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API Research Project MC-1

TABULAR SUMMARY
OF
CURRENT AND COMPLETED
BIOLOGICAL EXPERIMENTS

October 1, 1955

The Kettering Laboratory
in the
Department of Preventive Medicine and Industrial Health
College of Medicine
University of Cincinnati
Cincinnati, Ohio

API 06476

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TABLE 1

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY PAPI	FRACTION DISTIL- LING < 750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (% - week)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
<u>Non-catalytic cracking of virgin gas oil</u>							
2	Cracked Side- stream	21.2		0.0002	1 - 100	0-75	-
6	Cracked residuum	5.2	33	0.013	3 - 100	72-30	~ 0.08
59	Cracked residuum	8.5		0.005	3 - 100	82-69	0.02X
65	Cracked residuum	6.6	43.8	0.04	3 - 100	89-29	0.11X
72	Cracked residuum	9.6	35	0.06	3 - 100	73-18	0.21X
94	Cracked residuum	10.4	35	0.02	3 - 100	80-39	0.09X
108	Cracked residuum	2.3	32	0.12	3 - 100	71-28	0.12X
108					3 - 5	100-52	0.05 [±] .01
<u>Non-catalytic cracking of catalytic gas oil</u>							
20	Cracked residuum	4.7	51	0.24	3 - 100	100-22	~ 0.18
20					3 - 100	90-21	0.17X
20-1	50% oil No. 20, 50% dodecylbenzene				3 - 100	100-25	~ 0.18
23	FCC gas oil feed	26.7	78.5	0.043	3 - 100	100-19	~ 0.24
23					2 - 100	94-28	0.22 [±] .04 -.03
24	Cracked residuum from No. 23	5.9	32.3	0.24	3 - 100	100-15	~ 0.4
29	TCC gas oil feed	15.7	73	0.10	1 - 100	84-30	0.31 [±] .04
30	Cracked residuum from No. 29	8.5	36	0.23	1 - 100	100-33	0.26 [±] .04 -.02
34	Houdry gas oil feed	28.0		0.014	3 - 100	84-32	~ 0.1
35	Cracked residuum from No. 34	2.7	35	0.18	3 - 100	100-20	~ 0.15

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CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (% - weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
38	Total cracking charge; combin- ation unit	16.1	32.2	0.005	3 - 100	62-58	~ 0.06
39	Cracked residuum from No. 38	7.8	31.0	0.03	3 - 100	56-24	~ 0.15
44	FCC decanted oil feed	15.2	31.1	0.15	1 - 100	94-40	0.22X
45	Cracked residuum from No. 44	1.7	26.4	0.38	1 - 100	88-41	0.18X
46	FCC gas oil feed	23.6	87.9	0.03	3 - 100	100-24	~ 0.15
47	Cracked residuum from No. 46	9.6	76	0.21	3 - 100	93-17	~ 0.22
54	Total cracking charge	33.0	93.9	0.041	3 - 100	100-36	~ 0.09
55	Cracked residuum from No. 54	4.2	55.9	0.23	3 - 100	89-19	~ 0.21
61	Cracked residuum	6.3	66.8	0.05	3 - 100	88-26	~ 0.20
63	Houdry gas oil feed	25.6	48.5	0.05	3 - 100	89-26	0.12 [±] .02 0.01
63					3 - 100	100-19	0.18 [±] .03
63					3 - 100	89-28	0.21X
63					2 - 100	100-33	0.15 [±] .03 0.02
63					3 - 20	100-45	0.11 [±] .03
63					3 - 5	88-37	0.09 [±] .01 0.02
64	Cracked residuum from No. 63	19.9	52.5	0.11	3 - 100	100-23	0.17 [±] .02
91	FCC gas oil feed	20.4	80.1	0.037	2 - 100	95-23	0.26 [±] .06 0.04
92	Cracked residuum from No. 91	6.1	70.5	0.072	2 - 100	91-23	0.31 [±] .04 0.03
93	Cracked residuum	7.9	87	0.03	3 - 100	94-40	0.07 [±] .01

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MUTAGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
<u>Steam Cracking</u>							
86	Cracked residuum	3.5	51.9	0.02	1 - 100	100-36	0.17 ⁺ .01 -.03
<u>Viscosity Breaking</u>							
18	Cracked residuum from No. 17	3.1	23.7	0.018	3 - 100	56-30	~0.1
66 ¹	Cracked residuum	6.5	22.1	0.055	2 - 100	100-37	0.10 ⁺ .01
67 ¹	Cracked side- stream from fractionator pro- ducing No. 66	15.6	84.6	0.060	2 - 100	89-17	0.40 ⁺ .06 -.09
<u>Dubbs coking</u>							
52 ¹	Cracked sidestream	21.0	95.2	0.005	3 - 100	100-36	~0.1
53 ¹	Blowdown oil	10.5	61.3	0.15	3 - 100	100-15	~0.4
<u>Batch coking</u>							
87	Cracked sidestream	14.9		0.21	2 - 20	91-30	0.19 ⁺ .01 -.09
<u>Delayed coking</u>							
28	Cracked sidestream	15.3		0.03	3 - 100	100-15	~0.3
28					1 - 100	85-33	0.26 ⁺ .06 -.05
74	Total furnace	12.5	22.3	0.03	2 - 100	100-47	0.10 ⁺ .01 -.04
33	Cracked side- stream from No. 74	16.8	60	0.008	3 - 100	95-15	~0.33
33					1 - 100	95-30	0.39 ⁺ .09 -.07
84	Cracked sidestream	30.2	79	0.006	3 - 100	95-24	0.17 ⁺ .02 -.03
90	Cracked sidestream	30.5	90.2	0.003	3 - 100	100-38	0.10 ⁺ .02
96	Cracked sidestream	33.2	77.7	0.004	3 - 100	93-27	0.17 ⁺ .02 -.04

¹ Feed to unit included catalytically cracked components.

MUTAGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
<u>Delayed coking</u>							
97	Total furnace charge (including recycle)	16.6	57.8	0.11	3 - 100	87-22	0.16X
98	Cracked side-stream from No.97	31.0	100	0.001	3 - 100	73-39	0.15X
103	Cracked side-stream	25.2	43.9	0.02	3 - 100	94-23	0.19 ^{+.02} _{-.03}
41	Wax tailings, 50% benzene	1.2	9.6	1.03	2 - 100	85-25	0.15X
<u>Naphtha Reforming</u>							
19	Cracked residuum	17.0	91	0.00	3 - 100	86-37	0.08X
58	Cracked residuum from kerosene feed	6.3	85	0.06	3 - 100	89-30	~ 0.12
76 76	Cracked residuum	30.6	~ 91	0.001	3 - 100 3 - 50	100-30 83-50	~ 0.08 inc.
<u>Polyforming</u>							
13	Cracked residuum	10.1	63	0.006	2 - 100	89-61	0.12 ^{+.02} _{-.05}
37	Cracked residuum	11.2	66	0.005	3 - 100	94-46	~ 0.1
69	Cracked residuum	15.9	75.1	≤ 0.005	3 - 100	80-29	~ 0.10
<u>Hydroforming</u>							
49	Cracked residuum	10.1	~ 95	0.13	1 - 100	84-41	0.15 ^{+.01}
77	Cracked residuum	22.8	100	0.018	3 - 100	100-38	~ 0.07

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CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING 750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
Thermoform Catalytic Cracking							
7	Cracked residuum	20.2	~100	0.019	1 - 100	11-56	-
9	Cracked residuum	18.4	97	0.07	3 - 100	100-47	0.05±.01
9					3 - 100	100-41	~ 0.06
10	Cracked residuum	11.6	56.7	0.23	1 - 100	94-39	0.3X
10					1 - 100	90-31	~ 0.5
31	Cracked residuum	16.0	63	0.65	1 - 100	100-32	0.37±.03
36	Cracked residuum	21.9	~ 50	0.18	1 - 100	94-44	0.19±.01
40	Cracked residuum	19.8	77.2	0.09	1 - 100	100-42	0.16X
71	Cracked residuum	22.8	77	0.10	1 - 100	90-22	0.52±.05
71					1 - 20	90-37	0.36±.02
71					2 - 20 ¹	100-27	0.21±.02
71A					2 - 20 ¹	100-25	0.21±.03
71					2 - 5	94-36	0.19±.05
71					1 - 5	85-70	0.10±.03
78	Cracked residuum	16.1	45.7	0.41 ¹	1 - 100	88-20	0.60±.06
82	Cracked residuum	13.6	25.7	0.53	1 - 100	95-34	0.30±.02
82					1 - 10	100-50	0.20±.01
60	Sidestream	24.9	100	<.0004	3 - 100	57-48	~ 0.03X
109	Sidestream	24.1		0.35	3 - 100	93-25	0.14±.03

¹ API-71 involved repeated application until death. API-71A involved repeated application only until appearance of papilloma in each mouse. No significant difference in the average time to the appearance of gross carcinoma was noted.

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CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
<u>Fluid Catalytic Cracking</u>							
8	Cracked residuum	11.1	75	0.42	3 - 100	89-7	1.18 ^{+.45} _{-.26}
8					2 - 100	94-14	0.95 ^{+.33} _{-.43}
8					2 - 100	100-14	> 0.6
8					2 - 20	92-20	0.26X
8					1 - 100	100-32	0.43 ^{+.04} _{-.11}
8					1 - 100	100-31	0.40 ^{+.03} _{-.12}
8					1 - 100	94-24	0.57 ^{+.13} _{-.10}
8					1 - 20	100-50	0.14 ^{+.03} _{-.02}
8					1 - 20	97-42	0.21 ^{+.01} _{-.02}
8					1 - 50	91-40	0.23 ^{±.05}
8					1 - 50	100-32	0.37 ^{+.07} _{-.05}
8					1 - 5	88-48	0.20 ^{+.01} _{-.04}
8					3 - 15	100-18	0.25 ^{+.04} _{-.03}
8-4	50% API-8, 50% (white oil + W. Texas residuum)				3 - 100	90-23	0.14X
8-16	50% API-8, 50% sec.-amylbenzene				1 - 100	100-52	0.18 ^{+.01} _{-.05}
8-21	50% API-8, 50% API-8-24				1 - 100	87-43	0.32X
<u>Chromatography of API-8:</u>							
8-5	Aromatics				1 - 100	79-28	~ 0.3
8-5					1 - 100	92-22	0.42X
8-24	Colorless fraction				3 - 50	0-86	-
257	Solution of 0.239% BP in API-8-24				1 - 50	100-43	0.15 ^{±.02}
8-17	Reblend of all fractions				1 - 100	94-30	0.56 ^{+.14} _{-.13}

TABLE 1 (page 1)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, FMC
12	Cracked residuum	18.1		0.42	1 - 100	88-34	~0.4
12					3 - 100	100-14	~0.4
12-2	Colorless fraction from chromatography				3 - 100 ^a	0-93	-
25	700°+ bottoms from cracked residuum	24.3	49	0.09	3 - 100	95-19	0.24±.03
25-1	50% API-25, 50% (White oil + West Texas residuum	21.1			3 - 100	92-40	0.09±.01 -.02
26	Cracked residuum	7.3	61.3	0.63	1 - 100	100-20	0.0X
42	Cracked residuum	14.2	28.6	0.36	1 - 100	94-34	0.34±.03 -.06
43	Cracked residuum	24.2	24.5	0.27	1 - 100	100-37	0.18±.01 -.02
43-1	Dewaxed API-43	12.9	29.5	0.47	1 - 100	95-25	0.37±.04
43-1					2 - 20 ¹	94-17	0.36±.07 -.05
43-1A					2 - 20 ¹	100-19	0.32±.05 -.04
(44)	Cracked residuum	15.2	31.1	0.15	1 - 100	94-40	0.22X
48	Cracked residuum	6.0	47.1	0.32	1 - 100	100-36	0.19X
68	Cracked residuum	9.8	43.3	0.52	1 - 100	100-17	0.59±.05 -.06
73	Cracked residuum	17.5	21	0.35	1 - 100	83-22	0.41X
73					1 - 100	100-31	0.27±.05 -.03
85	Cracked residuum	8.1	42.6	0.42	1 - 100	100-25	0.44±.06 -.05
23	Sidestream	26.7	78.5	0.027	3 - 100	100-19	~0.24
23					2 - 100	94-28	0.22±.04 -.03
46	Sidestream	23.6	87.9	0.033	3 - 100	100-24	~0.15
88	Sidestream	22.5	69.3	0.029	2 - 100	94-26	0.25±.03 -.05
89	Sidestream	27.0	100	0.001	3 - 100	89-21	0.26±.04 -.05
89-3	3+-ringed aromatics of API-89, 40% solution in benzene				3 - 20	0-1	-

¹ API-43-1 involved repeated application until death. API-43-1A involved repeated application only until appearance of papilloma in each mouse. No significant difference in the average time to the appearance of gross carcinoma was noted. Painting discontinued after 41 weeks.

TABLE I (page 3)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
91	Sidestream	20.4	80.1	0.037	2 - 100	95-23	0.26 [±] .06 -.04
101	Sidestream	24.8	89.7	0.007	3 - 100	100-12 ¹	0.33X
102	Sidestream	23.5	99	0.015	2 - 20	69-43 ¹	0.16X
102					2 - 100	93-32 ¹	0.16X
104	Sidestream	25.8		0.011	2 - 20	75-53 ¹	0.08X
104					2 - 100	89-26 ¹	0.16 [±] .01
<u>Houdry</u>							
11	Cracked residuum	4.3	84	0.21	3 - 100	94-19	0.19X
34	Cracked residuum	28.0	~ 90	0.014	3 - 100	84-32	~ 0.1
50	Cracked residuum	21.3	85	0.07	3 - 100	100-21	~ 0.2
51	Cracked residuum	25.7	83	0.06	3 - 100	83-19	~ 0.2
63	Cracked residuum	25.6	48.5	0.05	3 - 100	89-26	0.12 [±] .02 -.01
63					3 - 100	100-19	0.18 [±] .03
63					3 - 100	90-28	0.21X
63					2 - 100	100-33	0.15 [±] .03 -.02
63					3 - 20	100-45	0.11 [±] .03
63					3 - 5	88-37	0.09 [±] .01 -.02
81	Cracked residuum	22.7	40.8	0.20	1 - 100	100-36	0.20 [±] .04 -.03
81					1 - 100	91-41	0.21X
81					1 - 20	97-52	0.14X
<u>Cycloversion</u>							
22	Cracked residuum	25.6	49.5	0.091	3 - 100	100-17	~ 0.3X

¹ The pattern of response to the irritational effects of this oil was similar to that observed with dodecylbenzene.

TABLE I (page C)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
<u>Solvent extraction</u>							
16	Phenol extract	9.7		≤ .003	3 - 100	67-73	~ 0.01
16	from Coastal 900-X				3 - 100	43-70	~ 0.01
17	Duosol extract from California waxy residuum, 50% in sec.-amyl- benzene	7.1	3	≈ .006	3 - 100	87-62	~ 0.1X
27	Phenol extract from San Joaquin naphthenic dis- tillate	11.0	80	≤ .002	3 - 100	89-17	~ 0.3
70	Nitro-benzene ex- tract from Barbers Hill 60/80	15.7	.5	0.007	3 - 100	93-44	0.06±.01
75	SO ₂ extract from TCC gas oil	14.4	100	≈ .001	3 - 100	77-51	~ 0.05
<u>Straight run distillation</u>							
56	Waxy Midcontin- ent distillate	29.9	52.4	0.003	3 - 100	88-22	~ 0.16
56					3 - 100	65-42	0.09X
56					3 - 20	84-54	0.06X
79	San Joaquin naph- thenic lube dis- tillate, narrow cut	16.6	~ 13	≤ .005	2 - 100	86-57	0.10X
120	Ditto, wider cut	19.5	~ 52 ¹	≤ .003	3 - 50	65-60	0.07 ⁺ .01 -.02
105	West Texas par- affin distillate	28.9	72.9	0.0003	3 - 100	88-33 ²	0.11 ⁺ .01 -.03
114	Gulf Coastal	24.6	~ 50 ¹	≤ .002	3 - 20	54-83	0.01 ⁺ .01
114	distillate				3 - 100	55-71	0.02X

¹ A.S.T.M. distillation.² The pattern of response to the irritational effects of this oil was similar to that observed with dodecylbenzene.

TABLE I (page 10)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (% -weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
115	Blend of Gulf Coastal distil- lates	23.2	~ 50 ¹	≤.002	3 - 20	77-80	0.02X
115					3 - 50	63-66	-
117	Gulf Coastal distillate	30.8	~ 90 ¹	0.000	3 - 50	75-64	-
Fractional distillation (British Medical Research Council)							
110-1	Kuwait Naphtha	61.0	100		3 - 20	0-55	-
111-4	Lagunillas dis- tillate	23.0			3 - 20	88-22	0.14 ⁺ .02 - .01
111-4					3 - 5	64-75	0.04 ⁺ .01 - .02
111-4a	75% API-111-4, 25% benzene	22.7			3 - 5	51-82	0.02 ⁺ .02 - .01
111-4b	Lagunillas dis- tillate b. 650- 690°				2 - 15	0-47	-
616	Solution of .16% BP in API-111-4b				3 - 50	100-16	0.35 ⁺ .10 - .07
111-5a	75% Lagunillas residuum, 25% benzene	15.4			3 - 5	56-74	0.02 [±] .01
111-6	50% API-110-1, 50% API-111-4				3 - 20	77-31	0.09 [±] .01
111-7	50% API-111-4 50% API-112-1				3 - 20	76-44	0.09 [±] .01 - .02
112-1	Oklahoma naphtha	65.9	100		3 - 20	0-58	-
112-3	Oklahoma distillate	39.7			3 - 20	0-58 ^a	- ³

¹

A.S.T.M. distillation.

²

Two papillomas appeared at 20 weeks but regressed.

³

The pattern of response to the irritational effects of this oil was similar to that observed with dodecylbenzene.

TABLE I (page 11)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (°API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (% - weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
<u>Lubricating oil</u>							
99	Naphthenic dis- tillate contain- ing antioxidant	20.0	~38	<.001	3 - 100	94-47	0.06 [±] .01
100	Solvent extract- ed, no additives	29.5	~0	<.001	3 - 100	0-80	-
100-1	0.2% Antioxidant ¹ in API-100				3 - 100	0-78	-
100-2	0.5% Antioxidant, 2,6-ditert.-butyl- 4-methylphenol in API-100				3 - 100	0-88	-
<u>Wax pressing</u>							
32	Dewaxed paraffin distillate frac- tion from Lima crude			0.000	(3-6) ^a -100	50-32 100-40	-
56	Feed to presses	29.9	52.4	0.003	6 - 100	50-15 87-22	-
57	Dewaxed oil from API-56	28.7	80	≈.002	6 - 100	50-17 100-25	-
<u>Filtration dewaxing of API-8</u>							
8-3	Filtrate oil, 85% of original (.94% S)	11.3	65		3 - 100	90-17	0.30 ⁺ .06 -.04
<u>Desulfurization of 8-3 by catalytic hydrogen- ation</u>							
21	Hydrogenated heavy gas oil (.15% S)	18.1	74	0.23	3 - 100	100-13	0.36 ⁺ .07 -.04

¹ Same type additive as that contained in API-99.^a Three applications per week for 14 weeks, six applications per week thereafter.

TABLE I (page 12)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	GRAV- ITY (API)	FRACTION DISTIL- LING <750°F. (%)	BENZO- PYRENE (%)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
<u>Acid treating</u>							
62	Hydrolyzed acid sludge	14.2		≤.002	3 - 100	25-79	-
<u>Effect of viscosity on tumor induction</u>							
114	Gulf Coastal distillate,	24.6	~ 50	≤.002	3 - 20	67-83	0.01±.01
114	235 SSU/100°				3 - 100	80-71	0.02X
114-1	95% API-114, 5%	25.4			3 - 20	86-74	0.03±.01
114-1	alkylpolystyrene 1750 SSU/100°				3 - 100	75-74	0.04±.01 0.02
<u>Fuel oil Blending</u>							
113	Industrial fuel oil	8.3	43	0.10	3 - 20 ¹	77-27	0.11X
113					3 - 20 ²	88-28	0.14±.02 0.01
113					3 - 20 ³	100-25	0.14±.02 0.01
113					2 - 20 ³	91-40	0.14±.02
113					1 - 20 ³	95-45	0.17±.01 0.02
113					3 - 100 ⁴	100-25	0.15±.02 0.01
113					3 - 5 ³	92-34	0.15±.02 0.01
113					3 - 20 ³	100-27	0.13X
113					3 - 20 ⁴	100-26	0.14±.03 0.02
118	Catalytically cracked residuum component of API-119		35.2	1.1	2/month- 100	100-50	0.32±.05 0.06
119	10% API-118, 90%	23.3			2/month- 100	81-85	0.12±.04 0.03
119	light catalytic cycle oil b. 450-600°				2 - 100	96-30	0.16±.02 0.01

- ¹ Approximate age of mice at start of experiment, 27 weeks.
² Approximate age of mice at start of experiment, 23 weeks.
³ Approximate age of mice at start of experiment, 20 weeks.
⁴ Approximate age of mice at start of experiment, 14 weeks.

TABLE I (page 13)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	FRACTION	ESTIMATED CORRECTED BOILING RANGE (in °F. at 760mm.)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
Fractional distillation (30 plate column)					
	Fraction from API-8				
8-6	0-9.3% ¹	435-560	2 - 100	0-66	-
8-7	9.3-19.4% ¹	560-630	2 - 100	0-74	-
8-8	19.4-30.3% ¹	630-695	2 - 100	0-74	-
8-9	30.3-39.8% ¹	695-710	2 - 100	56-62	~0.03
8-10	39.8-49.6% ¹	710-765	2 - 100	94-44	0.10 ⁺ _{-.02}
8-11	49.6-59.2% ¹	765-800	2 - 100	90-33	0.14 ⁺ _{-.02}
8-12	59.2-69.1% ¹	800-830	2 - 100	93-28	0.21 [±] .03
Diels-Alder Reaction					
8-12a	Non-adduct from reaction (95.4% of API-8-12) ¹		2 - 100	100-26	0.23 [±] .04
Fractional distillation (30 plate column)					
	Fraction from API-8				
8-13	69.1-78.5% ¹	830-850	2 - 100	79-25	0.17 [±] .02
8-14	78.5-80.8% ²	850-875	2 - 100		X
8-15	Residue; 80.8-100% ³	>875	2 - 100	92-35	0.11 ⁺ _{-.01}
8-18	Proportionate reblend of distillation fractions, 8-6 through 8-15		1 - 100	87-39	0.48 ⁺ _{-.15}
	Aromatics from API-8				
8-26a	28.5-30.8% ¹	641-646	3 - 10	0-76	-
8-26b	30.8-32.0% ¹	646-651	3 - 10	0-76	-
8-26c	32.0-34.1% ¹	651-656	3 - 10	0-76	-
8-26d	34.1-36.0% ¹	656-662	3 - 10	0-76	-

¹ 50% solution in benzene.² 33.3% solution in benzene. Analysis indicated a content of .85% BP.³ 50% solution in benzene. Analysis indicated a content of 2.0% BP.

TABLE I (page 14)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF EXPERIMENT	ESTIMATED CORRECTED BOILING RANGE (in °F. at 760 mm.)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
8-26e	36.0-38.0% ¹	662-668	3 - 10	0-76	-
8-26f	38.0-40.0% ¹	668-674	3 - 10	7-42	-
8-26g	40.0-43.9% ¹	674-686	3 - 10	20-72	-
8-26h	43.9-46.0% ¹	686-693	3 - 10	12-25	-
8-26i	46.0-50.3% ¹	693-709	3 - 10	36-61	-
8-26j	50.3-52.5% ¹	709-717	3 - 10	25-41	-
8-26k	52.5-54.8% ²	717-727	3 - 40	83-19	0.21X
8-26l	54.8-57.3% ¹	727-736	3 - 10	55-38	-
8-26m	57.3-60.4% ²	736-747	3 - 40 ³	93-35	0.24 ^{+.16} -.07
8-26n	60.4-62.4% ¹	747-759	3 - 10	100-39	0.17 ^{+.02} -.07
<u>Contribution of accelerators to above fractions</u>					
8-26-2	0.17% BP in 80% saturates through alkylnaphthalenes fraction of 8-26g, h, and i, and 20% benzene		3 - 50	100-19	0.19 ^{+.01} -.02
8-26-3	0.17% BP in 80% 3-ringed aromatic fraction of 8-26g, h, and i, and 20% benzene		3 - 50	100-26	0.14 ^{+.02} -.03
<u>Air Oxidation (cobalt naphthenate catalyst)</u>					
8	FCC cracked residuum (prior to oxidation)		2 - 100	94-14	0.95 ^{+.33} -.43
83	Product of 2 hour oxidation of API-8		2 - 100	100-17	0.39X
83-1	Product of 4 hour oxidation of API-8		2 - 100	94-17	0.45X
8-22	69% aromatics of API-8, 31% sec.- amylbenzene		1 - 100 ⁴	63-39	0.20X
83-2	69% aromatics of API-83, 31% sec.- amylbenzene		1 - 100 ⁴	79-45	0.23 ^{+.02} -.07

¹ 50% solution in benzene.² 50% solution in dodecylbenzene.³ Painting discontinued after 10 weeks; ⁴ 20 weeks.

TABLE I (page 15)

MUTAGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF FRACTION	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
<u>Materials regenerated from Diels-Alder reactions (Maleic anhydride extraction)</u>				
8-25a	Material from 1st adduct formed (2.7% of API-8), 1% in benzene	3 - 15	100-62	0.03±.01
8-25b	Material from 2nd adduct formed (1.8% of API-8), 1% in benzene	3 - 15	100-58	0.03±.01
8-23g	Material from total Class B ¹ adduct (1.6% of API-8), 1.5% in benzene	3 - 15	92-50	0.03±.01
8-23h	Material from total Class A ¹ adduct (3.5% of API-8), 2.2% in benzene	3 - 15	100-43	0.05±.01
<u>Chromatographic fractionation of extract similar to 8-23h</u>				
8-23a	Crystalline material from 1st fraction (.15% of API-8), .34% in benzene	3 - 15 ^b	0-68	-
8-23c	Crystalline material from 2nd fraction (.17% of API-8), .34% in benzene	3 - 12 ^b	0-68	-
8-23b	Material in mother liquor from 8-23a and 8-23c (1.5% of API-8), 1.5% in benzene	3 - 15	100-51	0.04±.01
8-23d	Third fraction (.4% of API-8), .8% in benzene	3 - 15	100-38	0.07±.01
8-23e	Fourth fraction (.33% of API-8), .57% in benzene	3 - 15 ^d	13-46	-
8-23f	Fifth fraction (.37% of API-8), .57% in benzene	3 - 15 ^d	0-68	-
8-26n-1	Total material from 8-26n, 2% in 50% benzene, 50% dodecylbenzene	3 - 50	0-8	-

¹ Class A adduct was that normally soluble in 5% aqueous NaOH; Class B adduct was not soluble in either 5% aqueous NaOH or benzene after hydrolysis.

Painting discontinued after 30 weeks; ^b 37 weeks; ^d 32 weeks.

TABLE I (page 16)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF FRACTION	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}
89-1	Anthracenic chromatographic fraction (1.6% of API-89) of material from total adduct, 2% in benzene	3 - 15	0-74 ¹	<0.02
89-2	Remainder of chromatographic fractions (mixed anthracenes, benzanthracenes, etc., 0.2% of API-89), .5% in benzene	3 - 10	100-68	0.03±.01
120-1	Material from naphthenic distillate, API-120, corresponding to API-89-2, 2% in benzene	3 - 20	0-4	-
<u>solvent extraction with conc. H₂SO₄</u>				
8-19	50% extract ^a from API-8-10 and 8-11, 50% benzene	2 - 100 ^a	22-32	<0.09
8-20	50% raffinate ^a from API-8-10 and 8-11, 50% benzene	2 - 100 ^a	83-25	~0.16
23-1	80% extract ^a from API-23, 20% benzene	2 - 100 ^a	90-26	0.24 ⁺ -.05 -.04
23-2	80% raffinate ^a from API-23, 20% benzene	2 - 100 ^a	100-44	0.13±.02
<u>Fractionation of API-12</u>				
12-7	30% non-adduct of Diels-Alder reaction on raffinate from sulfuric extraction of aromatic fraction b. ~680-780°, 70% benzene	2 - 20 ⁴	77-65	0.04 ⁺ -.01 -.02
12-8	Ditto from fraction b. ~780-950°, 70% benzene	2 - 15	90-58	0.07X

¹ Two papillomas appeared at 48 weeks but regressed.^a Accelerators removed prior to extraction and rebled proportionately in extract and raffinate.⁴ Painting discontinued after 24 weeks; ^a 43 weeks.

TABLE I (page 17)

CARCINOGENIC POTENCY OF VARIOUS FRACTIONS FROM THE REFINING OF PETROLEUM

API SAMPLE NUMBER	DESCRIPTION OF FRACTION	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC
<u>Chromatography</u>				
8-13a	First aromatic fraction, ¹ 2% ^a of API-8-13	3 - 20 ^b	9-36	<0.05
8-13b	Second aromatic fraction, 2.4% ^a of API-8-13	3 - 20 ^a	14-58	<0.03
8-13c	Third aromatic fraction, 8.7% ^a of API-8-13	3 - 20	100-42	0.07X
8-13d	Fourth aromatic fraction, 5.6% ^a of API-8-13	3 - 20	100-29	0.10±.02
8-13e	Fifth aromatic fraction, 5.6% ^a of API-8-13	3 - 20	86-40	0.07X
8-13f	Sixth aromatic fraction, 2% ^a of API-8-13	3 - 20 ^a	83-45	0.07 ⁺ .01 -.03
8-13g	Seventh aromatic fraction, 16.9% ^a of API-8-13	3 - 20	100-27	0.11X
8-13h	Eighth aromatic fraction, 2.4% ^a of API-8-13	3 - 20	100-37	0.09 ⁺ .01 -.02
8-13i	Ninth aromatic fraction, 6.9% ^a of API-8-13	3 - 20	73-36	0.09X
71-2	Proportionate reblend of all fractions from API-71	1 - 20	93-59	0.23 ⁺ .02 -.06
71-1	Reblend of all fractions except	1 - 20	83-64	0.16 ⁺ .01 -.04
71-1	dark resin preceeding aromatics	1 - 100	100-15	0.90X

¹ Preceeding colorless non-aromatic fraction, 48% of API-8-13, proved to be a non-accelerating solvent when diluted 50% with benzene. See API-266 on page 3 of Table VII.

^a Tested at this percentage in benzene.

^b Painting discontinued after 35 weeks; ^c 41 weeks.

TABLE II
CONTROL EXPERIMENTS WITH VARIOUS SOLVENTS

API EXPERI- MENT NUMBER	SOLVENT	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	STRAIN OF MICE	MAXIMUM INCIDENCE OF TUMORS (% - weeks)	INCIDENCE OF GROSS CARCINOMA (% - weeks)
80	White oil (95SSU)	3 - 100 ¹	C3H	0-80	0-80
95	White oil (95SSU)	3 - 100 ¹	CFW	0-80	0-80
221	Dodecylbenzene	3 - 100	C3H	33-37	0-52
221a	8-84% fraction b. 548-572° from dis- tillation of API-221	3 - 50 ²	C3H	0-52	0-52
224	Sec.-amylbenzene	3 - 100	CFW	18-59 ³	0-82
228	Benzene	3 - 100	C3H	0-100	0-100
228	Benzene	3 - 100	CFW	0-62	0-62
241	Distilled water	3 - 100 ⁴	C3H	7-78	7-78
294	Dodecane	3 - 50	C3H	0-80	0-80 ⁵
294a	Dodecane for 12 weeks followed by 70% dodecane, 30% 340SSU white oil	3 - 50	C3H	0-82	0-82
639	75% dodecylbenzene 25% benzene	3 - 50	C3H	4-15	0-19

- ¹ Painting discontinued after 60 weeks; ² 31 weeks; ⁴ 61 weeks.
³ Histopathological examination confirmed only one of the four gross
⁵ lesions as a papilloma; the others were termed hyperkeratosis.
 Histopathological examination showed one fibrosarcoma in 70 weeks.

TABLE III

EXPERIMENTS INVOLVING THE APPLICATION OF SOLUTIONS OF METHYLCHOLANTHRENE
IN VARIOUS SOLVENTS UPON THE SKIN OF C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	
218	Crude residuum, API-5	0.31	3 - 100	100-30	0.09±.01	
625	API-80, 95 SSU white oil	0.10	3 - 10	100-32	0.10±.01	
624	API-80	0.20	2 - 10	95-32	0.15 ⁺ ±.01 -.02	
293	340 SSU white oil	0.50	3 - 20	100-20	0.16X	
607	50% benzene, 50% 340 SSU white oil	0.10	3 - 10	93-38	0.09 ⁺ ±.01 -.02	
281	Cottonseed oil	0.04	3 - 100	89-69	0.03±.01	
291	Cottonseed oil	0.50	3 - 20	95-23	0.17 ⁺ ±.02 -.06	
246	Naphtha, API-112-1	0.21	3 - 20	100-22	0.19±.02	
246			3 - 20	100-21	0.19±.02	
248	Naphtha, API-110-1	0.21	3 - 20	100-22	0.16 ⁺ ±.02 -.01	
223	Sec.-amylbenzene, API-224	0.09	3 - 100	81-46	0.04±.01	
222	API-224	0.18	3 - 100	100-44	0.09 ⁺ ±.01 -.02	
234	API-224	0.35	2 - 100	100-27	0.27 ⁺ ±.04 -.08	
235	API-224	0.70	2 - 100	100-19	0.28±.03	
608	Decalin	0.08	3 - 50	92-45 ¹	0.04X	
609	Dinonylnaphthalene	0.08	3 - 50	88-56	0.05±.01	

1

The pattern of response to the irritational effects of this solution was similar to that observed with dodecylbenzene.

TABLE IV

EXPERIMENTS INVOLVING THE APPLICATION OF SOLUTIONS OF BENZOPYRENE
IN NON-ACCELERATING SOLVENTS UPON THE SKIN OF C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	
602	n-octane	0.21	3 - 100	100-36	0.08 ⁺ .02 - .03	
604	isooctane	0.15	3 - 100	100-31	0.10 [±] .01	
299	340 SSU white oil	0.08	3 - 5	96-43	0.04 [±] .01	
296	340 SSU white oil	0.20	3 - 50	100-36	0.08 [±] .01 - .02	
282	Benzene	0.08	3 - 20	100-50	0.07 [±] .01	
244	Benzene	0.17	3 - 100	100-33	0.09 [±] .01	
244			3 - 20	94-37	0.07X	
252	Benzene	0.32	3 - 100	100-26	0.13 [±] .01 - .02	
252		0.32	3 - 20	100-27	0.10X	
252		0.32	2 - 20	94-54	0.10X	
252		0.32	1 - 20	96-43	0.15X	
613	85% b-methyl- naphthalene,	0.20	2 - 15	100-40	0.08 [±] .01	
613	15% benzene		2 - 50	100-37	0.10X	
285	Cottonseed oil	0.50	3 - 20	100-32	0.09X	
286	Cottonseed oil	1.0	3 - 20	95-25	0.12 [±] .01	

TABLE V

EXPERIMENTS TO DETERMINE THE POTENCY OF MIXTURES OF POLYCYCLIC
HYDROCARBONS IN TECHNICAL WHITE OIL FOR THE SKIN OF MICE

API EXPERI- MENT NUMBER	HYDROCARBON	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg)	MAXIMUM INCIDENCE OF TUMORS (% - weeks)	RELATIVE CARCINO- GENIC POTENCY, F _{MC}
624	Methylcholanthrene control	0.20	2 - 10	95-32	0.15 [±] .01 - .02
623	Methylcholanthrene Benzopyrene	0.10 0.20	2 - 10	100-26	0.17 [±] .02
625	Methylcholanthrene control	0.10	3 - 10	100-32	0.10 [±] .01
626	Methylcholanthrene Benzanthracene	0.10 0.20	3 - 10	100-34	0.08X

TABLE VI

EXPERIMENTS INVOLVING THE APPLICATION OF SOLUTIONS OF METHYLCHOLANTHRENE (MC)
IN DODECYLBENZENE¹ UPON THE SKIN OF MICE

API EXPERI- MENT NUMBER	CONCEN- TRATION (% by weight)	STRAIN OF MICE	SCHEDULE OF APPLICA- TIONS (no./week - mg)	MAXIMUM INCIDENCE OF TUMORS (% - weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	P _{MC} ^o OF MC
221	0	C3H	3 - 100	33-37	-	-
221a	0	C3H	3 - 50 ^a	0-52	-	-
226	0.006	C3H	3 - 100	50-40	- ^b	-
226	0.006	CFW	3 - 100	41-54	-	-
225	0.012	C3H	3 - 100	81-43	0.05X	417
225	0.012	CFW	3 - 100	100-54	~0.03	~250
213	0.05	CFW	3 - 100	100-18	~0.30	~600
211	0.12	C3H	3 - 100	100-22	0.35 ⁺ .06 - .12	292
211	0.12	CFW	3 - 100	100-17	~0.30	~250
208	0.15	C3H	3 - 100	100-15	0.33 [±] .03	220
249	0.17	C3H	3 - 100	100-12	0.43 ⁺ .08 - .07	252
249	0.17	C3H	3 - 20	89-14	0.35 ⁺ .06 - .04	206
212	0.35	C3H	3 - 100	100-18	0.35 ⁺ .06 - .09	100

¹ Product obtained by alkylation of benzene with the propylene tetramer (aluminum chloride catalyst).

^a Painting discontinued after 31 weeks.

^b No gross or microscopic evidence of invasive malignancy.

TABLE VII

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%- weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	P _{MC} ^o OF BP
<u>PARAFFINS</u>						
602	n-octane	0.21	3 - 100	100-36	0.08 ⁺ .02 -.03	40
278	n-decane	0.21	3 - 50	100-21	0.18 ⁺ .02 -.01	86
295	dodecane	0.20	3 - 50	100-22	0.20±.02	100
269	cetane (chromato- graphed on silica gel)	0.20	3 - 50	50-10	X	
269			3 - 20	100-25	0.14 ⁺ .02 -.03	70
<u>OLEFINS</u>						
298	n-hexadecene-1	0.19	3 - 40	100-25	0.19 ⁺ .04 -.03	100
<u>CYCLOPARAFFINS</u>						
608	Decalin	0.08 ¹	3 - 50	92-45 ^a	0.04X	50 ¹
263	Cyclohexyldecane	0.18	3 - 20	95-20	0.22 ⁺ .06 -.04	122
279	7-cyclohexyltri- decane, PSC-504	0.18	3 - 40	100-29	0.12 ⁺ .02 -.04	67
<u>WHITE OIL (Mixtures of Paraffins and Cyclopar- affins)</u>						
258	API-80, 95 SSU white oil	0.23	1 - 50	95-51	0.15 ⁺ .02 -.01	65
264	API-80	0.18	3 - 100	100-31	0.09±.01	50
264			3 - 20	100-31	0.09±.01	50
264			3 - 5	100-36	0.09±.02	50
270	API-80	0.35	3 - 20	100-27	0.11X	31
271	API-80	0.5-0.1 ^a	3 - 20	100-27	0.11 ⁺ .01	

- ¹ Carcinogen in this case was methylcholanthrene.
^a The pattern of response to the irritational effects of this solution was similar to that observed with dodecylbenzene.
^a Solutions applied alternately.

TABLE VII (page 2)

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (% -weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC	PMC ^o OF BP
<u>FRACTIONS FROM 2 DISTILLATIONS OF API-80</u>						
	<u>Percent</u> <u>Boiling</u> <u>of API-80</u> <u>Range</u>					
276-1	0-3.5 505-585°	0.17	3 - 50	100-22	0.16 ⁺ _{-.04} ^{.07}	94
276-2	3.5-6.4 585-615°	0.17	3 - 50	100-22	0.15 ⁺ _{-.04} ^{.08}	88
276-3	6.4-10.9 615-630°	0.17	3 - 50	100-22	0.15 [±] .03	88
276-4	10.9-15.7 630-640°	0.17	3 - 50	100-32	0.08 [±] .01	47
276-7	8.7-16.7 625-645°	0.17	3 - 100	94-24	0.14 [±] .02	82
276-8	16.7-19.5 645-655°	0.17	3 - 100	100-28	0.11X	65
276-5	15.7-36.3 640-685°	0.17	3 - 100	100-30	0.10 [±] .01	59
276-9	19.5-30.3 655-675°	0.17	3 - 100	100-24	0.14 [±] _{-.03} ^{.01}	82
276-10	30.3-40.5 675-700°	0.17	3 - 100	100-24	0.11 ⁺ _{-.01} ^{.02}	65
276-6	36-100 >700°	0.17	3 - 100	100-29	0.10 [±] .01	59
276-6	(residue purified by percolation through silica gel)		3 - 50	92-29	0.09X	53
<u>FRACTIONS FROM DISTIL- LATION OF SATURATED COM- PONENTS OF TCC RESIDUUM, API-71</u>						
	<u>Percent</u> <u>Boiling</u> <u>Range</u>					
277-1	0-2.9 430-500°	0.18	3 - 30	88-17	0.22 ⁺ _{-.04} ^{.06}	122
277-3	6.1-7.4 550-565°	0.18	3 - 20	83-18	0.23 ⁺ _{-.10} ^{.50}	128
277-4	7.4-11.3 580-600°	0.18	3 - 40	100-25	0.17 ⁺ _{-.05} ^{.06}	94
277-5	11.3-15.4 600-620°	0.18	3 - 50	100-27	0.12 ⁺ _{-.03} ^{.02}	67

TABLE VII (page 3)

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	P _{MC} ^o OF BP
257	API-8-24, color- less fraction from chromatog- raphy of API-8	0.24	1 - 50	100-43	0.15 [±] .02	63
266	50% colorless fraction from chromatography of API-8-13, 50% benzene	0.15	3 - 100	100-34	0.07 [±] .01	47
<u>ALKYLBENZENES</u>						
605	Diisopropylbenzene	0.17	3 - 50	100-47	0.05 [±] .01	29
275	Triisopropyl- benzene	0.17	3 - 50	100-18	0.22 [±] .06 -.03	130
275		0.17	3 - 30	100-30	0.12 [±] .02	71
606	t-octyltoluene	0.17	3 - 50	100-21	0.17X	100
262	1-phenyldecane	0.18	3 - 20	95-16	0.33 [±] .05 -.04	183
629	Dodecylbenzene (DDB)	0.08	3 - 20	75-30	0.14 [±] .03 -.02	180
245	DDB	0.17	3 - 100	100-19	0.30 [±] .08 -.06	176
245			3 - 20	100-31	0.16 [±] .05	94
245			3 - 5	100-23	0.19 [±] .04	112
<u>LAB DISTILLATION OF COMMERCIAL ALKYLATES</u>						
	<u>Distillation of Alkylbenzene¹</u>					
274-8	Fraction b. 450- 500°	0.17	3 - 40	100-22	0.15 [±] .14 -.06	88
274-13	Fraction b. 555- 560°	0.17	3 - 50	100-12	0.40 [±] .08 -.06	236

¹ Product of alkylation of benzene with polypropylene.

TABLE VII (page 4)

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC	PMC ^o OF BP
267-1	Distillation of PDDB ¹ Fraction b.603- 642°	0.17	3 - 20	100-31	0.10 ^{+.02} -.01	59
267-3	Fraction b.655- 683°	0.17	3 - 20	100-33	0.07±.01	41
267-5	Fraction b.664- 730°	0.17	3 - 20	100-38	0.06±.01	35
267-8	Fraction b.659- 760°	0.17	3 - 20	100-36	0.07±.01	41
<u>ALKYLNAPHTHALENES</u>						
613	85% b-methyl- naphthalene, 15% benzene	0.20	2 - 50	100-37	0.10X	50
265	Butyl-dimethyl- naphthalene	0.16	3 - 20	100-25	0.14 ^{+.05} -.02	88
272	Monoamyl-naph- thalenes, b.570°	0.16	3 - 40	100-19	0.17 ^{±.03}	106
273	Diamyl-naphthalenes b.630-690°	0.16	3 - 50	100-19	0.28 ^{+.17} -.08	175
609	Dinonylnaphthalene	0.08 ^a	3 - 50	88-56	0.05±.01	63 ^a
<u>MIXTURES OF ACCELERATORS WITH WHITE OILS</u>						
260	5% DDB, 95% API-80	0.17	3 - 100	100-33	0.07±.01	41
259	20% DDB, 80% API-80	0.17	3 - 100	100-32	0.08 ^{+.01} -.02	47
633	50% DDB, 50% API-80	0.08	3 - 50	64-37	~ 0.06	~ 75
637	50% DDB, 50% API-80	0.17	3 - 50	100-27	0.10±.01	59

¹ Alkylbenzene, residual by-product of commercial alkylation of benzene with propylene tetramer.

^a Carcinogen in this case was methylcholanthrene.

TABLE VII (page 5)

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	RELATIVE CARCINO- GENIC POTENCY, PMC	PMC ^o OF BP
636	75% DDB, 25% API-80	0.08	3 - 50	100-27	$0.13 \pm .01$ $0.12 \pm .02$	163
638	75% DDB, 25% API-80	0.17	3 - 50	100-29	$0.12 \pm .02$ $0.11 \pm .01$	71
635	50% DDB, 50% 340 SSU white oil	0.08	3 - 50	42-36	~ 0.05	~ 63
297	50% dodecane, 50% 340 SSU white oil	0.20	3 - 100	100-24	$0.13 \pm .01$	65
297			3 - 50	100-29	$0.13 \pm .01$ $0.13 \pm .03$	65
297			3 - 20	100-33	$0.08 \pm .01$	40
614	75% dodecane, 25% 340 SSU white oil	0.20	3 - 50	100-28	$0.12 \pm .01$	60
614			2 - 50	100-26	$0.15 \pm .01$	75
614			1 - 50	100-34	$0.20 \pm .02$ $0.20 \pm .01$	100
<u>MIXTURES OF DDB WITH AROMATIC HYDROCARBONS</u>						
628	50% DDB, 50% b- methylnaphthalene	0.08	3 - 40	93-32	$0.11 \pm .02$	138
634	50% DDB, 50% benzene	0.08	3 - 50	95-23	$0.14 \pm .03$ $0.14 \pm .01$	175
644	50% DDB, 50% benzene	0.09	3 - 50	68-13	-	-
643	50% DDB, 50% benzene	0.17	3 - 50	30-13	-	-

TABLE VII (page 6)

ACCELERATING ACTIVITY OF VARIOUS SOLVENTS ON RATE OF INDUCTION
OF TUMORS BY DISSOLVED BENZOPYRENE (BP) IN C3H MICE

API EXPERI- MENT NUMBER	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (% -weeks)	RELATIVE CARCINO- GENIC POTENCY, P _{MC}	P _{MC} ^o OF BP	
DISTILLATES FROM VARIOUS CARCINOGENIC OILS							
603	Fraction of TCC residuum, API-9, b. 540-600°	0.16	3 - 50	100-30	0.14 ^{+.04} _{-.02}	88	
615	Lagunillas dis- tillate, b. 550- 650°	0.16	3 - 50	100-16	0.27 ^{+.07} _{-.05}	169	
616	Lagunillas dis- tillate, b. 650- 690°	0.16	3 - 50	100-16	0.35 ^{+.10} _{-.07}	219	
DISTILLATES FROM CRUDE ASSAYS BY BUREAU OF MINES ¹							
	Boiling Range	Specific Dispersion	Correl- ation Index				
617	480-660°	141	26	3 - 50	100-24	0.14±.01	78
618	480-660°	186	49	3 - 50	100-19	0.20±.02	118
619	480-660°	164	54	3 - 50	100-19	0.20 ^{+.03} _{-.02}	118
630	480-660°	154	31	3 - 50	92-19	0.18±.02	106
631	480-660°	190	53	3 - 50	100-18	0.23±.04	135
632	480-660°	145	37	3 - 50	95-19	0.20 ^{±.03} _{-.02}	116
632a	50% API-632, diluted 50% with benzene			3 - 50	5-13	-	-
640	480-660°	141	24	3 - 50	26-13	-	-
	Diluted 50% with benzene						
641	480-570°	130	21	3 - 50	10-10	-	-
	Diluted 50% with benzene						
642	570-660°	138	23	3 - 50	11-10	-	-
	Diluted 50% with benzene						

¹ Experiments run at a concentration of 0.17% BP.

TABLE VIII

EFFECT OF EARLY EXPOSURE TO ACCELERATING SOLVENTS ON RESULTS
OF SUBSEQUENT EXPOSURE TO CARCINOGENS

API EXPERI- MENT NUMBER	DESCRIPTION		STRAIN OF MICE	SCHEDULE OF APPLI- CATION OF CARCINOGEN (no./week - mg.)	INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% F.L. in weeks)
	MATERIALS APPLIED TO MICE DURING					
	FIRST SIX WEEKS OF EXPERIMENT	SEVENTH WEEK TO END OF EXPERIMENT				
221	DDB ^s	DDB	C3H	3 - 100	33-37	-
9	TCC resid- uum, API-9	API-9	C3H	3 - 100	100-47	36.2±3.9
221-9	DDB	API-9	C3H	3 - 100	100-21	14.5±1.8
221-9			C3H	3 - 100	100-22	12.8±2.4
253-9	PDB ^s	API-9	C3H	3 - 100	94-26	13 ⁺⁴ ₋₁
57	API-57 ^a	API-57	CFW	6 - 100	50-16 100-25	-
221-57	DDB	API-57	CFW	6 - 100	50-13 100-16	-
208	API-208 ⁵	API-208	C3H	3 - 100	100-15	10.4±.6
221-208	DDB	API-208	C3H	3 - 100	100-14	8.1±1.1
82	TCC resid- uum, API-82	API-82	C3H	1 - 10	100-50	30 ⁺⁷ ₋₁
600	Dodecane	API-82	C3H	1 - 10	100-42	30.7±4.0
601	340 SSU white oil	API-82	C3H	1 - 10	100-41	30.2±5.4
76	Reformer tar, API-76	API-76	C3H	3 - 50	83-52	~34
620	Dodecane	API-76	C3H	3 - 50	67-48	~33
621	95 SSU white oil	API-76	C3H	3 - 50	55-45	~43
622	340 SSU white oil	API-76	C3H	3 - 50	60-47	~35

Schedule of application of accelerator was the same as that of the carcinogen except in experiments 600 and 601 in which case 50 mg. was applied three times each week.

Time measured from date of initial painting with carcinogenic material. Dodecylbenzenes obtained by alkylation of benzene with 12-carbon olefins; DDB obtained with propylene tetramer; 2-phenyldodecane (PDB) obtained with 1-dodecene.

Filtrate oil from pressing of Midcontinent paraffinic distillate. Solution of 0.15% methylcholanthrene in dodecylbenzene.

API 06510

TABLE IX

EXPERIMENTS TO DETERMINE THE CARCINOGENIC PROMOTING ACTIVITY
OF VARIOUS MATERIALS FOR THE SKIN OF C3H MICE

API EXPERI- MENT NUMBER	CARCINO- GENIC INITIA- TOR, SINGLE APPLICA- TION	INCIDENCE OF TUMORS FROM SINGLE APPLICA- TION (%-weeks)	TIME OF 2nd APPLICA- TION (if appli- cable) (wks.-mg.)	PROMOTER USED FROM 3rd WEEK TO END	SCHEDULE OF APPLI- CATION OF PROMOTER (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% P.L. in weeks)
229	100 mg. API-229	13-13	none	none	-	13-64	-
230	100 mg. API-229		none	Dodecyl- benzene, DDB	3 - 100	92-34	11.8 [±] 2.8
231	100 mg. API-8, FCC res- iduum	0-63	none	none	-	0-63	-
232	100 mg. API-8		none	DDB	3 - 100	50-26	24 _X
239	100 mg. API-8		none	Distilled water	3 - 100	0-76	-
240	100 mg. API-8		none	API-80, 95 SSU white oil	3 - 100	0-76	-
290	100 mg. API-290	4-24	28-100	none	-	95-59	~ 46
287	100 mg. API-290		none	Alkyl- benzene, partly DDB	3 - 100	79-30	17 ⁺² ₋₄
288	100 mg. API-290	0-28	28-100	API-80	3 - 100	96-57	~ 48
289	100 mg. API-290	0-28	28-100	340 SSU white oil	3 - 100	89-72	~ 50
292	100 mg. API-290		none	Dodecane	3 - 50	94-26	16 ⁺³ ₋₁
292					2 - 50	94-53	24 ⁺⁶ ₋₂
292					1 - 50	81-59	44.0 [±] 3.9

- * Solution of 0.5 g. dimethylbenzanthracene in 100 ml. sec.-amylbenzene.
 * Solution of 0.5 g. dimethylbenzanthracene in 100 ml. 340 SSU white oil.

TABLE X

EFFECT OF TERMINATION OF EXPOSURE OF C3H MICE TO CATALYTICALLY
CRACKED OILS AT A CRITICAL PHASE OF THE EXPERIMENT

API EXPERI- MENT NUMBER	DESCRIPTION OF EXPERIMENT	SCHEDULE OF APPLICATIONS		MAXIMUM INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% F.L. in weeks)	AVERAGE TIME FROM PAPILLOMA TO GROSS CARCINOMA (weeks)
		(no./week - mg.)	TOTAL NUMBER OF WEEKS			
43-1	Dewaxed oil from catalytic- ally cracked residuum	2-20	- ¹	94-17	12.7 [±] 1.4	14
43-1A	Ditto	2-20	10-19 ²	100-19	13.8 [±] 1.2	16
43-1B	Ditto	2-20	9	16-12 ³	-	-
71	TCC residuum	2-20	- ¹	100-27	18.5 [±] 1.3	15
71A	Ditto	2 - 20	14-25 ²	100-25	18.3 [±] 1.5	16
71B	Ditto	2 - 20	12	53-18 ⁴	-	-

- ¹ Painting continued in each mouse until gross evidence of malignancy in that mouse.
- ² Painting of each mouse discontinued at time of appearance of papilloma in the individual mouse.
- ³ No additional tumors developed up to the 23rd week at which time applications were resumed. They were terminated in the 28th week after the appearance of a papilloma in an additional animal. All survivors had developed tumors by the 56th week.
- ⁴ Procedure similar to API-43-1B. Painting resumed at 30 weeks, discontinued after 32 weeks. By the 64th week all but one of the survivors had developed tumors. Gross malignancy was evident in 58% of the mice.

TABLE XI

EXPERIMENTS TO DETERMINE THE POTENCY
OF CERTAIN POLYCYCLIC HYDROCARBONS FOR THE SKIN OF C3H MICE

API EXPERI- MENT NUMBER	HYDROCARBON	SOLVENT	CONCEN- TRATION (% by weight)	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (% - weeks)
261	4,5-dimethyl- phenanthrene	Benzene	0.86	3 - 20	0-84
627	Benz [a] anthracene	Dodecane	0.50	3 - 50	53-45

TABLE XII
EXPERIMENTS ON THE RETARDATION OF TUMOR FORMATION
BY WASHING CFW MICE

API EXPERI- MENT NUMBER	CARCINOGENIC OIL APPLIED	PERIOD OF EXPOSURE TO OIL BEFORE RE- MOVAL BY WASHING	MATERIAL USED FOR INITIAL RINSE	AGENT FOR WASHING	SCHEDULE OF APPLICA- TIONS (no/week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% F.L. in wks.)
113	Industrial fuel oil,	control	none	none	3 - 100	94-36	~ 16
113	API-113	(no washing)			3 - 100 ¹	97-25	17.3±1.2
309	API-113	1 hour	none	detergent solution	3 - 100	40-67	X
310	API-113	4 hours	none	detergent solution	3 - 100	54-57	56X
311	API-113	4 hours	95 SSU white oil API-95	detergent solution	3 - 100	83-52	45X
315	API-113	7 hours	none	detergent solution	3 - 100 ¹	94-46	~ 35
12	FCC residuum, API-12	control (no washing)	none	none	3 - 100	100-14	~ 10.5
303	API-12	1 hour	none	soap solution	3 - 100	100-40	~ 27
304	API-12	9 hours	none	soap solution	3 - 100	100-21	~ 17
8	FCC residuum, API-8	control (no washing)	none	none	1-100	100-26	~ 12X
300	API-8	10 min.	none	soap solution	1 - 100	0-80	-
301	API-8	1 hour	none	soap solution	1 - 100	20-80	-
302	API-8	4 hours	none	soap solution	1 - 100	100-70	~ 60

¹ Strain of mice used for this experiment was C3H.

TABLE XII (page 2)

EXPERIMENTS ON THE RETARDATION OF TUMOR FORMATION
BY WASHING CFW MICE

API EXPERI- MENT NUMBER	CARCINOGENIC OIL APPLIED	PERIOD OF EXPOSURE TO OIL BEFORE RE- MOVAL BY WASHING	MATERIAL USED FOR INITIAL RINSE	AGENT FOR WASHING	SCHEDULE OF APPLICA- TIONS (no/week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% F.L. in weeks)
8	API-8	control (no washing)	none	none	3 - 100	100-9	~ 8x
305	API-8	20 min.	none	detergent solution	3 - 100	93-51	~ 40
308	API-8	20 min.	API-95	none	3 - 100	100-52	~ 32
306	API-8	1 hour	none	detergent solution	3 - 100	94-44	~ 33
307	API-8	1 hour	API-95	detergent solution	3 - 100	85-33	~ 25
312	Barrier cream applied API-8 applied Removal of oil by washing with detergent solution			9:00 AM 11:00 AM 12:00 AM	3 - 100	71-45	~ 40x
313	Barrier cream applied API-8 applied API-8 applied Removal of oil by washing with detergent solution			9:00 AM 11:00 AM 2:00 PM 4:30 PM	3 - 100	100-31	~ 25

TABLE XII (page 3)

EXPERIMENTS ON THE RETARDATION OF TUMOR FORMATION
BY WASHING C3H MICE

API EXPERI- MENT NUMBER	CARCINOGENIC OIL APPLIED	PERIOD OF EXPOSURE TO OIL BEFORE RE- MOVAL BY WASHING	MATERIAL USED FOR INITIAL RINSE	AGENT FOR WASHING	SCHEDULE OF APPLICA- TIONS (no./week - mg.)	MAXIMUM INCIDENCE OF TUMORS (%-weeks)	AVERAGE LATENT PERIOD FOR TUMOR INDUCTION (5% F.L. in weeks)
8	API-8	control (no washing)	none	none	3 - 15	100-18	12.4±1.2
8					3 - 100	89-9	5.2±.6
316	none	none	none	detergent solution	3 -	0-72	-
317	none	none	API-95	detergent solution	3 -	0-72	-
320	API-8	95 min.	95 SSU white oil API-80	detergent solution	3 - 100	95-16	10.8±1.2
318	API-8	75 min.	340 SSU white oil	detergent solution	3 - 100	100-21	16.6±1.4
319	API-8	85 min.	refined kerosene	detergent solution	3 - 100	94-21	16X
56	Feed to Wax Pressing,	control (no washing)	none	none	3 - 20	84-54	32X
56	API-56				3 - 100	65-42	24X
314	API-56	7 hours	none	detergent solution	3 - 100	67-74	55X