TABLE I

Substrate	Hydrolysis by purified glucuronidase in 4 hours Color density	Hydrolysis by supernatant rat spleen homogenate in 4 hours Color density
2-Naphthyl β-D-glucopyruronoside	515	900
Brucine salt of 2-naphthyl β-D-glucopyruronoside	540	900
Toluidine salt of 2-naphthyl β-D-glucopyruronoside	240	350
2-Naphthyl β-D-glucofururonolactone	0	0

cold water immediately before use), acidified with 1 cc. of 80% trichloroacetic acid and extracted with chloroform (10 cc.). The color density was measured in a photoelectric colorimeter (Klett) with a 540 mμ filter. The results are given in Table I. A calibration curve for the dye from 2-naphthol is given elsewhere.[27] The 2-naphthyl β-D-glucofururonolactone was not hydrolyzed at all by tissue homogenates or by purified β-glucuronidase. 2-Naphthyl β-D-glucopyruronoside was readily hydrolyzed. The toluidine salt was less readily hydrolyzed than either the acid or brucine salt.

(27) A. M. Seligman and M. M. Nachlas, *J. Clin. Invest.*, **29**, 31 (1950).

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[CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS]

The Structure of Monocrotaline. XIV. Synthesis of Monocrotalic Acid

BY ROGER ADAMS, B. L. VANDUUREN AND B. H. BRAUN

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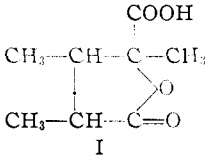
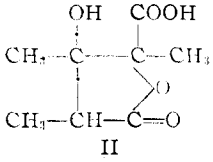
l-Monocrotalic acid, obtained by the hydrogenolysis of the alkaloid monocrotaline, has been synthesized by the pertungstic acid oxidation of α,β,γ-trimethylglutaconic acid. The levo-isomer of a diastereoisomer of monocrotalic acid was also obtained during resolution of the oxidation product with brucine. The stereochemical configuration of monocrotalic acid is discussed. The previously undescribed 2,3-dimethyl-2,3-dihydroxybutyric acid was synthesized by two methods.

In a previous paper[1] the synthesis of dihydroanhydromonocrotalic acid (I) was described. The structure of monocrotalic acid (II) as deduced by



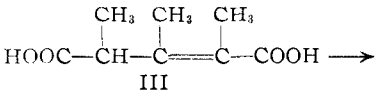
I



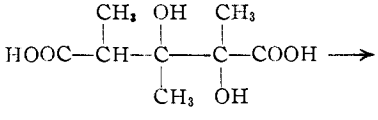
II

degradation reactions[2] was thus confirmed. Attempts to synthesize monocrotalic acid have now been successfully concluded.

The double bond in α,β,γ-trimethylglutaconic acid (III) could not be hydroxylated by means of neutral potassium permanganate; the use of osmium tetroxide and hydrogen peroxide also failed. With pertungstic acid[3] which favors *trans* addition, however, an oily acidic product resulted. This product, which could not be crystallized, proved to be a mixture of diastereoisomers of α,β-dimethyl-β-hydroxy-γ-carboxy-γ-valerolactone (II), formed by lactonization of the α,β,γ-trimethyl-α,β-dihydroxyglutaric acids (IV).



III



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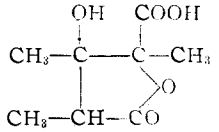
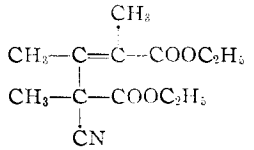


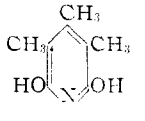
II

The oil from the pertungstic acid oxidation was treated with a mole equivalent of brucine in ethanol solution and seeded with the brucine salt of natural monocrotalic acid. An insoluble brucine salt separated which was readily purified and proved to be identical in melting point and rotation with the brucine salt of the authentic natural acid. Hydrolysis of the salt with hydrochloric acid yielded monocrotalic acid, identical in melting point and rotation with monocrotalic acid from monocrotaline.[4] The product gave no depression in melting point on admixture with an authentic specimen of monocrotalic acid. From the mother liquors of the crystallization of the first brucine salt, a second salt was obtained. This salt on hydrolysis yielded an acid, m.p. 180–182°, which gave a depression in melting point on admixture with monocrotalic acid. In a subsequent oxidation and resolution, the salt was not seeded with authentic brucine salt from monocrotalic acid. The brucine salt of the −60.8° acid crystallized out first and the brucine salt of monocrotalic acid was obtained from the mother liquors. From the mother liquors of the crystallization of the first two brucine salts, a third fraction was obtained. This product proved to be a mixture of the salts of the two *d*-rotatory acids and could not be separated by fractional crystallization.

The preparation of trimethylglutaconic acid presented unforeseen difficulties: Diethyl γ-cyano-α,β,γ-trimethylglutaconate (V) was prepared by the previously described method.[5,6] This ester on



V



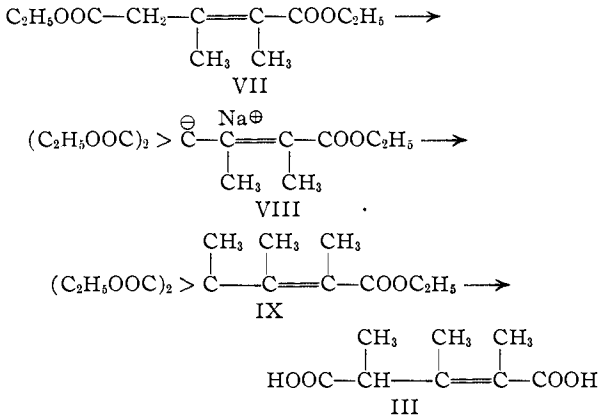
VI

(1) R. Adams and F. B. Hauserman, THIS JOURNAL, **74**, 694 (1952).
(2) R. Adams and T. R. Govindachari, *ibid.*, **72**, 158 (1950).
(3) M. Mugdan and D. P. Young, *J. Chem. Soc.*, 2988 (1949).
(4) R. Adams and R. F. Rogers, THIS JOURNAL, **61**, 2815 (1939).
(5) H. Rogerson and J. F. Thorpe, *J. Chem. Soc.*, **87**, 1685 (1905).
(6) G. A. R. Kon and H. R. Nanji, *ibid.*, 560 (1931).

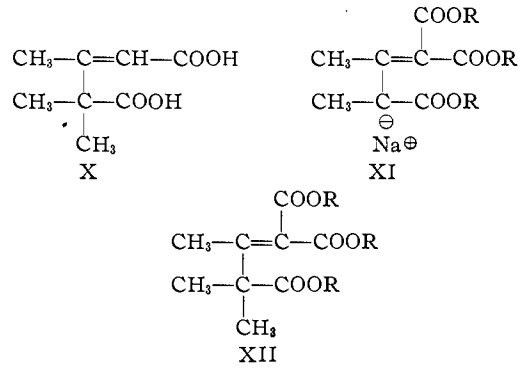
hydrolysis gave a 56% yield of 3,4,5-trimethyl-2,6-dihydroxypyridine[5] (VI) and a small amount of oil from which no pure trimethylglutaconic acid could be obtained.

Following the directions previously described for synthesizing diethyl α,β-dimethylglutaconate,[7,8] by simultaneous ethanolysis and methylation of ethyl isodehydroacetate, only occasionally was a pure product isolated. It was usually contaminated with diethyl β-methylglutaconate as determined by analysis, and could not be purified by fractional distillation. Toward the end of this investigation, it was discovered that pure α,β-dimethylglutaconic acid could be readily separated from a mixture of monomethylated and dimethylated acids obtained by saponification of the mixed esters merely by crystallization from ether.

The introduction of a third methyl group into diethyl α,β-dimethylglutaconate with sodium ethoxide and methyl iodide[9] was also an unsatisfactory reaction and in no instance was diethyl α,β,γ-trimethylglutaconate isolated pure as shown by analysis. Upon hydrolysis of the impure ester, no α,β,γ-trimethylglutaconic acid could be isolated. Synthesis of α,β,γ-trimethylglutaconic acid was finally achieved as follows: Pure diethyl α,β-dimethylglutaconate (VII) was subjected to carbethoxylation[10] with ethyl carbonate in the presence of sodium ethoxide to form the enolate VIII. This product was not isolated and was treated directly with one mole of methyl iodide. The product, diethyl α,β,γ-trimethyl-γ-carbethoxyglutaconate (IX), was obtained pure and in good yield. This ester, although stable to acid, readily lost one carbethoxy group in presence of aqueous ethanolic sodium hydroxide, probably analogous to the loss of a carbethoxy group observed in similar cases.[11] Further hydrolysis yielded III (45% yield).



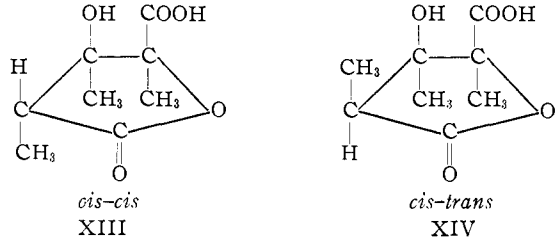
The solid product was separated from the contaminating oil and by crystallization yielded two compounds, melting at 127 and 131°, respectively, which from their properties were geometrical isomers. Only one of these compounds has been reported in the literature.[5] This acid melts with decomposition and loss of water and was therefore assigned the *cis* configuration. The other, more soluble acid, which melted at a slightly higher temperature without decomposition, was apparently the *trans* form. This acid is different from the *cis* and *trans* forms of β,γ,γ-trimethylglutaconic acid (X)[12] which could arise if, instead of VIII and IX, compounds of structures XI and XII had formed.



The infrared absorption spectra of the acids isolated were compared. From their virtual identity in the region 900–1000 cm.$^{-1}$, in which terminal methylene groups show a characteristic band, it was concluded that no such groups occur in the new acid. This fact excludes the possibility of a migration of the double bond.

When impure diethyl α,β-dimethylglutaconate was carbethoxylated and methylated and the impure diethyl α,β,γ-trimethyl-γ-carbethoxyglutaconate saponified, only the *cis* isomer could be isolated in 25% yield.

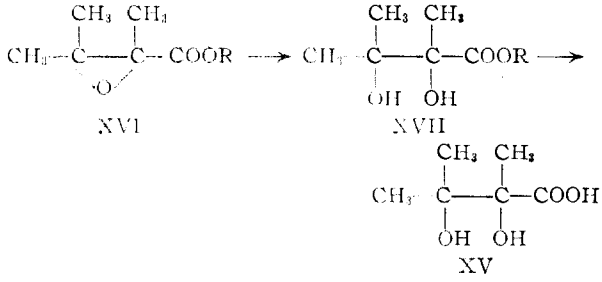
Stereoisomeric monocrotalic acids constructed from Fisher–Hirschfelder–Taylor atomic models indicate that *trans* hydroxylation of *cis*-α,β,γ-trimethylglutaconic acid could give only configurations XIII and XIV. No positive assignment of one or the other of these structures can be made at present.



The relative ease with which monocrotalic acid is decarboxylated when heated with strong alkali has been reported previously. It has now been found that pyridine is not a strong enough base to accomplish this degradation. To test the ease of decarboxylation of an open chain analog, 2,3-dimethyl-2,3-dihydroxybutyric acid (XV) was synthesized. The first method attempted was by performic acid oxidation of trimethylacrylic acid. The latter acid was prepared by the Reformatsky reaction of acetone and ethyl α-bromopropionate followed by dehydration and hydrolysis.[12–15] Be-

(7) N. Bland and J. F. Thorpe, *J. Chem. Soc.*, **101**, 1557 (1912).
(8) F. Feist, *Ann.*, **428**, 68 (1922).
(9) J. F. Thorpe and H. S. Wood, *J. Chem. Soc.*, **103**, 1752 (1913).
(10) A. Brändström, *Acta chim. Scand.*, **4**, 50 (1950).
(11) B. S. Gidvani, G. A. R. Kon and C. R. Wright, *J. Chem. Soc.*, 1027 (1932).
(12) W. H. Perkin and J. F. Thorpe, *ibid.*, **71**, 1169 (1897).
(13) R. C. Huston and G. L. Goerner, THIS JOURNAL, **68**, 2504 (1946).
(14) W. H. Perkin, *J. Chem. Soc.*, **69**, 1457 (1896).
(15) A. Giljarov, *J. Russ. Phys. Chem. Soc.*, **28**, 501 (1896).

cause of the poor yield of trimethylacrylic acid a low over-all amount of the dihydroxy acid was obtained. A higher yield of the desired product resulted from the hydrolysis of α,β,β-trimethylglycidate (XVI).[16] The oxirane ring was readily opened with boiling water containing a trace of hydrogen chloride and the resulting ester (XVII) was hydrolyzed with barium hydroxide to yield XV in good over-all yield. This acid lost carbon



XVI XVII XV

dioxide and water under similar but much more drastic conditions than those required for monocrotalic acid.

Acknowledgment.—The authors are indebted to Mr. J. Nemeth, Miss Emily Davis, Mrs. Esther Fett and Mrs. Katherine Pih for the microanalyses and to Miss Helen Miklas for the determination and interpretation of the infrared spectra.

Experimental

All melting points are corrected.

Diethyl γ-Cyano-α,β,γ-trimethylglutaconate.—Condensation of ethyl cyanoacetate with ethyl acetoacetate and direct methylation of the product by the method of Rogerson and Thorpe[5] as modified by Kon and Nanji[6] gave a 15% over-all yield of the desired product: b.p. 133–140° (3 mm.) (lit. b.p. 160–161° (25 mm.)).[5]

Hydrolysis of Diethyl γ-Cyano-α,β,γ-trimethylglutaconate.—The cyano ester was hydrolyzed with concentrated hydrochloric acid, as described previously.[5] 3,4,5-Trimethyl-2,6-dihydroxypyridine was obtained in 56% yield, m.p. 179° (lit. m.p. 180°).[5] The residue from the crystallization of the hydrochloride of the latter product yielded a small amount of oil from which no trimethylglutaconic acid could be isolated.

Ethyl Isodehydroacetate.—Ethyl acetoacetate was saturated with hydrochloric acid gas at 0° and the mixture kept at room temperature for 4 weeks. The product was obtained as described previously[17,18]; b.p. 172–174° (17 mm.) (lit. b.p. 170° (15 mm.)).[17] The yield was 59%, $n^{20}D$ 1.5169. During the distillation of the forerun, a fraction, b.p. 120–140° (17 mm.), was obtained which crystallized on cooling; m.p. 45–47°. The product proved to be mesitenolactone. This compound was obtained previously by the sulfuric acid-catalyzed[19] condensation of ethyl acetoacetate.

Diethyl α,β-Dimethylglutaconate.—This substance was prepared by simultaneous ethanolysis and methylation of ethyl isodehydroacetate.[7,8] The yield in two satisfactory runs was 54 and 61%, b.p. 126.5–129° (16 mm.) (lit. b.p. 129–130° (15 mm.)), $n^{20}D$ 1.4544.

Anal. Calcd. for $C_{11}H_{18}O_4$: C, 61.66; H, 8.47. Found: C, 61.58; H, 8.53.

In many experiments the methylation was only partial and mixtures of the mono- and dimethyl derivatives resulted.

α,β-Dimethylglutaconic Acid.—Impure diethyl α,β-dimethylglutaconate was hydrolyzed as described previously[7] by boiling with hydrochloric acid. The acid which resulted was obtained pure by two recrystallizations from ether, m.p. 148° (lit. m.p. 148°).[5]

(16) G. Darzens, *Compt. rend.*, **141**, 766 (1905).
(17) F. Feist, *Ann.*, **345**, 60 (1906).
(18) C. Duisberg, *ibid.*, **213**, 133 (1882).
(19) R. Anschütz, P. Bendix and D. Karp, *ibid.*, **259**, 148 (1890).

Diethyl α,β,γ-Trimethyl-γ-carbethoxyglutaconate.—The procedure of Brändström for the carbethoxylation of methyl ketones[10] was applied to diethyl α,β-dimethylglutaconate: To 270 ml. of ethyl carbonate (purified and redistilled) was added 7.8 g. of sodium in small pieces at 110°. The sodium rapidly dissolved to form a suspension of sodium ethoxide. The temperature was raised to 140° and 69 g. of pure diethyl α,β-dimethylglutaconate was added over a period of one hour. During this addition the mixture turned dark red. Ethanol was allowed to distil off (35 ml.). One-half hour after the addition of the ester had been completed, the temperature at the top of the distillation column began to rise rapidly. Heating was discontinued at this stage.

After the solution had cooled to room temperature, 60 g. of methyl iodide was added slowly. On gentle warming of the mixture, sodium iodide separated. The mixture was refluxed for one hour, cooled, washed first with dilute aqueous sodium bisulfite and then with water and finally dried over sodium sulfate. The solvent was removed under reduced pressure and the residue distilled *in vacuo*. The forerun, b.p. 102–147° (7.5 mm.), consisted mostly of unreacted starting material (21.2 g.). The product boiled at 147–153° (7.5 mm.), $n^{20}D$ 1.4607. The yield was 57.7 g. (60%).

Anal. Calcd. for $C_{15}H_{24}O_6$: C, 59.98; H, 8.06. Found: C, 59.97; H, 8.24.

***cis*- and *trans*-Trimethylglutaconic Acid.**—A mixture of 32 g. of α,β,γ-trimethyl-γ-carbethoxyglutaconate and 15 g. of sodium hydroxide dissolved in 100 ml. of 85% ethanol was boiled under reflux. The precipitated sodium carbonate was filtered off. The filtrate was concentrated at atmospheric pressure and taken to dryness under reduced pressure. The residue was taken up in 200 ml. of water, extracted once with ether and made acid to congo red with hydrochloric acid. A pale yellow oil separated. The oil dissolved on refluxing in constant boiling hydrochloric acid for one hour. The solution was concentrated to *ca.* 100 ml., an excess of acetone added and the precipitated inorganic material filtered. The filtrate was dissolved in 200 ml. of 5% aqueous sodium hydroxide, treated with Norite, filtered and acidified. On concentrating the mother liquor to one-half the original volume and permitting to stand, 8.2 g. (45%) of crystalline α,β,γ-trimethylglutaconic acid separated. Further concentration of the mother liquor yielded only oily material.

The crystalline product melted at 95–100° and was separated by fractional crystallization from dilute hydrochloric acid into two forms of trimethylglutaconic acid. The less soluble fraction constituted the *cis* form, which was obtained pure after four crystallizations, m.p. 127.5° (dec.) (lit. m.p. 127° (dec.)).[5] The yield was 1.5 g. (8%). The crude acid can be purified also by recrystallization from ether–petroleum ether (b.p. 30–60°). The *trans* form was obtained from the more soluble fractions and likewise required four crystallizations for purification, m.p. 131.5–132°. A melting point of a mixture of the acids showed sintering at 110° and complete melting at 117°.

Anal. (131.5–132° acid) Calcd. for $C_8H_{12}O_4$: C, 55.80; H, 7.02. Found: C, 55.99; H, 7.20.

Brucine Salt of Monocrotalic Acid.—A solution of 0.5 g. of monocrotalic acid, obtained by the hydrogenolysis of monocrotaline,[4] in 5 ml. of absolute ethanol was added to a solution of an equivalent amount of brucine in 25 ml. of absolute ethanol. The mixture was heated to boiling and filtered. On cooling, white needles separated. The salt was recrystallized twice from ethanol, 0.75 g. (50%), m.p. 213° (dec.). The ethanol-free salt melted at the same temperature.

Rotation.—0.0500 g. made up to 10 ml. with chloroform at 26° gave $\alpha^{26}D$ −0.082°, *l* 1, $[\alpha]^{26}D$ −16.4 (±1°).

Anal. Calcd. for $C_{31}H_{38}N_2O_9 \cdot C_2H_5OH$: C, 63.05; H, 7.00; C_2H_5OH, 3.8 mg. Found: C, 62.83; H, 6.96; C_2H_5OH, 3.2 mg.

Pertungstic Acid Oxidation of α,β,γ-Trimethylglutaconic Acid.—To a solution of 2.3 g. of α,β,γ-trimethylglutaconic acid in 75 ml. of water was added a solution of 20 mg. of tungsten trioxide in 2.0 g. of 30% hydrogen peroxide. The mixture was kept at 55–60° for 24 hours and then taken to dryness under reduced pressure. A viscous oil, 2.3 g., was left. This crude mixture of diastereoisomers of α,β-dimethyl-β-hydroxy-γ-carboxy-γ-valerolactone was resolved directly.

Resolution of Crude α,β-Dimethyl-β-hydroxy-γ-carboxy-γ-valerolactone with Brucine.—A solution of 2.3 g. of the oil just described in 5 ml. of absolute ethanol was added to a solution of 5.0 g. of brucine in 35 ml. of absolute ethanol. The mixture was heated to boiling, filtered and a trace of the brucine salt of monocrotalic acid added. On cooling a white crystalline solid separated. The yield was 0.51 g. (7%). After one recrystallization from absolute ethanol the melting point and rotation had reached a constant value; m.p. 213° (dec.).

Rotation. Brucine Salt I.—0.0200 g. made up to 5 ml. with chloroform at 26° gave $\alpha^{26}D$ −0.066°, *l* 1, $[\alpha]^{26}D$ −16.5 (±1°).

From the mother liquors there crystallized on standing 0.50 g. (6.9%) of a second brucine salt which was obtained pure after two recrystallizations from ethanol; m.p. 216–217° (dec.).

Rotation. Brucine Salt II.—0.0240 g. made up to 2.5 ml. with chloroform at 25° gave $\alpha^{25}D$ −0.287°, *l* 1, $[\alpha]^{25}D$ −30.0 (±1°).

Anal. Calcd. for $C_{31}H_{38}N_2O_9 \cdot C_5H_5OH$: C, 63.05; H, 7.00. Found: C, 63.06; H, 6.78.

The combined mother liquors from the crystallization of brucine salts I and II were evaporated under an air jet to 20 ml., filtered, and 20 ml. of dry ether added. On standing, 1.01 g. (13.9%) of a crystalline salt separated. Even by crystallization of this mixture three times from absolute ethanol and ether, no separation was effected. The melting point and rotation remained constant, m.p. 181–182° (dec.).

Rotation. Brucine Salt III.—0.0272 g. made up to 1.5 ml. with chloroform at 25° gave $\alpha^{25}D$ −0.240°, *l* 1, $[\alpha]^{25}D$ −13.3 (±1°).

Hydrolysis of Brucine Salt I. Monocrotalic Acid.—A solution of 0.20 g. of the brucine salt in 3 ml. of dilute hydrochloric acid was extracted 20 times with 1–2 ml. portions of ether. The ether extract was dried over anhydrous sodium sulfate, filtered and taken to dryness. A white crystalline residue, weighing 60 mg. (86%), was obtained. The product was recrystallized from ether–petroleum ether (b.p. 30–60°), m.p. 180–182° (dec.). The acid gave no depression of melting point on admixture with an authentic specimen of natural monocrotalic acid.

Rotation. Synthetic Monocrotalic Acid.—0.0250 g. made up to 2 ml. in absolute ethanol at 28° gave $\alpha^{28}D$ −0.063°, *l* 1, $[\alpha]^{28}D$ −5.04 (±0.5°).

Anal. Calcd. for $C_8H_{12}O_5$: C, 51.06; H, 6.43. Found: C, 50.95; H, 6.31.

Rotation. Natural Monocrotalic Acid.—0.043 g. made up to 2 ml. with absolute ethanol at 34° gave αD −0.100°; *l* 1; $[\alpha]^{34}D$ −4.65 (±0.5°) (lit. $[\alpha]^{28}D$ −5.33° in water).[4]

Hydrolysis of Brucine Salt II. −60.8° Isomer.—Brucine salt II was hydrolyzed and the acid isolated in the same manner as has been described above. The acid crystallized immediately on removal of the solvent; yield 81%. It was purified by recrystallization from ether–petroleum ether (b.p. 30–60°), m.p. 180–182° (dec.).

Rotation.—0.0072 g. made up to 3 ml. with absolute ethanol at 25° gave $\alpha^{25}D$ −0.150°, *l* 1, $[\alpha]^{25}D$ −60.8 (±1°).

Anal. Calcd. for $C_8H_{12}O_5$: C, 51.06; H, 6.43. Found: C, 51.03; H, 6.46.

Hydrolysis of Brucine Salt III.—This salt was hydrolyzed and the acid isolated in the same manner. The yield was 75%. The acid was recrystallized from ether–petroleum ether (b.p. 30–60°), m.p. 160–165°. Recrystallization did not alter the melting point.

Rotation.—0.0200 g. made up to 2.5 ml. with absolute ethanol at 29°; $\alpha^{29}D$ +0.232, *l* 1, $[\alpha]^{29}D$ +29.0° (±1°).

Trimethylglyceric Acid (α,β-Dihydroxy-α,β-dimethylbutyric Acid). A. Performic Acid Oxidation of Trimethylacrylic Acid.—To a solution of 5.6 g. of trimethylacrylic acid,[13–15] m.p. 70–70.5°, in 40 ml. of 98% formic acid, 6 ml. of 30% hydrogen peroxide was added and the mixture kept at 40° for 4 hours. At the end of this time the formic acid was removed under reduced pressure and the oily residue taken up in water containing a few drops of hydrochloric acid, in order to hydrolyze the formyl group. After standing overnight, the water was removed under reduced pressure. The residual oil crystallized on standing. The crystals were separated from the oil by filtration; yield 3.2 g. (43%). The product was recrystallized from a mixture of ethyl acetate and petroleum ether (b.p. 30–60°), m.p. 101–101.5°.

B. From α,β,β-Trimethylglycidate.—The procedure of Darzens[16] for the preparation of α,β,β-trimethylglycidate was modified as follows: A solution of potassium ethoxide was prepared from 20 g. of potassium and 200 ml. of absolute ethanol. The solution was cooled to 0° and a mixture of 30 g. of dry acetone and 70 g. of dry ethyl α-chloropropionate was added over a period of 30 minutes. The ice-bath was removed, the mixture was permitted to come slowly to room temperature and refluxed for one hour. The greater part of the ethanol was removed by distillation and the residue poured into an excess of water. The layers were separated and the aqueous solution extracted three times with ether. The combined organic layers were concentrated under reduced pressure.

The crude ethyl α,β,β-trimethylglycidate was added to 300 ml. of water containing 1.5 ml. of concentrated hydrochloric acid and boiled under reflux until homogeneous. The aqueous solution was then saturated with potassium carbonate and the water-insoluble layer that appeared separated. The aqueous solution was extracted with ether. The ether extract was added to the crude ester and the solvent removed. The crude residue was suitable for the next step in the synthesis. Ethyl trimethylglycerate has been described previously.[13]

The crude ester was hydrolyzed by refluxing for one hour with 1 liter of an aqueous solution containing one equivalent of barium hydroxide, acidified with hydrochloric acid and continuously extracted with ether for 5 days. The ether extract was dried and the solvent removed. The product was recrystallized from an ethyl acetate–petroleum ether (b.p. 30–60°) mixture. The yield was 29.5 g. (40% overall) of white crystals. After two more crystallizations from the same solvent, the acid was pure, m.p. 101.5–102°.

Anal. Calcd. for $C_6H_{12}O_4$: C, 48.56; H, 8.16. Found: C, 48.61; H, 8.41.

The product gave no depression in melting point when mixed with that obtained by the performic acid oxidation of trimethylacrylic acid.

***p*-Phenylphenacyl Trimethylglycerate.**—The ester was prepared from 1.0 g. of the acid and 1.8 g. of *p*-phenylphenacyl bromide by the standard procedure. The yield was 2.3 g. (100%). After three crystallizations from 95% ethanol, the melting point was 140.5–141°.

Anal. Calcd. for $C_{20}H_{22}O_5$: C, 70.16; H, 6.48. Found: C, 70.18; H, 6.75.

Effect of Alkalies on Trimethylglyceric Acid and Monocrotalic Acid.—At room temperature a solution of trimethylglyceric acid in excess of 0.4 *N* aqueous barium hydroxide (under nitrogen) was stable for 20 hours; at 100° overnight only 3% of the theoretical quantity of barium carbonate precipitated.

On being heated in an equal mixture of 0.4 *N* aqueous barium hydroxide and 2.5 *N* aqueous sodium hydroxide (1.5 *N* hydroxyl ion) for 16 hours, 49% of the theoretical amount of carbon dioxide was evolved as determined by the weight of barium carbonate precipitated.

Monocrotalic acid was unaffected in 0.4 *N* aqueous barium hydroxide at room temperature and was recovered unchanged after being kept overnight in this medium. Monocrotalic acid likewise was stable to decarboxylation on heating for 16 hours in pyridine solution at 110°.

A solution of monocrotalic acid in 0.4 *N* aqueous barium hydroxide upon submerging in an oil-bath maintained at 100° began to decompose rapidly with precipitation of carbonate. After one hour the barium carbonate amounted to 88% of that calculated for complete decarboxylation.

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