rials, contained 30% diene III and 70% of a mixture of dienes I and II, according to ultraviolet analysis.

The dienes were fractionally distilled under a blanket of nitrogen at atmospheric pressure in a Podbielniak[14] Hypercal column. The lower boiling cuts rich in dienes I and II were separately refractionated. The higher boiling cuts rich in diene III were treated with maleic anhydride to remove dienes I and II and refractionated.

The samples used for the thermal reaction at 500° had the following physical constants: mixture of dienes I and II, b.p. 131–133°, n^{20}D 1.4594; diene III, b.p. 139–140°, n^{20}D 1.4752. Their spectra showed that only the designated dienes were present.

1,3,5-Trimethyl-1,3-cyclohexadiene (VII).—Diene VII was isolated from the products obtained in the reaction of 3,5-dimethyl-2-cyclohexenone[24] with an excess of methylmagnesium bromide. The general procedure of Kharasch and Tawney[22] was employed using commercial magnesium turnings. The 66% yield of dienes boiling between 47–79° (18 mm.), n^{20}D 1.4776, was shown to consist of 45% of diene VII and 55% of diene X. Diene VII was fractionally distilled from diene X.

5,5-Dimethyl-1,3-cyclohexadiene. 4,4-Dimethylcyclohexene.—This compound was prepared by a previously described method.[25]

5,5-Dimethyl-1,3-cyclohexadiene (IV).—The diene was synthesized by brominating 4,4-dimethylcyclohexene and treating this dibromide with sodium ethoxide followed by the reaction of the resulting ether with potassium bisulfate according to a procedure of Hofmann and Damm.[26]

The diene used for the thermal reaction had the following properties, b.p. 111–114°, n^{20}D 1.4558. Its spectra showed it to contain only diene IV.

The physical properties, infrared spectra and ultraviolet spectral data of all the above synthesized cyclohexadienes are given in Tables VII, VIII and IX, respectively.

The Reaction with Dimethyl Acetylenedicarboxylate.—The method and apparatus used was essentially that described by Parker and Goldblatt.[6]

This reaction with the cyclohexadienes gave liquid and gaseous decomposition products. The liquid products were identified in some cases by saponification of the resulting esters and determination of the corresponding phthalic acids. The gaseous products were identified by mass spectrometry.

The results of the reactions of the various dienes with dimethyl acetylenedicarboxylate are given in Table X. The reaction was conducted at the temperature designated (starting at room temperature with slow heating) until no more gas was evolved (0.5–3 hr.). About 2.0–5.0 g. of reactant was used with an excess of the acetylenedicarboxylate.

Acknowledgment.—The authors express their thanks to Dr. D. F. Mason of the Chemical Engineering Department for the mass spectrographic gas analyses and to Miss H. Beck for the elementary analyses.

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[24] E. C. Horning, M. O. Denekas and R. C. Field, *Org. Syntheses*, **27**, 24 (1937).

[25] H. Pines, F. J. Pavlik and V. N. Ipatieff, THIS JOURNAL, **73**, 5738 (1951).

[26] F. Hofmann and P. Damm, *Mitt. Kohlenforschungsmit Breslau*, **2**, 113, 127 (1925); *C. A.*, **22**, 1249 (1928).

[JOINT CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF WAYNE UNIVERSITY AND THE INSTITUTO DE QUIMICA DE LA UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO]

Terpenoids. XXIV.[1] The Structure of the Cactus Triterpene Queretaroic Acid

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From two Mexican cacti, *Lemaireocereus queretaroensis* and *L. beneckei*, there has been isolated a new triterpene acid named queretaroic acid. Degradation experiments are reported which establish its constitution as 30-hydroxyoleanolic acid. Queretaroic acid is the only known naturally occurring triterpene, other than glycyrrhetic acid, which is oxygenated at C-30.

In continuation of our work on cactus triterpenes, especially of the genus *Lemaireocereus*,[4] there have been examined two additional Mexican representatives of this genus, *L. queretaroensis* and *L. beneckei*.[5] In each instance, the acidic triterpene fraction could be separated into oleanolic acid and a new triterpene acid, now named "queretaroic acid." The present paper is concerned with a description of the relevant experiments which led to the structure elucidation of this new pentacyclic triterpene.[6]

Analysis indicated the empirical formula $C_{30}H_{48}O_4$ for queretaroic acid (Ia) and the nature of all four oxygen atoms was proved by formation of a monomethyl ester Ib, a diacetate Id and a diacetoxy methyl ester Ic. Queretaroic acid is thus a dihydroxycarboxylic acid and its membership in the β-amyrin series of triterpenes was established by the ready oxidation of the diacetoxy methyl ester Ic with selenium dioxide to a hetero-annular diene II with the characteristic triple ultraviolet maxima at 243, 251 and 260 mμ.[7] In view of the co-existence of queretaroic acid with oleanolic acid in the cactus, it was assumed that the former was most likely x-hydroxy-oleanolic acid and all subsequent experiments were predicated on such a working hypothesis.

In order to locate the unknown hydroxyl group, methyl queretaroate (Ib) was subjected to chromium trioxide–sulfuric acid oxidation[8] and led in good yield to a ketodicarboxylic acid monomethyl ester Vb. The new functional groups were charac-

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[1] Paper XXIII, C. Djerassi and R. Hodges, THIS JOURNAL, **78**, 3534 (1956).

[2] Postdoctorate research fellow at Wayne University, 1954–1955, on funds supplied by the Division of Research Grants of the National Institutes of Health (grant No. G-3863).

[3] Postdoctorate research fellow at Universidad Nacional Autonoma de Mexico, 1954–1955, on funds supplied by the Rockefeller Foundation.

[4] For leading references, see Paper XXII, C. Djerassi, A. Bowers, S. Burstein, H. Estrada, J. Grossman, J. Herran, A. J. Lemin, A. Manjarrez and S. C. Pakrashi, THIS JOURNAL, **78**, 2312 (1956).

[5] *Cf.* H. Bravo, "Las Cactaceas de Mexico," Mexico, D. F., 1937, pp. 252, 265.

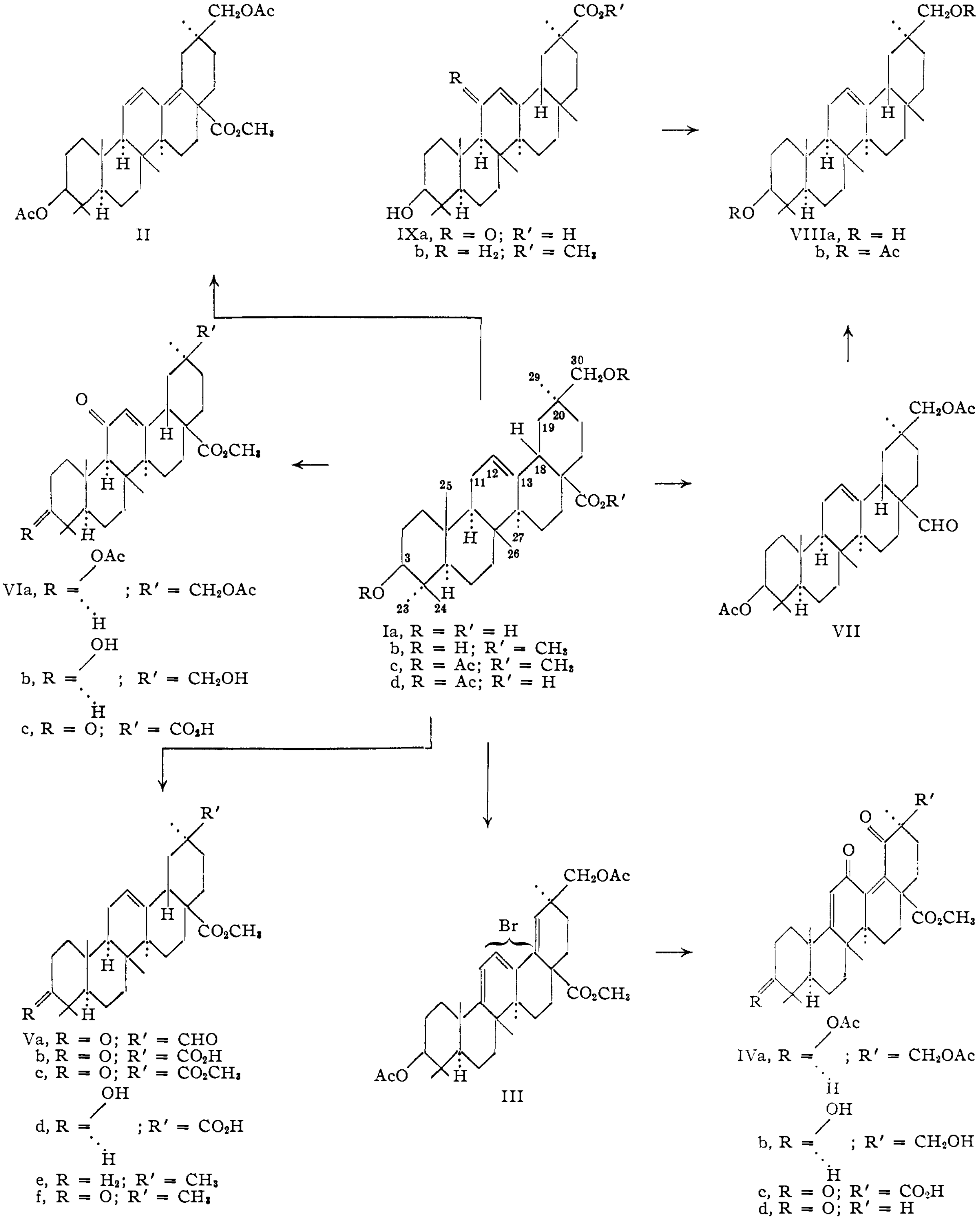
[6] A preliminary account of part of this work has been published (C. Djerassi, J. A. Henry, A. J. Lemin and T. Rios, *Chemistry & Industry*, 1520 (1955).

[7] This reaction, typical of β-amyrins, was discovered by L. Ruzicka, G. Müller and H. Schellenberg (*Helv. Chim. Acta*, **22**, 767 (1939)) while the location of the double bonds was established by D. H. R. Barton and C. J. W. Brooks (*J. Chem. Soc.*, 257 (1951)).

[8] *Cf.* K. Bowden, I. M. Heilbron, E. R. H. Jones and B. C. L. Weedon, *ibid.*, 39 (1946).

terized by methylation to a dimethyl ester Vc and by sodium borohydride reduction to a hydroxydicarboxylic acid monomethyl ester Vd. It was clear, therefore, that queretaroic acid possessed a primary hydroxyl group and on the assumption that the acid is a hydroxylated oleanolic acid, the most likely positions for the primary hydroxyl group would be C-27, C-29 or C-30.[9]

The first alternative, C-27, was excluded by the



II

IXa, R = O; R' = H
b, R = H_2; R' = CH_3

VIIIa, R = H
b, R = Ac

VIa, R = $\overset{\text{OAc}}{\underset{\text{H}}{=}}$; R' = CH_2OAc
b, R = $\overset{\text{OH}}{\underset{\text{H}}{=}}$; R' = CH_2OH
c, R = O; R' = CO_2H

Ia, R = R' = H
b, R = H; R' = CH_3
c, R = Ac; R' = CH_3
d, R = Ac; R' = H

VII

Va, R = O; R' = CHO
b, R = O; R' = CO_2H
c, R = O; R' = CO_2CH_3
d, R = $\overset{\text{OH}}{\underset{\text{H}}{=}}$; R' = CO_2H
e, R = H_2; R' = CH_3
f, R = O; R' = CH_3

III

IVa, R = $\overset{\text{OAc}}{\underset{\text{H}}{=}}$; R' = CH_2OAc
b, R = $\overset{\text{OH}}{\underset{\text{H}}{=}}$; R' = CH_2OH
c, R = O; R' = CO_2H
d, R = O; R' = H

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[9] C-23 and C-24 are excluded because the keto-acid Vb would have suffered decarboxylation. Of the remaining positions, C-25 and C-26 were considered unlikely since no naturally occurring triterpenes are known which are oxygenated at those carbon atoms.

following sequence of reactions. Vigorous oxidation of methyl diacetoxyqueretaroate (Ic) with chromium trioxide in acetic acid furnished the 11-ketone VIa (λ_{max}^{EtOH} 249 mμ), which was saponified to methyl 11-ketoqueretaroate (VIb) and then oxidized to the corresponding diketodicarboxylic acid monomethyl ester VIc. If the newly formed carboxyl group were located at C-27, VIc would now be a vinylogous β-keto-ester which should undergo facile decarboxylation. In point of fact, the keto-acid VIc was recovered unchanged after sublimation at 250°, thus eliminating C-27 from further consideration as the site of the primary hydroxyl group.

Since any unambiguous structure proof of a new triterpene rests ultimately on an interconversion with a triterpene of established constitution, two such tie-ups were carried out. In order to establish the nature of the pentacyclic skeleton and the position of the carboxyl group, which has so far been inferred only on the basis of biogenetic probability, queretaroic acid was related to oleanolic acid in the following fashion. Methyl queretaroate (Ib) was oxidized with chromium trioxide in a biphasic system,[10] and in addition to the keto-acid Vb, there could now be isolated a neutral product which proved to be the corresponding keto-aldehyde Va. Reduction of the latter by the Wolff-Kishner method followed by methylation produced methyl 3-desoxyoleanolate (Ve), which was shown to be identical with an authentic sample prepared by similar reduction of methyl oleanonate (Vf).

The above correlation of queretaroic acid with methyl desoxyoleanolate (Ve) strongly supported the original hypothesis that this new cactus triterpene was a hydroxylated derivative of oleanolic acid, and it appeared quite likely, on the basis of the earlier arguments, that the primary hydroxyl function was located in ring E. Since glycyrrhetic acid (IXa), the principal triterpene of licorice root, is known[11,12] to possess a carboxyl group attached to C-20,[13] it appeared to be the obvious candidate for a correlation with queretaroic acid, although it was appreciated that the latter could also bear the primary hydroxyl group at C-29.[14] Such an experimental connection was also important in proving rigorously the presence of a 3β-hydroxyl group, since this point had not been established in the above described transformation to 3-desoxyoleanolate (Ve).

Methyl 11-desoxoglycyrrhetate (IXb), the hydrogenolysis product[15] of methyl glycyrrhetate, was reduced with lithium aluminum hydride to the previously unknown Δ^{12}-oleanene-3β,30-diol (VIIIa), which was further characterized as the diacetate VIIIb. The identical diol VIIIa was obtained from queretaroic acid diacetate (Id) by conversion to the acid chloride (not isolated), Rosenmund reduction to the 28-aldehyde (VII) and Wolff-Kishner reduction. It follows, therefore, that queretaroic acid (Ia) can be given the systematic name[13] 30-hydroxy-oleanolic acid, which also defines completely its stereochemistry. It is pertinent to point out that queretaroic acid (Ia) is the only known naturally occurring triterpene, other than the physiologically active[16] glycyrrhetic acid (IXa), which is oxygenated at C-30.

Prior to the successful correlation of queretaroic acid (Ia) with glycyrrhetic acid (IXa), alternative approaches toward localizing the primary hydroxyl group of this cactus triterpene had been investigated and one such experimental sequence is outlined below.

The reaction of N-bromosuccinimide with triterpenes of the α- and β-amyrin groups has been reported[17] as another diagnostic tool since the former leads to the homoannular $\Delta^{9(11),12}$-diene, while a $\Delta^{9(11),12,18}$-triene is formed in the β-amyrin series. In our hands,[18] this reaction has proved to be very dependent on the reaction conditions employed and as illustrated in the Experimental section with methyl diacetoxyqueretaroate (Ic), it is possible to obtain a homoannular $\Delta^{9(11),12}$-diene or a bromotriene III, in which the bromine atom must be located on one of the carbon atoms involved in the chromophore. This was established by selenium dioxide oxidation of the bromotriene III to the bromine-free $\Delta^{9(11),13(18)}$-diene-12,19-dione IVa. Mild saponification produced the free 3,30-diol IVb,[19] and subsequent oxidation furnished a crude acid IVc which underwent decarboxylation (to IVd) during attempted crystallization. Similar observations have been recorded[11a] for an analogous 12,19-diketone in the glycyrrhetic acid series.

Experimental[20]

Isolation of Queretaroic Acid.—The detailed isolation procedure for triterpenes from cacti has already been described[4] and has also been followed in this case. From 4.27 kg. of dry *L. queretaroensis*[21] there was obtained about 100 g.

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[10] *Cf.* A. Zürcher, O. Jeger and L. Ruzicka, *Helv. Chim. Acta*, **37**, 2145 (1954).

[11] (a) L. Ruzicka and O. Jeger, *ibid.*, **25**, 775 (1942); (b) L. Ruzicka, O. Jeger and M. Winter, *ibid.*, **26**, 265 (1943).

[12] C. Djerassi and C. M. Foltz, THIS JOURNAL, **76**, 4085 (1954).

[13] J. M. Beaton and F. S. Spring (*J. Chem. Soc.*, 3126 (1955)) established the axial (β) orientation of the carboxyl group of IX and suggested a numbering system for *gem*-substituents in the triterpene series, whereby the α-substituent is given the lower number. Consequently, the carboxyl group of glycyrrhetic acid (IXa) is numbered as 30 rather than 29, and we have adopted this system in the present paper.

[14] Glycyrrhetic acid (IXa) could have been used also in that event by employing certain 30-nor derivatives available by decarboxylation (refs. 11 and 12).

[15] L. Ruzicka, H. Leuenberger and H. Schellenberg, *Helv. Chim. Acta*, **20**, 1271 (1937).

[16] J. Groen, H. Pelser, M. Frenke, C. E. Kamminga and A. F. Willebrands, *J. Clin. Invest.*, **31**, 87 (1952); W. I. Card, W. Mitchell, J. A. Strong, N. R. W. Taylor, S. L. Tompsett and J. M. G. Wilson, *Lancet*, **264**, 663 (1953).

[17] *Cf.* L. Ruzicka, O. Jeger and J. Redel, *Helv. Chim. Acta*, **26**, 1235 (1943).

[18] See Experimental section for model reaction with methyl acetyl oleanolate.

[19] It is noteworthy that no retro-aldol reaction with liberation of formaldehyde could be achieved (*cf.* D. H. R. Barton and P. de Mayo, *J. Chem. Soc.*, 887 (1954)).

[20] All melting points are uncorrected and were determined on the Kofler block. All rotations were measured in chloroform and ultraviolet absorption spectra in 95% ethanol solution. Infrared spectra were measured in part by Mrs. Dolores Phillips at Wayne University using a Baird Associates double beam spectrophotometer while the remaining ones were obtained at the Instituto de Quimica with a double beam Perkin-Elmer spectrophotometer. The microanalyses were performed by Spang Microanalytical Laboratory, Plymouth, Mich., and Dr. F. Pascher, Bonn, Germany.

[21] The plant collections were organized by Dr. Alberto Sandoval of the Instituto de Quimica, and the botanical identification was carried out by Dr. H. Bravo of the Instituto de Biologia, Mexico City. *L. queretaroensis* was collected near the outskirts of Queretaro (State of Queretaro) and *L. beneckei* in the Canyon del Zopilote (State of Guerrero).

of crude acidic triterpenes (negligible neutral fraction). Purification was best accomplished by conversion to the methyl ester with diazomethane in dioxane–ether and chromatography of the methyl esters. Approximately two parts of methyl oleanolate (eluted with benzene) to one part of methyl queretaroate (ether–chloroform 1:1) were isolated and essentially the same results were observed with *L. beneckei*.[21]

Characterization of Queretaroic Acid.—The starting material was **methyl queretaroate (Ib)**, as obtained from the chromatographic separation. The analytical sample was crystallized from methanol as needles, m.p. 223–224°, $[\alpha]_D$ +67°.

Anal. Calcd. for $C_{31}H_{50}O_4$: C, 76.50; H, 10.36. Found: C, 76.14; H, 10.52.

Saponification in ethylene glycol solution[22] and recrystallization of the rather insoluble acid from chloroform–ethanol furnished colorless crystals of **queretaroic acid (Ia)**, m.p. 318–323°.

Anal. Calcd. for $C_{30}H_{48}O_4$: C, 76.22; H, 10.24. Found: C, 75.87; H, 10.28.

A sample of queretaroic acid (Ia) was acetylated at room temperature with acetic anhydride–pyridine, and the resulting **queretaroic acid diacetate (Id)** was recrystallized from acetone, m.p. 292–295°, $[\alpha]_D$ +82°.

Anal. Calcd. for $C_{34}H_{52}O_6$: C, 73.34; H, 9.41. Found: C, 73.82; H, 9.46.

Similar acetylation of methyl queretaroate produced **methyl diacetylqueretaroate (Ic)**; the analytical sample crystallized from methanol–chloroform as needles, m.p. 211–212°, $[\alpha]_D$ +68.5°.

Anal. Calcd. for $C_{35}H_{54}O_6$: C, 73.64; H, 9.54. Found: C, 73.58; H, 9.88.

Selenium Dioxide Oxidation of Methyl Diacetylqueretaroate (Ic).—A solution of 0.5 g. of Ic in 30 cc. of acetic acid was refluxed with 0.5 g. of selenium dioxide for 2 hr., diluted with water, extracted with ether, evaporated and recrystallized several times from methanol–chloroform. The resulting diene II exhibited m.p. 245–247°; $\lambda_{\max}^{\text{EtOH}}$ 243, 251 and 260 mμ; log ε 4.25, 4.39 and 4.24.

Anal. Calcd. for $C_{35}H_{52}O_6$: C, 73.91; H, 9.22. Found: C, 73.50; H, 9.32.

Chromium Trioxide–Sulfuric Acid Oxidation of Methyl Queretaroate (Ib).—A solution of 0.5 g. of methyl queretaroate in 55 cc. of purified acetone was treated dropwise at room temperature with 2 cc. of a solution[8] of chromium trioxide (266.6 g.) in 1 l. of water containing 40 cc. of concd. sulfuric acid. After 10 minutes, water was added, the **ketodiacid ester Vb** was collected and recrystallized from methanol, yield 0.39 g., m.p. 267–269°, $[\alpha]_D$ +45°.

Anal. Calcd. for $C_{31}H_{46}O_5$: C, 74.66; H, 9.30. Found: C, 74.65; H, 9.49.

That the oxidation product was indeed an acid was demonstrated by the infrared spectrum (3.4 μ region), by its solubility in dilute potassium hydroxide solution (from which it could be recovered unchanged after acidification) and by methylation with ethereal diazomethane. Recrystallization from methanol–chloroform yielded the **dimethyl ester Vc**, m.p. 199–201°, $[\alpha]_D$ +73°.

Anal. Calcd. for $C_{32}H_{48}O_5$: C, 74.96; H, 9.44. Found: C, 74.81; H, 9.71.

The presence of a keto group in the original oxidation product Vb was established by reducing 50 mg. of the keto-acid Vb in 15 cc. of methanol (containing 0.5 cc. of water) with 50 mg. of sodium borohydride at room temperature for 30 minutes. After acidification, the resulting **alcohol Vd** was isolated by ether extraction and recrystallized from methanol, m.p. 292–293°, $[\alpha]_D$ +59°.

Anal. Calcd. for $C_{31}H_{48}O_5$: C, 74.36; H, 9.66. Found: C, 74.49; H, 9.91.

Methyl Diacetyl-11-ketoqueretaroate (VIa).—To a refluxing solution of 2.66 g. of methyl diacetylqueretaroate (Ic) in 120 cc. of glacial acetic acid was added 2.7 g. of chromium trioxide dissolved in 30 cc. of 85% acetic acid and heating was continued for 2.5 hr. After dilution with water, the product was extracted with ether, washed well with potassium hydroxide solution and with water and evaporated to dryness. The neutral residue (1.32 g.) was crystallized from methanol–chloroform to yield 0.98 g. of the 11-ketone, m.p. 213–216°, while the analytical sample showed m.p. 224–226°, $[\alpha]$ +33°; $\lambda_{\max}^{\text{EtOH}}$ 249 mμ, log ε 4.02; $\lambda_{\max}^{\text{CHCl}_3}$ 5.78–5.83, 6.02 and broad band in 8.0 μ region.

Anal. Calcd. for $C_{35}H_{52}O_7$: C, 71.88; H, 8.96. Found: C, 71.77; H, 9.26.

Methyl 11-Ketoqueretaroate (VIb).—A 0.5-g. sample of the above diacetate VIa was refluxed for 35 minutes with 100 cc. of 5% methanolic potassium hydroxide and the product was isolated by means of ether. Recrystallization from methanol led to 0.31 g. of neutral material, m.p. 251–253°; $\lambda_{\max}^{\text{EtOH}}$ 250 mμ, log ε 4.00, no acetate bands in infrared.

Anal. Calcd. for $C_{31}H_{48}O_5$: C, 74.36; H, 9.66. Found: C, 74.10; H, 9.97.

The above 11-ketone (80 mg.) in 20 cc. of acetone was oxidized with 2 cc. of the chromium trioxide–sulfuric acid reagent[8] for 10 minutes at room temperature and then extracted with ether. The ether solution was washed with dilute potassium hydroxide and the latter was acidified and re-extracted with ether. The total acid fraction weighed 65 mg. and after recrystallization, the **diketo diacid monomethyl ester VIc** exhibited m.p. 293–295°, $[\alpha]_D$ +75°; $\lambda_{\max}^{\text{CHCl}_3}$ 5.80, 5.90 and 6.0 μ. The acid was recovered unchanged after sublimation at 250° and 0.06 mm. as demonstrated by mixture melting point determination and comparison of the infrared spectra.

Anal. Calcd. for $C_{31}H_{44}O_6$: C, 72.62; H, 8.65. Found: C, 72.75; H, 8.83.

Methyl 3-Desoxyoleanolate (Ve). (a) **From Methyl Queretaroate (Ib).**—To an ice-cold solution of 500 mg. of methyl queretaroate (Ib) in 200 cc. of acetic acid and 20 cc. of chloroform was added over a period of 8 minutes 1.125 g. of chromium trioxide dissolved in 10 cc. of acetic acid and 30 cc. of water. The temperature was allowed to rise to 20° during 75 minutes, methanol was added and the mixture was poured into water. The product was worked up in the usual way to give a neutral (338 mg.) and an acidic (137 g.) fraction.

Crystallization of the neutral material from methanol gave 110 mg. of needles of the **keto-aldehyde Va**, m.p. 194–197°, raised upon further recrystallization to 207–209°, $[\alpha]_D$ +102°, $\lambda_{\max}^{\text{CHCl}_3}$ 5.80 and 5.90 μ.

Anal. Calcd. for $C_{31}H_{46}O_4$: C, 77.13; H, 9.61. Found: C, 77.44; H, 9.72.

Similar crystallization of the acidic fraction produced 32 mg. of the **keto diacid monomethyl ester Vb**, m.p. 267–270°, which proved to be identical (infrared comparison) with the sample prepared by the chromium trioxide–sulfuric acid procedure.

Anal. Calcd. for $C_{31}H_{46}O_5$: C, 74.66; H, 9.30. Found: C, 74.40; H, 9.48.

A mixture of 200 mg. of the keto-aldehyde Va, 1.3 cc. of 85% hydrazine hydrate, 6 cc. of ethanol and 20 cc. of diethylene glycol was refluxed for 1 hour, 100 mg. of solid potassium hydroxide was added and heating was continued for an additional hour. The condenser was removed and distillation was commenced until the temperature rose to 195°, whereupon refluxing was resumed for 3 hr. After cooling and pouring into dilute hydrochloric acid, the product was extracted with ether and directly methylated with diazomethane. The crude methyl ester was chromatographed on 15 g. of alumina and the benzene-eluted material (100 mg.) was recrystallized from methanol to give 50 mg. of needles, m.p. 158–162°. The analytical sample of **methyl 3-desoxyoleanolate** (Ve) was obtained from the same solvent, m.p. 166–168°, $[\alpha]_D$ +83°.

Anal. Calcd. for $C_{31}H_{50}O_2$: C, 81.88; H, 11.08. Found: C, 81.70; H, 11.35.

(b) **By Wolff–Kishner Reduction of Methyl Oleanonate (Vf).**—Methyl oleanonate (0.5 g., m.p. 180–182°) was subjected to the same reduction conditions as described under (a) and led to 325 mg. of methyl 3-desoxyoleanolate. The analytical sample exhibited m.p. 166–168°, $[\alpha]_D$ +83°, and identity with the specimen prepared according to (a) was established by mixture melting point determination and coincidence of the respective infrared spectra.

Anal. Calcd. for $C_{31}H_{50}O_2$: C, 81.88; H, 11.08. Found: C, 82.06; H, 11.20.

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[22] *Cf.* C. Djerassi, G. H. Thomas and H. Monsimer, THIS JOURNAL, **77**, 3579 (1955), footnote 26.

Δ^{12}-Oleanene-3β,30-diol (VIIIa). (a) **From Methyl 11-Desoxoglycyrrhetate (IXb).**—Methyl 11-desoxoglycyrrhetate (IXb)[15] (500 mg.) in 250 cc. of dry ether was added during 15 minutes to a stirred solution of 1 g. of lithium aluminum hydride in 100 cc. of ether. The mixture was stirred at room temperature for 30 minutes and then at reflux for 2 hr. Excess reagent was decomposed by addition of ethyl acetate, dilute hydrochloric acid was added and the product was isolated in the usual way. Crystallization from methanol–chloroform gave 420 mg. of needles, m.p. 230–235°, raised on further recrystallization to m.p. 238–240°, $[\alpha]_D$ +100° (pyridine), no infrared carbonyl band.

Anal. Calcd. for $C_{30}H_{50}O_2$: C, 81.39; H, 11.38. Found: C, 81.24; H, 11.40.

The diacetate VIIIb was prepared by the acetic anhydride–pyridine procedure (room temperature, overnight) and was recrystallized from methanol–chloroform; m.p. 179–181°, resolidifying and final melting at 197–198°, $[\alpha]_D$ +98.5°.

Anal. Calcd. for $C_{34}H_{54}O_4$: C, 77.52; H, 10.33. Found: C, 77.44; H, 10.42.

(b) **From Diacetylqueretaroic Acid (Id).**—A solution of 1.6 g. of diacetylqueretaroic acid (Id)[23] was refluxed for 1.5 hr. with 130 cc. of benzene and 10 cc. of thionyl chloride and then evaporated to dryness *in vacuo*. The solid acid chloride (1.2 g.) was triturated twice with dry petroleum ether and was then reduced directly by the Rosenmund procedure. This was accomplished by passing a rapid stream of hydrogen for 12 hr. through a stirred and heated (85°) solution of the crude acid chloride in 50 cc. of dry xylene in the presence of 1.2 g. of 5% palladium–barium sulfate catalyst, filtering and evaporating to dryness. The product was reacetylated with acetic anhydride–pyridine and chromatographed on 40 g. of alumina. Elution with benzene furnished 325 mg. of the desired **diacetoxyaldehyde VII** which was recrystallized from methanol–chloroform; m.p. 197–200°, $[\alpha]_D$ +80°. In order to demonstrate the presence of the aldehyde group (masked by the acetate bands) in the infrared, a 10-mg. sample was saponified and the crude product (no acetate bands in the 8.0 μ region) showed a strong infrared carbonyl band at 5.79 μ.

Anal. Calcd. for $C_{34}H_{52}O_5$: C, 75.51; H, 9.69. Found: C, 75.20; H, 9.85.

The above diacetoxyaldehyde VII (110 mg.) was reduced by the Wolff–Kishner procedure as described for Va and led to 65 mg. of the diol VIIIa, m.p. 240–241°, undepressed upon admixture with a sample prepared according to (a), $[\alpha]_D$ +97° (pyridine).

Anal. Calcd. for $C_{30}H_{50}O_2$: C, 81.39; H, 11.38. Found: C, 81.53; H, 11.50.

The diacetate VIIIb showed the previously observed double m.p. 179–182° and 197–198°, $[\alpha]_D$ +99.5°. Identity in this instance, as well as in the case of the free diols, was established by complete coincidence of the respective infrared spectra.

Anal. Calcd. for $C_{34}H_{54}O_4$: C, 77.52; H, 10.33. Found: C, 77.70; H, 10.49.

Reaction of Methyl Diacetylqueretaroate (Ic) with N-Bromosuccinimide.—N-Bromosuccinimide (500 mg.) was added to a solution of 0.5 g. of Ic in 100 cc. of dry carbon tetrachloride and the mixture was refluxed for 2 hr. The solution was filtered, washed with water, dried and 15 cc. of pyridine was added. After evaporation of the carbon tetrachloride, more pyridine (25 cc.) was added and the solution was heated on the steam-bath for 30 minutes. Isolation with ether followed by elution from alumina (25 g.) with 1:1 hexane–benzene and benzene, and crystallization from methanol gave 200 mg. of the **bromotriene III**,[24] m.p. 197–200°, $[\alpha]_D$ +430°, λ_{max}^{EtHo} 309 mμ, log ϵ 4.06.

Anal. Calcd. for $C_{35}H_{49}BrO_6$: C, 65.12; H, 7.65; Br, 12.38. Found: C, 64.69; H, 7.61; Br, 12.63.

In another experiment, 2.5 g. of methyl diacetylqueretaroate (Ic) in 150 cc. of carbon tetrachloride was refluxed with 1.75 g. of N-bromosuccinimide for 50 minutes. After processing as above, there was isolated 0.55 g. of **methyl $\Delta^{9(11)}$-dehydrodiacetylqueretaroate**, m.p. 203–206°, λ_{max}^{EtOH} 286 mμ, log ϵ 3.94.

Anal. Calcd. for $C_{35}H_{52}O_6$: C, 73.91; H, 9.22. Found: C, 74.22; H, 9.07.

Methyl 3β,30-Diacetoxy-$\Delta^{9(11),13(18)}$-oleadiene-12,19-dione-28-oate (IVa).—Various attempts to eliminate formaldehyde[19] either under alkaline (room temperature, refluxing or sealed tube) or acid conditions (sealed tube) failed since no trace could be observed with the chromotropic acid reagent.

The above diacetoxy diketodiene IVa (700 mg.) was left at room temperature overnight with 200 cc. of 5% methanolic potassium hydroxide, and the reaction mixture was then partitioned into neutral (125 mg., m.p. 258–261°) and acidic portions. The latter was directly methylated with diazomethane, whereupon 300 mg. of crystals, m.p. 258–269°, was obtained, which proved to be identical with the neutral product. Recrystallization from hexane–chloroform furnished the analytical sample, m.p. 263–265°, $[\alpha]_D$ −169°; λ_{max}^{EtOH} 280 mμ, log ϵ 4.02; λ_{max}^{nujol} 5.80, 5.96, 6.05 and 6.19 μ (absence of 8.0 acetate band)

Anal. Calcd. for $C_{31}H_{44}O_6$: C, 72.62; H, 8.65. Found: C, 73.33; H, 8.84.

A 300-mg. sample of IVb was oxidized with 300 mg. of chromium trioxide in 90 cc. of glacial acetic acid at room temperature overnight. Essentially all of the product represented an acidic, yellowish glass, but numerous attempts at crystallizing it failed. When the product after the crystallization attempts was again partitioned between chloroform and alkali, it now proved to be neutral, and it is most probable that the intermediate acid IVc suffered decarboxylation during the crystallization attempts. The neutral product was chromatographed on alumina and eluted with hexane–benzene mixtures and with pure benzene. Recrystallization from acetone–ether led to 150 mg. of a crystalline product, most likely the **30-nor-3,12,19-trione IVd**, which exhibited m.p. 269–272°, $[\alpha]_D$ −96°; λ_{max}^{EtOH} 276 mμ, log ϵ 3.92; $\lambda_{max}^{CHCl_3}$ 5.76, 5.86, 6.02 and 6.12 μ.

Anal. Calcd. for $C_{30}H_{40}O_5$: C, 74.97; H, 8.39. Found: C, 74.20; H, 8.29.

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[23] Contamination with a certain amount of the mixed anhydride (of acetic acid and Id) was indicated by an infrared carbonyl band at 5.51 μ.

[24] Using identical conditions, 1 g. of methyl acetyl oleanolate yielded 0.52 g. of the corresponding bromo-triene, m.p. 232–235°, $[\alpha]_D$ +391°, λ_{max}^{EtOH} 310 mμ, log ϵ 3.94.

Anal. Calcd. for $C_{33}H_{47}BrO_4$: C, 67.45; H, 8.07; Br, 13.64. Found: C, 67.82; H, 8.56; Br, 13.44.

A similar product was obtained by G. T. Newbold and F. S. Spring (*J. Chem. Soc.*, 533 (1944)) with β-amyrin benzoate.