

# ACCURATE ANALYSIS OF STRAIGHT-RUN GASOLINE

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## Introduction

The detecting of individual hydrocarbon in gasoline is one of the most difficult processes. In the case of analysis of gasoline, fractional distillation, is performed at first, and individual hydrocarbons will be detected by chemical treatments and physical estimations from each fractions, with or without the isolation of simplified substance or other special treatments.

But, only a few hydrocarbons having lower boiling points are confirmed, or are isolated in pure state. In many cases, the volumetric analysis of individual hydrocarbons (more than six carbons) is quite impossible.

As one of the properties of gasoline for a high speed engine, the quality of anti-knocking is required. This problem requires more minute identification of the kind and the volume of individual hydrocarbon in gasoline.

So, in analysing straight-run gasoline from crude petroleum<sup>(1)</sup> (Pendopo, Smatra), we engaged in another method (avoiding unstable loss by volatilization of its hydrocarbon in tedious and time-consuming treatment, such as re-distillation): to gain the accurate result in volume, the gasoline was cut, under careful fractional distillation, in as short fractions as possible. These short fractions were used directly in the test of density, aniline point, and nitration. It is necessary that individual hydrocarbons in gasoline be condensed in short fractions.

So, a rectifying column was specially planned to obtain a smooth counter-current of vapor in it.

The straight-run gasoline had a few unsaturated hydrocarbons. Therefore, an aromatic hydrocarbon in these fractions was directly excluded by nitration.

Constituents of paraffin and naphthene in each fraction were determined by the agreement of measured and calculated densities and aniline points. (This calculated value was estimated by the combination of physical data which were taken from the specimens that are determined in the experiment of various gasolines.

## Operation

(a) *Fractional Distillation.* As a testing oil, we used the straight-run gasoline (I.B.P.~150°C.) of crude petroleum (Pendopo, Smatra). This gasoline was frac-

(1) This gasoline has been studied by analysis of Raman-effect by S. Mizushima and co-workers. (Journal of the Chemical Society of Japan; Vol. 66, No. 1-6, p. 22, 1945).

tionally distilled by the apparatus shown in figure 1. A rectifying column (B) was constructed of a glass tube (length 270 cm.; dia. 2.4 cm.), in which 9 sets of double glass spirals and 8 groups of glass balls (dia. 0.5 cm.) were packed, and its outside was surrounded with a nichrome wire as an electric heater.

The double glass spirals (length 25 cm.) were made of a glass rod of 0.45 cm. in dia. with a 0.4 cm. dia. rod wound around it at a pitch of 1 cm. Over this was placed a glass tube of inner dia. 1.3 cm. and thickness 0.1 cm., with holes 1 cm. apart, and another rod 0.45 cm. in dia. wound in a spiral around this, also with a pitch of 1 cm. The spirals were held tightly to the tube. Each group of glass balls contained 20 balls.

Thermal insulation was secured by surrounding the column with a glass double jacket which was evacuated and silvered, except a line part (width 0.5 cm.) on one side for observation, and this jacket was covered with 2 cm. thickness of asbestos fibre.

In a dephlegmator (C), reflux cooling was performed in an up-right tube (dia. 1.2 cm.; length 20 cm.) fixing the electric heater and surrounding an another glass jacket containing the cold water in it.

In this apparatus, the reflux was controlled at the ratio 1:20; *i.e.*, 3 drops per one minute at part (III), 60 drops per one minute at part (II), 120 drops per one minute at part (I). This reflux condition is determined in the preliminary experiment, which the satisfactory separating condition was studied by distillation of mixture that consists of gasoline (free from aromatic hydrocarbon by use of 98 per cent sulphuric acid), pure-benzol, pure-toluol, pure-m-xylol (the latter three material's volumes had been previously measured).

The temperature of distillation is measured at every 2 cc. of condensed oil in a receiver by a thermometer hanging in the dephlegmator.

From 2000 cc. of the testing oil, 1760 cc. distillate was obtained, 100 cc. residual,

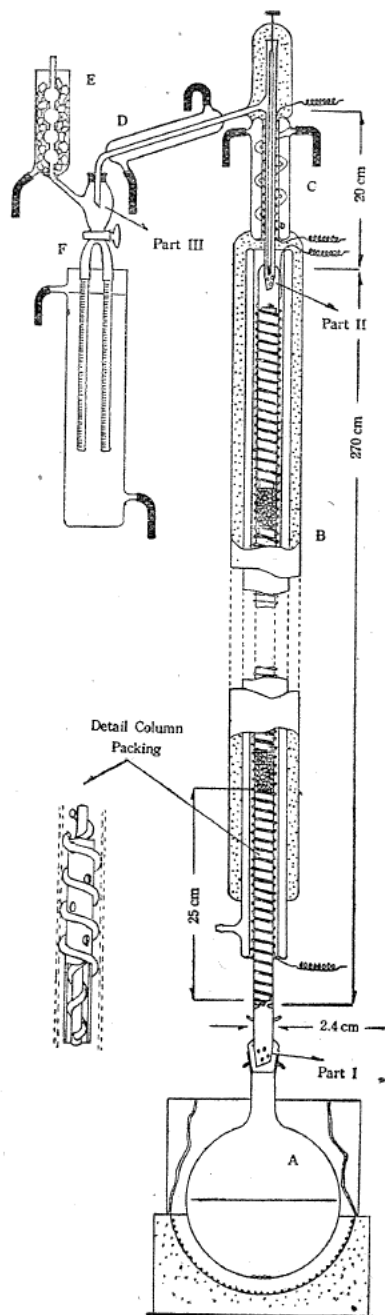


Fig. 1. Apparatus of Fractional Distillation

and 140 cc. loss (volatilized).

Each fraction of distillation, except the first distillate of 40 cc., was separated into 10 cc. samples and divided into 172 parts. The parts smaller than the 5th fraction had large loss by volatilization and the parts larger than 169th fraction were omitted from the calculations. We calculated the percentage of hydrocarbons in these fractions (1630 cc.).

(b) *Properties of Distillates.* An analysis of this oil was obtained by the method of M. Mizuta<sup>(2)</sup>.

The following is this result.

Unsaturated hydrocarbon ... 0.2% (by weight)	Naphthenic hydrocarbon ... 34.9%
Aromatic hydrocarbon ... 19.4%	Paraffinic hydrocarbon ... 45.4%

The density of each fraction was estimated in a measuring flask (capacity 2 cc.) at 20°C.

Six cc. of each fraction were mixed with two volumes of fuming nitric acid ( $D_4^{20}$  1.52) in a measuring tube (dia. 1 cm., graduated 0.1 cc.) below -20°C.

These mixtures were shaken frequently until the nitration came to an end (shown by the vanishing of red color in oil) and were allowed to stand for 30 minutes at 20°C., and next, the reduced volumes of aromatic hydrocarbons were estimated.

The oily layers, separated from those mixtures, were washed with 95 per cent sulphuric acid, were neutralized with 10 per cent solution of sodium carbonate (two times), were washed with distilled water, and were dried with calcium chloride. Those oils free from aromatic hydrocarbons were measured for densities and aniline points. These results are given in table 1.

Table 1. Fractional Distillation  
(Densities, Aniline Points, and Percentages of hydrocarbons)

A	B	C	D	E	F	G	H
1	34.40	0.6226					
2	36.40	0.6263					
3	37.00	0.6264					
4	37.00	0.6271					
5	37.00	0.6283					
6	42.40	0.6398					
7	51.60	0.7083					
8	56.80	0.6905					
9	60.00	0.6729	0.6669		1.1		
10	61.00	0.6615	0.6588		0		
11	61.50	0.6585			0.7		
12	61.80	0.6586			1.1		
13	61.90	0.6584	0.6569		1.2		
14	62.00	0.6583			0.9		
15	62.00	0.6583	0.6580		0		

(2) Testing method of Petroleum and Asphalten (in Japan), The 3rd Edition p. 155.

Table 1. (Continued)

A	B	C	D	E	F	G	H
16	62.50	0.6587			0		
17	63.60	0.6657			0		
18	65.40	0.6727	0.6692	65.10	0	89.0	11.0
19	66.50	0.6758	0.6692	65.10	1.6	87.6	10.8
20	67.20	0.6814	0.6694	64.90	2.6	86.5	10.9
21	68.00	0.6836	0.6727	63.75	1.7	83.6	14.7
22	69.00	0.6935	0.6772	57.05	2.5	78.0	19.5
23	69.60	0.6985	0.6817	60.35	3.9	72.1	24.0
24	70.10	0.6993	0.6835	59.70	5.2	68.7	25.5
25	70.40	0.7044	0.6851	59.10	5.7	67.2	27.1
26	71.00	0.7044	0.6867	58.45	5.8	65.4	28.8
27	71.00	0.7082	0.6884	57.85	5.9	63.5	30.6
28	71.00	0.7093	0.6905	56.99	5.9	61.3	32.8
29	71.20	0.7151	0.6935	55.88	8.8	56.4	34.8
30	71.20	0.7160	0.6964	54.77	12.1	51.4	36.5
31	71.40	0.7282	0.7035	52.10	11.3	44.9	44.8
32	72.00	0.7359	0.7103	49.53	9.6	38.9	51.5
33	72.30	0.7402	0.7170	49.99	10.0	31.9	58.1
34	72.60	0.7432	0.7217	45.20	10.6	27.0	62.4
35	73.50	0.7630	0.7321	42.16	28.2	16.5	55.3
36	74.40	0.7755	0.7420	40.19	22.1	14.0	63.9
37	75.40	0.7790	0.7470	38.86	30.3	10.4	59.3
38	76.50	0.7749	0.7583	37.75	31.5	8.6	59.9
39	77.20	0.7724	0.7756	36.84	25.3	8.2	66.5
40	78.30	0.7700	0.7578	36.60	18.9	8.9	72.2
41	79.60	0.7668	0.7568	36.70	15.3	10.4	74.3
42	80.30	0.7660	0.7555	36.43	13.8	10.9	75.3
43	81.00	0.7642	0.7593	37.45	10.3	13.9	75.8
44	81.40	0.7644	0.7607	38.29	5.1	16.6	78.3
45	82.10	0.7597	0.7535	41.33	5.0	23.5	71.5
46	84.80	0.7485	0.7473	43.92	4.3	29.7	66.0
47	87.40	0.7442	0.7408	46.63	2.5	36.6	60.9
48	89.20	0.7322	0.7358	48.71	1.1	42.0	50.9
49	91.00	0.7272	0.7271	55.73	2.0	45.6	52.4
50	92.00	0.7183	0.7241	56.78	0.9	49.4	49.7
51	92.40	0.7177	0.7171	57.69	0.9	52.8	46.3
52	92.60	0.7091	0.7193	58.45	0.9	54.6	44.5
53	92.50	0.7165	0.7184	58.75	1.2	55.3	43.5
54	93.00	0.7163	0.7179	58.93	1.2	55.9	42.9
55	93.90	0.7161	0.7181	58.90	2.3	55.2	42.5
56	93.90	0.7162	0.7183	58.80	2.9	54.6	42.5
57	94.40	0.7178	0.7189	58.58	2.2	54.3	43.5
58	95.00	0.7198	0.7204	58.11	1.9	53.0	45.1
59	95.10	0.7194	0.7196	58.36	2.2	54.3	43.5
60	95.30	0.7211	0.7191	58.55	2.9	53.8	43.3
61	96.10	0.7193	0.7215	56.09	3.0	54.2	42.8
62	97.00	0.7210	0.7221	55.89	2.8	53.7	43.5
63	98.10	0.7276	0.7226	55.73	3.1	52.9	44.0
64	98.80	0.7295	0.7232	55.58	3.1	52.3	44.6
65	99.30	0.7303	0.7237	55.43	2.8	51.9	45.3
66	100.20	0.7314	0.7239	55.04	2.1	50.9	47.0
67	100.60	0.7350	0.7261	54.63	1.1	49.9	49.0
68	100.70	0.7400	0.7283	53.96	0	48.0	52.0
69	101.50	0.7485	0.7304	53.28	3.9	43.7	52.4
70	101.70	0.7503	0.7317	52.88	7.2	40.8	52.0
71	101.90	0.7479	0.7321	52.76	7.1	46.5	52.4
72	101.40	0.7484	0.7317	52.88	6.9	41.0	52.1
73	101.70	0.7490	0.7353	51.74	6.2	37.3	56.5
74	101.90	0.7505	0.7377	50.99	5.9	34.8	59.3
75	102.00	0.7523	0.7384	50.76	5.1	34.3	60.6

Table 1. (Continued)

A	B	C	D	E	F	G	H
76	102.00	0.7521	0.7395	50.45	4.3	33.5	62.2
77	102.10	0.7534	0.7405	50.12	5.3	32.0	62.7
78	102.40	0.7557	0.7410	49.95	6.8	31.0	62.2
79	102.40	0.7536	0.7407	50.04	5.7	31.6	62.7
80	102.30	0.7525	0.7407	50.04	4.6	32.0	63.4
81	102.10	0.7545	0.7437	49.10	2.9	29.1	68.0
82	102.50	0.7600	0.7463	48.29	1.7	26.5	71.8
83	102.90	0.7640	0.7478	47.79	8.1	23.1	68.8
84	103.00	0.7660	0.7485	47.61	13.8	21.1	65.1
85	103.00	0.7655	0.7489	47.48	14.6	20.5	64.9
86	102.80	0.7657	0.7497	47.21	14.9	19.6	65.5
87	102.80	0.7673	0.7506	46.94	16.3	18.4	65.3
88	103.20	0.7711	0.7528	46.26	17.3	16.1	66.6
89	103.20	0.7740	0.7549	45.59	17.0	14.1	68.9
90	103.50	0.7773	0.7558	45.32	24.2	12.1	63.7
91	103.90	0.7768	0.7560	45.23	27.9	11.3	60.8
92	104.20	0.7792	0.7566	45.05	29.1	10.6	60.3
93	104.20	0.7814	0.7600	45.84	31.3	10.1	58.6
94	104.80	0.7850	0.7601	45.78	33.2	9.7	57.1
95	105.40	0.7869	0.7582	46.77	38.1	10.8	51.1
96	106.20	0.7905	0.7549	48.42	42.6	12.9	44.5
97	105.90	0.7935	0.7509	50.50	49.3	14.6	36.1
98	107.50	0.7950	0.7479	52.01	54.1	15.3	30.6
99	108.00	0.7970	0.7461	52.93	60.1	14.4	25.5
100	108.50	0.7997	0.7414	54.35	64.1	15.6	20.3
101	109.30	0.8064	0.7388	56.67	57.9	15.2	16.9
102	110.10	0.8071	0.7330	59.64	69.4	17.3	13.3
103	110.20	0.8081	0.7306	60.85	67.4	19.6	13.0
104	110.20	0.8080	0.7291	61.62	63.6	22.8	13.6
105	111.50	0.8060	0.7264	64.56	55.6	28.0	16.4
106	113.00	0.7952	0.7299	64.20	48.5	31.7	19.8
107	113.60	0.7793	0.7313	63.67	42.4	34.3	23.2
108	115.00	0.7677	0.7326	63.16	35.8	36.9	27.3
109	116.30	0.7596	0.7370	62.98	18.1	46.5	35.4
110	118.00	0.7370	0.7334	62.84	3.5	54.2	42.3
111	118.80	0.7342	0.7336	62.78	2.3	54.7	43.0
112	119.80	0.7346	0.7339	62.65	1.6	54.6	43.8
113	120.00	0.7321	0.7345	62.39	2.1	53.4	44.5
114	120.40	0.7342	0.7343	62.09	3.2	51.6	45.2
115	120.20	0.7338	0.7356	61.96	3.9	50.7	45.4
116	120.60	0.7363	0.7362	61.76	3.9	50.0	46.1
117	121.30	0.7378	0.7368	61.50	3.8	49.1	47.1
118	121.20	0.7379	0.7384	60.86	3.1	47.0	49.9
119	121.40	0.7392	0.7389	60.65	3.6	46.0	50.4
120	121.50	0.7401	0.7396	60.40	3.6	45.0	51.4
121	121.60	0.7419	0.7402	60.14	3.6	44.1	52.3
122	121.80	0.7430	0.7409	59.86	4.3	43.2	53.5
123	122.40	0.7455	0.7418	59.50	4.2	41.4	54.4
124	122.70	0.7426	0.7427	59.21	4.0	40.3	55.7
125	123.20	0.7441	0.7425	59.25	4.0	40.5	55.4
126	123.90	0.7421	0.7416	59.59	3.3	42.1	54.6
127	123.90	0.7438	0.7409	59.89	3.8	43.0	53.2
128	124.30	0.7424	0.7394	60.48	4.0	45.1	50.9
129	124.80	0.7409	0.7384	60.86	4.1	46.5	49.4
130	125.10	0.7404	0.7371	61.38	4.8	48.1	47.1
131	125.70	0.7372	0.7358	61.88	6.8	48.9	44.3
132	126.40	0.7383	0.7351	62.14	9.5	48.5	42.0
133	126.80	0.7394	0.7345	62.39	11.4	48.3	40.3
134	127.60	0.7427	0.7342	62.52	13.6	47.5	37.9
135	128.40	0.7474	0.7345	62.39	15.3	46.2	38.5

Table 1. (Continued)

A	B	C	D	E	F	G	H
136	129.00	0.7527	0.7362	61.76	16.6	43.4	40.0
137	130.80	0.7616	0.7371	61.37	17.4	41.7	40.9
138	130.90	0.7649	0.7384	60.86	18.2	39.7	42.1
139	131.80	0.7747	0.7514	61.44	22.9	37.0	40.1
140	133.30	0.7880	0.7523	61.09	27.5	33.9	38.6
141	134.00	0.7886	0.7524	61.02	31.2	32.0	36.8
142	134.50	0.7930	0.7526	60.93	34.1	29.0	36.9
143	135.30	0.7999	0.7528	60.88	37.6	28.7	33.7
144	137.70	0.8029	0.7528	60.88	41.9	26.7	31.4
145	138.70	0.8034	0.7528	60.88	45.3	25.2	29.5
146	138.50	0.8032	0.7529	60.81	48.4	23.6	28.6
147	138.50	0.8032	0.7530	60.79	51.8	22.0	26.2
148	138.40	0.8024	0.7530	60.79	54.9	20.6	24.5
149	138.50	0.8027	0.7531	60.74	57.1	19.5	23.4
150	138.50	0.8044	0.7532	60.67	58.1	19.0	22.9
151	138.50	0.8034	0.7534	60.62	56.6	19.6	23.8
152	138.50	0.8050	0.7537	60.51	55.0	20.1	24.9
153	138.40	0.8054	0.7540	60.37	53.4	20.6	26.0
154	138.20	0.8065	0.7540	60.09	52.6	20.5	26.9
155	138.40	0.8085	0.7552	59.90	52.6	20.1	27.3
156	138.80	0.8078	0.7559	59.62	52.9	19.5	27.6
157	139.50	0.8090	0.7567	59.30	53.1	18.9	28.0
158	140.30	0.8062	0.7571	59.13	53.2	18.6	28.2
159	141.00	0.8043	0.7570	59.20	45.0	22.0	33.0
160	141.90	0.7980	0.7563	59.48	36.4	26.1	37.5
161	144.60	0.7818	0.7560	59.62	36.4	29.0	40.9
162	146.30	0.7755	0.7557	59.69	22.9	32.2	44.9
163	146.90	0.7695	0.7557	59.69	17.3	34.6	48.1
164	147.50	0.7636	0.7571	59.67	12.6	36.4	51.0
165	149.00	0.7639	0.7571	59.67	12.6	36.4	51.0
166	149.80	0.7651	0.7560	59.58	12.1	36.4	51.5
167	150.20	0.7605	0.7559	59.62	12.1	36.8	51.8
168	151.00	0.7612	0.7544	59.81	10.2	37.9	51.9
169	152.10	0.7679	0.7549	60.04	13.6	37.1	49.3
170	153.60	0.7719	0.7537	60.58	17.7	36.8	45.5
171	155.70	0.7829	0.7530	60.79	22.6	35.4	42.0
172	157.40	0.7934	0.7517	61.30	39.6	33.0	36.4

(c) *Determination of Aromatic Hydrocarbon.* In reference to the distillation temperature and the density of the fractional distillation in table 1, we divided the distilled oil into three parts

Benzol-oil ..... the lower 54th fraction  
Toluol-oil ..... from the 55th to the 112th fraction  
Xylol-oil ..... the upper 113th fraction

We took 1 cc. out of each fraction and mixed these samples as above mentioned three parts.

Unsaturated hydrocarbons were removed by 80 per cent solution of sulphuric acid and then aromatic hydrocarbons in three parts were estimated from these reduced volumes by the two kinds of treatments, that is, by 100 per cent sulphuric acid (98 per cent sulphuric acid + anhydrous sulphuric acid) in a Weger burette, and by nitration in a measuring tube.

At the same time, aniline points were estimated for the above three kinds of oil (free from aromatic hydrocarbon).

The results are shown table 2.

Table 2. Percentages of Aromatics (by volume)

Series	(a) by Sulphonation	(b) by Nitration	(c) for Total Oil	(d) from Table 1.	Aniline Point free from Aromatics
Benzol-oil	6.4 %	6.7 %	2.0 %	1.9 %	54.75°C.
Toluol-oil	19.9 %	20.0 %	7.0 %	7.0 %	54.05°C.
Xylol-oil	20.9 %	21.4 %	7.8 %	7.8 %	62.10°C.

Table 2 shows the complete removal of aromatic hydrocarbon in each oil. For the percentages of aromatic hydrocarbon, we adopted those in table 2-(d).

### Analysis of Xylol Fraction

Moreover, we studied the determination of o-, m-, p-xylol and ethyl benzol, in the same xylol-oil which was a part of the straight-run gasoline distilled by the next method.

The straight-run gasoline in a distilling flask (see figure 2, its globular part is 250 cc.; its neck is 2 cm. diameter and 20 cm. height, packing glass balls, dia. 0.4 cm., and its outside is covered with Japanese paper.), was separated into 5°C. fractions by distillation. We thought 114 ~ 156°C. distillate in all 5°C. fractions as xylol-oil, and they were used in the next experiment. These 5°C. fractions were separated into 2°C. fractions by re-distillation, and fractions which had been distilled at the same temperature were mixed together. These mixed fractions were again distilled into 2°C. fractions, and these all xylol oil was divided completely into 2°C. fractions. Each fraction was nitrated with mixed acid, and

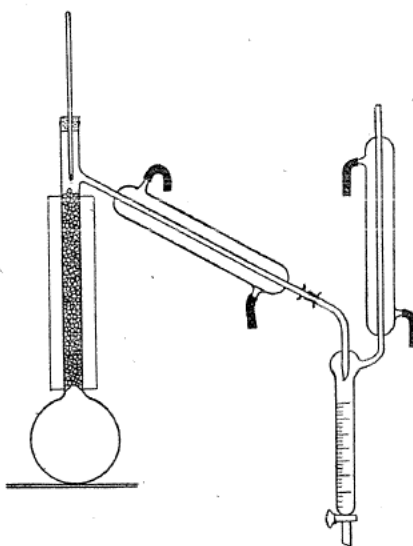


Fig. 2.

crystals of the tri-nitro compound were obtained and their quantities measured. These results are shown in table 3.

The fractions were nitrated by mixed acids as follows: 10 cc. of glacial acetic acid and 2 cc. of 2°C. fractions were mixed in a 300 cc. Meyer flask, and cooled by stirring in ice water. 15 cc.  $\text{HNO}_3$  ( $D_4^{20}$  1.50) and 25 cc.  $\text{H}_2\text{SO}_4$  (60 Bé) were added to the mixture in the flask and allowed to stand for 30 minutes. Crystalline solids were precipitated. The samples were then boiled for one or two hours until the

reaction was complete.

Table 3. Percentage of m- and p-xylol

Temp. of Dist. °C	Nitro Compound			Percentage of m-xylol + p-xylol cc.
	Wt. of Comp. gr.	M.P. °C.	M.P. (After washed by alcohol) °C.	
114-116	0.0810	174	179	7.1
116-118	0.1490	175	179	3.7
118-120	0.2048	175	180	5.2
120-122	0.2580	176	179	6.5
122-124	0.3764	176	179	9.5
124-126	0.5010	170	179	12.6
126-128	0.8062	172	179	20.3
128-130	0.8878	167	180	22.4
130-132	1.0496	170	180	26.5
132-134	1.3490	171	179.5	34.1
134-136	1.3220	169	180	33.4
136-138	1.2410	176	180	31.3
138-140	1.2230	174	180	30.9
140-142	1.0782	160	179	37.2
142-144	0.9080	170	178	22.9
144-146	0.7508	169	178	18.9
146-148	—	—	—	—
148-150	0.6108	154	169	15.4
150-152	0.1696	154	170	4.2
152-154	0.3006	180	231	7.5
154-156	0.6604	180	210	16.6

The mixtures containing the crystalline solids were again cooled with ice, diluted with 200 cc. of ice water, and allowed to stand for one-half hour. They were then filtered and the precipitates washed with 100 cc. of ice water and dried at 75° to 80° C.

Melting points of nitro compounds which are expected to be found in xylol fraction nitrated by mixed acid, are as follows;

2-4-Dinitro Ethyl Benzol .....	oil
2-4-6-Trinitro " " .....	M.P. 37°C.
2-4-5-Trinitro m-Xylol .....	M.P. 90°C.
2-4-6- " " .....	M.P. 182°C.
2-5-6- " " .....	M.P. 125°C.
2-3-5-Trinitro p-Xylol .....	M.P. 137°C.

o-Xylol is decomposed by such nitration. We thought that their main elements



of the nitro compounds in the separated crystalline solids are 2-4-6-trinitro m-xylol and 2-3-5-trinitro p-xylol.

After surveying the melting point and the weight of the crystals, we counted up the volumes of the mixture (m-xylol + p-xylol).

We calculated by following method the quantities of all aromatic hydrocarbons in 2°C. fractions. Avoiding the heat from reaction, 10 cc. of each 2°C. fractions were shaken with the same volume of conc.-sulphuric acid, and the decreased volume was measured. Result is shown in table 4.

Table 4. Percentage of Aromatic Hydrocarbon (in xylol-oil)

Temp. of Distill. °C.	% of Aromatic Hydrocarbon	Temp. of Distill. °C.	% of Aromatic Hydrocarbon
106-108	23.77	134-136	43.30
108-110	20.58	136-138	42.00
110-112	—	138-140	38.90
112-114	—	140-142	36.20
114-116	16.33	142-144	32.20
116-118	15.24	144-146	30.20
118-120	14.76	146-148	24.60
120-122	13.40	148-150	20.10
122-124	14.95	150-152	22.00
124-126	18.76	152-154	—
126-128	24.50	154-156	25.10
128-130	27.90	156-158	—
130-132	35.15	158-160	19.88
132-134	41.60		

We drew the graphs of figure 3, according to table 3 and 4.

We obtained percentage of ethyl benzol + o-xylol and m-xylol + p-xylol from the predicted area.

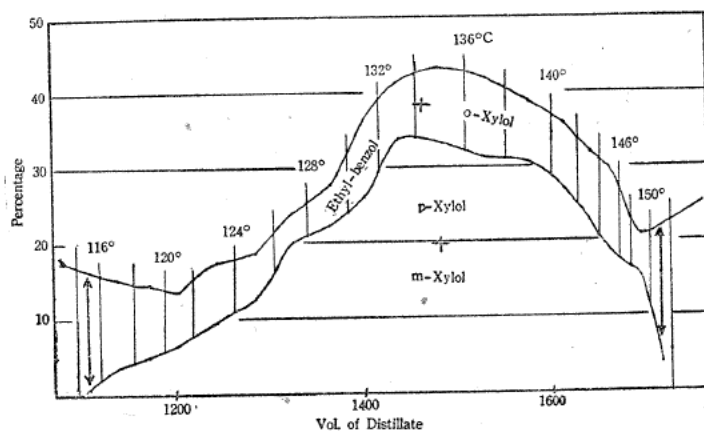


Fig. 3. Constituent of Xylol

This result is as follow:

m-Xylol + p-Xylol..... 4.26 %  
 o-Xylol + Ethylbenzol ..... 2.54 %

(d) *Estimation of Paraffin and Naphthene.* Percentages of paraffins and naphthenes, lower than the 17th fraction, were calculated on the distilled temperatures and the densities. In the case upper than the 18th fraction, these hydrocarbons were calculated on the combination with hydrocarbons (its existence may be expected in fractions) according to the experimental values. These values (calculated and surveyed by combination of hydrocarbons such as table 5) were satisfied as shown in figure 4. That is to say, the differentiation between the measured value and the calculated value concerning the density and the aniline point was very near to that of the physical constants between the isomers belonging to same series.

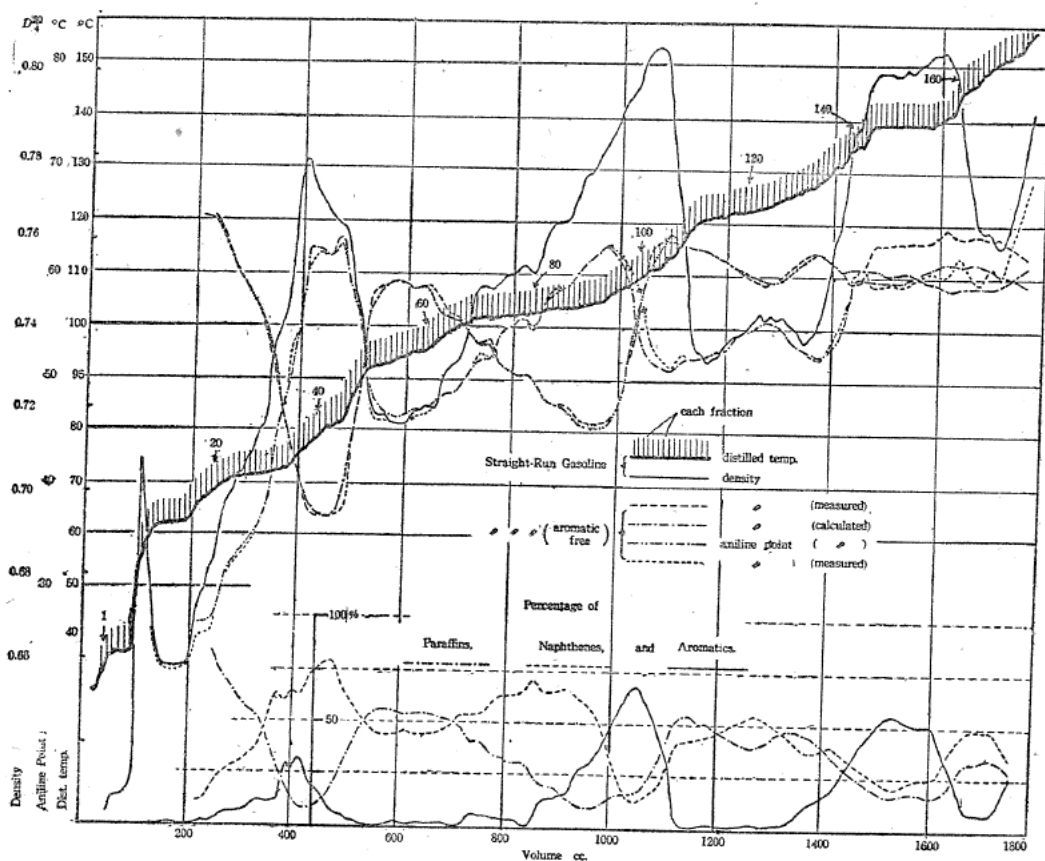


Fig. 4. Curves of Fractional Distillation, Density and Aniline Point (measured and calculated), and Contained Volume of Hydrocarbons

We have the result that the hydrocarbons in gasoline were distilled in suitable co-boiling state and the calculated value of the density and the aniline point agreed with well each other, especially in fractions lower than the 138th. So, paraffins and naphthenes (above six carbons) in the gasoline are estimated such as in table 6.

Table 5. Use of Density and Aniline Point in Calculation

Applicable Hydrocarbon	Density $D_4^{20}$	Aniline Point °C.	Number of Fractions
n-Pentane	0.6263		2- 6
Cyclopentane	0.7460		6- 9
2-Methylpentane	0.6565		7- 17
n-Hexane	0.6594	68.8	18- 33
2-Methylhexane	0.6785	72.9	38- 60
Methylcyclopentane	0.7487	35.0	18- 37
Cyclohexane	0.7782	31.0	38- 50
Methylcyclohexane	0.7695	41.0	50-104
n-Heptane	0.6837	68.0	60-104
Isooctane	0.7050	74.0	105-138
Dimethylcyclohexane	0.7700	48.5	105-134
"	0.7805	48.0	135-170
Isononane	0.7150	56.0	139-170

Methylcyclopentane and cyclohexane are calculated on the assumption that methyl cyclopentane is richest as naphthene in the 34th fraction and cyclohexane is richest in the 42nd fraction.

The values in above mentioned isooctane and iso-nonane are the mean value of their physical constants.

Table 6. Constitution of Gasoline (Pendopo Oil)

Name of Hydrocarbon	Volume Percentage
C = 5 (Isopentane)	4.2
n-Pentane	4.1
Cyclopentane	0.9
C = 6 Isohexane (as 2-Methylpentane)	5.8
n-Hexane	6.9
Methylcyclopentane	3.9
Benzol	2.0
Cyclohexane	5.3
C = 7 Isoheptane (as 2-Methylpentane)	5.7
n-Heptane	6.7
Methylcyclohexane	16.5
Toluol	7.0
C = 8 Isooctane	9.8
n-Octane	15.7
Dimethylcyclohexane	6.01
m-Xylol + p-Xylol	4.26
Ethylbenzol + o-Xylol	2.54
C = 9 Isononane	5.1

Table 1 gives the measured values and the calculated percentage of hydrocarbon. Figure 4 shows various curves of table 1 and of the calculated densities and aniline points.

### Conclusion

The experiments have been operated by the methods that we stated in introduction. We estimated the series of hydrocarbons and determined or inferred even the kinds and the volumes of individual hydrocarbons in gasoline. Table 6 is a result of the analysis of the straight-run gasoline of Pendopo oil. Our apparatus showed as many good efficiencies for analysis of gasoline as follows.

- 1). Individual hydrocarbons were divided satisfactorily in each fractions.
- 2). So, it was comparatively easy that we can calculate the almost of paraffins and naphthenes, by few preliminary chemical treatments.

This result agreed fairly well with that of Raman-effect (though there are a few exceptions).