TABLE 200

Storage Tests of Experimental Referee Broadened - Specification Fuels at 43 ° C (110 ° F)

Fuel	Initial Soluble Gum	Precip-itate	Soluble Gum[1]	Insoluble Gum	Total Gum
	mg/100 mL				
		4 Weeks			
ERBS 3B 12.3[2]	0.9	0.1	3.2	0.6	3.9
ERBS 3B 11.8[3]	1.5	0.1	2.4	0.2	3.1
ERBS 3B 12.8[4]	1.0	0.1	1.8	0.0	2.0
		8 Weeks			
ERBS 3B 12.3		0.1	1.8	0.4	2.3
ERBS 3B 11.8		0.1	1.1	0.3	1.5
ERBS 3B 12.8		0.1	1.0	0.0	1.1
		12Weeks			
ERBS 3B 12.3		0.2	3.9	0.2	4.3
ERBS 3B 11.8		0.1	3.8	0.3	4.3
ERBS 3B 12.8		0.1	2.8	0.5	3.4
		16 Weeks			
ERBS 3B 12.3		0.3	2.2	0.3	2.8
ERBS 3B 11.8		0.2	2.4	0.3	2.9
ERBS 3B 12.8		0.2	2.2	0.0	2.4
		24 Weeks			
ERBS 3B 12.3		0.1	1.9	0.3	2.3
ERBS 3B 11.8		0.1	2.8	0.3	3.2
ERBS 3B 12.8		0.1	1.7	0.3	2.1

[1] Existent gum by steam jet evaporation
[2] Experimental Referee Broadened - Specification Fuel containing 12.3% Hydrogen.
[3] Experimental Referee Broadened - Specification Fuel containing 11.8% Hydrogen.
[4] Experimental Referee Broadened - Specification Fuel containing 12.8% Hydrogen.

Taken from Reference No. 13

TABLE 201

Aging Test at 80 ° C (176 ° F) Of Shale Oil Refinery Streams

	mg/100 mL								
	3 Days			7 Days			14 Days		
Description	Filterable Residue	Adherent Insolubles	Total Insolubles	Filterable Residue	Adherent Insolubles	Total Residue	Filterable Insolubles	Adherent Insolubles	Total Insolubles
Occidental crude shale oil	11.3	0.2	11.5	10.7	0.9	11.6	16.5	1.7	18.2
Whole hydrotreated Occidental crude	0.5	0.4	0.9	0.2	0.4	0.6	0.1	0.2	0.3
Crude shale hydrotreater recycle	0.03	0.2	0.2	0	0.5	0.5	0.3	0.1	0.4
Tower overhead	35.8	10.3	46.2	58	140	198	36.2	358	394
Raffinate	16.1	7.8	23.6	65	148	213	14.5	563	578
JP-8 off-spec	1.1	1.8	2.9	2.0	7.1	9.1	0.5	17.5	18.0

Taken from Reference No. 13

TABLE 202

Heptane Insolubles in Shale Oil Refinery Streams After Aging at 80 ° C (176 ° F) Test

	mg/100 mL						
	Unaged	7 Days			14 Days		
Description	Filterable Residue	Filterable Residue	Adherent Insolubles	Total Insolubles	Filterable Residue	Adherrent Insolubles	Total Insolubles
Occidental crude shale oil	29.6	7.6	1.3	8.9	114	1.5	115
Whole hydrotreated Occidental crude	1.6	0.5	0.2	0.7	0	0	0
Crude shale hydrotreater recycle	0.4	0	0.5	0.5	0	0.2	0.2
Tower overhead	12.6	142	107	249	126	320	446
Raffinate	14.5	150	83	233	91	583	674
JP-8 off-spec	6.6	2.9	8.0	10.9	4.9	13.0	17.9

Taken from Reference No. 13

TABLE 2[illegible]

Effect of Styrene and Mercaptans on Sediment Formation[1]

Mercaptan added	Color T.R.[2]	Sediment mg / 100 ml	S %	Acid Number
None	25	0	---	0
Thiophenol	25	4.2	---	0
2-Naphthalenethiol	25	400	96	0
n-Dodecyl mercaptan	11.5	600	8.3	0
t-Dodecyl mercaptan	7	30	5.5	0.6

[1] Fourteen Days Storage at 43.3° C (110° F) in Cetane; Open Flasks
Mercaptan and Styrene Concentration 0.3 moles/l.
[2] Tag-Robinson

Taken from Reference No. 88

TABLE 204

Effect Of Indene And Mercaptans On Color Loss and Sediment Formation[1]

Added Mercaptans	mols/l	Added Indene mols/l	Color (T.R.)[3]	Sediment (mg/100 ml)	S%[2]	Acid Number
None	-	0.6	25	25	-	0
Thiophenol	0.3	0.6	25	1800	11.1	-
p-Toluenethiol	0.3	0.6	24	1714	10.7	-
2-Naphthalenethiol	0.3	0.6	25	4000	6.4	-
n-Dodecylmercaptan	0.3	0.3	23.5	0.9	-	0.05
	0.3	0.6	12.5	0	-	0
t-Dodecyl mercaptan	0.3	0.3	13.5	8.6	-	0.16
	0.3	0.6	11.2	12.5	3.8	0

[1] Three Days Storage at 43.3° C (110° F) in Cetane in Open Flasks
[2] Sulfur determination on sediment after recrystallization
[3] Tag-Robinson

Taken from Reference No. 88

TABLE 205

Effect of n-Octadecene and Aromatic Mercaptans in Cetane on Sediment Formation[1]

Added Mercaptan	Sediment, mg/l
None	0
Thiophenol	1000
4-Chlorothiophenol	3000
2-Naphthalene thiol	2000

[1] Stored one month at 43.3 °C(110 °F) Concentration of n-octa-1-decene: 0.3 mole/l (7.6%) Concentration of aromatic mercaptan: 0.3 mole/l (1%S)

Taken from Reference No. 88

TABLE 206

Effect of Sulfur Compounds and Normal Olefins On Stability[1]

Aromatic Mercaptan			Olefin			Color (T.R.)[2] after storage in dark	Sediment(mg/100 ml)	
	mole/l	S%		mole/l	%		after storage in dark	after exposure to sunlight
Thiophenol	0.3	1	1-Octene	0.3	3.35	23	0	0
	0.3	1		0.6	6.7	19	0	0
Thiophenol	0.3	1	1-Dodecene	0.3	5	23.5	0	-
	0.3	1		0.6	10	19	0	200
p-Toluenethiol	0.6	2	1-Octadecene	1.2	23	10.5	0	5000

[1] 5 Weeks Storage at 43.3 °C(110 °F) In Cetane
[2] Tag-Robinson

Taken f Reference No. 88

TABLE 207

Effect of Mercaptans on Stability of Pyrrole Solutions[1]

Pyrrole, Mole/L	Mercaptan Added	In Cetane		In Xylene	In Tetrahydronaphthalene
		Mole/L	Sediment, mg./100 ml.	Sediment, Mg./100ml.	Sediment, mg./100 ml
Nil	---	Nil	0.2	0	0
0.3	---	Nil	0	0	0
Nil	Benezenethiol	0.3	0.1	---	201
0.15	Benzenethiol	0.15	0	---	880
Nil	2-Naphthalenethiol	0.3	0	0	---
0.15	2-Naphthalenethiol	0.15	0	14.5	---
Nil	tert-Dodecanethiol	0.3	0.5	6	660
0.15	tert-Dodecanethiol	0.15	2.5	2.5	1560

[1]Six weeks storage at 43.3 °C(110 ° F.)

TABLE 208

Effect of Olefins on Stability of Pyrrole Solutions[1]

Added Compd.,0.3 Mole/L.		Sediment,
Olefin	Pyrrole	mg./100 ml.
Nil	Yes	0
n-Octadecene	No	0
	Yes	3.2
Cyclohexene	No	0
	Yes	1.2
Styrene	No	Turbidity
	Yes	3
Dipentene	No	90.3
	Yes	183.5 (5.5% N)

[1]Four weeks storage at 43.3 °C (110 ° F) in cetane

TABLE 209

Storage and Analytical Data for Mixture of n-Butylsulfide[1] and 1-Phenyl-2-butene[2] in n-Heptane

Bottle No.	Storage time[3] and sample identification	Gum recovered, mg / 100 ml	Radioactivity, μc		Tagged compound reacted to gum, %	
			H^3	S^{35}	Hydrocarbon	Sulfur Compound
	0 Days					
1	Mixture	—	24.225	14.259	—	—
1	Gum	70.6	.018	.279	0.08	1.96
1	Gum	78.8	.024	.294	.10	2.06
	8 Days					
2	Mixture	—	24.047	14.353	—	—
2	Gum	22.4	.034	.141	.14	.98
2	Gum	21.9	.023	.088	.10	.61
	16 Days					
3	Mixture	—	23.585	14.693	—	—
3	Gum	27.7	.042	.197	.18	1.34
3	Gum	28.7	.025	.083	.11	.56
4	Mixture	—	24.798	14.067	—	—
4	Gum	15.4	.025	.085	.10	.60
4	Gum	26.1	.035	.188	.14	1.34
	32 Days					
5	Mixture	—	24.970	14.758	—	—
5	Gum	35.5	.038	.224	.15	1.52
5	Gum	33.4	.035	.182	.14	1.23
6	Mixture	—	25.347	15.038	—	—
6	Gum	30.2	.031	.142	.12	.94
6	Gum	20.7	.039	.094	.15	.63
	64 Days					
7	Mixture	—	24.301	14.240	—	—
7	Gum	31.8	.043	.181	.18	1.27
7	Gum	24.1	.023	.109	.10	.77
8	Mixture	—	24.655	14.838	—	—
8	Gum	31.9	.027	.179	.11	.121
8	Gum	30.9	.033	.174	.13	1.17
9	Mixture	—	24.567	14.288	—	—
9	Gum	26.4	.025	.118	.10	.83
9	Gum	35.3	.028	.204	.11	1.43
10	Mixture	—	24.058	14.210	—	—
10	Gum	31.8	.032	.184	.13	1.29
10	Gum	26.3	.025	.091	.10	.64

[1] Labeled with Sulfur-35.
[2] Labeled with Tritium.
[3] Stored at 43.3 °C (110 °F).

Taken from Reference No. 132

TABLE 210

Storage and Analytical Data for Mixture of 1-Hexanethiol[1] and Cyclohexene[2] in n-Heptane

Bottle No.	Storage time[3] and sample identification	Gum recovered, mg / 100 ml	Radioactivity, μc		Tagged compound reacted to gum, %	
			H^3	S^{35}	Hydrocarbon	Sulfur Compound
	0 Days					
1	Mixture	—	15.764	9.245	—	—
1	Gum	3.3	.003	.027	0.02	0.29
1	Gum	4.5	.003	.028	.02	.30
	8 Days					
2	Mixture	—	15.967	9.278	—	—
2	Gum	3.4	.010	.065	.06	.70
2	Gum	7.7	.009	.076	.06	.82
	15 Days					
3	Mixture	—	15.660	9.317	—	—
3	Gum	13.1	.026	.161	.17	1.73
3	Gum	11.9	.026	.132	.17	1.42
	33 Days					
4	Mixture	—	15.608	9.256	—	—
4	Gum	28.4	.063	.367	.40	3.96
4	Gum	28.1	.050	.319	.32	3.45
5	Mixture	—	15.433	9.235	—	—
5	Gum	48.9	.092	.580	.60	6.28
5	Gum	59.4	.093	.690	.60	7.47
6	Mixture	—	15.449	9.052	—	—
6	Gum	30.5	.063	.403	.41	4.45
6	Gum	31.5	.065	.393	.42	4.34
	64 Days					
7	Mixture	—	15.510	9.226	—	—
7	Gum	64.1	.090	.811	.58	8.79
7	Gum	62.9	.091	.778	.59	8.43
8	Mixture	—	15.678	9.225	—	—
8	Gum	57.0	.074	.671	.47	7.27
8	Gum	74.7	.114	.891	.73	9.66
9	Mixture	—	15.720	9.250	—	—
9	Gum	64.2	.099	.838	.63	9.06
9	Gum	65.8	.099	.805	.63	8.70
10	Mixture	—	15.299	9.137	—	—
10	Gum	70.2	.086	.888	.56	9.72
10	Gum	68.8	.096	.885	.63	9.69

abeled with Sulfur-35.
abeled with Tritium.
ored at 43.3 °C (110 °F).

Taken from Reference No. 132

TABLE 211

Storage and Analytical Data for Mixture of 1-Hexanethiol and 1-Phenyl-2-butene In n-Heptane

Bottle No.	Storage time and sample identification	Gum recovered mg / 100 ml	Radioactivity, μc		Tagged compound reacted to gum, %	
			H^3	S^{35}	Hydrocarbon	Sulfur Compound
	0 Days					
1	Mixture	—	15.370	8.254	—	—
1	Gum	19.9	.089	.060	0.58	0.73
1	Gum	18.1	.089	.064	.58	.78
	8 Days					
2	Mixture	—	16.885	8.794	—	—
2	Gum		Sample Lost — Trap Breakage			
2	Gum	225.4[1]	.453	1.749	2.68	19.89
	15 Days					
3	Mixture	—	16.763	8.861	—	—
3	Gum	256.6	.439	1.989	2.62	22.45
3	Gum	233.0	.471	1.906	2.81	21.51
	31 Days					
4	Mixture	—	16.584	9.010	—	—
4	Gum		Sample Lost — Trap Breakage			
4	Gum	258.6[1]	.445	2.108	2.68	23.40
5	Mixture	—	16.547	8.905	—	—
5	Gum	264.9	.450	2.127	2.72	23.88
5	Gum	254.5	.478	2.163	2.89	24.29
6	Mixture	—	16.521	8.823	—	—
6	Gum	256.0	.402	2.135	2.43	24.20
6	Gum	243.1	.476	2.151	2.88	24.38
	64 Days					
7	Mixture	—	16.334	8.855	—	—
7	Gum	389.0	.599	3.493	3.66	39.45
7	Gum	254.1[1]	.440	2.201	2.69	24.86
8	Mixture	—	15.988	9.026	—	—
8	Gum	286.4	.487	2.323	3.05	25.74
8	Gum	282.3	.455	2.360	2.85	26.15
9	Mixture	—	16.978	9.041	—	—
9	Gum	267.2	.457	2.234	2.69	24.71
9	Gum	262.8	.355	2.186	2.09	24.18
10	Mixture	—	16.627	9.110	—	—
10	Gum	263.8	.448	2.213	2.69	24.29
10	Gum	265.3	.444	2.203	2.67	24.18

[1] Not used in statistical calculations.

Taken from Reference No. 132

TABLE 212
Oxygen Consumption by 200 ml of Fuel in 43.3 °C (110 °F) Aerated Storage

Mixture Composition[1]	Days in Storage	Cumulative O_2 Consumed, ml
iiacyclopentane and 1-phenyl-2-butene in n-heptane	7	103
	9	206
	13	309
	14	412
	15	515
	16	618
	19	721
	22	824
	23	927
	26	1030
	27	1133
	28	1236
	29	1339
	30	1442
	33	1545
n[illegible] gasoline	68	50
[illegible]xene-1 (only) in n-heptane	32	1
Phenyl-2-butene (only) in n-heptane	4	103
	6	206
	8	309
	11	412
	12	515
	13	618
	14	721
	18	824
	19	927
	21	1030
	25	1133
	26	1236
	27	1339
	28	1442
	29	1545
	32	1648
	33	1751
	34	1854
5-Hexadiene (only) in n-heptane	14	103
	27	206
	34	272

[illegible]-Heptane: 74.5 Vol. %
Hydrocarbon: 25.0 Vol. %
S[illegible] Compound: 0.5 Vol. %

a[illegible] from Reference No. 100

TABLE 213

Amount of Vapor Transfer Gum Formed in Hydrocarbon-Sulfur Compound Blends[1] in Sealed Storage and With Air Replenishment[2]

Sample Composition	VT Gum (mg/100 ml)	
	Sealed Storage	With Air Replenishment
Thiophenol and 1-hexene	871	904
Thiophenol and 1-5-hexadiene	770	737
Thiophenol and 1-phenyl-2-butene	288	1768
Thiophenol and cyclohexene	394	740
Thiophenol and tetralin	121	424
Hexanethiol and 1-phenyl-2-butene	314[3]	437[4]
Butyldisulfide and 1-hexene	2	5
Thiacyclopentane and 1-phenyl-2-butene	42	1432
Very Unstable gasoline	65[3]	79[4]
1-Hexene (only)	–	133
1-Phenyl-2-butene (only)	–	2246
1,5-Hexadiene (only)	–	.5

[1]Blend Composition:
n-Heptane-74.5 Vol. %
Hydrocarbon-25.0 Vol. %
Sulfur Compound-0.5 Vol. %

[2] Stored at 43.3 °C (110 °F) for 32 days.
[3] 64 days
[4] 69 days

Taken from Reference No. 100

TABLE 214

REACTION OF ^{14}C LABELED N-HEPTANE IN A N-HEPTANE AND THIOPHENOL MIXTURE[1]

Days Storage at 110 ° F	% n-Heptane reacted		Vapor transfer gum recovered, mg/100 ml	
	Sample[2] A	Sample[2] B	Sample A	Sample B
0	0.005	0.001	4.1	6.8
8	.000	.001	10.9	8.2
15	.001	.001	6.7	6.6
23	.001	.000	13.4	12.7
33	.001	.000	11.9	18.1

[1]Mixture Composition:
n-Heptane - 99.5% vol.
Thiophenol - 0.5% vol.

[2]A and B are duplicate samples

Taken from Reference No. 100

TABLE 215

Reaction of Labeled Tetralin In a Tetralin, Thiophenol, and n-Heptane Mixture[1]

Days Storage at 43.3 °C (110 °F)	% Tetralin Reaction		Vapor Transfer Gum mg / 100 ml	
	Sample A[2]	Sample B[2]	Sample A	Sample B
With ^{14}C labeled tetralin				
0	0.205	0.266	10.5	8.7
8	3.618	3.475	71.7	60.3
15	3.455	3.651	105.5	108.6
23	3.321	3.026	162.4	101.2
32	3.518	3.372	264.1	215.5
With ^{3}H labeled tetralin				
0	0.201	—	10.0	—
4	3.516	—	19.0	—
8	3.494	—	26.9	—
15	2.788	—	37.0	—
32	3.325	—	121.2	—

[1]Mixture Composition:
n-Heptane - 74.5 Vol. %
Tetralin - 25.0 Vol. %
Thiophenol - 0.5 Vol. %

[2]A and B are duplicate samples

Taken from Reference No. 100

TABLE 216

Preliminary Tests Of Hydrocarbons (with 3 ml TEL added) as Base for TEL Blends

Hydrocarbons	Test temp., °F	Test duration, hrs	Precipitate, mg/100 ml	Gum, mg/100 ml		
				Insoluble	Soluble	Total
Decane	110	16	0.2	0.3	0.7	1.0
Decane	150	16	.1	.2	.9	1.1
Decane	170	16	.4	.6	.9	1.5
Decane	190	16	.2	.5	.7	1.2
Decane	200	16	32.9	1.0	7.6	8.6
Isooctane	180	16	.2	.8	1.1	1.9
Isooctane	180	168	42.0	1.0	2.9	3.9
Isooctane	200	16	.2	.8	1.1	1.9
Heptane	200	16	34.2	1.6	3.9	5.5
Octane	200	16	33.3	1.6	5.3	6.9
Toluene	200	16	42.3	1.1	14.0	15.1
Methylcyclohexane	200	16	18.5	1.0	6.5	7.5
Regular gasoline	200	16	7.1	.9	18.1	19.0
Gasoline mixture	200	16	.2	.6	2.2	2.8

Taken from Reference No. 135

TABLE 217

Data from 93.3 °C (200 °F) Oven Tests[1] of Leaded Binary Hydrocarbon Blends[2]

Reactive Hydrocarbon	Lead precipitate, mg / 100 ml	Gum, mg / 100 ml			% O_2 in air	% Component reacted		
		Insoluble	Soluble	Total	In outage	TEL	HC	O_2
Indan	45.2	1.7	8.7	10.4	4.5	81	19	79
Tetralin	36.3	1.0	9.1	10.1	7.5	73	24	64
3,4-Dimethyl-1-hexene	34.4	1.7	3.3	5.0	6.8	76	4	68
2-Methyl-2-hexene	32.6	1.1	1.4	2.5	4.4	70	16	79
1-Ethylcyclopentene	28.3	1.2	5.3	6.5	2.2	62	26	90
1-Hexene	24.6	0.8	1.6	2.4	12.2	58	4	42
1-Octene	24.4	.8	1.2	2.0	12.9	56	2	39
1,2-Dimethylcyclopentene	21.7	1.0	4.6	5.6	3.8	53	46	82
Cyclohexene	19.5	1.6	2.5	4.1	10.7	50	14	49
4-Methyl-1-pentene	13.8	3.8	1.5	5.3	16.6	35	10	21
2,5-Dimethyl-1,5-hexadiene	11.0	1.7	3.3	5.0	11.3	52	6	46
Toluene	10.9	1.8	2.2	4.0	17.6	31	0	16
Isooctane	9.9	1.8	1.0	2.8	18.0	32	–	14
1,2,4-Trimethylbenzene	9.2	1.8	0.9	2.7	17.9	29	0	15
n-Decane	7.8	1.8	1.1	2.9	18.8	29	0	10
1-Heptene	7.3	1.3	1.2	2.5	18.2	24	<1	13
n-Propylbenzene	6.2	2.2	1.1	3.3	18.8	28	0	10
Methylcyclohexane	4.7	2.5	1.7	4.2	19.0	20	0	10
Allylbenzene	3.6	2.5	1.2	3.7	19.7	17	0	6
Naphthalene	2.8	1.7	1.1	2.8	19.7	15	0	6
Indene	2.2	1.3	8.5	9.8	19.1	5	3	10

[1]16 Hours at 93.3 °C(200 °F)
[2]Blend composition: 0.5% Reactive Hydrocarbon, 99.5% Isooctane, 3 ml TEL/gal

Taken from Reference No. 135

TABLE 218

Data from Oven Tests of Leaded Binary Hydrocarbon Blends[1]

Hydrocarbon[2]	Sample No. Of blend	40-hr. test - 180 ° F					Approximate purity, percent[2]
		Precipitate mg/100 ml	Soluble gum mg/100 ml	Insoluble gum mg/100 ml	Total gum mg/100 ml	Oxygen remaining, percent	
Isooctane (base)	74	1.4	0.9	1.7	2.6	--	99.9
	78	.8	1.0	1.5	2.5	--	do.
	80	2.0	.3	1.8	2.1	--	do.
	96	3.2	.9	1.9	2.8	20.0	do.
	141	.8	.2	1.0	1.2	--	do.
	148	1.2	.5	1.5	2.0	20.7	do.
n-Hexane	88	2.3	.9	1.3	2.2	20.1	--
Cyclohexane	135	.7	.4	1.8	2.2	20.8	99+
Methylcyclohexane	109	2.0	1.1	1.6	2.7	20.3	--
Ethylcyclopentane	107	3.5	.6	1.0	1.6	20.0	99+
n-Decane	140	1.0	.5	1.9	2.4	--	99.9
1-Hexene	159	1.4	.9	1.7	2.6	20.5	98.8
1-Heptene	112	2.8	1.0	1.7	2.7	20.1	--
1-Octene	153	1.2	1.5	1.1	2.6	20.6	99.9
1-Nonene	113	2.0	.1	1.5	1.6	20.3	--
4-Methyl-1-pentene	147	2.2	.6	2.3	2.8	20.4	99.9
2-Methyl-2-hexene	154	2.2	1.1	2.2	3.3	20.1	99.9
Cyclohexene	114	8.9	2.2	2.8	5.0	16.3	99.8
	157	6.0	1.0	3.7	4.7	17.6	99.9
1-Ethylcyclopentene	134	22.0	2.5	2.3	4.8	8.5	99.9+
1,2-Dimethylcyclopentene	160	20.3	4.8	2.2	7.0	6.0	99.14
1,2-Dimethylcyclohexene	150	15.8	5.8	.9	6.7	8.5	--
	151	17.5	6.5	1.5	8.0	7.9	99.91
1,2,3-Trimethylcyclopentene	167	16.8	4.7	1.3	6.0	5.5	99.87
3,3,5-Trimethylcyclohexene	163	1.0	1.3	2.2	3.5	20.7	99.26
4,4-Dimethylcyclohexene	164	.84	1.1	2.6	3.7	20.7	99.78
2,5-Dimethyl-1,5-hexadiene	161	3.6	1.9	2.7	4.6	18.2	95-99.7
Indene	129	2.9	8.2	1.7	9.9	18.6	99.9+
Indan	128	2.1	1.6	2.5	4.1	19.8	99.6
Toluene	101	3.1	.7	1.5	2.2	20.1	--
n-Propylbenzene	119	1.9	1.9	3.1	5.0	20.6	--
1,2,4-Trimethylbenzene	115	.8	1.5	1.2	2.7	20.8	99.5
Naphthalene	145	.9	.8	1.7	2.5	20.5	--
Tetralin	149	1.5	.9	1.5	2.4	20.1	99.9+
	152	1.8	.9	1.8	2.7	20.0	99.9+

[1]Blends contained 99.5% isooctane, 0.5% of the listed hydrocarbon, and 3 ml tetraethyllead per gallon.
[2]Purity check by FID gas chromatography.

Taken from Reference No. 135

TABLE 219

Effects of Nitrogen Compounds on Sediment Formation in Purified n-Decane

Compound Added[1]	Storage Conditions[2]	Cumulative Sediment (g/500g Decane) 1 Day	5 Days	20 Days	30 Days	60 Days	Comments
None	Light	---	---	---	---	---	Clear, Colorless Throughout
None	Dark	---	---	---	---	---	
2,5-Dimethylpyrrole	Light	.362	.718	1.13	1.30	1.69	Dark Brown Solution
2,5-Dimethylpyrrole	Dark	.036	0.100	.353	.524	1.05	Dark Brown Solution
Indole	Light	.012	.021	.022	.036	.043	Pink Solution
Indole	Dark	---	---	---	---	---	Colorless
Carbazole	Light	Trace	Trace	.019	.020	.051	Yellow Solution
Carbazole	Dark	---	---	---	---	---	Yellow Solution
2,4,6-Trimethylpyridine	Light	---	---	---	---	---	Clear, Colorless
2,4,6-Trimethylpyridine	Dark	---	---	---	---	---	Clear, Colorless
Quinoline	Light	---	---	Trace	Trace	Trace	Light Yellow Solution
Quinoline	Dark	---	---	---	---	---	Clear, Colorless
2,6-Dimethylaniline	Light	---	.004	.004	.005	.005	Purple Solution
2,6-Dimethylaniline	Dark	---	.001	.001	.002	.002	Purple Solution
n-Hexylamine	Light	---	---	---	---	---	Clear, Colorless
n-Hexylamine	Dark	---	---	---	---	---	Clear, Colorless
Methylcyclohexylamine	Light	---	---	---	---	Trace	Yellow Solution
Methylcyclohexylamine	Dark	---	---	---	---	Trace	Light Yellow Solution
2-Methylpiperidine	Light	Trace	Trace	.001	.001	.001	Light Yellow Solution
2-Methylpiperidine	Dark	---	---	Trace	.001	.001	Light Yellow Solution
n-Caproamide	---	---	---	---	---	Trace[3]	Trace[3] Light Yellow Solution
n-Caproamide	---	---	---	---	---	Trace[3]	Trace[3] Light Yellow Solution

[1] Each compound added to purified n-decane at 2000 ppm N level.

[2] Light = (UV) irradiation (366 nm, 1100 μW/cm^2); Dark = stored in darkness.

[3] Trace of liquid appeared after 30 days.

Taken from Reference No. 36

Sediment Formation in n-Decane Under the Influence of Organic Acids and Phenols

Compound Added[1]	Storage Conditions[2]	Cumulative Sediment (g/500g Decane) 1 Day	5 Days	15 Days	30 Days	60 Days	Comments
2,5-Dimethylpyrrole (DMP)	Light	.213	.524	.869	1.12	1.52	Dark Red
2,5-Dimethylpyrrole (DMP)	Dark	--	.060	.197	.394	.840	Dark Red
2,5-DMP plus Decanoic Acid	Light	.390	.821	1.25	1.49	1.84	Dark Red
2,5-DMP plus Decanoic Acid	Dark	.057	1.47	.497	.890	1.50	Dark Red
2,5-DMP plus Cyclohexane Carboxylic Acid	Light	.391	.821	1.26	1.56	1.83	Dark Red
2,5-DMP plus Cyclohexane Carboxylic Acid	Dark	.083	.216	.621	1.08	1.84	Dark Red
Cyclohexane Carboxylic Acid	Light	--	--	--	--	--	Clear,
Cyclohexane Carboxylic Acid	Dark	--	--	--	--	--	Colorless
2,5-DMP plus 2,4,6-Trimethylphenol	Light	.275	.459	.682	.910	1.33	Colorless
2,5-DMP plus 2,4,6-Trimethylphenol	Dark	--	.010	.126	.336	1.00	Colorless
2,4,6-Trimethylphenol	Light	--	--	--	--	--	Clear,
2,4,6-Trimethylphenol	Dark	--	--	--	--	--	Colorless
2,5-DMP plus di-t-Butylphenol	Light	--	.022	.173	.376	.639	
2,5-DMP plus di-t-Butylphenol	Dark	--	--	.035	.131	.496	
Di-t-Butylphenol	Light	--	--	--	--	--	Clear,
Di-t-Butylphenol	Dark	--	--	--	--	--	Colorless
Indole plus Decanoic Acid	Light	--	Trace	.131	.236	.347	Dark Red
Indole plus Decanoic Acid	Dark	--	--	--	--	--	Colorless
Indole plus di-t-Butylphenol	Light	--	--	.023	.036	.039	Dark Red
Indole plus di-t-Butylphenol	Dark	--	--	--	--	--	Colorless
Indole	Light	.012	.013	ND	.045	.046	
Indole	Dark	--	--	--	--	--	

[1] Nitrogen compounds added at 2,000 ppm N level; acids and phenols at 500 ppm O level.

[2] Light = UV radiation (366 nm; 1100 $\mu W/cm^2$).

Taken from Reference No. 36

TABLE 221

Analysis of Sediments from Various Nitrogen-Containing Additives in Hydrocarbon Fuels[1]

Additive(s)	Storage Conditions	Fuel[2]	Storage Time	% C	% H	% N	% O	% S
DMP	Light	n-Decane	5 days	62.28	5.33	11.66	20.53	---
DMP	Light	n-Decane	60 days	63.89	5.09	12.31	18.71	---
DMP	Light	JP-5	80 days	59.71	5.54	11.29	23.28	.18
DMP & Decanoic Acid	Light	JP-5	80 days	62.30	5.88	10.95	20.07	.80
DMP & Decanoic Acid	Dark	JP-5	80 days	61.09	5.88	10.84	22.04	.15
Average of 11 Samples			---	61.30	5.67	11.29	21.51	---

[1] All samples air saturated, stored under ambient conditions; n-Decane samples irradiated with UV light (366 nm); JP-5 sample irradiated by sunlight; O_2 level = saturation at beginning of experiment.

[2] n-Decane was purified by silica gel percolation; JP-5 was ordinary jet fuel.

Taken from Reference No. 36

TABLE 222

Comparison of Several DMP[1] Runs-Development of "Standard" Data

Exp No	Date	Storage	Cumulative Sediment (g/500 g Decane) 1 Day	5 Day	15 Day	30 Day	60 Day
1	2/77-4/77	Light	.362	.718	1.13	1.30	1.69
		Dark	.036	.100	.353	.524	1.05
2	6/77-7/77	Light	.213	.524	.869	1.12	1.52
		Dark	---	.060	.197	.394	.840
3	10/77-12/77	Light	.221	.621	.869	1.21	1.54
		Dark	.019	.060	.140	.389	.793
4	3/78-5/78	Light	.229	.500	.888	1.14	1.42
		Dark	.002	.030	.125	.278	.530
Average		Light	.256	.591	.939	1.19	1.54
		Dark	.014	.063	.204	.396	.803

[1] DMP = 2,5 - Dimethylpyrrole, added at 2000 ppm N level

Taken from Reference No. 37

TABLE 223

Survey of Effects of Various Nitrogen Compounds on Sediment Formation in n-Decane

Nitrogen Compound	Amount	Storage	Cumulative Sediment (g/500 g Decane)				
			1 Day	5 Days	15 Days	30 Days	60 Days
2,5-Dimethylpyrrole	6.8g	Light[1]	.256	.591	.939	1.19	1.54
2,5-Dimethylpyrrole	6.8g	Dark	.018	.086	.136	.377	.710
Isoquinoline	9.2g	Light	--	--	--	--	[3]
Isoquinoline	9.2g	Dark	--	--	--	--	[3]
Acridine	12.0g	Light	--	--	.086	.008	.147
Acridine	12.0g	Dark	--	--	--	TRACE	TRACE
Trioctylamine	25.3g	Light	--	--	--	--	[3]
Trioctylamine	25.3g	Dark	--	--	--	--	[3]
Pyrrolidine	5.1g	Light	--	--	--	--	[3]
Pyrrolidine	5.1g	Dark	--	--	--	--	[3]
Quinoline plus decanoic acid[4]		Light[2] Dark	--	TRACE	TRACE	TRACE	TRACE[5]
Isoquinoline plus decanoic acid[4]		Light[2]	--	--	--	--	[3]
		Dark	--	--	--	--	[3]

[1] UV light at 366 nm and 1100 $\mu W/cm^2$ unless otherwise noted.
[2] Sunlight.
[3] Solution colorless and clear throughout.
[4] 500 ppm O.
[5] Yellow colored, cloudy.

Taken from Reference No. 37

TABLE 224

Effects of Various Pyrroles and Indoles on Sediment Formation in n-Decane

Nitrogen Compound	Amount	Storage[2]	Cumulative Sediment[1] 1 Day	5 Days	15 Days	30 Days	60 Days
2,5-Dimethylpyrrole[3]	6.8g	Light	[5]	.654	.782	1.07	1.40
2,5-Dimethylpyrrole	6.8g	Dark	[5]	.060	.204	.396	.803
Pyrrole[4]	4.8g	Light	---	.062	.207	.309	.400
Pyrrole	4.8g	Dark	---	---			
2,4-Dimethyl-3-ethyl-pyrrole	8.8g	Light	[5]	.117	.143	.145	.194
2,4-Dimethyl-3-ethyl-pyrrole	8.8g	Dark	[5]	.110	.112	.149	.171
1,2,5-Trimethylpyrrole	7.8g	Light	[5]	.087	.331	.695	.935
1,2,5-Trimethylpyrrole	7.8g	Dark	[5]	---	---	.040	.089
2,6-Dimethylquinoline	11.2g	Light	[5]	---	TRACE	TRACE	TRACE
2,6-Dimethylquinoline	11.2g	Dark	---	---	---	---	---
1,2-Dimethylindole	10.4g	Light	[5]	.079	.079	.192	.384
1,2-Dimethylindole	10.4g	Dark	[5]	---	---	---	---
2-Methylindole	9.4g	Light	[5]	.413	.649	2.09	2.27
2-Methylindole	9.4g	Dark	[5]	.010	.600	1.15	1.40
2,5-Dimethyindole	10.4g	Light	[5]	.078	.270	1.48	2.27
Indole[6]	8.4g	Light	[5]	.005	.040	0.90	.180
Indole	8.4g	Dark	[5]	---	---	---	---

[1] In grams per 500 g decane.
[2] Light Storage was sunlight.
[3] Average of two runs.
[4] Stored under UV light.
[5] Not measured at this time period.
[6] Average of three runs.

Taken from Reference No. 37

TABLE 225

Effects of Various Hydrocarbons on Sediment Formation with DMP and Indole in n-Decane

Nitrogen Compound[1]	Hydrocarbon	Storage	Cumulative Sediment (g / 500g Decane) 1 Day	5 Days	15 Days	30 Days	60 Days
DMP[2]	None (n-decane only)	Light[3]	.221	.621	.869	1.21	1.58[2]
DMP[2]	None (n-decane only)	Dark	.019	.060	.140	.389	.793[2]
DMP	1-Dodecene	Light	.213	.378	.750	.999	1.28
DMP	1-Dodecene	Dark	.037	.065	.163	.317	.599
DMP	i-Propylcyclohexane	Light	.231	.392	.841	1.14	1.45
DMP	i-Propylcyclohexane	Dark	.023	.061	.158	.292	.514
DMP	2,2,4-Trimethylhexane	Light	.257	.502	.839	1.08	1.36
DMP	2,2,4-Trimethylhexane	Dark	.015	.056	.151	.356	.797
DMP	sec-Butylbenzene	Light	.195	.515	.856	1.17	1.45
DMP	sec-Butylbenzene	Dark	.009	.044	.145	2.80	.566
DMP	1,7-Octadiene	Light	.348	.642	.962	1.19	1.44
DMP	1,7-Octadiene	Dark	.023	.124	.288	.466	.693
DMP	4-Methyl-1-Cyclohexene	Light	.210	.482	.933	1.10	1.49
DMP	4-Methyl-1-Cyclohexene	Dark	.067	.166	.314	.505	.734
DMP	α-Methylstyrene	Light	.253	.536	.802	1.11	1.41
DMP	α-Methylstyrene	Dark	.088	.033	.122	2.73	.602
Indole	1-Dodecene	Light	--	--	.053	.076	.127
Indole	1-Dodecene	Dark	--	--	--	--	--
Indole	sec-Butylbenzene	Light	--	--	.057	.075	.101
Indole	sec-Butylbenzene	Dark	--	--	--	--	--
Indole	None (n-decane only)	Light	.012	.021	.022	.036	.043
Indole	None (n-decane only)	Dark	--	--	--	--	--

[1] Added at 2000 ppm N level; DMP = 2,5-dimethylpyrrole

[2] Average of several runs

[3] UV light at 366 nm and 1100 μ W/cm²

Taken from Reference No. 37

TABLE 226

Effects Of Carboxylic Acids on Sediment Formation with 2,5-Dimethylpyrrole (DMP)[1] in n-Decane

Acid[2]	Storage	Cumulative Sediment (g / 500g Decane)				
		1 Day	5 Days	15 Days	30 Days	60 Days
None[3]	Light	.256	.591	.939	1.19	1.54
None[3]	Dark	.018	.086	.136	.377	.710
Benzoic	Light	.259	.475	.857	1.06	1.96
Benzoic	Dark	.057	.165	.414	.585	1.12
Decanoic	Light	.390	.821	1.25	1.49	1.84
Decanoic	Dark	.057	.147	.497	.990	1.50
Cyclohexane Carboxylic	Light	.391	.821	1.26	1.56	1.83
Cyclohexane Carboxylic	Dark	.083	.216	.621	1.08	1.84

[1] DMP present at 2,000 ppm N level in all samples.
[2] Added at 500 ppm O level.
[3] Standard average of 3 runs.

Taken from Reference No. 37

TABLE 227

Effect of Phenols on Sediment Formation With DMP in n-Decane

Nitrogen Compound[1]	Additive[1]	Storage Conditions	Cumulative Sediment (g / 500g Decane)				
			1 Day	5 Days	15 Days	30 Days	60 Days
DMP	None	Light[2]	.256	.591	.939	1.19	1.54
DMP	None	Dark	.014	.063	.204	.369	.803
DMP	Phenol	Light	[3]	[3]	.015[4]	.092[4]	1.34
DMP	Phenol	Dark	[3]	[3]	.011[4]	.090[4]	.659
DMP	4-t-Butylphenol	Light	[3]	.414	[3]	.815	1.26
DMP	4-t-Butylphenol	Dark	[3]	.043	.045[3]	.314	.890
DMP	2,4-Dimethylphenol	Light	.081	.271	.569	.658	1.15
DMP	2,4-Dimethylphenol	Dark	--	.018	.213	.573	1.15
DMP	2,3-Dimethylphenol	Light	.148	2.66	.266[3]	.482	.930
DMP	2,3-Dimethylphenol	Dark	--	.059	.269	.448	1.08
DMP	2,6-di-t-Butylphenol	Light	--	.022	.173	.376	.639
DMP	2,6-di-t-Butylphenol	Dark	--	--	.035	.131	.496
DMP	2,4-di-t-Butylphenol	Light	.042	.275	.540	.843	1.20
DMP	2,4-di-t-Butylphenol	Dark	--	.010	.178	.532	.981
DMP	2-t-Butyl-4-methylphenol	Light	.033	2.62	.512	.810	1.11
DMP	2-t-Butyl-4-methylphenol	Dark	--	.069	.196	.544	1.19
DMP	2,5-di-Isopropylphenol	Light	--	.146	.356	.587	.879
DMP	2,5-di-Isopropylphenol	Dark	--	--	.093	.335	.864
DMP	2,4,6-Trimethylphenol	Light	.275	.459	.682	.910	1.33
DMP	2,4,6-Trimethylphenol	Dark	--	.010	.126	.336	1.00
DMP	2,4,6-tri-t-Butylphenol	Light	.006	.202	.405	.634	.927
DMP	2,4,6-tri-t-Butylphenol	Dark	--	.001	.057	.187	.637

See footnotes at end of TABLE 227 next page

Taken from Reference No. 37

TABLE 227

Effect of Phenols on Sediment Formation With DMP in n-Decane. --continued

Nitrogen Compound[1]	Additive[1]	Storage Conditions[2]	Cumulative Sediment (g / 500g Decane)				
			1 Day	5 Days	15 Days	30 Days	60 Days
DMP	2-Hydroxy-3-isopropyl[5]	Light	--	.092	.270	.473	.770
DMP	2-Hydroxy-3-isopropyl[5]	Dark	--	--	.020	.099	.283
DMP	2,6-di-t-Butyl-4-methylphenol	Light	.003	.040	.153	.272	.823
DMP	2,6-di-t-Butyl-4-methylphenol	Dark	--	.010	.058	.108	.603
Indole	None	Light	.012	.021	.022	.036	.043
Indole	None	Dark	--	--	--	--	--
Indole	2,5-di-t-Butylphenol	Light	--	--	.023	.036	.039
Indole	2,5-di-t-Butylphenol	Dark	--	--	--	--	--
Indole	2,6-di-t-Butyl-4-methylphenol	Light	--	.006	.065	.065	.067
Indole	2,6-di-t-Butyl-4-methylphenol	Dark	--	--	--	--	--

[1] Nitrogen compound at 2,000 ppm N; oxygen compound at 500 ppm O; DMP = 2,5-Dimethylpyrrole

[2] Light = UV light, 366 nm at 1100μ W/cm^2.

[3] Too lacky to filter.

[4] Glassy sediment could not be measured accurately until end of test period. These values are too low.

[5] 3-i-Propylcatechol.

Taken from Reference No. 37

Effects of Sulfur Compounds on Sediment Formation with Nitrogen Compounds in n-Decane

Nitrogen Compound[1]	Sulfur Compound[2]	Storage	Cumulative Sediment (g / 500g Decane) 1 Day	5 Days	15 Days	30 Days	60 Days
DMP	None	UV Light	.256	.275	.939	1.19	1.54
DMP	None	Dark	.014	.063	.204	.369	.803
DMP	n-Octylsulfide	UV Light	.209	.577	.867	1.13	1.41
DMP	n-Octylsulfide	Dark	--	--	.039	.174	.681
DMP	n-Dodecanethiol	UV Light	.161	.269	.551	.802	1.15
DMP	n-Dodecanethiol	Dark	--	--	.047	.202	.468
DMP	Benzyldisulfide	Sunlight	[3]	.317	.656	.968	1.26
DMP	Benzyldisulfide	Dark	[3]	.049	.153	.426	.704
DMP	Benzylphenylsulfide	Sunlight	[3]	.301	.632	.966	1.59
DMP	Benzylphenylsulfide	Dark	[3]	.049	.152	.356	.628
DMP	Thiophenol	UV Light	.080	.081	.081	.081	.587
DMP	Thiophenol	Dark	--	--	--	.013	.014
DMP	Thiophenol[4]	UV Light	.001	.021	.226	.301	1.12
DMP	Thiophenol[4]	Dark	--	--	--	TRACE	.064
DMP	p-Thiocresol	UV Light	[3]	.024	.032	.069	.233
DMP	p-Thiocresol	Dark	[3]	--	--	.013	.014
2-Methylindole	Thiophenol	UV Light	.002	.032	.124	.125	.361
2-Methylindole	Thiophenol	Dark	TRACE	TRACE	TRACE	TRACE	.005
DMP	1-Naphthalenethiol	Sunlight	.028	.204	[5]	.423	.756
DMP	2-Naphthalenethiol	Sunlight	.063	.108	[5]	.158	.572
DMP	None	Sunlight	.134	.671	[5]	1.32	1.94

[1] Added at 2,000 ppm N level. DMP = 2,5-Dimethylpyrrole.
[2] Added at 3,000 ppm S unless otherwise noted.
[3] Too tacky to measure at this point.
[4] 500 ppm S level.
[5] Not measured at this time period.

Taken from Reference No. 37

TABLE 229

Effects of Deoxygenation on Sediment Formation with 2,5-Dimethylpyrrole in n-Decane

Dissolved Oxygen	Storage	Cumulative Sediment (g/500g Decane) 1 Day	5 Days	15 Days	30 Days	60 Days
< 1 ppm[1]	UV Light	.032	.154	.298	.645	.918
	Dark	—	.032	.024	.025	.230
78 ppm[2]	UV Light	.204	.363	1.06	1.41	1.72
	Dark	.022	.092	.219	.483	.890

[1] O_2 removed by sparging fuel with N_2.
[2] Air sparged after each weighing period.

Taken from Reference No. 37

TABLE 230

Effects of Moisture and Sulfuric Acid on Sediment Formation with Nitrogen Compounds in n-Decane

Nitrogen Compound[1]	Additive	Storage	Cumulative Sediment (g / 500g Decane) 1 Day	5 Days	15 Days	30 Days	60 Days
DMP	None	UV Light[2]	.256	.591	.939	1.19	1.54
DMP	None	Sunlight	.134	.672	[3]	1.34	1.94
DMP	None	Dark[2]	.014	.063	.204	.396	.803
DMP	H_2O[4]	UV Light	[3]	.358	.584	.714	1.06
DMP	H_2O[4]	Dark	[3]	.042	.122	.249	.594
DMP	H_2O[4]	Sunlight	.142	.418	[3]	.661	1.16
DMP	H_2SO_4[5]	Sunlight	.198	.660	[3]	.937	1.89
Indole	None	UV Light	.012	.021	.022	.036	.043
Indole	None	Dark	--	--	--	--	--
Indole	H_2O[4]	UV Light	[3]	.017	.032	.032	.069
Indole	H_2O[4]	Dark	[3]	—	--	—	--

[1] Added at 2,000 ppm N level. DMP = 2,5-Dimethylpyrrole.
[2] Standard run - see Table 222.
[3] Not measured this time period.
[4] Saturated solution of H_2O in decane.
[5] Saturated solution of H_2SO_4 in decane.

Taken from Reference No. 37

TABLE 231
Insolubles for Solvents With Added 2,5-Dimethylpyrrole[1,2]

	mg/100 ml				
			Total Insolubles		
Solvent	Filtered Sediment	Adherent Gum	Duplicates	Mean	Std. Dev.
Shale OFM	48.7	1.8	50.5		
	52.1	2.3	54.4	52.5	± 2.8
Toluene	27.2	3.1	30.3		
	34.5	4.4	38.9	34.6	± 6.1
Dodecane	34.0	1.8	35.8		
	35.1	2.2	37.3	36.6	± 1.1
Benzene[3]	24.8	3.6	28.4		
	34.0	4.2	38.2	33.3	± 6.9

2, 5-Dimethylpyrrole concentration equivalent to 450 ppm N.

Aged at 80 °C for 4 days

A 65 °C stress for 10 days was used, which is comparable to 80 °C for 4 days.

aken from Reference No. 47

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