

FIG. 1

Chemical Name	Relative Ignition Delay (Normalized to Isooctane)				
	Pure Isooctane 1.0000	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane					
Base Oil 1		1.0271	1.0380	1.0436	1.0487
Base Oil 2		1.0221	0.9765	0.9419	0.9134
Base Oil 3		1.0033	0.9298	0.8668	0.8051
Base Oil 4		1.0207	0.9914	0.9334	0.8855
Base Oil 5		0.8983	0.7901	0.7717	
Base Oil 6		0.8974	0.8450	0.8552	0.8706
Base Oil 7		0.8771	0.9508	1.0367	1.0710
Base Oil 8		1.0444	0.9203	0.8423	0.8492
Base Oil 9		0.9809	0.9048	0.8380	0.7938
Base Oil 10		0.9629	0.8547	0.8086	0.7697
Base Oil 11		0.9847	0.8776	0.7885	0.7401
Base Oil 12		0.9635	0.8528	0.7698	0.7017

FIG. 1 (Cont.)

Chemical Name	Relative Ignition Delay (Normalized to Isooctane)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	1.0000				
Base Oil 13		0.9875	0.8553	0.7555	0.6928
Base Oil 14		0.9460	0.8400	0.7653	0.7151
Base Oil 15		0.9769	0.8540	0.7458	0.6670
Base Oil 16		0.9668	0.8709	0.7618	0.6806
Base Oil 17		0.9807	0.8492	0.7458	0.6778
Base Oil 18		0.9766	0.8243	0.7157	0.6549
Base Oil 19		0.9797	0.7892	0.6678	0.6055
Base Oil 20		0.8287	0.7536	0.7136	0.6602
Base Oil 21		0.9422	0.7857	0.6681	0.5935
Base Oil 22		0.9631	0.7394	0.6576	0.5702
Base Oil 23		0.9554	0.7675	0.6521	0.5702
Base Oil 24		0.9573	0.7259	0.5829	0.5087

FIG. 1 (Cont.)

Chemical Name	Relative Ignition Delay (Normalized to Isooctane)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	1.0000				
Base Oil 25		0.9295	0.7569	0.6370	
Base Oil 26		0.9265	0.7237	0.5956	0.5189
Base Oil 27		0.9282	0.7148	0.5794	0.5074
Base Oil 28		0.9160	0.7048	0.5683	0.4958
Base Oil 29		0.8666	0.6502	0.5242	0.4559
Base Oil 30		0.8960	0.6376	0.4989	0.4359
Base Oil 31		0.8406	0.6033	0.4860	0.4217
Base Oil 32		0.9156	0.6906	0.5461	0.4754
Base Oil 33		0.9164	0.6916	0.5526	0.4805
Base Oil 34		0.8396	0.5402	0.4208	0.3566
Base Oil 35		0.7342	0.4758	0.3845	0.3298
Base Oil 36		0.6460	0.4569	0.3750	0.3225

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FIG. 2

Chemical Name	Relative Combustion Delay (Normalized to Isooctane)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	1.0000				
Base Oil 1		1.0052	0.9751	0.9166	0.8589
Base Oil 2		1.0207	0.9842	0.9355	0.8982
Base Oil 3		1.0281	0.9899	0.9417	0.8764
Base Oil 4		1.0025	0.9752	0.9060	0.8574
Base Oil 5		0.9743	0.8762	0.3804	
Base Oil 6		0.9845	0.9772	0.9825	0.9843
Base Oil 7		0.9776	0.9905	0.9589	0.9158
Base Oil 8		1.0292	0.8645	0.7594	0.7703
Base Oil 9		0.9947	0.8804	0.7656	0.6755
Base Oil 10		1.0067	0.9511	0.9196	0.8792
Base Oil 11		0.9703	0.7880	0.6145	0.4880
Base Oil 12		0.9900	0.8577	0.7161	0.6097

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FIG. 2 (Cont.)

Chemical Name	Relative Combustion Delay (Normalized to Isooctane)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	1.0000				
Base Oil 13		0.9862	0.8507	0.7153	0.6058
Base Oil 14		0.9628	0.8453	0.7411	0.6625
Base Oil 15		1.0031	0.8835	0.7727	0.6671
Base Oil 16		0.9858	0.9016	0.7887	0.7074
Base Oil 17		0.9781	0.8116	0.6549	0.5406
Base Oil 18		0.9820	0.8575	0.7382	0.6451
Base Oil 19		0.9794	0.8101	0.6733	0.5758
Base Oil 20		0.7320	0.6155	0.5444	0.4434
Base Oil 21		0.9449	0.7329	0.5646	0.4348
Base Oil 22		0.9515	0.6650	0.5371	0.3708
Base Oil 23		0.9444	0.6804	0.4596	0.3188
Base Oil 24		0.9300	0.7043	0.5064	

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FIG. 2 (Cont.)

Chemical Name	Relative Combustion Delay (Normalized to Isooctane)				
	Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane	1.0000				
Base Oil 25		0.94881	0.70959	0.52401	0.39666
Base Oil 26		0.9405	0.7018	0.5221	0.3849
Base Oil 27		0.9077	0.6506	0.4509	0.2984
Base Oil 28		0.9204	0.6317	0.4215	0.2753
Base Oil 29		0.9094	0.6084	0.4005	0.2546
Base Oil 30		0.9021	0.5764	0.3455	0.2094
Base Oil 31		0.8845	0.5990	0.3931	0.2588
Base Oil 32		0.9092	0.6240	0.3935	0.2592
Base Oil 33		0.9121	0.6385	0.4154	0.2777
Base Oil 34		0.9131	0.6621	0.4752	0.3299
Base Oil 35		0.9038	0.6984	0.5025	0.3449
Base Oil 36		0.8876	0.6851	0.4836	0.3257

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FIG. 3

Chemical Name	Observation	Relative Ignition Delay (Normalized to Isooctane)				
		Pure Isooctane	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane		1.0000				
Base Oil 1/Base Oil 4 (80/20)	Slightly Haze		1.0107	0.9944	0.9926	0.9854
Base Oil 1/Base Oil 4 (60/40)	Clear		1.0109	0.9894	0.9678	0.9499
Base Oil 1/Base Oil 4 (40/60)	Clear		1.0127	0.9840	0.9551	0.9193
Base Oil 1/Base Oil 4 (20/80)	Clear		1.0134	0.9858	0.9379	0.8976
Base Oil 1/Base Oil 8 (80/20)	Clear		1.0135	1.0084	1.0027	0.9997
Base Oil 1/Base Oil 8 (60/40)	Clear		1.0147	1.0092	0.9990	0.9918
Base Oil 1/Base Oil 8 (40/60)	Clear		0.9977	0.9946	0.9960	0.9946
Base Oil 1/Base Oil 8 (20/80)	Clear		1.0001	0.9921	0.9953	0.9894

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FIG. 4

Chemical Name	Observation	Relative Combustion Delay (Normalized to Isooctane)				
		Pure Isooctane 1.0000	1% in Isooctane	5% in Isooctane	10% in Isooctane	15% in Isooctane
Isooctane						
Base Oil 1/Base Oil 4 (80/20)	Slightly Haze		0.9869	0.9381	0.8859	0.8379
Base Oil 1/Base Oil 4 (60/40)	Clear		0.9917	0.9447	0.8869	0.8348
Base Oil 1/Base Oil 4 (40/60)	Clear		0.9850	0.9400	0.8858	0.8310
Base Oil 1/Base Oil 4 (20/80)	Clear		0.9916	0.9368	0.8806	0.8331
Base Oil 1/Base Oil 8 (80/20)	Clear		0.9962	0.9552	0.9104	0.8649
Base Oil 1/Base Oil 8 (60/40)	Clear		0.9998	0.9650	0.9271	0.8916
Base Oil 1/Base Oil 8 (40/60)	Clear		0.9835	0.9716	0.9433	0.9182
Base Oil 1/Base Oil 8 (20/80)	Clear		0.9946	0.9739	0.9602	0.9414

FIG. 5

	Base Oil 28	Base Oil 30	Base Oil 24	Base Oil 8
	Decene dimer	Decene trimer	2,6,10,15,19,23-Hexamethyltetracosane	Hydrocarbons, C4, 1,3-butadiene-free, polymd., pentaisobutylene fraction, hydrogenated
% Carbon as Quaternary Carbon*	0%	0%	0%	20%
% Carbon as CH*	10%	13.3%	20%	5%
% Carbon as CH2*	80%	66.7%	53.3%	20%
% Carbon as CH3*	20%	20%	26.7%	55%
Relative Combustion Delay (Normalized to Isooctane), 1% in Isooctane	0.9204	0.9021	0.9444	1.0292
Relative Combustion Delay (Normalized to Isooctane), 5% in Isooctane	0.6317	0.5764	0.6804	0.8645
Relative Combustion Delay (Normalized to Isooctane), 10% in Isooctane	0.4215	0.3455	0.4596	0.7594
Relative Combustion Delay (Normalized to Isooctane), 15% in Isooctane	0.2753	0.2094	0.3188	0.7703

*Estimated based on molecular structure

FIG. 5 (Cont.)

	Base Oil 4	Base Oil 5	Base Oil 6	Base Oil 7
	Hydrogenated Polyisobutene, Mn 370, Mw/Mn 1.30	Hydrogenated Polyisobutene, Mn 1300, Mw/Mn 1.65	Polyisobutene, Mn 440, Mw/Mn 1.80	2,6,10,15,19,23- Hexamethyl- 2,6,10,14,18,22- tetracosahexaene
% Carbon as Quaternary Carbon*	20%	25%	25%	20%
% Carbon as CH*	5%	0%	0%	20%
% Carbon as CH ₂ *	20%	25%	25%	33.3%
% Carbon as CH ₃ *	55%	50%	50%	26.7%
Relative Combustion Delay (Normalized to Isooctane), 1% in Isooctane	1.0025	0.9743	0.9845	0.9776
Relative Combustion Delay (Normalized to Isooctane), 5% in Isooctane	0.9752	0.8762	0.9772	0.9905
Relative Combustion Delay (Normalized to Isooctane), 10% in Isooctane	0.9060	0.3804	0.9825	0.9589
Relative Combustion Delay (Normalized to Isooctane), 15% in Isooctane	0.8574		0.9843	0.9158

*Estimated based on molecular structure

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FIG. 6

	Base Oil 23	Base Oil 19	Base Oil 18
	dipentaerythritol ester	dipentaerythritol ester of branched acids	dipentaerythritol ester of branched acids
% Carbon as Quaternary Carbon *	13%	15%	20%
% Carbon as CH *	1%	3%	0%
% Carbon as CH ₂ *	72%	48%	43%
% Carbon as CH ₃ *	14%	33%	37%
Relative Combustion Delay (Normalized to Isooctane), 1% in Isooctane	0.94881	0.9794	0.9820
Relative Combustion Delay (Normalized to Isooctane), 5% in Isooctane	0.70959	0.8101	0.8575
Relative Combustion Delay (Normalized to Isooctane), 10% in Isooctane	0.52401	0.6733	0.7382
Relative Combustion Delay (Normalized to Isooctane), 15% in Isooctane	0.39666	0.5758	0.6451

*Determined by DEPT (Distortionless Enhancement by Polarization Transfer) Carbon-13 NMR

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FIG. 6 (Cont.)

	Base Oil 2	Base Oil 10
	Monopentaerythritol ester of branched acids	dipentaerythritol ester of branched acids
% Carbon as Quaternary Carbon *	21%	23%
% Carbon as CH *	2%	0%
% Carbon as CH2 *	35%	31%
% Carbon as CH3 *	42%	45%
Relative Combustion Delay (Normalized to Isooctane), 1% in Isooctane	1.0207	1.0067
Relative Combustion Delay (Normalized to Isooctane), 5% in Isooctane	0.9842	0.9511
Combustion Delay (Normalized to Isooctane), 10% in Isooctane	0.9355	0.9196
Combustion Delay (Normalized to Isooctane), 15% in Isooctane	0.8982	0.8792

*Determined by DEPT (Distortionless Enhancement by Polarization Transfer) Carbon-13 NMR

FIG. 7

Components added to Base Oil 2	Insoluble	Soluble
2 wt% Molybdenum friction modifier		x
2.7 wt% Mixture of zinc dithiophosphates		x
1 wt% Phenolic antioxidant		x
3 wt% Mixture of conventional detergents for lubricants	x	
3.5 wt% Mixture of conventional dispersants based on polyisobutene	x	

Components added to Base Oil 1	Insoluble	Soluble
1.7 wt% Proprietary mixture of conventional detergents for lubricants	x	
0.5 wt% Conventional dispersants based on polyisobutene	x	
Components added to mixture of Base Oil 1: Base Oil 4 (50:50)		
1.0 wt% Proprietary mixture of conventional detergents for lubricants		x
3.0 wt% Conventional dispersants based on polyisobutene		x

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FIG. 8

	Example 1	Example 2	Example 3
Component and Method Description			
Mixture of molybdenum dithiophosphate, primary and secondary zinc dithiophosphates	14050535	14057560	14072729
Mixture of molybdenum dithiophosphate, and secondary zinc dithiophosphates	3.7	3.7	3.7
Corrosion inhibitor, antioxidants, and antifoam additive	5.82	5.82	3.32
Corrosion inhibitor, antioxidants, ashless friction modifier, and overbased detergent			
Polypropylene glycol stearyl ether	0.95	0.95	0.95
Polymethacrylate dispersant	1.6	1.6	1.6
Polyalkyl methacrylate copolymer viscosity modifier			
Dispersant based on polyisobutene			
Base Oil 2	87.93		90.43
Base Oil 10		87.93	
Base Oil 1			
Base Oil 4			

FIG. 8 (Cont.)

	Example 4	Example 5	Example 6
Component and Method Description			
Mixture of molybdenum dithiophosphate, primary and secondary zinc dithiophosphates	14072735	14072739	14075470
Mixture of molybdenum dithiophosphate, and secondary zinc dithiophosphates	3.7	3.7	3.7
Corrosion inhibitor, antioxidants, and antifoam additive	3.32	3.32	2.52
Corrosion inhibitor, antioxidants, ashless friction modifier, and overbased detergent			
Polypropylene glycol stearyl ether	0.95	0.95	0.95
Polymethacrylate dispersant	1.6	1.6	1.6
Polyalkyl methacrylate copolymer viscosity modifier			
Dispersant based on polyisobutene			
Base Oil 2	45.43	72.43	82.23
Base Oil 10			
Base Oil 1	45	18	9
Base Oil 4			

FIG. 8 (Cont.)

Component and Method Description	Example 7	Comparative Example 1
Mixture of molybdenum dithiophosphate, primary and secondary zinc dithiophosphates	14072308	Conventional Synthetic Engine Oil
Mixture of molybdenum dithiophosphate, and secondary zinc dithiophosphates	2.55	
Corrosion inhibitor, antioxidants, and antifoam additive		
Corrosion inhibitor, antioxidants, ashless friction modifier, and overbased detergent	2.97	
Polypropylene glycol stearyl ether	0.95	
Polymethacrylate dispersant	0.95	
Polyalkyl methacrylate copolymer viscosity modifier	9.8	
Dispersant based on polyisobutene	1.8	
Base Oil 2		
Base Oil 10		
Base Oil 1	40	
Base Oil 4	40.98	

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FIG. 8 (Cont.)

	Example 1	Example 2	Example 3
Component and Method Description			
D4052, Specific Gravity of Liquids, 60 F	14050535	14057560	14072729
D445, Kinematic Viscosity at 150C, MM2/S	0.961		0.9604
D445, Kinematic Viscosity, 40C, MM2/S	4.31		4.11
D445, Kinematic Viscosity, 100C, MM2/S	104		97.85
D4683, Apparent Viscosity, CP	11.47	25.23	10.92
D4951, BORON, MASS%	0.008	0.008	3.39
D4951, MAGNESIUM, MASS%	<0.001	<0.001	0.008
D4951, MOLYBDENUM, MASS%	0.147	0.147	0.001
D4951, PHOSPHORUS, MASS%	0.228	0.226	0.141
D4951, ZINC, MASS%	0.195	0.196	0.229
D874, Sulfated Ash, MASS%			0.193

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FIG. 8 (Cont.)

	Example 4	Example 5	Example 6
Component and Method Description			
D4052, Specific Gravity of Liquids, 60 F	14072735	14072739	14075470
D445, Kinematic Viscosity at 150C, MM2/S	0.9598	0.96	0.9599
D445, Kinematic Viscosity at 150C, MM2/S	1.82	2.83	3.80
D445, Kinematic Viscosity, 40C, MM2/S	14.39	38.84	59.19
D445, Kinematic Viscosity, 100C, MM2/S	3.58	6.52	8.32
D4683, Apparent Viscosity, CP	1.46	2.31	2.83
D4951, BORON, MASS%	0.007	0.008	<0.001
D4951, MAGNESIUM, MASS%	0.001	0.002	0.002
D4951, MOLYBDENUM, MASS%	0.142	0.146	0.145
D4951, PHOSPHORUS, MASS%	0.229	0.228	0.232
D4951, ZINC, MASS%	0.193	0.192	0.192
D874, Sulfated Ash, MASS%			

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FIG. 8 (Cont.)

Component and Method Description	Example 7	Comparative Example 1
D4052, Specific Gravity of Liquids, 60 F	14072308	Conventional Synthetic Engine Oil
D445, Kinematic Viscosity at 150C, MM2/S		
D445, Kinematic Viscosity, 40C, MM2/S	47.92	
D445, Kinematic Viscosity, 100C, MM2/S	12.11	
D4683, Apparent Viscosity, CP	2.81	
D4951, BORON, MASS%	0.014	
D4951, MAGNESIUM, MASS%	0.088	
D4951, MOLYBDENUM, MASS%	0.121	
D4951, PHOSPHORUS, MASS%	0.154	
D4951, ZINC, MASS%	0.123	
D874, Sulfated Ash, MASS%	0.66	

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FIG. 8 (Cont.)

	Example 1	Example 2	Example 3
Component and Method Description	14050535	14057560	14072729
Ignition Delay (Normalized to Isoctane) 1% in Isooctane	0.9180	0.8670	
Ignition Delay (Normalized to Isoctane) 5% in Isooctane	0.7914	0.7524	
Ignition Delay (Normalized to Isoctane) 10% in Isooctane	0.7227		
Ignition Delay (Normalized to Isoctane) 15% in Isooctane	0.6860		
Combustion Delay (Normalized to Isoctane) 1% in Isooctane	1.0091	0.9680	
Combustion Delay (Normalized to Isoctane) 5% in Isooctane	0.9480	0.9150	
Combustion Delay (Normalized to Isoctane) 10% in Isooctane	0.8908		
Combustion Delay (Normalized to Isoctane) 15% in Isooctane	0.8309		

FIG. 8 (Cont.)

	Example 4	Example 5	Example 6
Component and Method Description	14072735	14072739	14075470
Relative Ignition Delay (Normalized to Isooctane) 1% in Isooctane			
Relative Ignition Delay (Normalized to Isooctane) 5% in Isooctane			
Relative Ignition Delay (Normalized to Isooctane) 10% in Isooctane			
Relative Ignition Delay (Normalized to Isooctane) 15% in Isooctane			
Relative Combustion Delay (Normalized to Isooctane) 1% in Isooctane			
Relative Combustion Delay (Normalized to Isooctane) 5% in Isooctane			
Relative Combustion Delay (Normalized to Isooctane) 10% in Isooctane			
Relative Combustion Delay (Normalized to Isooctane) 15% in Isooctane			

FIG. 8 (Cont.)

	Example 7	Comparative Example 1
Component and Method Description	14072308	Conventional Synthetic Engine Oil
Relative Ignition Delay (Normalized to Isooctane) 1% in Isooctane	0.8817	0.8164
Relative Ignition Delay (Normalized to Isooctane) 5% in Isooctane	0.7578	0.5984
Relative Ignition Delay (Normalized to Isooctane) 10% in Isooctane		0.4899
Relative Ignition Delay (Normalized to Isooctane) 15% in Isooctane		0.4309
Relative Combustion Delay (Normalized to Isooctane) 1% in Isooctane	0.9579	0.9213
Relative Combustion Delay (Normalized to Isooctane) 5% in Isooctane	0.8652	0.6374
Relative Combustion Delay (Normalized to Isooctane) 10% in Isooctane		0.4155
Relative Combustion Delay (Normalized to Isooctane) 15% in Isooctane		0.2810