with what appears to be the most reliable for pure water at 20°.

TABLE VI—REVISED

COMPARISON OF COMPUTED AND EXPERIMENTAL SPECIFIC VOLUMES

Weight fraction water	v exptl. at 20°	v calcd. at 20° Old table	v calcd. at 20° New table
1.000	Lange 1.00180 Dorsey 1.00184	1.00261	1.00186
0.78475	0.92818	0.92826	.92816
.60841	.87037	.87006	.87023
.40917	.80836	.80836	.80853
.21471	.75103	.75101	.75103
.03123	.69888	.69918	.69904
.000	.....	.69068	.69053

TABLE VII—REVISED

AVERAGE COEFFICIENT OF SPECIFIC VOLUME CHANGE FROM 0–20° OF AQUEOUS SOLUTIONS OF HYDROGEN PEROXIDE AS A FUNCTION OF THE WEIGHT FRACTION OF WATER

The entries of the table are to be multiplied by 10^{-4}.

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	7.85	7.82	7.80	7.79	7.77	7.75	7.72	7.71	7.68	7.66
.1	7.65	7.62	7.60	7.58	7.55	7.53	7.50	7.48	7.45	7.42
.2	7.40	7.37	7.34	7.32	7.29	7.26	7.23	7.20	7.17	7.14
.3	7.11	7.08	7.05	7.02	6.98	6.95	6.92	6.88	6.85	6.81
.4	6.77	6.74	6.70	6.66	6.62	6.57	6.53	6.49	6.45	6.40
.5	6.36	6.31	6.26	6.21	6.16	6.11	6.05	6.00	5.94	5.88
.6	5.83	5.77	5.70	5.64	5.57	5.50	5.43	5.36	5.29	5.21
.7	5.14	5.06	4.97	4.88	4.79	4.70	4.61	4.51	4.41	4.31
.8	4.21	4.09	3.98	3.86	3.73	3.61	3.47	3.34	3.20	3.06
.9	2.92	2.74	2.56	2.37	2.18	1.97	1.76	1.54	1.31	1.07
1.0	0.83									

DEPARTMENT OF CHEMISTRY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS. RECEIVED JUNE 21, 1950

5,8-Dimethoxyquinoline[1]

BY C. E. KASLOW AND VERNON V. YOUNG[2]

It was desired to prepare 5,8-dimethoxyquinoline (III) in quantity for orientation studies and as the starting point in certain syntheses. 5,8-Dihydroxyquinoline has been reported in the literature. It was prepared by the alkali fusion of 8-hydroxy-5-quinolinesulfonic acid[3] and by the reduction of 5-nitroso-8-hydroxyquinoline[4] with iron and hydrochloric acid. Neither of these methods seemed to be feasible routes for the preparation of III. A series of dimethoxy-2,4-dimethylquinolines[5] has been prepared by condensation of acetylacetone with a dimethoxyaniline followed by ring closure in hot concentrated sulfuric acid. Since the Skraup reaction has been used with success in the preparation of 6,7-dimethoxyquinoline[6] from *p*-aminoveratrole and 7,8-dimethoxyquinoline[7] from *o*-aminoveratrole, it seemed the most direct route for the synthesis of III from 2,5-dimethoxyaniline. However, the Skraup reaction, with the usual modification of conditions, gave none of the desired product. Likewise the short-time Skraup reaction[8] as well as the modification[9] using acrolein failed to give III.

The alternate methods involved several steps starting either with ethyl ethoxalylacetate or with diethyl ethoxymethylenemalonate according to the general procedures described by Surrey and Hammer[10] and Price and Roberts,[11] respectively. Except for the availability of the esters, there was no advantage of one method over the other for the preparation of 5,8-dimethoxy-4-quinolinol (I). With ethyl ethoxalylacetate, the best results were obtained when one mole of the sodium salt was converted to the free ester, extracted with ether, dried and the ether removed by distillation then the crude ester used in the condensation reaction with 0.75 mole of 2,5-dimethoxyaniline Methylene dichloride was also used as an extractor for the ester, in which case it is only

TABLE I

SUBSTITUTED 5,8-DIMETHOXY-4-HYDROXYQUINOLINES

Compound	Formula	M. p., °C.	Nitrogen, % Calcd.	Found
2-$CO_2C_2H_5$[a]	$C_{14}H_{15}NO_5$	146–147	5.06	5.01
2-CO_2H[b]	$C_{12}H_{11}NO_5$	215–216 (dec.)	5.62	5.57
3-$CO_2C_2H_5$[c]	$C_{14}H_{15}NO_5$	197–198	5.06	5.27
3-CO_2H[d]	$C_{12}H_{11}NO_5$	261–262 (dec.)	5.62	5.38

[a] Recrystallized from acetone, isopropyl alcohol or water. [b] Recrystallized from ethyl alcohol. [c] Recrystallized from acetone or isopropyl alcohol. [d] Recrystallized from ethyl alcohol.

(1) Taken mainly from a thesis presented by Vernon V. Young in partial fulfillment of the requirements for the M. A. degree, August, 1947.

(2) Commercial Solvents Corporation, Terre Haute, Indiana.

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(6) Frisch and Bogert, *J. Org. Chem.*, **9**, 338 (1944).

(7) Rajagopalan, *C. A.*, **35**, 7965 (1941).

(8) Elderfield, Gensler, Williamson, Griffing, Kupchan, Maynard, Kreysa and Wright, THIS JOURNAL, **68**, 1584 (1946).

(9) Bernstein and Yale, *ibid.*, **70**, 254 (1948).

(10) Surrey and Hammer, *ibid.*, **68**, 113 (1946).

(11) Price and Roberts, *ibid.*, **68**, 1204 (1946); "Organic Syntheses," Vol. 28, John Wiley and Sons, Inc., New York, N. Y., 1948, p. 38.

necessary to dry the solution before addition of the 2,5-dimethoxyaniline.

Experimental

5,8-Dimethoxy-4-quinolinol (I). Method A.—2,5-Dimethoxyaniline (0.75 mole) was condensed with ethyl ethoxalylacetate (from one mole of the sodium salt) essentially according to the procedure of Surrey and Hammer.[10] The crude ethyl 5,8-dimethoxy-4-hydroxy-2-quinolinecarboxylate (190 g., m. p. 139–143°) was saponified in dilute sodium hydroxide and upon acidification gave 165 g. of crude 5,8-dimethoxy-4-hydroxy-2-quinolinecarboxylic acid (m. p. 215–216° dec.). The crude substance was decarboxylated by heating in phenyl ether giving an 88% yield of crude I (m. p. 216–219°). I was recrystallized from isopropyl alcohol giving short tan-colored crystals which melted at 220–221°.

Anal. Calcd. for $C_{11}H_{11}NO_3$: N, 6.82. Found: N, 6.76.

Method B.—Following the general procedure of Price and Roberts,[11] an 86% yield of crude ethyl 5,8-dimethoxy-4-hydroxy-3-quinolinecarboxylate (m. p. 190–194°) was obtained by condensation of 0.35 mole of diethyl ethoxymethylenemalonate[12] with 0.3 mole 2,5-dimethoxyaniline. The crude ester (69.2 g.) was saponified, yielding 61.7 g. of crude 5,8-dimethoxy-4-hydroxy-3-quinolinecarboxylic acid (m. p. 254–256° dec.) which gave a 93% yield of crude I (m. p. 217–220°) when decarboxylated in boiling phenyl ether.

5,8-Dimethoxy-4-chloroquinoline (II).—Two-tenths mole (41 g.) of I was heated with 150 ml. of phosphoryl trichloride until the solid was dissolved, then most of the excess phosphoryl trichloride was removed in vacuum and the residue poured into a flask containing 200–300 ml. of chipped ice and water. The cold solution was made alkaline with concentrated ammonia water, allowed to stand 2–3 hours and the solid removed by filtration. The crude II was recrystallized from dilute (25–50%) ethyl alcohol giving long white needles; the yield was 35 g. (78%), m. p. 110–111°.

Anal. Calcd. for $C_{11}H_{10}ClNO_2$: Cl, 15.84. Found: Cl, 16.08.

5,8-Dimethoxyquinoline (III).—One-tenth mole (22.4 g.) of II was reduced with hydrogen and palladium–charcoal in accordance with the generally accepted procedure.[13] After isolation of the 5,8-dimethoxyquinoline, the solid was recrystallized from low boiling ligroin (60–80°) as short white needles. The yield was 15.2 g. (80%), m. p. 75–76°.

Anal. Calcd. for $C_{11}H_{11}NO_2$: N, 7.39. Found: N, 7.28.

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CONTRIBUTION NO. 498 FROM THE
CHEMISTRY LABORATORY OF INDIANA UNIVERSITY
BLOOMINGTON, INDIANA RECEIVED MAY 18, 1950

The Utilization of Formaldehyde by Propionic Acid Bacteria[1]

BY FREDERICK W. LEAVER

During studies on the fermentation of various substrates by *Propionibacterium arabinosum* C^{14} formaldehyde (0.001 *M*) was included in the medium to test the possibility that it could be utilized. Glycerol, *i*-erythritol, pyruvate and glucose served as substrates in separate experiments, and in each case a substantial amount of C^{14} was incorporated in the resulting propionic acid. This acid was extracted from the medium by ether and purified by partition chromatography.[2] The propionic acid from the glycerol fermentation was diluted approximately 1:1 with known acid as carrier and the S-benzylthiouronium salt was made and recrystallized from hot water. The melting point (148–149° uncor.) was the same as that of an authentic sample, and the mixed melting point was not depressed. The specific activity of the acid regenerated from the derivative was the same as that determined prior to making the derivative. The activity was determined by counting as barium carbonate the carbon dioxide resulting from the wet combustion[3] of the free propionic acid. The propionic acid was degraded to carbon dioxide and acetic acid by oxidation with chromic acid.[4] The resulting acetate which represents the α- and β-carbons of the original propionic acid was separated from any residual propionic acid by partition chromatography, converted to carbon dioxide by wet combustion, and the activity determined. The activity of the carboxyl group of the propionic acid was calculated from the values for the total propionate and the acetate derived therefrom. An aliquot of this acetate from the glycerol fermentation was further degraded by pyrolyzing the barium salt to carbon dioxide and acetone. The carbon dioxide represents the α carbon of the original propionic acid. The acetone was degraded by NaOI to CHI_3 and acetate, and the CHI_3, which represents the β-carbon of the propionic acid was oxidized to CO by $AgNO_3$, and then to CO_2 by I_2O_5. The activity expressed as counts per minute per mM. of carbon was distributed in the propionic acid as shown.

$$\underset{CH_3}{916}\text{—}\underset{CH_2}{858}\text{—}\underset{COOH}{1570}$$

A summary of the activities found in the propionic acid produced from the fermentation of various substrates is given in the table.

Since it has previously been shown that carbon dioxide is fixed only in the carboxyl group of propionic acid,[5] it is clear that the formaldehyde was not utilized exclusively via conversion to carbon dioxide. Furthermore, since the specific activity of the carboxyl group is appreciably higher than that of the carbon dioxide in every case it seems apparent that formaldehyde carbon was incorporated into the carboxyl position of propionate by some mechanism in addition to carbon

(1) This work was supported in part by a grant from the Atomic Energy Commission and the Office of Naval Research and in part by a grant from the Prentiss Foundation. The radiocarbon was obtained in allocation from the U. S. Atomic Energy Commission. Acknowledgment of many helpful suggestions is due to Dr. H. G. Wood.

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