pentene by chlorosulfonic acid had taken place largely on carbon atom 2, with about 20% on carbon atom 3.[18]

Summary

1. Sulfonation of 2-pentene by chlorosulfonic acid in chloroform solution at 0–5° gave a mixture of isomeric pentenesulfonic acids.

2. By comparison of the catalytically-reduced mixture with pentane-2 and -3-sulfonic acids, the sulfonation was shown to have occurred to the extent of approximately 80% on carbon atom number 2 and 20% on carbon atom number 3.

(18) Inasmuch as Lucas, Schlatter and Jones[5] claim that 2-pentene derived from 2-pentanol consists of approximately 75% *trans*- and 25% *cis*-isomer, it is possible that the *trans*-isomer may have sulfonated in the 2-position and the *cis*-isomer in the 3-position. However, proof of this possibility would rest upon sulfonation experiments with the pure isomers.

HOUSTON, TEXAS

RECEIVED APRIL 12, 1948

[CONTRIBUTION FROM THE LABORATORIES OF THE UNIVERSITY OF MARYLAND]

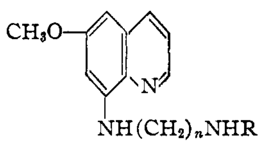
Synthetic Antimalarials. Some Derivatives of 8-Aminoquinoline. II[1]

BY NATHAN L. DRAKE, ROBERT A. HAYES, JOHN A. GARMAN, ROBERT B. JOHNSON, GORDON W. KELLEY, SIDNEY MELAMED AND RICHARD M. PECK

Continuing the research that led to the synthesis of pentaquine (SN 13,276),[2,3] a number of new 8-aminoquinolines have been synthesized. In eleven of these, only the terminal amino group of SN 13,276 has been varied; in seven more, the length of the side chain has been changed. One compound containing an additional nuclear substituent has also been made.

Two general methods were used for the synthesis of all but one of the drugs. Method I consisted of heating 8-amino-6-methoxyquinoline in the presence of water with the appropriate side chain chloride hydrochloride in much the same manner as was reported for the synthesis of SN 13,276.[3] Method II consisted of the reductive alkylation of the appropriate 6-methoxy-8-aminoalkylaminoquinoline with the requisite aldehyde or ketone in ethanol solution in the presence of Adams catalyst at room temperature.[4] The condensation of isopropyla-

TABLE I



UM No.	R	n	Method of synthesis	Salt[a] prepared	Overall yield[b] of salt, %	M. p.[c] of salt, °C.	Analyses,[d] % Calculated Carbon	Calculated Hydrogen	Found Carbon	Found Hydrogen	Homogeneity %[e]
137 Q	$CH(CH_3)CH_2CH_2CH_3$	5	I	A	15	167.1–168.2	65.75	8.67	65.48, 65.41	8.66, 8.84	
135 Q	$CH(C_2H_5)_2$	5	I	B	41	103–105	45.71	7.10	45.80, 45.75	7.33, 7.18	
136 Q	$CH(CH_3)C_2H_5$	5	I	C	54	164.3–165.1	57.57	7.57	57.67, 57.50	7.62, 7.56	
139 Q	$CH(CH_2)_4CH_3$	5	I	A	12	168–169	66.8	8.48	66.64	8.44	
170 Q	$CH_2C(CH_3)_3$	5	I	A	22	188.9–189.5	65.75	8.76	66.00, 65.85	8.75, 8.65	98 ± 2
177 Q	$CH_2CH(CH_3)_2$	5	II	C	20	175.7–176.9	57.57	7.57	57.79, 57.70	7.61, 7.81	98 ± 2
178 Q	$CH_2CH(CH_3)C_2H_5$	5	II	C	26	149.5–150.5	65.75	8.73	65.52, 65.81	9.02, 9.04	98 ± 2
179 Q	$(CH_2)_3CH_3$	5	I	C	14	135.6–136.8	57.57	7.57	57.90, 57.62	7.17, 7.28	94 ± 3
180 Q	$(CH_2)_4CH_3$	5	I	C	27	123.5–124.9	58.54	7.80	58.73, 58.89	7.90, 7.94	94 ± 3
181 Q	$CH_2CH_2CH(CH_3)_2$	5	I	C	5	143.3–144.6	58.54	7.80	58.74, 58.88	7.92, 7.93	98 ± 2
182 Q	$CH(CH_3)CH(CH_3)_2$	5	I	C	7	164.2–165.1	58.54	7.80	58.54, 58.81	7.68, 7.94	97 ± 2
183 Q	$CH(CH_3)CH(CH_3)_2$	4	II	C	7	173.4–175.0	57.57	7.57	57.55, 57.78	7.65, 7.67	98 ± 2
171 Q	$CH_2C(CH_3)_3$	4	II	A	41	197.2–198.6	64.96	8.55	65.10, 65.02	8.45, 8.55	91 ± 5
165 Q	$CH_2C(CH_3)_3$	3	I	C	10	200.1–201.1	56.54	7.33	56.57, 56.48	7.30, 7.28	98 ± 2
168 Q	$CH(C_2H_5)_2$	3	I	D	41	133–135	46.67	6.31	46.89, 46.75	6.45, 6.39	
172 Q	$CH(C_2H_5)_2$	2	I	D	40	237.0–237.4	45.43	6.01	45.67, 45.64	6.21, 6.19	
176 Q	$CH(CH_3)CH_2CH_2CH_3$	2	I	D	17	233.1–233.9	45.43	6.01	45.83, 45.62	6.37, 6.26	
166 Q	$CH_2C(CH_3)_3$	2	I	D	6	235.6–236.8	45.43	6.01	45.76, 45.85	6.22, 6.17	96 ± 3

[a] A represents the monohydrochloride; B, a diphosphate; C, a monohydrobromide; and D, a dihydrobromide. [b] The yields for those compounds prepared by Method I were calculated from the amino alcohol. Those prepared by method II were calculated from the aminoalkylaminoquinoline. [c] Melting points in this table and in following tables are corrected. [d] Analyses by Miss Eleanor Werble, Mrs. Mary Aldridge and Byron Baer. [e] Homogeneities were determined by the countercurrent extraction technique. See Williamson and Craig, *J. Biol. Chem.*, **168**, 687 (1947). For simplified method of calculation see Lieberman, *ibid.*, **173**, 63 (1948).

(1) This work was entirely supported by a grant-in-aid from the United States Public Health Service (RG-191).

(2) N. L. Drake, *et al.*, THIS JOURNAL, **68**, 1536 (1946).

(3) N. L. Drake, *et al.*, *ibid.*, **68**, 1529 (1946).

(4) A. C. Cope, private communication. This general method was used by Cope to make 8-(4-isopropylamino-*n*-butylamino)-6-methoxyquinoline (SN-13,275).

TABLE II

Compound	Melting point, °C.	Calculated Carbon	Calculated Hydrogen	Found Carbon		Found Hydrogen	
5-Chloro-N-(2-amyl)-1-amylamine hydrochloride	128–129	52.62	10.16	52.37	52.50	9.87	10.03
5-Chloro-N-(3-amyl)-1-amylamine hydrochloride	85.2–88.0	52.62	10.16	52.99		10.09	
5-Chloro-N-(2-butyl)-1-amylamine hydrochloride	145.5–147.0	50.50	9.89	50.28	50.54	9.82	9.82
5-Chloro-N-cyclohexyl-1-amylamine hydrochloride	221–223	55.00	9.59	54.77	54.88	9.50	9.55
5-Chloro-N-neopentyl-1-amylamine hydrochloride	180.7–183.7	Ionic Cl, 15.6		Ionic Cl, 15.5, 15.7			
5-Chloro-N-(1-butyl)-1-amylamine hydrochloride	222.3–225.2	Ionic Cl, 16.6		Ionic Cl, 16.6, 16.6			
5-Chloro-N-(1-amyl)-1-amylamine hydrochloride	229.0–231.6	Ionic Cl, 15.6		Ionic Cl, 15.7, 15.9			
5-Chloro-N-(isoamyl)-1-amylamine hydrochloride	221.7–224.1	Ionic Cl, 15.6		Ionic Cl, 15.7, 15.8			
5-Chloro-N-(2-methyl-3-butyl)-1-amylamine hydrochloride	137.4–138.9	Ionic Cl, 15.6		Ionic Cl, 15.5, 15.6			
3-Bromo-N-neopentyl-1-propylamine hydrobromide	253–254	33.33	6.57	33.42	33.27	6.61	6.89
3-Chloro-N-(3-amyl)-1-ethylamine hydrochloride	134–136	48.00	9.57	47.48	47.41	9.69	9.16
2-Chloro-N-(3-amyl)-1-ethylamine hydrochloride	135.6–136.2	45.16	9.14	44.52	44.47	8.94	9.31
2-Chloro-N-(2-amyl)-1-ethylamine hydrochloride	137.4–138.2	45.16	9.14	43.77	43.91	9.29	9.13
2-Chloro-N-neopentyl-1-ethylamine hydrochloride	246–247	45.16	9.14	45.30	45.20	9.18	9.08

TABLE III

Compound	Method of synthesis	Yield, %	Boiling point °C.	Mm.	Analyses, % Calculated	Found
5-(2-Amylamino)-1-pentanol	B	76	119–121	7.5	N. E. 173	175
5-(3-Amylamino)-1-pentanol	B	62	110–112	4	N. E. 173	175, 175
5-(2-Butylamino)-1-pentanol	B	74	107–109	3.5	N. E. 159	162
5-(Cyclohexylamino)-1-pentanol	B	84	[b]		C, 71.4	71.04, 71.25
					H, 12.45	12.73, 12.65
5-(Neopentylamino)-1-pentanol	A	76	126–131	17	N. E. 173	174
5-(*n*-Butylamino)-1-pentanol	B	62	155–156	28	N. E. 159	163
5-(*n*-Amylamino)-1-pentanol	B	61	164–165	30	N. E. 173	174
5-(Isoamylamino)-1-pentanol	A	70	136–138	10	N. E. 173	175
5-(2-Methyl-3-butylamino)-1-pentanol	A	58	130–132	13	N. E. 173	174
N-(3-Methoxypropyl)-neopentylamine	A	69	73–75	20	N. E. 158	159
3-(3-Amylamino)-1-propanol	[a]	51	102–105	12	N. E. 145	148
2-(3-Amylamino)-1-ethanol	A	70	96–98	7	N. E. 131	131
2-(2-Amylamino)-1-ethanol	A	83	81–83	6.4	N. E. 131	132
2-Neopentylamino-1-ethanol	A	74	75–80	10	N. E. 131	132

[a] This compound was prepared from trimethylene chlorohydrin and 3-aminopentane. [b] This compound was not distilled. It was isolated by crystallization from petroleum ether and melted at 79.0–80.5°.

minoamylbromide hydrobromide with 8-amino-6-methoxy-5-(4-methoxyphenoxy)-quinoline gave only starting material when Method I was attempted but proceeded satisfactorily when the reactants were refluxed in alcohol.[5] Most of the drugs were finally purified as monohydrochlorides, hydrobromides or hydriodides; four of them were purified as dihydrobromides, and one as a diphosphate. All but one of the drugs prepared are listed in Table I.

The synthesis of all but one of the side chains for the compounds prepared by Method I was carried out by the action of thionyl chloride on the appropriate aminoalcohol. 3-Methoxy-N-neopentyl-1-propylamine was heated with an excess of constant-boiling hydrobromic acid. In most cases the side chain was used for the condensation without purification. The side chains prepared are listed in Table II.

The desired alkylaminoalcohols were prepared by (A), reductive alkylation of the appropriate aminoalcohol with the appropriate aldehyde or ketone, or (B), in the case of several of the alkylaminoamyl alcohols, from dihydropyran according to the procedure used in the preparation of isopropylaminopentanol.[3] All of the aminoalcohols prepared are listed in Table III.

Short-term chronic toxicities of the compounds are listed in Table IV.

Experimental

2-Aminopentane.[6]—A mixture of 258 g. of 2-pentanone and 250 ml. of anhydrous ammonia was heated at 140° with hydrogen and Raney nickel at 4000 p. s. i. After the reduction mixture was filtered, it was made acidic with hydrochloric acid and steam distilled to remove non-basic impurities. The aqueous residue was then made strongly basic, extracted with ether and the dried extracts were carefully distilled; 170 g. of product which boiled at 89° was obtained (66%).

3-Aminopentane.[7]—This compound was synthesized from diethyl ketone by the reductive amination method used in the preparation of 2-aminopentane; the reduction

(5) E. Rohrman and H. A. Shonle, THIS JOURNAL, **66**, 1640 (1944).

(6) I. Tafel, *Ber.*, **22**, 1854 (1889).

(7) W. A. Noyes, THIS JOURNAL, **15**, 539 (1893).

TABLE IV

THE TOXICITY OF SOME 8-AMINOQUINOLINES[a]

Drug	Pamaquine equivalent	Qualitative aspects of toxicity resemble those observed with:
SN 13,276	0.25	
UM 135Q	.5	Pamaquine
UM 136Q	.5	Pentaquine
UM 137Q	.5	Pentaquine
UM 139Q	1.0	Pamaquine
UM 165Q	0.5	Plasmocid
UM 166Q	2	Plasmocid
UM 168Q	4	Plasmocid
UM 170Q	0.5	Pamaquine or pentaquine
UM 171Q	0.5	Pamaquine
UM 172Q	2	Plasmocid
UM 176Q	2	Plasmocid
UM 177Q	0.5	Pamaquine
UM 178Q	.5	Pamaquine
UM 179Q	.5	Pamaquine
UM 180Q	.5	Pentaquine closely
UM 181Q	.5	Pamaquine
UM 182Q	.5	Pamaquine
UM 183Q	.5	Pamaquine

[a] We are indebted to Dr. L. H. Schmidt, Christ Hospital, Mount Auburn, Cincinnati, Ohio, for the data from which this table was compiled. The test, which is for short term chronic toxicity in Rhesus monkeys, has been described (see "Survey of Antimalarial Drugs 1941–1945," Wiselogle ed., Vol. I, Edwards Bros., Ann Arbor, Michigan, 1946, p. 508).

was carried out at 150°. The yield was 59.7%,[8] and the boiling point of the amine was 91–92°.

Alkylaminoalcohols, Method (A).—A mixture of 1 mole of the primary amine and 1.25 moles of the desired aldehyde or ketone was heated with hydrogen in the presence of Adams catalyst at 100° and 2000 p. s. i.; the reduction was complete in about four hours. The catalyst was removed by filtration and the filtrate was distilled under diminished pressure. The yield varied from 56–83%.

Alkylaminopentanols, Method (B).—A solution of 20.4 ml. of concentrated hydrochloric acid in 250 ml.of distilled water was cooled to 0–5° in an ice-bath. The ice-bath was removed and 84 g. (1.0 mole) of dihydropyran was added all at once. The resulting mixture was stirred until it became homogeneous, allowed to stand for ten minutes, and then cooled in an ice-bath to 10–15°. To this solution was added slowly with cooling 1.25 moles of the desired amine while the temperature was kept below 25°. The resulting mixture was shaken with hydrogen and Adams catalyst at 25° and an initial pressure of 2000 p. s. i. The process was complete in about two hours. The catalyst was removed by filtration, and the solution was saturated with solid sodium hydroxide. The upper layer was separated and distilled under diminished pressure. The yield varied from 61–76%.

3-(3-Amylamino)-1-propanol.—A mixture of 38.8 g. of trimethylene chlorohydrin and 72 g. of 3-aminopentane was allowed to stand at room temperature for eighty hours, according to the method of Elderfield.[9] The precipitate was removed by filtration and the filtrate was heated at 115° to remove excess amine. After acidification with hydrochloric acid and re-addition of the original precipitate, the solution was extracted with ether, and the extracts were discarded. The aqueous portion was saturated with potassium hydroxide and extracted with ether. The extracts were dried and concentrated, and the residue was distilled under diminished pressure; 30.5 g. (51%) of product which boiled at 102–105° (12.5 mm.) was obtained. The neutral equivalent was 148 (calcd. 145) and the refractive index was $n^{25}D$ 1.4466.

ω-Chloro-N-alkyl-1-alkylamine Hydrochlorides.—To a stirred solution of 1 mole of the appropriate aminoalcohol in 600 ml. of petroleum ether (90–100°) was added slowly 138 g. (1.1 moles) of thionyl chloride. The mixture was stirred and refluxed for three hours and then allowed to stand overnight. The crude product was removed by filtration and washed well with petroleum ether. In most cases the product was used without further purification. The product can be purified by recrystallization from absolute ethanol and ether.

3-Bromo-N-neopentyl-1-propylamine Hydrobromide.—A solution of 63 g. of 3-methoxy-N-neopentyl-1-propylamine in 420 g. of 48% hydrobromic acid was warmed overnight on a steam-bath, and the solution was then evaporated to dryness under reduced pressure. The crude semisolid residue was used directly in the next step. Recrystallization of a small portion from acetone yielded a white crystalline material which melted at 252–253°.

Anal. Calcd. for $C_8H_{19}NBr_2$: C, 33.22; H, 6.57. Found: C, 33.42, 33.27; H, 6.61, 6.69.

5-Bromo-N-isopropyl-1-amylamine Hydrobromide.—This compound was prepared by the reaction of 5-isopropylamino-1-pentanol[3] and 48% hydrobromic acid at reflux temperature for four hours.The product was isolated by removal of the excess hydrobromic acid under diminished pressure, and the crude material was used directly in the next step.

8-(ω-Alkylaminoalkylamino)-6-methoxyquinoline, Method I.—A mixture of 1 mole of the side chain, 2 moles of 8-amino-6-methoxyquinoline, and 100 ml. of water was heated and stirred at 80° for twenty hours, and then at 100° for four hours. The melt was poured into an equal volume of water, and alkali and sodium acetate were added successively until the pH rose to 5.0. The mixture was then heated to 60° and extracted with several portions of benzene.[10] The aqueous portion was cooled to 20°,[11] treated with aqueous alkali, and extracted with ether. The product was obtained from the dried, concentrated ether solution by distillation under diminished pressure.

8-(ω-Alkylaminoalkylamino)-6-methoxyquinoline, Method II.—An aqueous solution of 28.5 g. (0.07 mole) of 8-(4-aminobutylamino)-6-methoxyquinoline dihydrochloride hemihydrate[4] was treated with aqueous alkali and extracted with chloroform. The concentrated extracts were dissolved in 75 ml. of albsolute ethanol, 0.20 mole of the desired aldehyde or ketone was added and the solution was hydrogenated over Adams catalyst at 2000 p. s. i. The reduction required about one hour. After removal of the catalyst by filtration, the solution was evaporated to dryness, and the residue was distilled in a molecular still.

The substitution of 26.9 g. (0.07 mole) of 8-(5-aminoamylamino)-6-methoxyquinoline dihydrochloride trihydrate[12] in the above procedure yields the desired alkylaminoamylaminoquinoline.

8-(5-Isopropylaminoamylamino)-6-methoxy-5-(4-methoxyphenoxy)-quinoline Monohydriodide.—A mixture of 30.9 g. of 8-amino-6-methoxy-5-(4-methoxyphenoxy)-quinoline, 35 g. of 5-bromo-N-isopropyl-1-amylamine hydrobromide, 100 ml. of absolute ethanol, and 75 ml. of ethylene glycol was refluxed for seventy-two hours, cooled,

(8) This compound was also prepared in 29% yield by the catalytic reduction of 3-pentanone oxime. The oxime was prepared by the method of "Organic Syntheses," Coll. Vol. II, John Wiley & Sons, Inc., New York, N. Y., p. 313. See also R. Scholl, *Ber.*, **21**, 506 (1888).

(9) R. C. Elderfield, THIS JOURNAL, **68**, 1579 (1946).

(10) The small amount of crystalline material that usually separated from the cooled benzene extracts was returned to the aqueous mixture, as was a 200-ml. aqueous extract of the combined benzene extracts. About 1 mole of 8-amino-6-methoxyquinoline was recovered from the benzene solution by concentration and distillation under diminished pressure.

(11) In some cases the product crystallized at this point in the procedure. If so, it was removed by filtration and then treated with alkali.

(12) Baldwin, *J. Chem. Soc.*, 2959 (1929).

and poured into an aqueous solution of 13.6 g. of sodium acetate trihydrate. The *p*H of the solution was adjusted to 4.5 and the mixture was extracted with chloroform. The chloroform solution was shaken first with 10% sodium hydroxide solution and then with salt water. It was dried, concentrated to 500 ml., and 250 ml. of petroleum ether (60–80) was added. The product was adsorbed by passing the solution through a column of activated alumina and was eluted with a mixture of chloroform and petroleum ether. The eluate, when concentrated under diminished pressure yielded 15 g. of a viscous oil. The oil was dissolved in aqueous hydrochloric acid and, after the *p*H had been adjusted to 5.0 with sodium acetate, a 10% excess of potassium iodide was added. An oil precipitated which, after decantation of the solution, was taken up in hot methanol. Addition of ether precipitated an impure salt which was recrystallized from methanol-ether; 5 g. (11.4%) of monohydriodide which melted at 159.0–160.5° was obtained.

Anal. Calcd. for $C_{25}H_{33}N_3O_3.HI$: C, 54.5; H, 6.17. Found: C, 54.26, 54.11; H, 6.42, 6.12.

Monohydrochlorides and Hydrobromides of 8-Alkylaminoalkylaminoquinolines.—Two general methods for the preparation of these salts were used. The first consisted of dissolving the base in dilute acetic acid and adding and excess of a concentrated aqueous solution of sodium bromide or sodium chloride. The other method consisted of dissolving the base in a slight excess of dilute hydrochloric or hydrobromic acid and adding a concentrated aqueous solution of sodium acetate until the *p*H of the mixture was 5.0. The salts were recrystallized from water, ethanol, or ethanol and ether.

Dihydrobromides and Diphosphates of 8-Alkylaminoalkylaminoquinolines.—These salts were prepared by adding a slight excess of 48% hydrobromic acid or 85% phosphoric acid to a refluxing ethanol solution of the base. The solution was cooled and the crystals removed by filtration. The product was recrystallized from ethanol or ethanol and ether.

Summary

1. Eighteen new relatives, and one nuclear substitution product of pentaquine (SN-13,276), together with the intermediates necessary for their preparation, are described.

2. Short-term chronic toxicities, determined in Rhesus monkeys, are given.

3. None of the drugs is less toxic than pentaquine.

COLLEGE PARK, MD. RECEIVED AUGUST 23, 1948

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY]

Alkane-choleic Acids: Compounds of Paraffin Hydrocarbons with Desoxycholic Acid[1]

BY ERNEST H. HUNTRESS AND RALPH F. PHILLIPS[2,3,4]

The number of addition products of desoxycholic acid with organic compounds of widely diverse types is legion, but the only choleic acids from alkanes reported at the time of our work was carried out (February, 1938–June, 1939) were two products incidentally mentioned[5] without details in a report on polycyclic carcinogenic hydrocarbons. Furthermore, Rheinboldt had long been concerned with studies on desoxycholic acid addition products, but none of his work involved alkanes until a paper published[6] after our experiments had been completed. This included certain data on desoxycholic acid compounds of the normal alkanes with 11, 12, 13, 14, 15, 16, 35 and 43 carbon atoms.

Under suitable conditions every one of the thirty-four alkanes which were studied in our work combined with desoxycholic acid in methanol solution to give in good yield a definite compound containing from two to eight moles of desoxycholic acid per mole of hydrocarbon. The composition of this resultant alkane-choleic acid was established by determination of the neutralization equivalent of the complex by titration with standard alkali. In the consolidation of our many experiments to the simple form of Table II, we have taken the mean neutralization equivalent of several runs rarely differing among themselves by more than 3–4 units out of 400–440. Comparison of the values of Table II with the various Kz values for a given composition (Table I) shows that the nearest correspondence is rarely in doubt. Our results show that in general the number of coördinated molecules of desoxycholic acid diminishes with increased forking of the hydrocarbon chain, but that this effect is not sufficiently critical to serve as an infallible means of distinction.

TABLE I

CALCULATED NEUTRALIZATION EQUIVALENTS OF ALKANE-CHOLEIC ACIDS

N = number of molecules of desoxycholic acid (mol. wt., 392) per mole of alkane = Kz (coördination number)

Neutralization Equivalent = (392 N + M.W.)/N = 392 + (M.W./N)

N	1	2	3	4	5	6	7	8
C_5H_{12}	464	428	416	410	406.4	404	402.3	401
C_6H_{14}	478	435	420.7	413.5	409.2	406.3	404.3	402.7
C_7H_{16}	492	442	425.3	417	412	408.6	406.3	404.5
C_8H_{18}	506	449	430	420.5	414.8	411	408.3	406.3
C_9H_{20}	520	456	434.7	424	417.6	413.3	410.3	408
$C_{10}H_{22}$	534	463	439.3	427.5	420.4	415.7	412.3	409.8

Experimental Part

Materials Used.—For many of the samples of highly purified alkanes used in this work the authors are indebted to Messrs. H. Beatty, J. H. Bruun, G. Calingaert, P. L. Cramer, N. L. Drake, G. Egloff, A. V. Grosse, F. D. Rossini and the late F. C. Whitmore as individuals, and

(1) Presented April 23, 1942, at the Memphis Meeting of the American Chemical Society.

(2) This paper has been constructed from a thesis submitted in May, 1939, by Ralph F. Phillips in partial fulfillment of the requirements for the degree of Ph.D. in Organic Chemistry.

(3) A. D. Little Fellow in Chemistry, M. I. T., 1938–1939.

(4) Present address: Sugar Research Foundation, 52 Wall Street, New York 5, N. Y.

(5) Fieser and Newman, THIS JOURNAL, **57**, 1603 (1935).

(6) Rheinboldt, *J. prakt. Chem.*, [2] **153**, 313–326 (1939).