0.80	0.27	0.91	0.24	0.72	0.56	0.53	0.53	0.59	1.00	0.65	1.00
IN	0.66	0.68	0.64	0.72	0.76	0.67	0.70	0.69	0.71	0.71	0.24	0.63	0.34	0.63	0.79	0.20	0.20	0.26	0.65	1.00	0.65
δCO	0.96	0.73	0.89	0.73	0.70	0.66	0.72	0.73	0.80	0.80	0.27	0.91	0.24	0.72	0.57	0.53	0.53	0.59	1.00	0.65	1.00

Table S13. υ-values obtained from ICrA evaluation of crude bulk properties and some characteristics of their vacuum residue fractions, and oil compatibility parameters.

υ	Crude D15	Crude S	> 540	VR SG	VR CCR	VR S	VR C7asp	VR C5asp	CO_C7 asp	CO_C5 asp	VR Kw	T50	Kw	SP (mod.)	SP cr. (mod.)	RCI (md.)	N-Heptane, wt.%	SBN/IN	SBN	IN	δCO
Crude D15	0.00	0.24	0.08	0.22	0.26	0.30	0.25	0.24	0.15	0.16	0.69	0.08	0.72	0.24	0.40	0.39	0.39	0.38	0.02	0.33	0.02
Crude S	0.24	0.00	0.19	0.13	0.13	0.06	0.17	0.16	0.16	0.17	0.78	0.27	0.67	0.30	0.37	0.49	0.49	0.50	0.24	0.30	0.25
> 540	0.08	0.19	0.00	0.20	0.25	0.26	0.22	0.22	0.13	0.13	0.72	0.08	0.65	0.31	0.44	0.38	0.38	0.38	0.09	0.34	0.09
VR SG	0.22	0.13	0.20	0.00	0.07	0.14	0.11	0.12	0.12	0.12	0.87	0.27	0.73	0.23	0.32	0.50	0.50	0.50	0.24	0.25	0.24

VR CCR	0.26	0.13	0.25	0.07	0.00	0.14	0.12	0.12	0.17	0.17	0.86	0.30	0.71	0.26	0.30	0.55	0.56	0.56	0.27	0.23	0.28
VR S	0.30	0.06	0.26	0.14	0.14	0.00	0.21	0.20	0.21	0.22	0.77	0.33	0.64	0.32	0.37	0.51	0.51	0.52	0.31	0.32	0.31
VR C7asp	0.25	0.17	0.22	0.11	0.12	0.21	0.00	0.04	0.16	0.15	0.79	0.29	0.70	0.26	0.33	0.51	0.51	0.52	0.26	0.29	0.26
VR C5asp	0.24	0.16	0.22	0.12	0.12	0.20	0.04	0.00	0.17	0.16	0.78	0.28	0.71	0.26	0.34	0.50	0.50	0.50	0.25	0.30	0.25
CO_C7 asp	0.15	0.16	0.13	0.12	0.17	0.21	0.16	0.17	0.00	0.02	0.77	0.18	0.71	0.24	0.35	0.45	0.45	0.45	0.16	0.27	0.16
CO_C5 asp	0.16	0.17	0.13	0.12	0.17	0.22	0.15	0.16	0.02	0.00	0.77	0.18	0.71	0.26	0.36	0.46	0.46	0.46	0.17	0.27	0.17
VR Kw	0.69	0.78	0.72	0.87	0.86	0.77	0.79	0.78	0.77	0.77	0.00	0.67	0.27	0.69	0.66	0.37	0.36	0.41	0.70	0.74	0.70
T50	0.08	0.27	0.08	0.27	0.30	0.33	0.29	0.28	0.18	0.18	0.67	0.00	0.64	0.32	0.47	0.37	0.37	0.36	0.06	0.35	0.06
Kw	0.72	0.67	0.65	0.73	0.71	0.64	0.70	0.71	0.71	0.71	0.27	0.64	0.00	0.97	0.68	0.47	0.47	0.51	0.72	0.63	0.72
SP (mod.)	0.24	0.30	0.31	0.23	0.26	0.32	0.26	0.26	0.24	0.26	0.69	0.32	0.97	0.00	0.28	0.43	0.43	0.44	0.24	0.34	0.24
SP cr. (mod.)	0.40	0.37	0.44	0.32	0.30	0.37	0.33	0.34	0.35	0.36	0.66	0.47	0.68	0.28	0.00	0.74	0.73	0.74	0.41	0.19	0.41
RCI (md.)	0.39	0.49	0.38	0.50	0.55	0.51	0.51	0.50	0.45	0.46	0.37	0.37	0.47	0.43	0.74	0.00	0.00	0.01	0.38	0.73	0.38
N-Heptane, wt.%	0.39	0.49	0.38	0.50	0.56	0.51	0.51	0.50	0.45	0.46	0.36	0.37	0.47	0.43	0.73	0.00	0.00	0.01	0.38	0.73	0.38
SBN/IN	0.38	0.50	0.38	0.50	0.56	0.52	0.52	0.50	0.45	0.46	0.41	0.36	0.51	0.44	0.74	0.01	0.01	0.00	0.38	0.72	0.38
SBN	0.02	0.24	0.09	0.24	0.27	0.31	0.26	0.25	0.16	0.17	0.70	0.06	0.72	0.24	0.41	0.38	0.38	0.38	0.00	0.33	0.00
IN	0.33	0.30	0.34	0.25	0.23	0.32	0.29	0.30	0.27	0.27	0.74	0.35	0.63	0.34	0.19	0.73	0.73	0.72	0.33	0.00	0.33
δCO	0.02	0.25	0.09	0.24	0.28	0.31	0.26	0.25	0.16	0.17	0.70	0.06	0.72	0.24	0.41	0.38	0.38	0.38	0.00	0.33	0.00

Table S14. μ-values obtained from ICrA evaluation for similarity of investigated 41 crude oils

Mu	Arab Light	Arabian Med	Basrah Light	Basrah Med.	Bonga	Cheleken	Kirkuk	REBCO	Rhemoura	Siberian Light	Vald'Agri
Albanian	0.226	0.276	0.364	0.393	0.341	0.240	0.226	0.273	0.261	0.251	0.215
Arab Light	1.000	0.917	0.803	0.753	0.650	0.718	0.908	0.722	0.737	0.733	0.902
Arabian Med	0.917	1.000	0.864	0.816	0.610	0.666	0.897	0.672	0.690	0.691	0.869
Arab Heavy	0.772	0.838	0.877	0.853	0.545	0.552	0.773	0.576	0.588	0.587	0.759
Aseng	0.596	0.538	0.435	0.408	0.832	0.828	0.575	0.833	0.821	0.820	0.592
Azery Light	0.675	0.617	0.508	0.487	0.822	0.903	0.661	0.879	0.895	0.907	0.677
Basrah Light	0.803	0.864	1.000	0.933	0.547	0.555	0.793	0.560	0.584	0.582	0.780
Basrah Med	0.753	0.816	0.933	1.000	0.539	0.527	0.762	0.541	0.559	0.558	0.752
Basrah heavy	0.599	0.670	0.774	0.818	0.464	0.411	0.623	0.458	0.457	0.455	0.602
Bonga	0.650	0.610	0.547	0.539	1.000	0.784	0.643	0.847	0.850	0.844	0.679
Boscan	0.228	0.288	0.396	0.423	0.295	0.160	0.241	0.241	0.203	0.187	0.228
Buzachi	0.467	0.510	0.574	0.606	0.746	0.636	0.491	0.710	0.684	0.672	0.498
Cheleken	0.718	0.666	0.555	0.527	0.784	1.000	0.698	0.868	0.880	0.891	0.707
CPC	0.694	0.638	0.518	0.472	0.639	0.744	0.675	0.686	0.700	0.718	0.677
El Bouri	0.599	0.605	0.573	0.568	0.831	0.714	0.604	0.808	0.781	0.767	0.613
El Sharara	0.747	0.686	0.580	0.539	0.765	0.857	0.736	0.791	0.824	0.839	0.762
Es Sider	0.769	0.719	0.621	0.595	0.728	0.806	0.772	0.759	0.781	0.786	0.780
Forties Blend	0.772	0.714	0.618	0.593	0.732	0.768	0.763	0.755	0.795	0.818	0.798
Helm	0.499	0.526	0.570	0.609	0.711	0.616	0.502	0.683	0.667	0.647	0.507
Iranian Heavy	0.749	0.752	0.696	0.692	0.734	0.720	0.755	0.787	0.767	0.759	0.743
Johan Sverdrup	0.621	0.584	0.539	0.536	0.900	0.735	0.610	0.811	0.808	0.798	0.637
Kazakh	0.669	0.621	0.541	0.528	0.825	0.828	0.647	0.883	0.879	0.864	0.648
KEBCO	0.833	0.804	0.730	0.705	0.782	0.786	0.831	0.793	0.811	0.818	0.854
Kirkuk	0.908	0.897	0.793	0.762	0.643	0.698	1.000	0.705	0.723	0.728	0.914
Kumkol	0.561	0.508	0.408	0.375	0.509	0.629	0.554	0.577	0.585	0.599	0.553

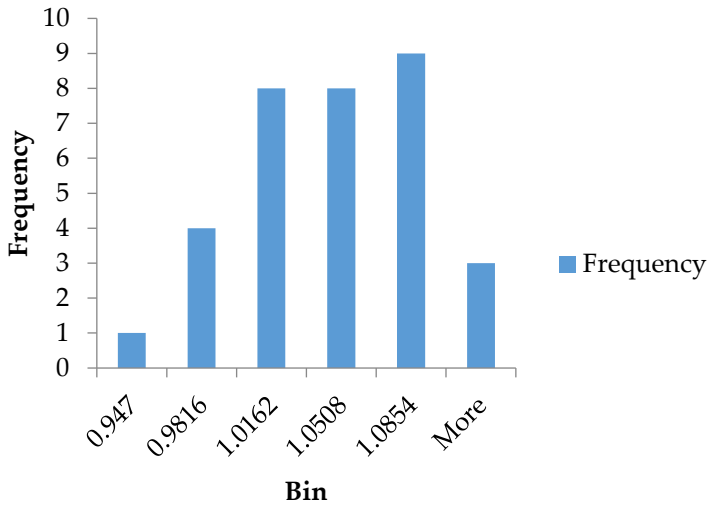
Kuwait Export	0.787	0.861	0.880	0.866	0.554	0.621	0.806	0.639	0.645	0.641	0.781
Okwuibome	0.697	0.666	0.639	0.641	0.826	0.717	0.700	0.720	0.745	0.759	0.733
Payara Gold	0.630	0.603	0.569	0.582	0.903	0.730	0.642	0.793	0.793	0.793	0.676
Prinos	0.601	0.613	0.701	0.689	0.604	0.539	0.602	0.593	0.583	0.559	0.592
Ras Gharib	0.409	0.475	0.582	0.619	0.414	0.286	0.430	0.364	0.346	0.318	0.407
REBCO	0.722	0.672	0.560	0.541	0.847	0.868	0.705	1.000	0.927	0.920	0.712
Rhemoura	0.737	0.690	0.584	0.559	0.850	0.880	0.723	0.927	1.000	0.952	0.738
Sepia	0.615	0.581	0.535	0.557	0.810	0.748	0.582	0.750	0.745	0.732	0.598
Siberian Light	0.733	0.691	0.582	0.558	0.844	0.891	0.728	0.920	0.952	1.000	0.746
SGC	0.654	0.637	0.594	0.623	0.697	0.681	0.642	0.760	0.760	0.746	0.661
Tartaruga Verde	0.613	0.574	0.547	0.569	0.838	0.685	0.591	0.754	0.745	0.729	0.618
Tempa Rossa	0.504	0.567	0.682	0.709	0.337	0.274	0.525	0.297	0.303	0.290	0.496
Vald'Agri	0.902	0.869	0.780	0.752	0.679	0.707	0.914	0.712	0.738	0.746	1.000
Varandey	0.725	0.681	0.582	0.557	0.840	0.866	0.727	0.876	0.897	0.922	0.742
Western Desert	0.759	0.692	0.592	0.559	0.785	0.843	0.737	0.824	0.861	0.879	0.767

Table S15. υ-values obtained from ICrA evaluation for similarity of investigated 41 crude oils

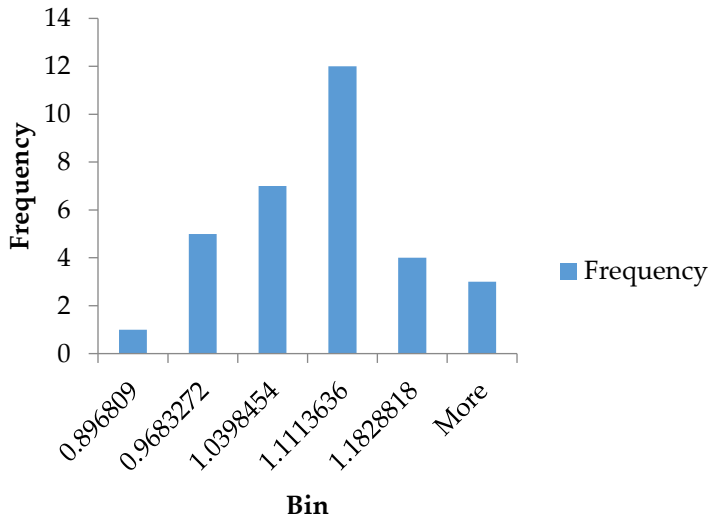
Nu	Arab Light	Arabian Med	Basrah Light	Basrah Med.	Bonga	Cheleken	Kirkuk	REBCO	Rhemoura	Sib. Light	Vald'Agri
Albanian	0.579	0.529	0.442	0.410	0.465	0.566	0.579	0.532	0.546	0.553	0.588
Arab Light	0.000	0.080	0.194	0.241	0.346	0.277	0.086	0.275	0.260	0.263	0.093
Arabian Med	0.080	0.000	0.133	0.180	0.387	0.331	0.098	0.325	0.308	0.306	0.127
Arab Heavy	0.224	0.159	0.119	0.141	0.450	0.442	0.221	0.421	0.409	0.409	0.236
Aseng	0.401	0.461	0.562	0.587	0.165	0.168	0.419	0.165	0.177	0.178	0.404
Azery Light	0.318	0.377	0.485	0.504	0.172	0.090	0.330	0.114	0.099	0.086	0.315
Basrah Light	0.194	0.133	0.000	0.061	0.449	0.440	0.201	0.436	0.414	0.415	0.215

Basrah Med	0.241	0.180	0.061	0.000	0.455	0.467	0.231	0.454	0.436	0.437	0.242
Basrah heavy	0.399	0.328	0.223	0.178	0.533	0.585	0.372	0.540	0.541	0.543	0.394
Bonga	0.346	0.387	0.449	0.455	0.000	0.211	0.350	0.150	0.147	0.152	0.316
Boscan	0.670	0.610	0.504	0.477	0.602	0.736	0.659	0.657	0.695	0.710	0.670
Buzachi	0.530	0.488	0.422	0.389	0.249	0.359	0.502	0.287	0.313	0.325	0.497
Cheleken	0.277	0.331	0.440	0.467	0.211	0.000	0.295	0.128	0.117	0.105	0.287
CPC	0.231	0.288	0.410	0.455	0.285	0.180	0.253	0.240	0.226	0.208	0.249
El Bouri	0.396	0.391	0.422	0.425	0.164	0.280	0.388	0.188	0.215	0.228	0.380
El Sharara	0.245	0.307	0.413	0.451	0.228	0.135	0.254	0.202	0.169	0.154	0.230
Es Sider	0.226	0.277	0.374	0.399	0.267	0.189	0.221	0.236	0.215	0.210	0.214
Forties Blend	0.224	0.283	0.379	0.402	0.264	0.227	0.230	0.242	0.202	0.179	0.197
Helm	0.499	0.472	0.428	0.387	0.287	0.381	0.493	0.316	0.332	0.352	0.490
Iranian Heavy	0.245	0.242	0.299	0.300	0.259	0.273	0.237	0.207	0.228	0.235	0.250
Johan Sverdrup	0.376	0.415	0.458	0.459	0.097	0.261	0.384	0.187	0.190	0.200	0.359
Kazakh	0.326	0.374	0.453	0.464	0.169	0.166	0.345	0.111	0.117	0.131	0.345
KEBCO	0.163	0.193	0.267	0.289	0.214	0.209	0.163	0.203	0.186	0.178	0.141
Kirkuk	0.086	0.098	0.201	0.231	0.350	0.295	0.000	0.289	0.272	0.266	0.079
Kumkol	0.111	0.163	0.264	0.296	0.166	0.046	0.117	0.094	0.087	0.074	0.120
Kuwait Export	0.208	0.135	0.115	0.127	0.441	0.373	0.186	0.357	0.351	0.355	0.213
Okwuibome	0.295	0.327	0.353	0.350	0.166	0.274	0.289	0.272	0.248	0.234	0.257
Payara Gold	0.367	0.395	0.428	0.413	0.094	0.266	0.353	0.205	0.205	0.205	0.320
Prinos	0.394	0.384	0.294	0.305	0.391	0.456	0.391	0.403	0.413	0.437	0.402
Ras Gharib	0.586	0.521	0.413	0.374	0.580	0.708	0.562	0.631	0.649	0.678	0.587
REBCO	0.275	0.325	0.436	0.454	0.150	0.128	0.289	0.000	0.071	0.077	0.283
Rhemoura	0.260	0.308	0.414	0.436	0.147	0.117	0.272	0.071	0.000	0.046	0.258
Sepia	0.379	0.414	0.458	0.435	0.182	0.244	0.408	0.244	0.249	0.262	0.394
Sib. Light	0.263	0.306	0.415	0.437	0.152	0.105	0.266	0.077	0.046	0.000	0.249

SGC	0.342	0.360	0.402	0.371	0.298	0.314	0.351	0.236	0.236	0.251	0.333
Tartaruga Verde	0.382	0.422	0.448	0.424	0.158	0.310	0.402	0.242	0.252	0.267	0.376
Tempa Rossa	0.487	0.424	0.309	0.280	0.654	0.716	0.463	0.695	0.689	0.701	0.493
Vald'Agri	0.093	0.127	0.215	0.242	0.316	0.287	0.079	0.283	0.258	0.249	0.000
Varandey	0.271	0.317	0.415	0.438	0.156	0.129	0.266	0.121	0.101	0.075	0.253
Western Desert	0.237	0.305	0.404	0.436	0.211	0.152	0.257	0.173	0.137	0.118	0.228



a



b

Figure S1. Histogram of vacuum residue fraction density (a), and that of vacuum residue density[2] (b)

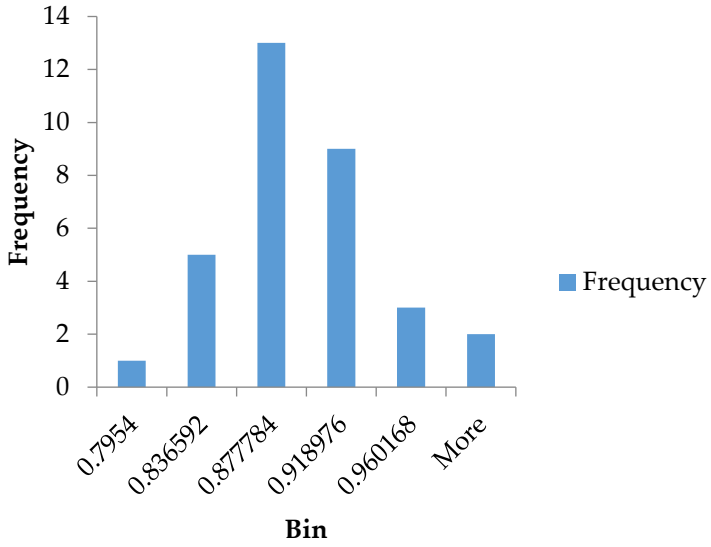
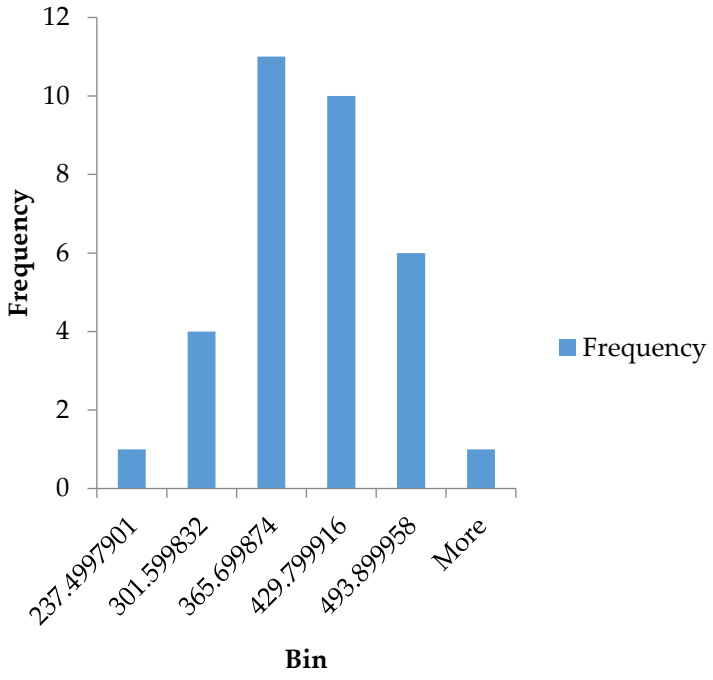


Figure S2. Histogram of crude oil density



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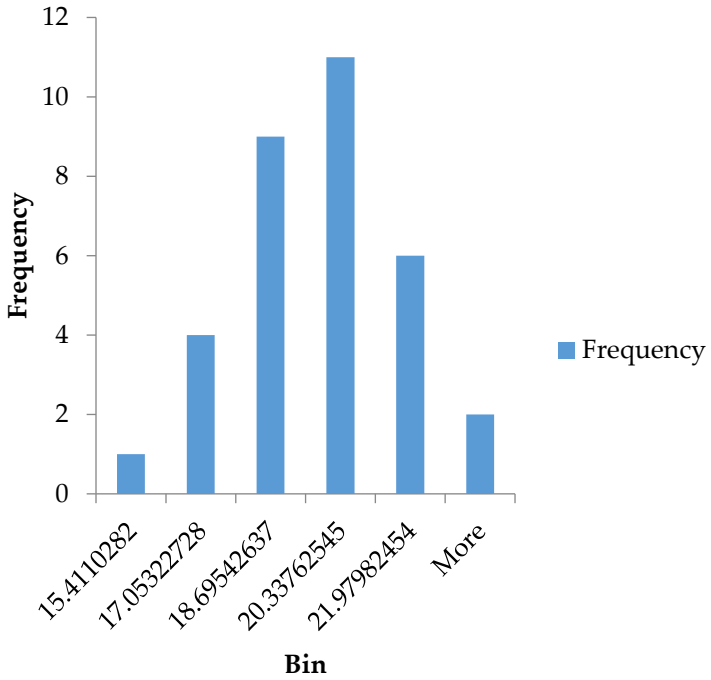
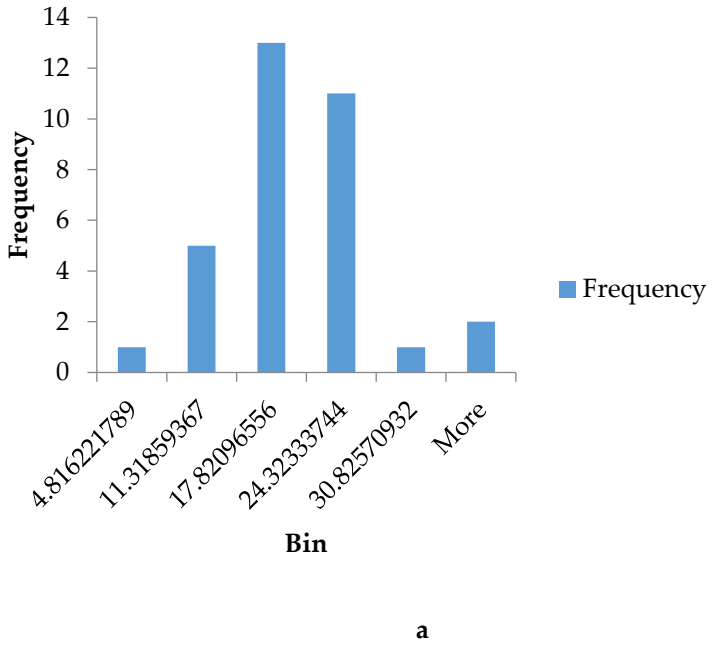
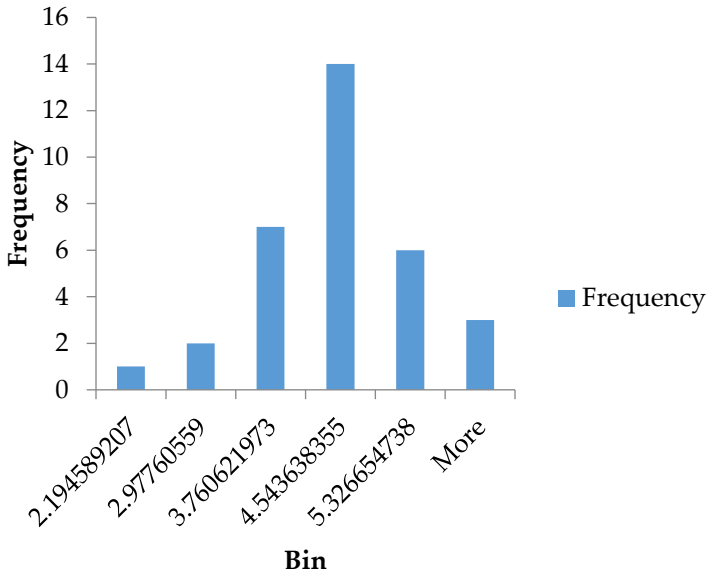


b

Figure S3. Histogram of crude oil T50% (a), and that of T50%^{2} (b)



a



b

Figure S4 Histogram of crude oil $S_{p\ critical}$ (a), and that of $S_{p\ critical}^{0.5}$ (b)