

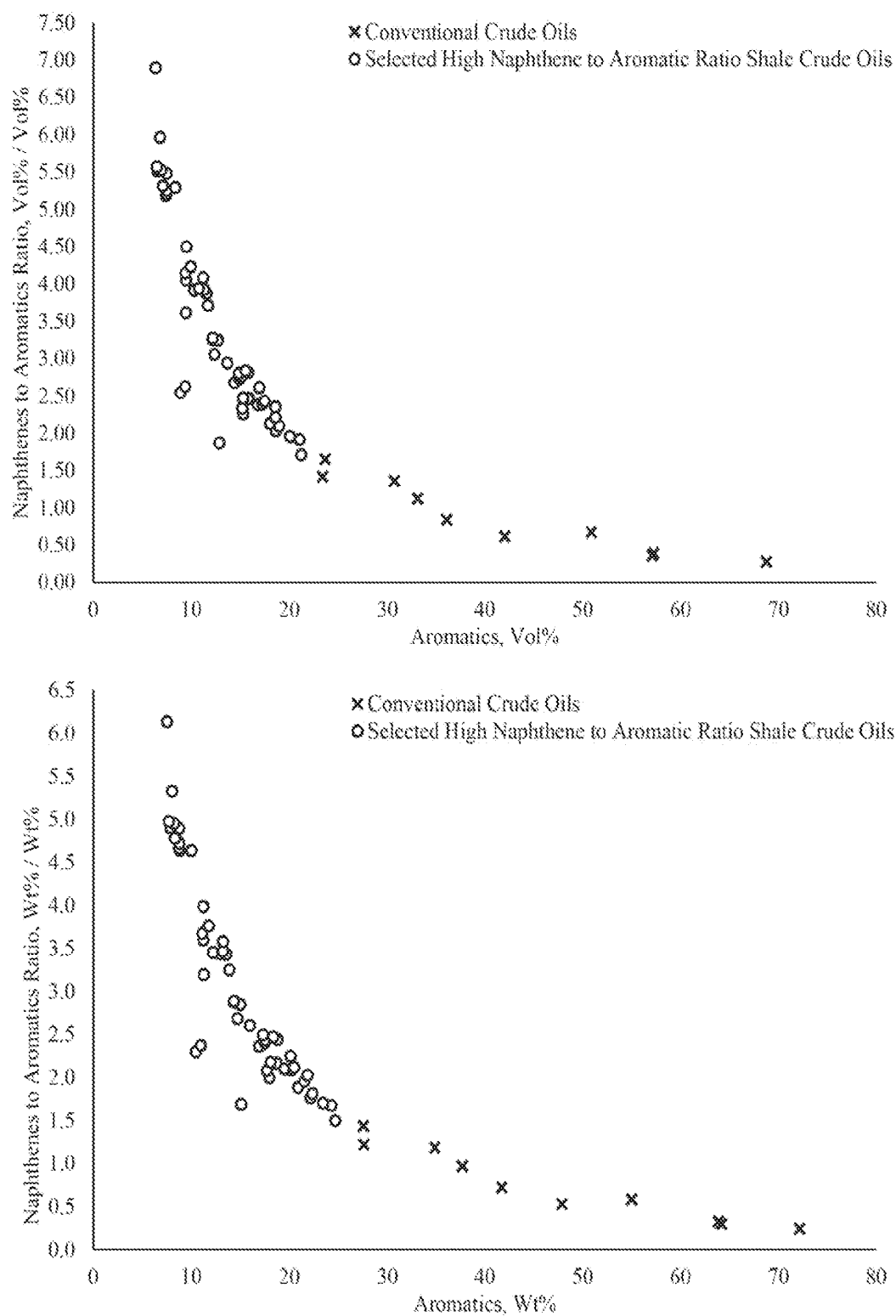


FIG. 1

SUBSTITUTE SHEET (RULE 26)

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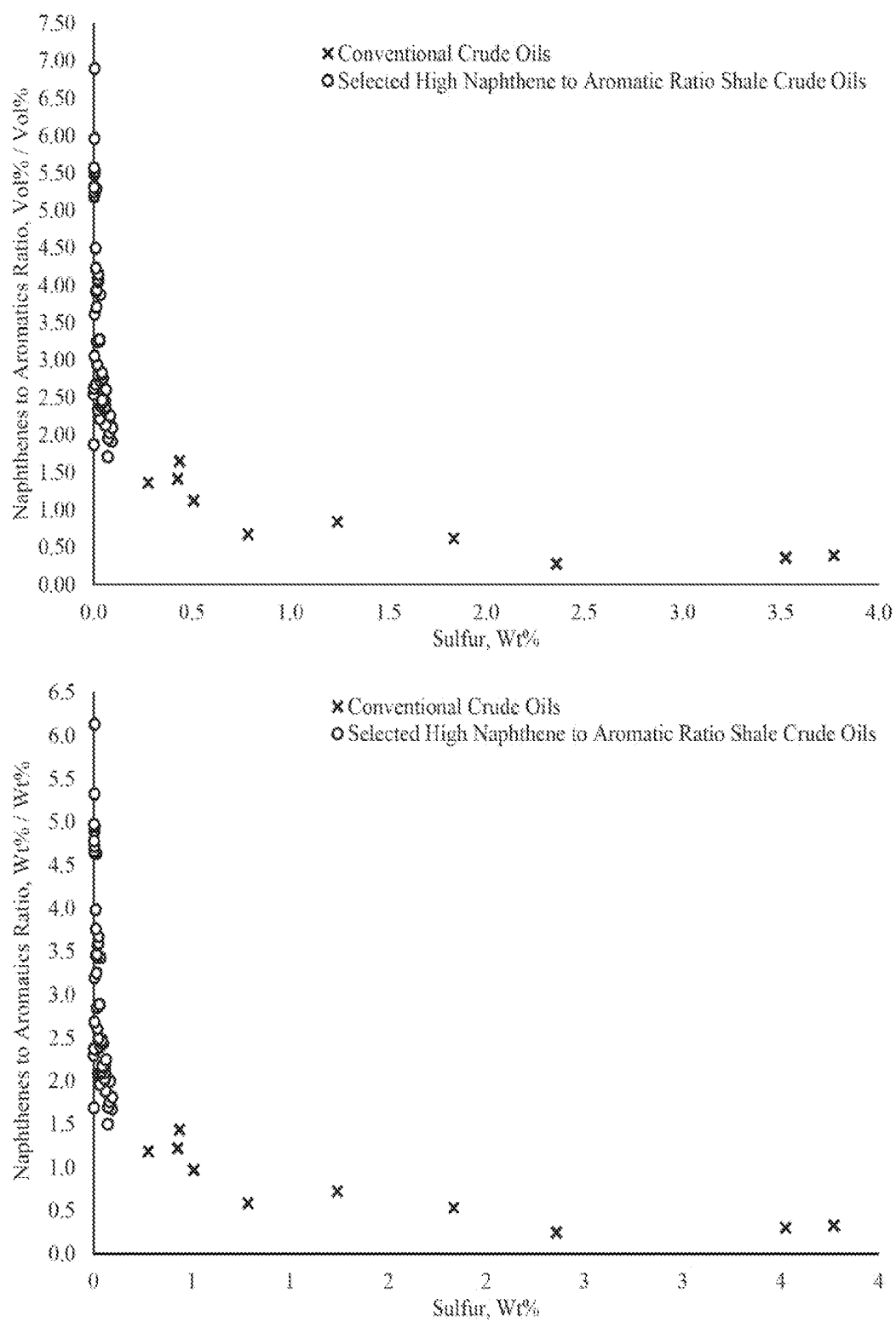


FIG. 2

SUBSTITUTE SHEET (RULE 26)

Boiling Point Range	°C	-	-	166 - 352	166 - 352	-
Property		ASTM D975 Diesel No. 2 S15	ASTM D396 Fuel Oil No. 2 S500	ISO 8217 DMA ECA Sulfur Level	Selected High Naphthene to Aromatics Ratio Shale Diesels Min - Max	Conventional Diesels Min - Max ULSD (Meas.)
Number of Diesel Samples					53	9
Distillation Temperature						
10% Vol Recovered	°C				185.2 - 204.9	201.3 - 237.2
90% Vol Recovered	°C	282 - 338	282 - 338		256.6 - 314.5	311.5 - 320.8
KV at 40°C	mm ² /s	1.9 - 4.1	1.9 - 4.1	2.000 - 6.000	1.7 - 2.4	2.3 - 4.5
Sulfur, Max	wt%	0.0015, Max	0.05, Max	0.1, Max	0.00049 - 0.04851	0.15077 - 1.70721
Density at 15 °C	kg/m ³	-	876, Max	890.0, Max	786 - 831	826 - 886
Cetane Index	-	40, Min		40, Min	49.5 - 60.7	35.4 - 51.3
Composition						
n-Paraffins	wt%				14.3 - 34.5	0.8 - 16.3
i-Paraffins	wt%				18.1 - 41.9	9.5 - 25.2
Cyclo-Paraffins (Naphthenes)	wt%				21.7 - 53.4	30.7 - 51.8
Aromatics	wt%	35 vol%, Max			5.9 - 17.6	18.2 - 40.4
Saturated Hydrocarbons (n-Paraffins + i-Paraffins + Cyclo-Paraffins)	wt%				82.4 - 94.1	56.8 - 81.4
Cyclic Hydrocarbons (Aromatic + Naphthenes)	wt%				29.2 - 67.1	58.1 - 83.9
Naphthenes to Aromatic Ratio	wt% /wt%				2.5 - 7.7	0.8 - 2.2
Cetane Index to Aromatics Ratio	-				2.8 - 9.7	1.0 - 2.8

* Measured ULSD values based on Vol%

FIG. 3

Boiling Point Range	Unit	166 – 352 °C Selected High Naphthene to Aromatics Ratio Shale Diesels Min - Max	166 – 352 °C Min - Max	166 – 352 °C Min - Max
Property				
Number of Diesel Samples		53	15	9
Distillation Temperature				
10% Vol Recovered	°C	185.2 – 204.9	199.5 – 204.2	201.3 – 237.2
50% Vol Recovered	°C	202.8 – 252.6	241.4 – 252.9	244.2 – 286.4
90% Vol Recovered	°C	256.6 – 314.5	310.6 – 313.8	311.5 – 320.8
Density	g/cm ³	0.786 – 0.831	0.808 – 0.844	0.826 – 0.886
KV at 40°C	mm ² /s	1.67 – 2.45	2.19 – 2.49	2.34 – 4.46
Cetane Index	-	49.5 – 60.7	44.8 – 57.2	35.4 – 51.3
Sulfur	wppm	4.9 – 485.1	21.3 – 2943.2	1507.7 – 17072.1
Aliphatic Sulfur	wppm	4.9 – 224.0	6.8 – 1441.4	527.9 – 8094.2
Aliphatic Sulfur to Sulfur Ratio	wppm / wppm	0.17 – 1.00	0.11 – 1.00	0.33 – 0.50
Nitrogen	wppm	0.7 – 45.9	2.8 – 44.5	27.9 – 174.4
Basic Nitrogen	wppm	0.1 – 20.5	0.6 – 19.1	12.3 – 69.6
Basic Nitrogen to Nitrogen Ratio	wppm / wppm	0.1 – 1.0	0.19 – 0.49	0.39 – 0.64
Aromatics	wt%	5.9 – 17.6	6.4 – 28.1	18.2 – 40.4
Paraffins	wt%	32.8 – 70.8	33.5 – 50.7	10.3 – 41.5
Naphthenes	wt%	21.7 – 53.4	33.7 – 50.6	30.7 – 51.8
Cyclic Hydrocarbons (Aromatic + Naphthenes)	wt%	29.2 – 67.1	49.3 – 66.4	58.1 – 83.9
Saturated Hydrocarbons (Paraffins + Naphthenes)	wt%	82.4 – 94.1	71.7 – 93.6	56.8 – 81.4
Naphthenes to Aromatics Ratio	wt% / wt%	2.5 – 7.7	1.3 – 6.9	0.8 – 2.2
Cetane Index to Aromatics Ratio	-	2.8 – 9.7	1.6 – 8.9	1.0 – 2.8

FIG. 4

Boiling Point Range	Unit	279-371 °C Selected High Naphthene to Aromatics Ratio Min - Max	279-371 °C Other Shale Diesels Min - Max	279-371 °C Conventional Diesels Min - Max
Property				
Number of Diesel Samples		56	12	9
Distillation Temperature		-	-	-
10% Vol Recovered	°C	288.5 - 298.0	295.3 - 296.9	295.2 - 301.0
50% Vol Recovered	°C	296.4 - 316.7	313.0 - 315.4	312.5 - 322.0
90% Vol Recovered	°C	319.7 - 340.8	339.9 - 340.8	339.5 - 343.2
Density	g/cm ³	0.821 - 0.838	0.845 - 0.871	0.857 - 0.918
KV at 40°C	mm ² /s	3.71 - 6.21	4.63 - 6.35	5.85 - 11.39
Cetane Index	-	60.2 - 76.3	54.2 - 66.4	36.6 - 60.6
Sulfur	wppm	9.2 - 983.3	35.0 - 5345.7	3311.6 - 23532.2
Aliphatic Sulfur	wppm	9.1 - 397.3	35.0 - 1864.2	938.0 - 9077.1
Aliphatic Sulfur to Sulfur Ratio	wppm / wppm	0.15 - 1.0	0.09 - 1.00	0.26 - 0.53
Nitrogen	wppm	1.4 - 154.5	42.1 - 184.7	97.6 - 357.2
Basic Nitrogen	wppm	0.5 - 62.8	13.5 - 59.9	44.8 - 202.3
Basic Nitrogen to Nitrogen Ratio	wppm / wppm	0.12 - 1.0	0.17 - 0.42	0.4 - 0.65
Aromatics	wt%	4.6 - 19.9	13.87 - 28.61	23.6 - 42.5
Paraffins	wt%	27.2 - 63.4	27.9 - 42.9	7.4 - 33.9
Naphthenes	wt%	26.4 - 61.2	37.2 - 52.4	30.2 - 45.9
Cyclic Hydrocarbons (Aromatic + Naphthenes)	wt%	36.6 - 72.5	57.0 - 71.9	65.2 - 85.2
Saturated Hydrocarbons (Paraffins + Naphthenes)	wt%	79.7 - 95.3	70.9 - 85.6	50.1 - 75.5
Naphthenes to Aromatics Ratio	wt% / wt%	2.5 - 13.0	1.4 - 3.8	0.7 - 1.8
Cetane Index to Aromatics Ratio	-	3.1 - 15.8	1.9 - 4.8	0.9 - 2.6

FIG. 5

Boiling Point Range	Unit	232-371 °C	232-371 °C	232-371 °C
Property		Crude 78 Straight Run Diesel	Crude 79 Straight Run Diesel	Crude 80 Straight Run Diesel
Density at 15.6°C	g/mL	0.8458	0.8325	0.8316
D86 Equivalent T10	°C	269	278	277
D86 Equivalent T50	°C	293	300	298
D86 Equivalent T90	°C	331	341	337
Cetane Index	-	58.50	67.60	67.50
Hydrogen content	mass%	13.24	13.72	13.76
Derived Cetane Number	-	56.44	65.83	65.28
Cloud Point	°C	-5	0	-3
Paraffin Content	wt%	32.78	39.15	39.53
Naphthene Content	wt%	41.54	45.07	45.47
Aromatic Content	wt%	25.68	15.78	14.99
Naphthenes / Aromatics Ratio	wt%/wt%	1.62	2.86	3.03
Saturates Content (Naphthenes + Paraffins)	wt%	74.32	84.22	85.00
Cyclics Content (Naphthenes + Aromatics)	wt%	67.22	60.85	60.46
Pour Point	°C	-10	-5	-8
Mini Flash Point, Continuous Closed Cup	°C	113.5	116.5	115.5
CFPP	°C	-8.00	-5.00	-7.00
Kinematic Viscosity at 40°C	cSt	3.86	4.23	4.18
Sulfur Content	mg/kg	456	289	293
Aliphatic Sulfur Content	mass%	0.029	0.037	0.04
Aliphatic Sulfur/Non-Aliphatic Sulfur Ratio	wppm/ wppm	0.64	1.28	1.37
Nitrogen Content	wppm	56.00	47.30	39.30
Basic Nitrogen Content	wppm	26	24	23
Basic Nitrogen/Nitrogen Ratio	wppm/ wppm	0.46	0.51	0.59
Cetane Index to Aromatics Ratio	-	2.3	4.3	4.5
Derived Cetane Number to Aromatics Ratio	-	2.2	4.2	4.4

FIG. 6

Boiling Point Range	°C		295-360	288-371	177-371	177-371	177-371
		ASTM D975, No.2 S15	Diesel 1 *HDT	Diesel 2 *HDT	Diesel 3 *HDT	Diesel 4 *HDT	Diesel 5 *HDT
Density at 15.6 °C	g/ml		0.8336	0.8332	0.8186	0.8175	0.8189
API Gravity	-			38.1	41.2	41.4	41.1
Sulfur Content	mg/kg	Max, 15	1.4	1.5	0.5	0.3	0.6
Nitrogen Content	mg/kg		0.3	0.3	0.6	<0.2	<0.2
Cloud Point	°C		6	8	-8	-4	-13
Pour Point	°C		2	2	-18	-14	-23
Freeze Point	°C		8	8.1	-5.6	-3.5	-10.2
Smoke Point	mm		25.3		28.1	28.7	
Derived Cetane Number	-	Min, 40	68.7	-	60.6	60.9	-
Cetane Index	-	Min, 40	74.7	73.8	57.8	58.1	57.4
Net Heat of Combustion	MJ/kg		42.9	43.0	43.1	43.1	-
Volumetric Heating Value	MJ/liter		35.8	35.8	35.3	35.2	-
GC Distillation							
Temperature, 10% off	°C		294	290	194	193	196
Temperature, 50% off	°C		329	328	267	267	265
Temperature, 90% off	°C	282 - 338	359	371	350	352	347
Composition							
Paraffins	wt%		43.49	43.07	40.63	40.16	41.67
1-Ring Naphthenes	wt%		19.48	18.22	19.86	20.71	23.18
1-Ring Aromatics	wt%		14.51	14.03	12.53	11.77	18.13
Multi Ring Aromatics			5.37	6.71	2.68	2.71	4.59
Total Naphthenes	wt%		36.63	36.19	44.16	45.36	35.60
Total Aromatics	wt%	Max, 35	19.88	20.74	15.21	14.48	22.72
Saturated Hydrocarbons (Paraffins + Naphthenes)	wt%		80.12	79.26	84.79	85.52	77.27
Cyclic Hydrocarbons (Aromatics + Naphthenes)	wt%		56.51	56.93	59.37	59.84	58.32
Naphthenes to Aromatics Ratio	wt% / wt%		1.8	1.7	2.9	3.1	1.6
Cetane Index to Aromatics Ratio	-		3.8	3.6	3.8	4.0	2.5
Derived Cetane Number to Aromatics Ratio	-		3.5	-	4.0	4.2	-

*Sample hydrotreated

FIG. 7

SUBSTITUTE SHEET (RULE 26)

		ASTM D975, No.2 S15	EN 590			
Boiling Point Range	°C			288-371	177-371	177-371
	Units			Diesel 2A *HDT and **ASAT	Diesel 3A *HDT and **ASAT	Diesel 4A *HDT and **ASAT
Density at 15.6 °C	g/ml		Max, 0.845 Min, 0.820	0.8264	0.8127	0.8123
API Gravity	-			39.5	42.4	42.5
Sulfur Content	mg/kg	Max, 15	Max, 10	<0.2	0.2	0.2
Nitrogen Content	mg/kg			<0.2	<0.2	<0.2
Cloud Point	°C			8	-7	-7
Pour Point	°C			2		
Freeze Point	°C			8.0		
Smoke Point	mm				35.6	35.4
Derived Cetane Number	-	Min, 40	Min, 51	82.2	67.4	67.2
Cetane Index		Min, 40	Min, 46	75.8	60.5	60.2
Net Heat of Combustion	MJ/kg			43.0	43.2	43.2
Volumetric Heating Value	MJ/liter			35.5	35.1	35.1
GC Distillation						
Temperature, 10% off	°C			284	196	194
Temperature, 50% off	°C			323	267	266
Temperature, 90% off	°C	282 - 338	360 (Max, 95%)	367	351	352
Composition						
Paraffins	wt%			45.17	42.69	42.60
1-Ring Naphthenes	wt%			29.40	28.56	28.58
1-Ring Aromatics	wt%			0.00	0.00	0.00
Multi Ring Aromatics				0.00	0.00	0.00
Total Naphthenes	wt%			54.83	57.31	57.40
Total Aromatics	wt%	Max, 35	Max, 8 (Polycyclic)	0.00	0.00	0.00
Saturated Hydrocarbons	wt%			100	100	100
Cyclic Hydrocarbons	wt%			54.83	57.31	57.4
Naphthenes to Aromatics Ratio	wt%/wt%			∞	∞	∞
Cetane Index to Aromatics Ratio	-			∞	∞	∞

*Sample hydrotreated

**Sample exposed to aromatic saturation conditions

FIG. 8

SUBSTITUTE SHEET (RULE 26)

Boiling Point Range	°C	177-371	288-371	177-371	288-371
	Units	Diesel 6 *HDT and **ASAT	Diesel 7 *HDT and **ASAT	Diesel 8 *HDT and **ASAT	Diesel 9 *HDT and **ASAT
Density at 15.6 °C	g/ml	0.79	0.81	0.79	0.81
API Gravity	-	48.2	43.7	47.6	42.2
Sulfur Content	mg/kg		0.2	<0.2	0.2
Nitrogen Content	mg/kg	<0.2	<0.2	<0.2	<0.2
Cloud Point	°C	-9.6	5.5	-9.6	3.9
Smoke Point	mm	25.2	27.7	24.1	24.6
Cetane Index	-	62.3	87.9	60.9	81.8
GC Distillation					
Temperature, 10% off	°C	187.9	286.7	188.7	286.0
Temperature, 50% off	°C	229.7	321.9	229.8	318.1
Temperature, 90% off	°C	316.4	359.9	319.3	359.7
Composition					
Paraffins	wt%	65.83	80.9	65.20	70.8
Total Naphthenes	wt%	27.90	12.7	24.85	19.2
Total Aromatics	wt%	6.27	6.4	9.95	10.0
Saturated Hydrocarbons	wt%	93.7	93.6	90.1	90.0
Cyclic Hydrocarbons	wt%	34.2	19.1	34.8	29.2
Naphthenes to Aromatics Ratio	wt%/wt%	4.4	2.0	2.5	1.9
Cetane Index to Aromatics Ratio	-	9.9	13.7	6.1	8.2

*Modeled sample exposed to hydrotreating conditions

**Modeled sample exposed to aromatic saturation conditions

FIG. 9

SUBSTITUTE SHEET (RULE 26)

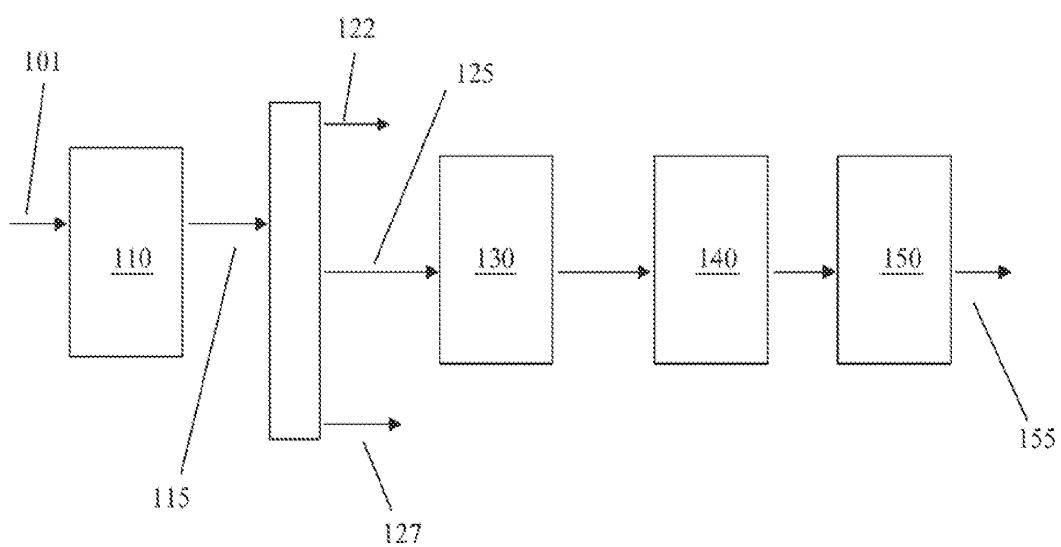


FIG. 10

Properties	Unit	Crude 78 Diesel *HDT	Crude 78 Diesel *HDT + **ASAT	Crude 78 Diesel *HDT + †Cat Dewax + **ASAT	Crude 79 Diesel *HDT + †Cat Dewax + **ASAT
Distillation Temperature	-				
D86 Equivalent T10	°C	271	274	283	277
D86 Equivalent T50	°C	293	292	296	293
D86 Equivalent T90	°C	329	329	328	335
Kinematic Viscosity at 40 °C	cSt	3.98	4.11	4.40	4.23
Sulfur Content	wppm	2.9	0.4	0.5	<0.2
Nitrogen Content	wppm	<0.2	<0.2	<0.2	<0.2
Density at 15.6 °C	g/mL	0.8323	0.8296	0.8316	0.8235
Cetane Index (D4737 Proc A)	-	65.29	67.97	68.07	70.78
Derived Cetane Number	-	62.25	65.51	64.11	66.80
Cloud Point	°C	-5	-6	-13	-19
Composition					
Paraffins	wt%	35.82	36.24	35.90	40.50
Naphthenes	wt%	51.51	56.43	55.58	53.73
Aromatics	wt%	12.67	7.33	8.52	5.77
Saturated Hydrocarbons	wt%	87.33	92.67	91.48	94.23
Cyclic Hydrocarbons (Aromatic + Naphthenes)	wt%	64.18	63.76	64.1	59.5
Naphthene to Aromatics Ratio	wt% / wt%	4.07	7.70	6.52	9.31
Cetane Index to Aromatics Ratio	-	5.2	9.3	8.0	12.3
Derived Cetane Number to Aromatics Ratio	-	4.9	8.9	7.5	11.6

*Sample hydrotreated

**Sample exposed to aromatic saturation conditions

†Catalytic dewaxing

FIG. 11

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Property	Unit	Base Diesel	B100 RME	B7	B20	HVO	Blend A	Blend B
Cetane Number	-	52.5	53.7#	52.6#	52.7#	79.2	59.7	61.2
Cetane Index	-	55.6	-	-	-	93.9	62.8	62.1
Density at 15°C	g/mL	0.8342	0.8823	0.8374	0.8434	0.780	-	-
Density at 15.6°C	g/mL	-	-	-	-	-	0.8286	0.8338
Flash Point	°C	88	-	-	-	82.0	106.7	113.3
N-Paraffin Content	wt%	-	-	-	-	5.11	13.52	17.88
Isoparaffin Content	wt%	-	-	-	-	93.30	26.8	21.49
Total Paraffins Content	wt%	-	-	-	-	98.40	40.32	39.37
Total Naphthenes Content	wt%	-	-	-	-	0.44	52.09	54.17
Total Aromatics Content	wt%	30.6	0†	28.3†	24.2†	0.07	7.6	6.46
Multi Ring Aromatics Content	wt%	1.6	0†	1.5†	1.3†	0.00	0.33	0.28
Saturated Hydrocarbons (Naphthenes + Paraffins)	wt%	-	-	-	-	98.8	92.4	93.5
Cyclic Hydrocarbons (Naphthenes + Aromatics)	wt%	-	-	-	-	0.51	59.7	60.6
Naphthenes / Aromatics Ratio	wt%/wt%	-	-	-	-	6.3	6.9	8.4
Cetane Number to Aromatics Ratio	-	1.7	α†	1.9†	2.2†	1131	7.9	9.5
Cetane Index to Aromatics Ratio	-	1.8#	-	-	-	1341	8.3	9.6
Olefin Content	wt%	-	-	-	-	1.09	0	0
T10	°C	227.5	-	-	-	264.7	250.7	259.2
T50	°C	279.1	-	-	-	280.2	284.3	286.6
T90	°C	310.9	-	-	-	291.5	330.2	325.8
T95	°C	319.1	-	-	-	295.0	348.7	342
Carbon Content	wt%	-	-	-	-	-	85.87	86.1
Hydrogen Content	wt%	-	-	-	-	-	14.13	13.9
Net Heat of Combustion	MJ/kg	43.1	37.5	42.7	42.0	44.1	43.6	43.5
Volumetric Heating Value	MJ/liter	36.0	33.1	35.8	35.4	34.4	36.1	36.3
Kinematic Viscosity at 40°C	cSt	2.82	4.51	<4.5±	<4.5±	2.995	4.19	4.17
Sulfur Content	wppm	<3	<3	<3±	<3±	<3	0	0
FAME Content	Vol%	0†	100†	7†	20†	<0.10	0†	0†
Ester Content	%(m/m)	-	97.1	-	-	-	-	-

FIG. 12

		Tailpipe emissions				Engine out emissions		
	Fuel Consumption	CO ₂	CO	HC	NO _x	CO PR	HC PR	NO _x PR
Unit	liter/100 km	g/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Fuel								
1_Base Diesel	10.06	265.3	256.27	31.03	278.8	958.1	249.73	832.83
2_B7 Diesel	10.13	266.37	231.07	26.7	300.83	909.57	252.63	867
3_B20 Diesel	10.14	264.78	259.16	30.33	334.89	944.64	250.31	931.53
4_HVO	10.51	254.53	62.43	8.03	271.6	566.93	111.2	844.23
5_Blend_A	9.94	258.8	135.9	16.9	271.67	809.93	178.3	738.5
6_Blend_B	9.88	259.2	122.97	13.83	273.77	771.97	157.67	740.97

FIG. 13A

5_Blend_A Percent (%) Change versus Comparators±		Tailpipe emissions				Engine out emissions		
Comparator	Fuel Consumption	CO ₂	CO	HC	NO _x	CO PR	HC PR	NO _x PR
1_Base Diesel	1.2%	2.5%	47.0%	45.5%	2.6%	15.5%	28.6%	11.3%
2_B7 Diesel	1.9%	2.8%	41.2%	36.7%	9.7%	11.0%	29.4%	14.8%
3_B20 Diesel	2.0%	2.3%	47.6%	44.3%	18.9%	14.3%	28.8%	20.7%
4_HVO	5.4%	-1.7%	-117.7%	-110.5%	0.0%	-42.9%	-60.3%	12.5%

±Positive percentage (%) indicates that a result for Blend A is lower than the comparator. Negative (-) percentage indicates that a result for Blend B is higher than the comparator.

FIG. 13B

6_Blend_B Percent (%) Change versus Comparators±		Tailpipe emissions				Engine out emissions		
Comparator	Fuel Consumption	CO ₂	CO	HC	NO _x	CO PR	HC PR	NO _x PR
1_Base Diesel	1.8%	2.3%	52.0%	55.4%	1.8%	19.4%	36.9%	11.0%
2_B7 Diesel	2.5%	2.7%	46.8%	48.2%	9.0%	15.1%	37.6%	14.5%
3_B20 Diesel	2.6%	2.1%	52.6%	54.4%	18.3%	18.3%	37.0%	20.5%
4_HVO	6.0%	-1.8%	-97.0%	-72.2%	-0.8%	-36.2%	-41.8%	12.2%

±Positive percentage (%) indicates that a result for Blend A is lower than the comparator. Negative (-) percentage indicates that a result for Blend B is higher than the comparator

FIG. 13C

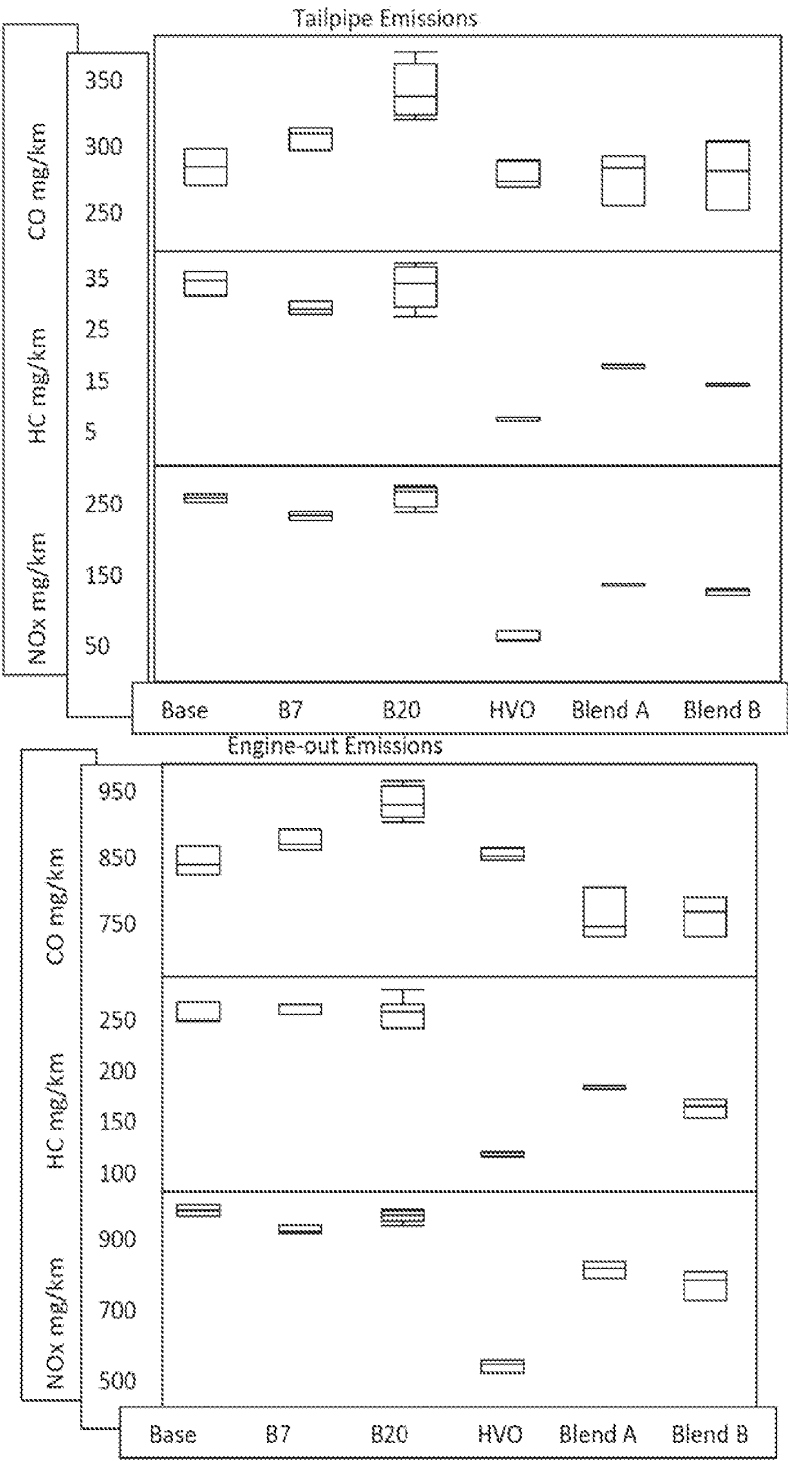


FIG. 14

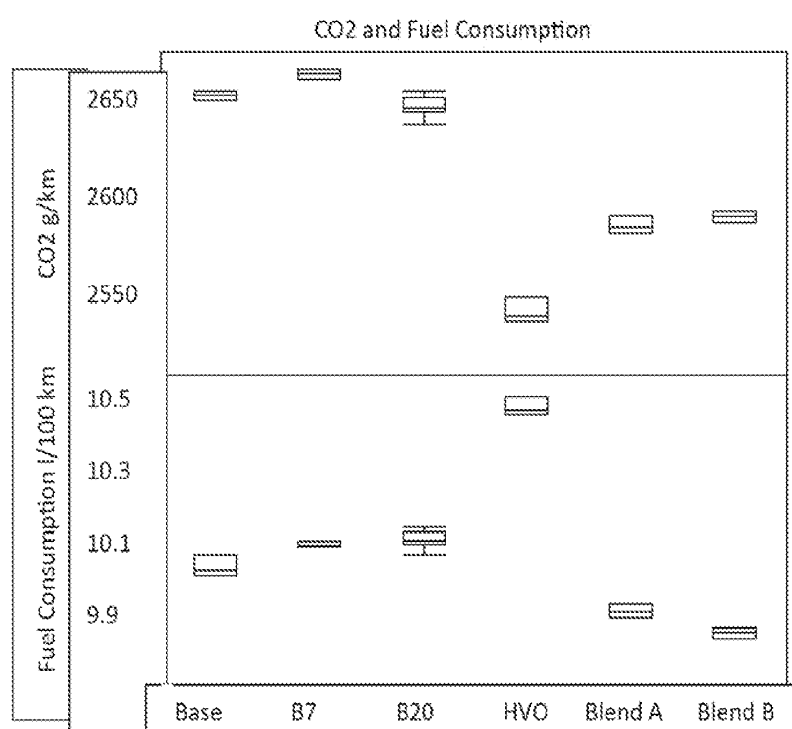


FIG. 15