

TABLE 3.1
Composition of the Gas-To-Liquids (GTL) sample used in density and viscosity measurements

Component	Mole %	MW* g/mole	Density* g/cc @ 15.6 °C
H ₂ S	0.00	34.1	
CO ₂	0.00	44.0	
Methane	0.00	16.0	
Ethane	0.00	30.1	
Propane	0.95	44.1	
i-Butane	0.00	58.1	
n-Butane	6.19	58.1	
neo-Pentane	0.00	72.2	
i-Pentane	0.00	72.2	
n-Pentane	10.80	72.2	
C6	12.41	84.0	0.6900
C7	11.48	96.0	0.7270
C8	10.49	107.0	0.7490
C9	8.87	121.0	0.7680
C10	7.48	134.0	0.7820
C11	6.16	147.0	0.7930
C12	5.62	161.0	0.8040
C13	4.24	175.0	0.8150
C14	3.36	190.0	0.8260
C15	2.65	206.0	0.8360
C16	2.11	222.0	0.8430
C17	1.68	237.0	0.8510
C18	1.32	251.0	0.8560
C19	1.05	263.0	0.8610
C20	0.87	275.0	0.8660
C21	0.60	291.0	0.8710
C22	0.46	300.0	0.8760
C23	0.33	312.0	0.8810
C24	0.25	324.0	0.8850
C25	0.18	337.0	0.8880
C25+	0.45	367.1	0.8979
Total	100.00		

* Molecular weights and densities are from the generalized values of Katz and Firoozabadi (1978) and Whitson (1984).

TABLE 3.2

Composition of the crude oil sample used in density, viscosity, and gel strength measurements

Sample	Composition	Mol. Wt.	Density @ 15.6 °C
Components	Wt%	g/mole	g/cc
C2	0.009		
C3	0.167		
IC4	0.259		
NC4	0.954		
IC5	0.630		
NC5	0.967		
C6	1.836		
BENZENE	0.340		
C7	3.358		
TOLUENE	0.792		
C8	4.078	100.0	0.7576
C9	4.115	113.0	0.7759
C10	3.715	126.0	0.7897
C11	3.174	138.0	0.8064
C12	2.989	153.0	0.8287
C13	3.308	162.0	0.8335
C14	3.160	174.0	0.8490
C15	3.108	179.0	0.8609
C16	2.757	192.0	0.8672
C17	2.636	208.0	0.8710
C18	2.590	216.0	0.8780
C19	2.543	234.0	0.8846
C20	2.296	241.0	0.8981
C21	2.134	252.0	0.9015
C22	2.037	263.0	0.9062
C23	1.898	285.0	0.9085
C24	1.781	304.0	0.9108
C25	1.669	307.0	0.9138
C26	1.624	555.0 (C ₂₅₊)	0.9851 (C ₂₅₊)
C27	1.557		
C28	1.532		
C29	1.482		
C30+	34.506		
Total	100.000		

TABLE 3.3
Density of water.

Temp. °C	Density, g/ml	Temp. °C	Density, g/ml	Temp. °C	Density, g/ml
0.0	0.999840	21.0	0.997991	40.0	0.992212
3.0	0.999964	22.0	0.997769	45.0	0.990208
4.0	0.999972	23.0	0.997537	50.0	0.988030
5.0	0.999964	24.0	0.997295	55.0	0.985688
10.0	0.999699	25.0	0.997043	60.0	0.983191
15.0	0.999099	26.0	0.996782	65.0	0.980546
15.56	0.999012	27.0	0.996511	70.0	0.977759
16.0	0.998943	28.0	0.996231	75.0	0.974837
17.0	0.998774	29.0	0.995943	80.0	0.971785
18.0	0.998595	30.0	0.995645	85.0	0.968606
19.0	0.998404	35.0	0.994029	90.0	0.965305
20.0	0.998203	37.78	0.993042	100.0	0.958345

TABLE 3.4
Experimental density data* of tested crude oil, GTL, and their blends

Temperature °C	Crude:GTL (1:0)	Crude:GTL (3:1)	Crude:GTL (1:1)	Crude:GTL (1:3)	Crude: GTL (0:1)
Density g/cc					
23.8	-	-	-	-	0.7377
24.0	0.8987	-	-	-	-
24.1	-	0.8703	-	-	-
24.2	-	-	0.8385	-	-
24.4	-	-	-	0.7986	-
35.0	0.8911	0.8634	0.8315	0.7916	0.7282
40.0	0.8893	0.8618	0.8294	0.7891	0.7247
45.0	0.8880	0.8600	0.8282	0.7873	0.7224
50.0	0.8868	0.8583	0.8268	0.7853	0.7210
60.0	0.8844	0.8565	0.8257	0.7814	0.7197

* All measurements are at atmospheric pressure.

TABLE 3.5
Experimental viscosity data* of tested crude oil, GTL, and their blends

Temperature °C	ANSC:GTL (1:0)	ANSC:GTL (3:1)	ANSC:GTL (1:1)	ANSC:GTL (1:3)	ANSC:GTL (0:1)
Viscosity mPa.s					
20	17.30	6.80	4.10	2.30	1.30
30	10.80	5.30	3.00	1.90	1.10
40	7.70	4.30	2.30	1.60	0.96
50	6.40	3.70	1.90	1.40	0.81
60	5.50	3.40	1.70	1.30	0.68

* All measurements are at atmospheric pressure.

TABLE 3.6
Compositional data of GTL 1 sample by gas chromatography

Sample	Gas to liquids product (GTL)	25% Wax / 75% GTL	50% Wax/ 50% GTL
Components	Wt%	Wt%	Wt%
C2	0.002	0.003	0.003
C3	0.145	0.107	0.066
IC4	0.003	0.011	0.007
NC4	1.215	0.904	0.245
IC5	0.146	0.110	0.069
NC5	2.972	2.212	1.367
C6	7.826	5.800	3.901
BENZENE	0.003	0.002	0.001
C7	8.889	6.633	4.167
TOLUENE	0.029	0.022	0.016
C8	8.764	6.570	4.147
C9	8.539	6.384	4.071
C10	7.940	6.230	3.972
C11	7.290	5.607	3.989
C12	6.446	5.241	3.827
C13	5.748	4.908	3.854
C14	5.065	4.610	3.942
C15	4.414	4.367	4.101
C16	3.811	4.189	4.348
C17	3.273	4.096	4.699
C18	2.799	4.071	5.119
C19	2.389	4.070	5.522
C20	2.026	4.001	5.753
C21	1.705	3.795	5.674
C22	1.421	3.422	5.236
C23	1.165	2.914	4.511
C24	0.939	2.353	3.650
C25	0.747	1.816	2.804
C26	0.607	1.369	2.086
C27	0.583	1.094	1.584
C28	0.433	0.764	1.104
C29	0.247	0.458	0.710
C30+	2.418	1.866	5.457
Total	100.000	100.000	100.000

TABLE 3.7
Characteristics of the GTL 2 sample.

Analysis	Values
Density, kg/L @ 15 °o	0.7845
API Gravity @ 60 °F	54
Cetane No.	73.7
Sulfur content (% mass)	20 PPB
Aromatic (% v/v)	0.1
Saturates (% v/v)	99.8
Olefins (% v/v)	0.1
Flash Point (°C)	72
Cloud Point (°C)	3
Water & Sediment (%)	<0.02
Carbon Residue (% mass)	0.02
Ash (% mass)	<0.001
Viscosity (cSt @ 40 °C)	3.57
Corrosion	1A
Pour Point (°C)	0
Carbon/Hydrogen (% mass)	
Carbon	84.91
Hydrogen	14.94
Nitrogen	0.57
Residual	-1.09
Oxygen (by difference)	Negligible

TABLE 3.8
Compositional data of GTL 2 sample by gas chromatography

Carbon no.	n-Paraffin mole %	i-Paraffin mole %	Aromatic mole %	Napthene mole %	Olefin mole %
9	1.124	0.000	0.000	0.000	0.000
10	1.630	0.000	0.000	0.000	0.000
11	0.702	0.000	0.000	0.000	0.000
12	2.492	1.030	0.000	0.000	0.000
13	4.851	6.114	0.000	0.000	0.000
14	8.429	6.158	0.000	0.000	0.000
15	7.469	4.887	0.000	0.000	0.000
16	6.857	3.769	0.000	0.000	0.000
17	5.721	4.172	0.000	0.000	0.000
18	4.691	7.587	0.000	0.000	0.000
19	3.440	5.631	0.000	0.000	0.000
20	2.559	3.274	0.000	0.000	0.000
21	1.801	2.913	0.000	0.000	0.000
22	0.955	1.292	0.000	0.000	0.000
23	0.175	0.280	0.000	0.000	0.000
Total	52.895	47.105	0.000	0.000	0.000

TABLE 3.9
Compositional data for GTL 1 and crude oil blends

Sample	25:75 Wax/GTL 80g @ 320g oil	25:75 Wax/GTL 100g @ 300g oil	50:50 Wax/GTL 80g @ 320g oil	50:50 Wax/GTL 100g @ 300g oil	80g GTL @ 320g oil* (1:4)	100g GTL @ 300g oil* (1:3)
Components	Wt%	Wt%	Wt%	Wt%	Wt%	Wt%
C2	0.000	0.001	0.002	0.001	0.007	0.007
C3	0.033	0.050	0.088	0.069	0.162	0.161
IC4	0.128	0.149	0.210	0.160	0.207	0.195
NC4	0.734	0.832	0.951	0.797	1.006	1.019
IC5	0.502	0.508	0.568	0.484	0.533	0.509
NC5	1.098	1.195	1.074	1.015	1.368	1.468
C6	2.758	3.050	2.443	2.463	3.034	3.333
BENZENE	0.270	0.255	0.271	0.244	0.272	0.255
C7	3.904	4.060	3.509	3.476	4.465	4.741
TOLUENE	0.623	0.588	0.621	0.565	0.639	0.601
C8	4.572	4.662	4.111	4.092	5.015	5.249
C9	4.506	4.579	4.042	4.048	5.000	5.221
C10	4.121	4.202	3.696	3.737	4.560	4.771
C11	3.663	3.760	3.291	3.367	3.997	4.203
C12	3.403	3.490	3.112	3.208	3.681	3.853
C13	3.584	3.640	3.360	3.413	3.796	3.918
C14	3.421	3.492	3.293	3.367	3.541	3.636
C15	3.312	3.359	3.266	3.342	3.369	3.434
C16	3.042	3.105	3.083	3.194	2.968	3.021
C17	2.914	2.985	3.047	3.184	2.763	2.795
C18	2.919	2.991	3.145	3.292	2.632	2.642
C19	2.847	2.923	3.154	3.329	2.512	2.505
C20	2.653	2.747	3.050	3.230	2.242	2.229
C21	2.493	2.571	2.876	3.079	2.048	2.027
C22	2.324	2.409	2.711	2.894	1.913	1.883
C23	2.122	2.169	2.456	2.600	1.752	1.715
C24	1.909	1.948	2.180	2.286	1.613	1.571
C25	1.723	1.744	1.929	1.984	1.484	1.438
C26	1.572	1.592	1.718	1.757	1.421	1.370
C27	1.470	1.478	1.563	1.570	1.362	1.314
C28	1.375	1.378	1.437	1.422	1.313	1.258
C29	1.249	1.274	1.301	1.270	1.235	1.173
C30+	28.757	26.796	28.444	27.061	28.088	26.484
Total	100.000	100.000	100.000	100.000	100.000	100.000

* Values are calculated based on the measured GTL and TAPS crude oil composition.

TABLE 3.10
Compositional data for GTL 2 and crude oil blends

Sample	100g GTL @ 300g oil* (25% GTL+75% crude oil)	80g GTL @ 320g oil* (20% GTL+80% crude oil)
Components	Wt%	Wt%
C2	0.006	0.007
C3	0.125	0.133
IC4	0.194	0.207
NC4	0.716	0.763
IC5	0.472	0.504
NC5	0.725	0.773
C6	1.377	1.468
BENZENE	0.255	0.272
C7	2.519	2.687
TOLUENE	0.594	0.634
C8	3.058	3.262
C9	3.244	3.418
C10	3.040	3.175
C11	2.501	2.635
C12	2.898	2.916
C13	4.692	4.415
C14	5.535	5.060
C15	5.201	4.782
C16	4.699	4.311
C17	4.578	4.189
C18	5.359	4.805
C19	4.571	4.165
C20	3.524	3.279
C21	3.129	2.930
C22	2.291	2.240
C23	1.585	1.648
C24	1.336	1.425
C25	1.251	1.335
C26	1.218	1.299
C27	1.168	1.246
C28	1.149	1.226
C29	1.112	1.186
C30+	25.879	27.605
Total	100.000	100.000

* Values are calculated based on the measured GTL and TAPS crude oil composition.

TABLE 3.11
Yield stress data of GTL 1 and crude oil blends

Test sample (mixture reference)	Test number	Brookfield Viscometer Model	Temperature (°F)	Yield Point Maximum torque (dyne-cm)	Yield stress (dyne/cm ²)
(i)	14	RV	40	747	20.7
(i)	21	HB	20	26736	739
(i)	7	HB	9	>57496	>1589
(ii)	13	LV	40	>674	>18.6
(ii)	18	RV	40	2307	63.7
(ii)	22	HB	20	50079	1384
(ii)	6	HB	9	>57496	>1589
(iii)	12	LV	60	2.69	0.07
(iii)	15	RV	40	>7187	>199
(iii)	16	HB	40	19491	539
(iii)	5	HB	9	>57496	>1589
(iv)	11	HB	60	0.0	0
(iv)	17	HB	40	43122	1192
(iv)	23	HB	20	>57496	>1589
(iv)	4	HB	9	>57496	>1589
(v)	20	HB	20	2587	71
(v)	1	RV	9	>7187	>199
(v)	2	HB	9	13167	364
(v)	10	HB	0	24206	669
(vi)	19	HB	20	3335	92
(vi)	3	HB	9	8279	229
(vi)	8	HB	9	15869	438
(vi)	9	HB	0	22366	618