TABLE I

COMPARATIVE PHYSIOLOGICAL ACTIVITY OF HYDROXYPANTOTHENIC ACID

Organism	Incubation period, hr.	Synthetic (+) calcium pantothenate (standard)	Liver concentrate "potency" 3300	Sodium hydroxypantothenate (racemic value × 2)
Saccharomyces cerevisiae (GM)	14	100	24.6	5.2
Streptococcus lactis (R)	20	100	27.2	5.3–2.4[b]
Streptococcus lactis (R)	38	100	24.7	23.0–2.4
Lactobacillus casei ε	17	100	27.3	1.5–1.7
Lactobacillus casei ε	23	100	25.3	1.5–1.8
Lactobacillus casei ε	24[a]		27.0	20.2–12.7
Lactobacillus arabinosus (17-5)	20	100	24.2	1.5
Bacillus brassicae (6-26)	38	100	26.9	1.7
Propionibacterium pentosaceum (P-11)	38	100	25.6	3.0–1.3

[a] This culture was grown in the improved medium used for the assay of pantothenic acid in crude tissue extracts (Pennington, Snell and Williams, to be published); other bacterial determinations were made in the pantothenic acid-free medium B of Snell, *et al.*[8] [b] The values given indicate those obtained in a single assay from low to high dosage levels within the assay range.

higher than has been observed. On the contrary, the concentrates from natural sources behaved exactly as synthetic calcium pantothenate, thus indicating that the "pantothenic acid" activity of natural extracts is due to a single substance as originally postulated,[14] and not to a mixture of related substances. Incidentally, the "potency" of pure synthetic calcium pantothenate appears to be very close to what would be predicted from results obtained before the synthesis[15] was accomplished.

Tests on the physiological activity of hydroxypantothenic acid for animals have not yet been made.

We acknowledge with thanks the coöperation of our colleagues in the Merck Laboratories, and the financial support of the Rockefeller Foundation and the University of Texas.

Summary

"Hydroxypantothenic acid" (N-(α-hydroxy-β,-β′-dimethylolbutyryl)-β-alanine) has been synthesized and shown to possess striking biological activity. Its effectiveness varies with the microorganisms and the testing conditions.

From the variable results obtained with this compound and the concordant results obtained when concentrates from natural sources are tested for pantothenic acid, it is concluded that natural pantothenic acid is probably a single substance and that hydroxypantothenic acid probably does not occur in such concentrates.

(14) Williams, Lyman, Goodyear, Truesdail and Holaday, THIS JOURNAL, **55**, 2912 (1933).

(15) Williams, Truesdail, Weinstock, Rohrmann, Lyman and McBurney, *ibid.*, **60**, 2719 (1938).

AUSTIN, TEXAS RECEIVED MAY 10, 1940

[CONTRIBUTION FROM THE GATES AND CRELLIN LABORATORIES OF CHEMISTRY, CALIFORNIA INSTITUTE OF TECHNOLOGY, No. 775]

Oxidation of Alginic Acid by Periodic Acid

BY H. J. LUCAS AND W. T. STEWART[1]

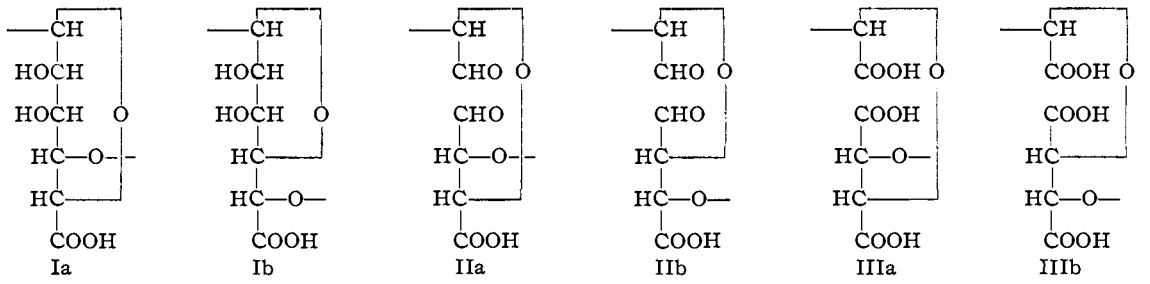
Evidence in regard to the structure and mode of linkage of the mannuronic acid units in alginic acid[2] has been obtained recently by Hirst, Jones and Jones.[3] They subjected alginic acid to partial degradative methanolysis by means of methanolic hydrogen chloride and completely methylated the partially degraded alginic acid. This under drastic treatment with methanolic hydrogen chloride gave the methyl ester of 2,3-dimethylmethyl-*d*-mannuronide which was then hydrolyzed to 2,3-dimethyl-*d*-mannuronic acid. The last was oxidized to 2,3-dimethyl-*d*-mannosaccharic acid. From this and other evidence they concluded that in the mannuronic units of alginic acid hydroxyl groups are attached to C_2 and C_3, while bridge and ring linkages are attached to C_4 and C_5. Although the evidence did not permit a decision between pyranose and furanose structures, the former was favored in view of the resistance of alginic acid toward hydrolysis, and its large negative rotation.

Independent evidence from the oxidation of alginic acid is desirable. Periodic acid would be expected to convert the mannuronic units of al-

(1) Kelco Company Fellow, 1938–1939.

(2) Nelson and Cretcher, THIS JOURNAL, **51**, 1914 (1929); **52**, 2130 (1930); **54**, 3409 (1932); Bird and Haas, *Biochem. J.*, **25**, 403 (1931); Schoeffel and Link, *J. Biol. Chem.*, **100**, 397 (1933).

(3) Hirst, Jones and Jones, *Nature*, **143**, 857 (1939); *J. Chem. Soc.*, 1880 (1939).



ginic acid, of structure Ia or Ib, to the corresponding dialdehyde unit IIa or IIb, which when oxidized by bromine would be expected to yield the corresponding tricarboxylic acid unit IIIa or IIIb. Hydrolysis of II would yield glyoxal and *d*-erythuronic acid while hydrolysis of III would yield glyoxylic and *meso*-tartaric acids.

The isolation of glyoxal would be especially significant, for it can arise only by the scission of the bond between C_2 and C_3. The isolation of *meso*-tartaric acid from III is desirable also as a confirmation. However, its isolation would not be as conclusive as that of glyoxal, for *meso*-tartaric acid could result from the dismutation of erythuronic acid, which would be formed if the scission took place between C_4 and C_5 rather than between C_2 and C_3. The structure which would permit this to happen, *i. e.*, bridge and ring formation involving C_2 and C_3, appears to be quite improbable, as pointed out by Hirst, Jones and Jones.[3] It is of interest to note that the scission of 2,3-dimethyl-*d*-mannosaccharic acid to dimethyl-*meso*-tartaric acid, which was accomplished by these authors with periodic acid, took place between C_4 and C_5. Thus the isolation by them of dimethyl-*meso*-tartaric acid is of value as regards configurations at C_2 and C_3, while the isolation here of *meso*-tartaric acid as an oxidation product of alginic acid itself would be important as regards configurations at C_4 and C_5.

The isolation of glyoxal in 42% yield from the hydrolysis of the oxidation product II, and of *meso*-tartaric acid in 25% yield from the hydrolysis of oxidation product III corroborates the findings of Hirst, Jones and Jones[3] that the mannuronic units in alginic acid are correctly represented by structure Ia or structure Ib. No decision between these two structures can be made on this new evidence.

Confirmation that C_2 and C_3 hold hydroxyl groups was obtained from the periodic acid oxidation of methyl alginate, prepared from alginic acid and diazomethane. The intermediate oxidation products are the methyl esters of the compounds of structure II and III. Hydrolysis of these would yield the same products as in the case of alginic acid itself. Glyoxal was obtained in 30% yield by the hydrolysis of the first oxidation product. However, no *meso*-tartaric acid was isolated from the product corresponding to III.

The methods described by others for the recovery of reaction products resulting from the oxidation of carbohydrates with periodic acid[4] were followed in the main. However, an improvement in the separation of reaction product II from iodic and periodic acids was realized by adding tertiary butyl alcohol to the reaction mixture. This threw down the reaction product while the inorganic materials remained in solution.

This investigation was made possible by a grant from the Kelco Company of San Diego. The authors express their appreciation for this aid, and also their thanks to Professor C. Niemann for helpful advice.

Experimental

Alginic Acid.—This was material obtained from *Macrocystis pyrifera*, similar to that used previously.[5] It was precipitated from its solution in dilute aqueous sodium hydroxide by the addition of dilute hydrochloric acid in slight excess, centrifuged and washed with 50% aqueous alcohol until free of inorganic chloride. The product, a fine white powder, was dried at 30 mm. over calcium chloride. The ash was reduced to 0.7 from 2.5% by this treatment. This drying probably was not powerful enough to convert the acid to the lactone.[5]

Methyl Alginate.—This was prepared by the action of an ether solution of diazomethane upon freshly precipitated alginic acid.[5] The methoxyl content of 18.2% corresponds to 1.1 MeO per C-6 unit. But part of this (5.08% or 0.3 MeO per C-6 unit) was ether methoxyl, as shown by ammonolysis.

Oxidation of Methyl Alginate.—A mixture of 5 g. (0.0259 equiv.) of the above methylated alginic acid and 77 ml. of 0.499 *M* periodic acid (0.038 mole) was stirred until thoroughly dispersed and then allowed to stand for

(4) Jackson and Hudson, THIS JOURNAL, **59**, 2049 (1937); **60**, 989 (1938); Levene and Kreider, *J. Biol. Chem.*, **120**, 593 (1937).

(5) Lucas and Stewart, THIS JOURNAL, **62**, 1070 (1940).

twenty hours, by which time 1.1 mole of periodic acid per equiv. of alginic acid had disappeared.[6]

After iodate and periodate ions had been removed with 5 g. of barium carbonate (stirring and filtering), 6 ml. of 7 *N* sulfuric acid was added and the solution was diluted to 250 ml. After heating on a steam-bath for sixteen hours, sulfate ions were removed by the addition of 5 g. of barium carbonate, and the solution was decolorized with Norit A.

Glyoxal from Oxidation of Methyl Alginate.—A mixture of 225 ml. of the above hydrolyzate (90% of the total), 30 ml. of alcohol and 7.8 g. of phenylhydrazine was heated for one hour on a steam-bath. The precipitated yellowish glyoxalphenylosazone after drying weighed 1.66 g. (0.007 mole), a 30% yield of crude material. After two crystallizations from alcohol and one from benzene this melted at 169–170° to a red-brown liquid.[7]

Anal. Calcd. for $C_{14}H_{14}N_4$: N, 23.5. Found: N, 23.6.

To the remaining 25 ml. of solution was added a solution of 1.2 g. of 2,4-dinitrophenylhydrazine in 50 ml. of glacial acetic acid and the mixture was heated for one hour on a steam-bath. After cooling, the orange precipitate was collected on a sintered glass filter plate, washed once with 5 ml. of hot glacial acetic acid, twice with 5 ml. of alcohol and once with 10 ml. of ether. The dry weight of 0.267 g. (0.00064 mole) represents a yield of 25%. The solid melted at 321° with decomposition,[8] and after crystallization from nitrobenzene, at 323°.

Anal. Calcd. for $C_{14}H_{10}O_8N_8$: C, 40.2; H, 2.4; N, 26.8. Found: C, 40.5; H, 2.6; N, 26.4.

Bromine Oxidation of Oxidized Methyl Alginate.—A mixture of 10 g. (0.0518 mole) of methyl alginate and 154 ml. of 0.499 *M* periodic acid (0.076 mole) was stirred until dispersed, then allowed to stand for twenty hours. The subsequent steps of oxidation to stage III and hydrolysis involved removal of iodic and periodic acids with barium carbonate, oxidation with bromine for twenty-four hours in presence of barium carbonate, removal of bromine by aeration, removal of barium ions by sulfuric acid, removal of bromide ions by silver carbonate, removal of silver ions by hydrogen sulfide and then hydrolysis by heating for sixteen hours. Stirring with bromine for twenty-four hours in the presence of barium carbonate followed by removal of barium ions with sulfuric acid was expected to form oxalic and *meso*-tartaric acids. Two methods of separation were attempted, (1) precipitating oxalic acid from the solution of oxalic and tartaric acid by means of silver oxide, and (2) heating the residue after evaporation with benzoyl chloride to form dibenzoxysuccinic anhydride from the tartaric acid. In the first case no tartaric acid could be isolated from the filtrate after removal of silver ions by hydrogen sulfide, and in the second, no crystalline material could be isolated.

Separation of *meso*-Tartaric Acid from Oxalic Acid.—When oxalic acid dihydrate and *meso*-tartaric acid monohydrate are heated separately with excess benzoyl chloride at 100–150°, the former is decomposed while the latter is converted into *meso*-dibenzoxysuccinic anhydride. When a mixture of 0.126 g. (0.001 mole) of oxalic acid dihydrate and 0.15 g. (0.0009 mole) of *meso*-tartaric acid monohydrate is heated with 10.4 g. (0.074 mole) of benzoyl chloride the anhydride can be isolated from the reaction mixture by first extracting it and benzoyl chloride from the solid acids with ether and then diluting this with low boiling petroleum ether, which precipitates the anhydride. This is purified by dissolving in ethyl ether and adding petroleum ether (b. p. 60–70°). The solid is finally washed with a little water to remove unchanged acid; recovery, 0.15 g. (*ca.* 50%); m. p.[9] 207°.

The failure of this method as applied to the oxidation product from methyl alginate may have been due to the presence of other oxidation products or to oxidation of the tartaric acid by bromine in diffused light.[10]

When 0.700 g. (0.0028 mole) of $CuSO_4 \cdot 5H_2O$ in 12 ml. of water was added to a solution of 0.1500 g. (0.001 mole) of anhydrous *meso*-tartaric acid (dried at 100° over phosphorus pentoxide) and 0.1260 g. (0.001 mole) of oxalic acid dihydrate in 30 ml. of water, and the *p*H was adjusted to 2.0 by the addition of a few drops of sulfuric acid, 0.1520 g. (0.00095 mole) of copper oxalate hemihydrate (95% recovery) separated during two hours of standing. After precipitation of copper ions from the solution with hydrogen sulfide, and of sulfate ions with barium hydroxide, evaporation of the solution gave 0.1600 g. (95% recovery) of *meso*-tartaric acid monohydrate which, after conversion to the anhydrous acid, melted at 140°. This method of separation was used in the subsequent work.

Brucine *meso*-Tartrate.—This was prepared by dissolving 0.1000 g. (0.000595 mole) of *meso*-tartaric acid monohydrate in a solution of 0.7800 g. (0.00167 mole) of brucine tetrahydrate in 10 ml. of alcohol and 30 ml. of water. After heating for three hours on a steam-bath, excess brucine was removed by shaking with chloroform. The solution was concentrated to 20 ml. and the brucine tartrate which separated was crystallized twice from water, washed with absolute alcohol and dried at 100° and 30 mm.; m. p. (uncor.) 259° with decomposition; $[\alpha]^{30}D$ −23°; (α^{30} −0.23°; l = 1 dm.; c = 0.5%).

Anal. Calcd. for $(C_{25}H_{26}N_2O_4)_2C_4H_6O_6$: C, 63.3; H, 5.53; N, 5.96; MeO, 13.22. Calcd. for $C_{23}H_{26}N_2O_4 \cdot C_4H_6O_6$: C, 59.54; H, 5.94; N, 5.15; MeO, 11.40. Found: C, 59.72; H, 5.77; N, 5.60; MeO, 11.48.

These analyses indicate that this salt, even when prepared with an excess of brucine, is a monobrucine tartrate. Confirmation is given by the recovery of brucine from the salt by heating with barium hydroxide solution, centrifuging, extracting brucine from the filtrate and washings with chloroform, from the precipitated barium salts with alcohol, and evaporating the solutions.

Recovery from 0.5918 g., calcd. for monobrucine salt: 0.4317 g.; for dibrucine salt: 0.4967 g. Found: 0.4272 g.

(6) The change in periodate concentration was followed by titration with standard sodium arsenite, Willard and Greathouse, THIS JOURNAL, **60**, 2869 (1938). This is simpler than the method of Fleury and Lange, *J. pharm. chim.*, **17**, 107 (1903), which requires standard solutions of arsenite and iodine.

(7) Literature, 169–170°: Fischer, *Ber.*, **17**, 575 (1884); Hess and Uibrig, *ibid.*, **50**, 367 (1917); 170–171°, Jackson and Hudson.[4]

(8) Lucas and Prater, THIS JOURNAL, **57**, 725 (1935), report 322°, with decomposition; Gladstone and Hickling, *J. Chem. Soc.*, 824 (1936), report 330° (cor.).

(9) Brigl and Gruner, *Ber.*, **65**, 641 (1932), report the m. p. as 207°. The anhydride is difficult to purify.

(10) In direct sunlight *d*-tartaric acid is oxidized by bromine; Ciusa and Piergallini, *Atti accad. Lincei*, **23**, I, 821 (1914).

Brucine tartrate was prepared as above also from 0.001 mole of each of the reactants, 0.466 g. of brucine tetrahydrate and 0.168 g. of *meso*-tartaric acid monohydrate. The unreacted brucine, obtained by extracting the solution with chloroform and the solid with alcohol, was recovered by evaporating the extracts. The unreacted acid was recovered by evaporating the aqueous phase. The results summarized in Table I and the analysis of the salt show that it is monobrucine tartrate. Thus the same salt is formed when the unreacted brucine is extracted by chloroform, no matter what excess of brucine is taken initially.

Anal. Found: C, 60.41; H, 6.00; N, 5.37; MeO, 11.35.

TABLE I

	Actual wt., g.	Weight expected, if salt is: Mono-brucine tartrate, g.	Di-brucine tartrate, g.
Brucine tartrate	0.442	0.544	0.469
Unreacted brucine recovered	.106	.088	.027
Unreacted acid recovered	.029	.031	.089

Oxidation of Alginic Acid with Periodic Acid.—Dried alginic acid, 15 g. (0.085 equiv.) was stirred vigorously with 425 ml. of 0.380 *M* periodic acid until peptized, which required about one and one-half hours. The mixture stood at room temperature for twenty to twenty-four hours during which time periodic acid was reduced (1.1 mole per equivalent of alginic acid). The oxidation proceeded comparatively rapidly during the first two hours (Fig. 1). Addition of 1600 ml. of tertiary butyl alcohol threw down an amorphous precipitate. This was centrifuged down and washed four times with 50 ml. of aqueous tertiary butyl alcohol (1 part of alcohol to 3 of water). After drying at 30 mm. over sulfuric acid the resulting fluffy white residue, which corresponds to reaction product II, weighed 13 g.

This material is easily peptized when added to water and the aqueous solution reduces Fehling solution; $[\alpha]^{25}D$ +36.7 (α^{25} +0.11°; l = 1 dm.; c = 0.3%).

Hydrolysis of II and Isolation of Glyoxal.—Two grams (0.0115 equiv.) of II was heated with 100 ml. of water on a steam-bath for two hours to effect solution. The hot solution was filtered, acidified with 2.5 ml. of 10 *N* hydrochloric acid and diluted to 200 ml. This was heated on a steam-bath until the optical rotation became constant (α +0.06) after sixteen hours. The hydrolyzate was neutralized with sodium hydroxide and divided into two equal portions. One-half was heated with 2.7 g. of phenylhydrazine at 100° for two hours, the other with a solution of 4.5 g. of 2,4-dinitrophenylhydrazine in 175 ml. of hot glacial acetic acid. The former half yielded 0.580 g. (0.00244 mole) of yellow glyoxal phenylosazone, melting after purification at 169–170°.

Anal. Found: N, 23.7.

The latter half yielded 0.660 g. (0.00158 mole) of orange-red glyoxal dinitrophenylosazone, melting at 317° with decomposition, and at 323° after purification as before.

Anal. Found: C, 40.6; H, 2.5; N, 26.4.

The yield of glyoxal in the form of osazones is 42 and 27%, respectively.

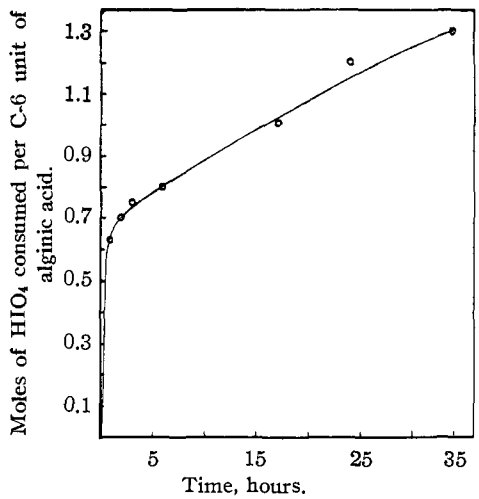


Fig. 1.

Bromine Oxidation of II to III and Isolation of Brucine *meso*-Tartrate.—Ten grams (0.0575 equiv.) of II dispersed in 475 ml. of water, 12 ml. of bromine and 43.4 g. of barium carbonate were stirred mechanically for twenty-four hours. Bromine was removed by aeration and the solution freed from barium ions by the addition of an equivalent amount of sulfuric acid. The solution was diluted to 900 ml. and then heated on the steam-bath until hydrolysis was complete (zero rotation after sixteen hours). The hydrolyzate was concentrated to 400 ml., made slightly alkaline while hot with barium hydroxide and kept hot for three hours. During this time glyoxalic acid was converted in part to oxalic and glycolic acids. The precipitated barium salts, *viz.*, barium oxalate and barium tartrate (barium glycolate is slightly soluble in water), were centrifuged down and washed twice with 40 ml. of hot water. Barium ion was precipitated by the careful addition of sulfuric acid to a suspension of the salts in 150 ml. of water. At this point the solution contained oxalic and *meso*-tartaric acids.

The solution was concentrated at 40 mm. to 30 ml., 4 g. of $CuSO_4 \cdot 5H_2O$ was added, and the *p*H was adjusted to 2.0 with sulfuric acid. The precipitated copper oxalate was removed by filtration, the filtrate diluted to 70 ml., cupric ion was precipitated with hydrogen sulfide and sulfate ion with barium hydroxide. On the addition of 45 ml. of water, 50 ml. of alcohol and 20 g. (an excess) of brucine, followed by heating for three hours on the steam-bath, removal of excess brucine with chloroform and concentration of the aqueous solution to 30 ml. at 40 mm., 8.0 g. (0.0147 mole) of monobrucine *meso*-tartrate was recovered in 25% yield. After two crystallizations from water this melted at 259° with decomposition: $[\alpha]^{30}D$ −22° (α −0.11°; l = 1 dm.; c = 0.5%).

Anal. Calcd. for $C_{23}H_{26}N_2O_4(C_4H_6O_6)$: C, 59.5; H, 5.9; N, 5.15; MeO, 11.4. Found: C, 60.0; H, 6.0; N, 5.4; MeO, 11.4.

Dibenzoxysuccinic Anhydride from Hydrolyzate.—When 0.669 g. (0.00123 mole) of the above brucine salt was heated with 22 ml. of 0.1202 *M* (0.0026 mole) barium hydroxide for one hour on the steam-bath, an insoluble barium salt separated. This was centrifuged down.

washed with 10 ml. of water and 20 ml. of alcohol, and dried. After quantitatively freeing this of barium ions with sulfuric acid and removing barium sulfate, the solution was taken to dryness in a vacuum desiccator. The residue of 0.196 g. (0.0012 mole as tartaric acid monohydrate) was heated slowly with 0.85 g. (0.0059 mole) of benzoyl chloride to 150° over a period of three hours. The reaction mixture was extracted with 30 ml. of ether, the clear extract concentrated to 4 ml., and 10 ml. of petroleum ether, b. p. 60–70°, was added. Crystallization of dibenzoxysuccinic anhydride was promoted by scratching the sides of the vessel. The supernatant liquid was decanted, the solid was dissolved in 10 ml. of ether and then thrown down by the addition of 10 ml. of petroleum ether; recovery 0.23 g. (0.00068 mole), m. p., 206°.

Anal. Calcd. for $C_{18}H_{12}O_7$: saponification equiv., 85.0. Found: sapon. equiv., 86.1.

Summary

Alginic acid has been oxidized by means of periodic acid to a substance, presumably the corresponding polymeric dialdehyde acid, which undergoes hydrolysis in dilute acid. From the hydrolyzate glyoxal has been obtained in 42% yield.

The polymeric dialdehyde acid has been oxidized by bromine water. From the hydrolyzate of the resulting acid, *meso*-tartaric acid has been isolated in 25% yield.

Methyl alginate has been subjected to oxidation by periodic acid. Glyoxal in 30% yield has been isolated.

These results show that the scission of the mannuronic acid units of alginic acid takes place between the second and third carbon atoms. Therefore, hydroxyl groups are attached to C_2 and C_3, while bridge and ring linkages are attached to C_4 and C_5. The presence of other structural units in small amount is not excluded.

No conclusion has been drawn in regard to furanoside or pyranoside structure, or to alpha or beta configuration at C_1.

PASADENA, CALIFORNIA RECEIVED APRIL 15, 1940

[CONTRIBUTION FROM THE DEPARTMENT OF BOTANY, UNIVERSITY OF MINNESOTA]

Linoleyl Alcohol. II. Preparation, Properties, and Rearrangement[1]

BY J. P. KASS AND G. O. BURR

In a previous communication[2] we have shown that the linoleyl alcohol prepared by the reduction of methyl linoleate with sodium in butyl alcohol, as described by Turpeinen,[3] is a mixture of the expected octadecadiene-9,12-ol-1 with the product of its rearrangement, octadecadiene-10,-12-ol-1, the anomalous properties of the alcohol being fully accounted for by the presence of the conjugated isomerides. The molecular rearrangement, accompanied by the appearance of typical absorption spectra in the ultraviolet,[4] is general among the polyenic acids[4] and has been found[5] to proceed much more rapidly in high-boiling anhydrous solvents than in aqueous alcohols. Preliminary determinations of the velocity of isomerization of linoleic and linolenic acids in 20% sodium ethoxide or in a 20% ethyl alcoholic solution of potassium hydroxide have shown only a negligible rise in the spectroscopic activities of the recovered acids at the end of one hour of boiling, and it was therefore correctly surmised that the reduction of the esters of these acids to the corresponding alcohols may be effected in ethyl alcohol without rearrangement, provided the time of heating in the anhydrous alkali was kept at a minimum. The physical and chemical properties of the alcohols prepared in this manner closely parallel those of the parent acids. Since these alcohols are of biological interest[6] as curative agents in the "fat deficiency" syndrome,[7] this paper describes the preparation and properties of the unconjugated linoleyl and linolenyl alcohols, and the rearrangement of the former to a mixture of octadecadiene-10,12-ols, the characteristics of which are essentially identical with those of the mixed alcohol prepared by the reduction of methyl linoleate with sodium in butanol.[2,3]

Experimental

Preparation of Linoleyl Alcohol.—A solution of 45 g. of methyl linoleate[8] in 300 cc. of anhydrous ethanol was treated at once with 18 g. of sodium cut in large pieces

(1) This work was supported by grants from the Hormel Foundation and the Graduate School of the University of Minnesota. Presented before the American Chemical Society Convention in Cincinnati, April 9, 1940.

(2) Kass, Miller and Burr, THIS JOURNAL, **61**, 482 (1939).

(3) Turpeinen, *ibid.*, **60**, 56 (1938).

(4) Moore, *Biochem. J.*, **31**, 138 (1937).

(5) Kass and Burr, THIS JOURNAL, **61**, 3292 (1939).

(6) Burr and Kass, work in progress.

(7) Burr and Burr, *J. Biol. Chem.*, **86**, 587 (1930).

(8) Rollet, *Z. physiol. Chem.*, **62**, 410 (1909).