Methyl Cyclohexanecarboxylate-7-C^{14}.—Following the addition of 100 ml. of methyl acetate and 3 ml. of concentrated sulfuric acid to the methanolic solution of cyclohexanecarboxylic acid-C^{14} above, the water–ester azeotrope was slowly removed through 24 in. of glass helices over a period of 4.5 hr. A total of 125 ml. of distillate was collected. The cooled reaction mixture was poured into 250 ml. of ice–water containing 10 g. of sodium carbonate. Chloroform (100 ml.) was added, the layers were separated, the aqueous layer was extracted twice (50 ml. and 25 ml.) with chloroform, and the combined chloroform solutions were washed with 10% sodium carbonate and water, and dried over magnesium sulfate. Removal of solvent followed by vacuum distillation through 10 in. of glass helices gave 25.5 g. of ester, b.p. 73–76° (13 mm.), 90% yield based on starting benzoic acid. Toward the end of the distillation 2 g. of unlabeled ester was added to reduce holdup of labeled material; the yield has been corrected for it.

1,2-Dicyclohexylethanedione-1,2-C^{14}.—The product was prepared as reported earlier for the unlabeled material. Reaction times and amounts were 9.65 g. of sodium (10% excess), 27.5 g. of methyl cyclohexanecarboxylate-7-C^{14}, and 22-hr. reaction time for preparation of the ketol (not isolated); for the oxidation, 80 ml. of glacial acetic acid, 8 ml. of anhydrous methanol, 40 g. of copper acetate monohydrate, and a reflux period of 4 hr. were employed. Final distillate was collected in several fractions: b.p. 103–110° at 0.45 mm., total 16.5 g. (corrected for 1 g. of unlabeled material added near the end of the distillation), 78% yield based on ester. Analysis of this material by the dry combustion technique[5] indicated it had a specific activity of 2.748 ± 0.0011 mc./mole. A fraction of it was diluted with unlabeled diketone to give material of a specific activity of 0.4639 ± 0.0074 mc./mole, measured by scintillation techniques, after correction for considerable quenching.

meso- **and *dl*-2,3-Dicyclohexyl-2,3-butanediol-2,3-C^{14}.** *meso-*.—Benzil-C^{14} [5] (0.630 g., 3 mmoles) in ether was added to an ether solution of 12 mmoles of methyllithium and refluxed overnight. Following a customary work-up and removal of solvent, the residue was treated with 5 g. of unlabeled *meso* glycol[5] and the mixture was crystallized from hexane–benzene to yield 3.9 g. of fine, white crystals of *meso*-2,3-diphenyl-2,3-butanediol-2,3-C^{14}. The filtrate was treated two additional times with 5 g. of unlabeled glycol to produce 4.1 and 6.4 g. of product, total 14.4 g. This material was hydrogenated as described above.

dl-.—Labeled benzil-C^{14} (0.630 g.) was treated similarly with 12 mmoles of methylmagnesium iodide. Utilization of 10 g. of unlabeled racemate[5] in three portions gave 9.9 g. of white needles, m.p. 124°. The hydrogenation of this material has been described above.

Dilution Studies.—The technique has been described in a previous paper.[5] Approximately 4 mmoles of diketone or ketol were added to an ether solution of organometallic reagent (4–6:1 with respect to diketone or ketol), prepared under argon, at reflux temperature. Following a standard but quantitative work-up of the reaction mixture after suitable reflux, the ether solution was concentrated to dryness, the residue was taken up in methanol, and known aliquots were added to the weighed amounts of dilution materials. Subsequent concentration to dryness followed by three to five recrystallizations from hexane gave pure materials. The results have been compiled in Table I. Assay was by either the vibrating-reed electrometer (entries 1 and 9) or the Tri-Carb scintillometer (all other entries).

Control Study.—To eliminate any possibility of either glycol interconversion or selective decay during some of the extended reaction periods, the following experiment was carried out under conditions employed in the dilution studies. *meso*-2,3-Dicyclohexyl-2,3-butanediol-2,3-C^{14} (0.2020 g., specific activity 0.2456 mc./mole) and the *dl* diastereoisomer (0.2003 g., specific activity 0.08538 mc./mole) were refluxed together with a 24:1 molar ratio of methylmagnesium iodide for 72 hr. Reisolation by dilution techniques showed activities of 0.2441 and 0.08481 mc./mole for the *meso* and *dl* forms, respectively, indicating essentially quantitative recovery.

Acknowledgment.—This research was conducted under AEC Contract No. AT-(40-1)-2833. The author wishes to express his appreciation for some encouraging correspondence from Dr. P. N. Rylander of Engelhard Industries prior to initiating certain phases of the rhodium-catalyst utilization. It is a pleasure to acknowledge considerable obligation to Dr. C. J. Collins and his co-workers, Dr. B. M. Benjamin, and Dr. V. F. Raaen for numerous stimulating discussions, constructive criticism, and many personal courtesies. The present work had as its stimulus the related research[5] carried out under Dr. Collins' senior authorship.

A Stereospecific Synthesis of (±)-Quinic Acid

JOSEPH WOLINSKY, ROBERT NOVAK,[1] AND ROBERT VASILEFF

Department of Chemistry, Purdue University, Lafayette, Indiana

Received June 15, 1964

A stereospecific synthesis of (±)-quinic acid is described. Methyl α-acetoxyacrylate is condensed with 1,3-butadiene and the resulting adduct is hydrolyzed to 1-hydroxy-3-cyclohexene-1-carboxylic acid. Bromo lactonization and dehydrobromination produces 1-hydroxy-Δ^{5}-3-oxabicyclo[3.2.1]octen-2-one which is converted with osmium tetroxide into (±)-quinide. Hydrolysis of (±)-quinide affords (±)-quinic acid.

(−)-Quinic acid, 1,3,4,5-tetrahydroxy-1-cyclohexanecarboxylic acid (I), has been known since 1790[2] and occurs widely in the plant kingdom.[3] Large quantities have been found in apple,[4] peach,[5] and rose[6] tissue. Derivatives of quinic acid, *i.e.*, chlorogenic acid,[7] isochlorogenic acid,[8] *p*-coumaryl quinate,[9] etc.,[10] are also common in plants.

Quinic acid has been considered as a possible intermediate in aromatic biosynthesis for nearly one-half

(1) This paper was taken from a portion of a thesis submitted by R. N. in partial fulfillment of the requirements for the M.S. degree from Purdue University, Jan., 1964.

(2) Hofmann, *Crells Ann.*, **II**, 314 (1790).

(3) H. Rentschler and H. Tanner, *Chem. Abstr.*, **48**, 9578 (1954); **49**, 1236 (1955); R. Ulrich and O. Thaler, *Compt. rend.*, **240**, 1625 (1955); D. E. Hathway, *Biochem. J.*, **63**, 380 (1956); J. K. Palmer, *Science*, **126**, 504 (1957); J. Carles, *Bull. soc. chim. Biol.*, **39**, 1177 (1957); A. Schneider, *Compt. rend.*, **246**, 2029 (1958); S. V. Ting and E. J. Deszyck, *Nature*, **183**, 1404 (1959); V. Plouvier, *Bull. soc. franc. physiol. vegetale*, **7**, 44, (1961); S. M. Manskaya and L. A. Kodina, *Chem. Abstr.*, **55**, 3055 (1961).

(4) A. C. Hulme, *J. Exptl. Botany*, **2**, 298 (1957).

(5) E. Anet and T. M. Reynolds, *Nature*, **172**, 1188 (1953).

(6) L. Weinstein, W. Smith, and H. Laurencot, *Contrib. Boyce Thompson Inst.*, **19**, 341 (1958).

(7) K. Gorter, *Ann.*, **358**, 327 (1907); G. C. Whiting and J. G. Carr, *Nature*, **180**, 1479 (1957).

(8) L. A. Griffiths, *Biochem. J.*, **70**, 120 (1958);

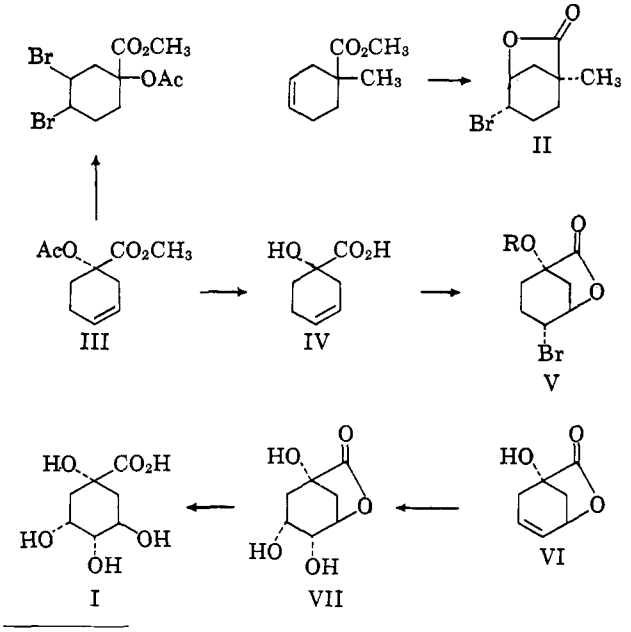
(9) A. H. Williams, *Chem. Ind.* (London), 1200 (1958); A. Pollard, M. E. Kieser, and D. J. Sissons, *ibid.*, 952 (1958); H. R. Schutte, and W. Langenbeck, *Naturwiss.*, **44**, 63 (1957); E. Haslam, R. D. Haworth, and G. K. Makinson, *J. Chem. Soc.*, 5153 (1961).

(10) C. C. Levy and M. Zucker, *J. Biol. Chem.*, **235**, 2418 (1960); D. F. Horler and H. E. Nursten, *J. Chem. Soc.*, 3786 (1961); E. Haslam, R. D. Haworth, and D. A. Lawton, *ibid.*, 2173 (1963).

century.[11] Davis[12] reviewed the early work on the utilization of quinic acid and elegantly demonstrated that 5-dehydroquinic acid,[13] 5-dehydroshikimic acid,[14] and shikimic acid,[12] but not quinic acid, are normal intermediates in microbial aromatic biosynthesis. Quinic acid is not common in bacteria and is only utilized when quinic dehydrogenase is fortuitously present to catalyze its conversion into 5-dehydroquinic acid. Many authors have drawn an analogy between microbial and plant biosynthesis; however, recent work[15] suggests that plants may possess an alternate pathway for transforming quinic acid into aromatic amino acids. It is clear that the role of quinic acid in the plant kingdom is not presently understood and deserves further attention.

The preparation of uniformly labeled quinic acid, utilizing *Ginko biloba*, has been reported by Weinstein.[16] Specifically labeled quinic acid would be of greater interest; however, the synthesis devised by Grewe[17] does not lend itself for this purpose. For this reason a stereospecific route to quinic acid, utilizing intermediates which could be readily labeled with C^{14}, was developed and is the basis of this report. After this work was completed another route to quinic acid was described by Smissman.[18]

The formation of the bromo lactone (II) on addition of bromine to methyl 1-methyl-3-cyclohexene-1-carboxylate suggested that the related bromo acetoxylactone (V, R = Ac), with three substituents oriented exactly as found in quinic acid, might similarly be produced from methyl 1-acetoxy-3-cyclohexene-1-carboxylate (III). It was visualized that dehydrobromination and *cis* hydroxylation of the resulting unsaturated lactone (VI) from the least hindered side of the molecule would lead to (±)-quinide (VII) as outlined below.



In accordance with the scheme set forth above, methyl pyruvate was converted to methyl α-acetoxyacrylate which was then condensed with 1,3-butadiene at 160° to give the desired methyl 1-acetoxy-3-cyclohexene-1-carboxylate (III). Addition of bromine to the adduct III gave, contrary to the observation made with the methyl analog (II), the normal dibromo addition compound. For this reason the adduct III was hydrolyzed to the crystalline hydroxy acid (IV). Bromo lactonization[19] of hydroxy acid IV gave a mixture of bromo lactone V (R = H) and an incompletely characterized bromodihydroxycyclohexanecarboxylic acid. The appearance of an infrared maximum at 5.62 μ confirmed the presence of a γ-lactone in V. Dehydrobromination of the bromo lactone V was effected by prolonged heating at 130–180° with triethylamine in benzene.

Hydroxylation of the unsaturated lactone (VI) with osmium tetroxide proceeded smoothly and afforded a solid which was identical in all respects with an authentic sample of (±)-quinide which was prepared by heating (−)-quinic acid at 230° for several hours. Hydrolysis of (±)-quinide afforded (±)-quinic acid.

It is of interest to note that brief heating of (−)-quinic acid at 230° provides an excellent method for the preparation of (−)-quinide. Prolonged heating is required to effect the racemization of the lactone, presumedly by way of a reversible conversion to a symmetric δ-lactone as suggested by Grewe.[17] Support for this hypothesis was found in the presence of a shoulder at 5.8 μ in the infrared spectrum of crude (±)-quinine which suggests the presence of a small amount of δ-lactone contaminant.

Experimental[20]

Addition of Bromine to Methyl 1-Methyl-3-cyclohexene-1-carboxylate.—A solution of 4.5 g. of bromine in carbon tetrachloride was added to a solution of 4.4 g. of methyl 1-methyl-3-cyclohexene-1-carboxylate,[21] b.p. 79° (20 mm.), $n^{20}D$ 1.4600, in carbon tetrachloride. The solvent was removed and petroleum ether (b.p. 35–37°) was added, resulting in the formation of a white solid. Recrystallization from petroleum ether gave long needles, m.p. 92.5–93.5°, ν_{max} 5.62 μ.

Anal. Calcd. for $C_8H_{11}BrO_2$: C, 43.85; H, 5.06; Br, 36.48. Found: C, 43.80; H, 5.18; Br, 36.60.

Methyl 1-Methyl-2,4-cyclohexadiene-1-carboxylate.—A mixture of 14.0 g. of N-bromosuccinimide, 12.4 g. of methyl 1-methyl 3-cyclohexene-1-carboxylate, 10 mg. of benzoyl peroxide, and 150 ml. of carbon tetrachloride was heated at reflux for 90 min. The succinimide was removed by filtration and distillation afforded 13 g. of colorless bromo ester, b.p. 72–78° (2–3 mm.).

Anal. Calcd. for $C_9H_{13}BrO_2$: C, 46.37; H, 5.62; Br, 34.28. Found: C, 46.03; H, 5.28; Br, 34.50.

A solution of 14.6 g. of the allylic bromide in 50 ml. of benzene containing 14.6 g. of triethylamine was heated for 24 hr. The triethylamine hydrobromide was removed and distillation gave 4.3 g. of the diene: b.p. 55–56° (6 mm.); ν_{max} 3.35, 5.79, and 6.34 μ; λ_{max} 256 mμ (ε 5300).

(11) R. Robinson, *J. Chem. Soc.*, **111**, 876 (1917); H. O. L. Fischer and G. Dangschat, *Ber.*, **65**, 1009 (1932); *Helv. Chim. Acta*, **18**, 1206 (1935); J. A. Hall, *Chem. Rev.*, **20**, 305 (1937).

(12) B. D. Davis, *J. Biol. Chem.*, **191**, 315 (1951).

(13) U. Weiss, B. D. Davis, and E. S. Mingioli, *J. Am. Chem. Soc.*, **75**, 5572 (1953).

(14) I. I. Salamon and B. D. Davis, *ibid.*, **75**, 5567 (1953).

(15) L. H. Weinstein, C. A. Porter, and H. J. Laurencot, *Contrib. Boyce Thompson Inst.*, **21**, 201 (1961).

(16) L. H. Weinstein, C. A. Porter, and H. J. Laurencot, *ibid.*, **22**, 439 (1962).

(17) R. Grewe, W. Lorenzen, and L. Vining, *Ber.*, **87**, 793 (1954).

(18) E. E. Smissman and M. A. Oxman, *J. Am. Chem. Soc.*, **85**, 2184 (1963).

(19) See E. E. VanTamelen and M. Shamma [*ibid.*, **76**, 2315 (1954)] and J. Klein [*ibid.*, **81**, 3611 (1959)] for discussions of the halo lactonization of γ,δ-unsaturated carboxylic acids.

(20) All boiling and melting points are uncorrected. Nuclear magnetic resonance spectra were measured at 60 Mc. by Mr. W. E. Baitinger and A. K. Moreland with the Varian Associates V-4300-B and A-60 spectrometers. Chemical shifts are given with reference to tetramethylsilane. Microanalyses were performed by Dr. C. S. Yeh and associates.

(21) A. A. Petrov and N. P. Sopov, *Zh. Obshch. Khim.*, **18**, 1781 (1948).

Anal. Calcd. for $C_9H_{12}O_2$: C, 71.02; H, 7.95. Found: C, 71.21; H, 8.35.

The maleic anhydride adduct of methyl 1-methyl-2,4-cyclohexadiene-1-carboxylate was recrystallized from benzene and showed m.p. 113.5–115°.

Anal. Calcd. for $C_{13}H_{14}O_5$: C, 62.39; H, 5.64. Found: C, 62.34; H, 5.48.

Methyl α-Acetoxyacrylate.—A mixture of 10.0 g. (0.098 mole) of methyl pyruvate, 20.0 g. (0.196 mole) of acetic anhydride, and 0.5 g. of *p*-toluenesulfonic acid was heated at reflux for 16 hr. Fractional distillation at reduced pressure gave 5.23 g. (37%) of the acrylate: b.p. 67–69° (10 mm.); $n^{25}D$ 1.4270; ν_{max} 5.68, 5.75, and 6.09 μ [lit.[22] b.p. 63–64° (10 mm.); $n^{25}D$ 1.4089].[23] The acrylate was transformed on standing into a hard, transparent, colorless solid.

Methyl 1-Acetoxy-3-cyclohexene-1-carboxylate (III).—A mixture of 6.53 g. (0.033 mole) of methyl α-acetoxyacrylate, 7 ml. of butadiene, and 0.5 g. of pyrogallol was heated at 160° for 24 hr. Distillation gave 6.5 g. (70%) of a colorless liquid: b.p. 100–105° (9 mm.), $n^{25}D$ 1.4639; ν_{max} 5.75 and 6.06 μ; n.m.r. signals at 2.08 ($-CH_2-$), 2.50 (CH_3-CO_2-), 3.74 (CH_3-O), and 5.68 (—CH=CH) p.p.m.

Anal. Calcd. for $C_{10}H_{14}O_4$: C, 60.59; H, 7.12. Found: C, 61.22; H, 7.36.

Methyl 3,4-Dibromo-1-acetoxycyclohexanecarboxylate.—A solution of 0.7 g. of the adduct III in carbon tetrachloride was added to an excess of bromine in carbon tetrachloride. The solvent was removed and the residual oil was recrystallized from petroleum ether and then sublimed *in vacuo* to give 0.75 g. (60%) of colorless crystals: m.p. 101–102°, ν_{max} 5.75 μ; n.m.r. signals at 2.1 ($O=C-CH_3$), 2.4–3.0 ($-CH_2-$), 3.75 ($-O-CH_3$), and 4.52 [>(H)C—Br] p.p.m.

Anal. Calcd. for $C_{10}H_{14}Br_2O_4$: C, 33.54; H, 3.94. Found: C, 33.89; H, 4.00.

1-Hydroxy-3-cyclohexene-1-carboxylic Acid (IV).—A mixture of 4.38 g. (0.022 mole) of the acetoxy ester III, 1.77 g. (0.044 mole) of sodium hydroxide, and 50 ml. of water was stirred for 1 week. The mixture was adjusted to pH 3 with concentrated hydrochloric acid and then was continuously extracted with ether for 1 day. The ether was removed and crystallization from acetone–petroleum ether gave 2.26 g. (72%) of a white solid, m.p. 78–87°. A sample purified by sublimation exhibited m.p. 82–84°; ν_{max} 3.4–4.4, 5.85, and 6.05 μ; n.m.r. signals at 1.75–2.67 ($-CH_2-$), 5.72 (CH=CH), and 7.22 ($-CO_2H$ and —OH) p.p.m.

Anal. Calcd. for $C_7H_{10}O_3$: C, 59.14; H, 7.09. Found: C, 58.85; H, 6.91.

1-Hydroxy-5-bromo-3-oxabicyclo[3.2.1]octan-2-one (V).—An aqueous solution of 3.83 g. (0.027 mole) of hydroxy acid IV was neutralized with 2.3 g. (0.029 mole) of sodium bicarbonate and titrated with bromine water. The neutral and acidic products were separated by continuous ether extraction for 1 day. The ether was removed and the residue, 4.0 g., was heated with methylene chloride. The insoluble portion, 2.0 g., was removed by filtration. The insoluble solid, purified by sublimation, showed m.p. 166–167°.

Anal. Calcd. for $C_7H_{11}BrO_4$: C, 35.16; H, 4.64. Found: C, 35.13; H, 4.73.

The methylene chloride mother liquor obtained above was evaporated and the residue was crystallized from petroleum ether–ether to give 2.02 g. of bromo lactone V: m.p. 114–116°; ν_{max} 2.8, 3.0, and 5.62 μ; n.m.r. signals at 1.8–3.0 ($-CH_2-$), 3.24 (—OH), multiplet at 4.33 (—CH—Br), and triplet at 4.82 (—CH—O) p.p.m.

Anal. Calcd. for $C_7H_9BrO_3$: C, 38.03; H, 4.07. Found: C, 37.86; H, 3.99.

1-Hydroxy-Δ⁵-3-oxabicyclo[3.2.1]octen-2-one (VI).—A solution of 2.02 g. (0.009 mole) of the bromo lactone V and 2 ml. of triethylamine in 70 ml. of benzene was heated in a sealed tube at 130–180° for 1 week. After cooling, the triethylamine hydrobromide, 1.29 g. (76%), was removed by filtration. The solvent was distilled and the residue was partially crystallized on standing. The solid was separated and sublimed to afford 393 mg. of colorless crystals: m.p. 73–75°; ν_{max} 2.8, 2.98, 5.62, and 6.12 μ; n.m.r. signals at 2.1–2.8 ($-CH_2-$), 3.88 (—OH), triplet at 4.82 (—CH—O), and multiplet at 6.08 (—CH=CH) p.p.m.

Anal. Calcd. for $C_7H_8O_3$: C, 59.99; H, 5.75. Found: C, 59.82; H, 5.88.

The oil remaining after removing the solid was chromatographed on silica gel. Recovered bromo lactone V was eluted with 70% chloroform–30% methylene chloride, while the unsaturated lactone VI (200 mg.) was eluted with 1% methanol in chloroform.

(±)-Quinide.—A solution of 0.183 g. (0.72 mmole) of osmium tetroxide in 1.2 ml. of freshly distilled tetrahydrofuran was added to a Dry Ice cooled solution of 0.1 g. (0.71 mmole) of the unsaturated lactone VI in 1.0 ml. of pyridine and 0.5 ml. of tetrahydrofuran. After standing for 5 hr., 40 ml. of anhydrous ether was added. The mixture was kept at −78° for 30 min. in order to ensure complete precipitation of the osmium complex. The complex was separated by filtration, washed with ether, and immediately dissolved in ethanol–methylene chloride. Hydrogen sulfide was bubbled through the solution for 1 min. and the insoluble black sulfide, 296 mg., was removed by filtration. The solvents were distilled and the residue was sublimed under diminished pressure to give 96 mg. (76%) of a white powder, m.p. 180–196°, lit.[24] m.p. 200°. The infrared spectrum (Nujol mull) of this product was identical with that of an authentic sample of (±)-quinide prepared as described below. The infrared spectra (Nujol mulls) of (−)-quinide and (±)-quinide were not identical.

Anal. Calcd. for $C_7H_{10}O_5$: C, 48.27; H, 5.79. Found: C, 47.90; H, 5.85.

The triacetate derivative of (±)-quinide was prepared using acetic anhydride and a trace of pyridine and showed m.p. 142–143°. The infrared spectrum of the acetate, in chloroform solution, was identical with that of authentic (−)-quinide triacetate and (±)-quinide triacetate. The infrared spectrum of the synthetic acetate determined as a Nujol mull was identical with that of authentic (±)-quinide triacetate, but was different from that of (−)-quinide triacetate.

(±)-Quinic Acid.—A heterogeneous mixture of 0.311 g. (0.0018 mole) of (±)-quinide, 0.084 g. (0.0011 mole) of calcium hydroxide, and 10 ml. of water was kept at room temperature for 2 days. The resulting mixture was filtered and the filtrate was placed on a Dowex AG5OW-X (Bio-RAD Laboratories) column, 50–100 mesh. Elution with water gave 0.290 g. of crude (±)-quinic acid. Recrystallization from ethanol gave a sample, m.p. 155–156°, $[\alpha]^{28.9}D$ 0.00° (*c* 5.8, H_2O), lit.[17] m.p. 149° for (±)-quinic acid. The infrared spectrum (Nujol mull) was identical with that of (−)-quinic acid.

(−)-Quinide from (−)-Quinic Acid.—D-Quinic acid, 10 g., was heated at 230° for 9 min. in an open flask. After cooling the glassy residue was recrystallized from absolute ethanol. Several recrystallizations from ethanol and sublimation *in vacuo* gave a sample of (−)-quinide, m.p. 175–195°, $[\alpha]^{23}D$ −16.75° (*c* 8.3, H_2O); lit.[25] m.p. 187°, $[\alpha]D$ −17.30°, for (−)-quinide.

(−)-Quinide triacetate, prepared from (−)-quinide using acetic anhydride and pyridine, was recrystallized from methylene chloride–petroleum ether and showed m.p. 133–135°, lit.[26] m.p. 132°.

(±)-Quinide from (−)-Quinic Acid.—(−)-Quinic acid, 22 g., was heated at 230° in an open flask for 4 hr. The dark residue was heated with absolute ethanol and the mixture was filtered. (±)-Quinide slowly crystallized from the filtrate. A pure sample (1.6 g.) was obtained by several recrystallizations from ethanol and sublimation *in vacuo* and exhibited m.p. 184–202°. (±)-Quinide triacetate was recrystallized from methylene chloride–petroleum ether and showed m.p. 143–144°, lit. m.p. 139°,[25] 142°.[17]

(22) W. O. Kenyon and D. D. Reynolds, U. S. Patent 2,514,672 (July, 1950); *Chem. Abstr.*, **44**, 9474 (1950).

(23) H. J. Hagemeyer, U. S. Patent 2,450,754 (Oct., 1948); *Chem. Abstr.*, **43**, 3451 (1949).

(24) O. Hesse, *Ann.*, **110**, 333 (1859).

(25) H. O. L Fisher, *Ber.*, **54**, 775 (1921).

(26) E. Erwig and W. Koenigs, *ibid.*, **22**, 1457 (1889).