103. *Sapogenins. Part XIV. The Constitution of Glycyrrhetic Acid and its Relation to Oleanolic Acid.*

By PHILIP BILHAM, GEORGE A. R. KON, and WALTER C. J. ROSS.

Glycyrrhetic acid has been converted into *deoxydeoxoglycyrrhetic acid*, unimolecular films of which have a limiting area of only 46 sq. A.; the carboxyl group in this acid must therefore be attached to a terminal ring of the hydropicene skeleton, namely, at C_{20} in ring E. The new acid is thus epimeric with γ-oleananic acid, and deoxoglycyrrhetic acid with oleanolic acid.

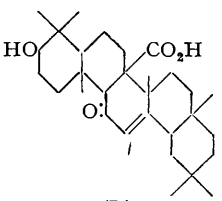
Acetylketo-oleanolic acid, which is known to be closely related to glycyrrhetic acid, has been pyrolysed and the resulting ketone, *oleadienone* II, reduced to *oleadienol* II. This alcohol gives unimolecular films of small area, indicating that the polar group, representing the carbonyl group of the parent acid, is situated in one of the end rings; this is to be expected on the basis of the formula (XIII) for the keto-acid, but is incompatible with formulæ based on the structure (II) previously assigned to oleanolic acid.

The dehydro-acid obtained by the reduction of keto-oleanolic acid (Kitasato, *Acta Phytochim.*, 1934—5, **8**, 1) is shown to be identical with the product obtained by the dehydration of methyl acetyloleanolate with selenium dioxide (Ruzicka, Grob, and Sluys-Veer, *Helv. Chim. Acta*, 1939, **22**, 788) and subsequent hydrolysis.

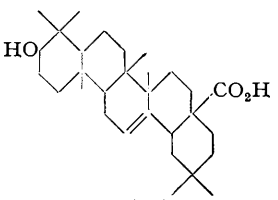
Glycyrrhetic acid has been similarly reduced to *dehydrodeoxoglycyrrhetic acid* (dehydro*epi*oleanolic acid), the *methyl* ester of which has been acetylated to an *ester* identical with that obtained by the oxidation of acetyldeoxoglycyrrhetic ester with selenium dioxide. This dehydro-ester has an absorption spectrum indistinguishable from that of methyl acetyldehydro-oleanolate and of acetyldehydroamyrin (Picard and Spring, J., 1941, 35). There can be little doubt that all these compounds have a similar structure, from which it follows that the carbonyl group of glycyrrhetic acid occupies the same position as that of keto-oleanolic acid; these two compounds are regarded as the epimeric forms of the same structure (XIII).

GLYCYRRHETIC acid, the sapogenin of liquorice root, is probably the most interesting compound of those now examined because its constitution, already largely elucidated by Ruzicka and his collaborators, affords a test of the conclusions reached in the previous papers of this series regarding the position of the carboxyl group in triterpene acids of the β-amyrin group.

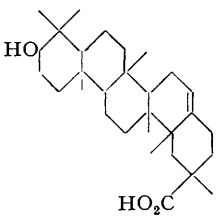
It is a hydroxy-keto-acid $C_{30}H_{46}O_4$; the carbonyl group is inert and the double bond occupies a position αβ with respect to it, giving rise to a characteristic absorption spectrum (Ruzicka, Leuenberger, and Schellenberg, *Helv. Chim. Acta*, 1937, **20**, 1271). The carbonyl group is reduced to methylene by catalytic reduction and the resulting deoxoglycyrrhetic acid can be converted into β-amyrin (Ruzicka and Marxer, *ibid.*, 1939, **22**, 195). It follows from this that deoxoglycyrrhetic acid and oleanolic acid, which has been similarly converted into β-amyrin (Ruzicka and Schellenberg, *ibid.*, 1937, **20**, 1553), are identical except for the position of the carboxyl group, which is represented in β-amyrin by a methyl group. Taking into account its behaviour on dehydrogenation, and also the ready hydrolysis of glycyrrhetic esters, Ruzicka and Marxer formulate glycyrrhetic acid as (I), oleanolic acid being represented by (II).



(I.)



(II.)

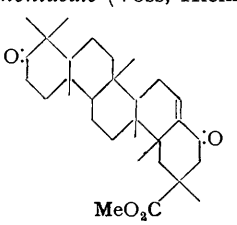


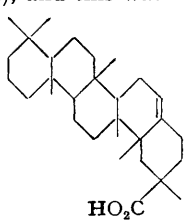
(III.)

Bilham and Kon (*Nature*, 1941, **147**, 745; J., 1941, 552) have suggested that the carboxyl group of oleanolic acid should be placed on C_{20} in ring E, and a further revision of its constitution (preceding paper) leads to the structure (III).

Now it should be an easy matter to distinguish between a compound of the latter formula and one such as (I) by the surface-film method, after elimination of the hydroxyl and keto-groups: the structure with the carboxyl in the middle of the molecule will give films of large area of the order of 120 sq. A., with the molecule lying flat on the water surface, whereas one with the carboxyl group at one end of the molecule, like (III), will give films of comparatively small area.

Methyl glycyrrhetate, the starting point of our investigation, was prepared by the alcoholysis of commercial *glycyrrhizinum ammoniacale* (Voss, Klein, and Sauer, *Ber.*, 1937, **70**, 122), and this was oxidised with chromic

(IV.)




(V.)

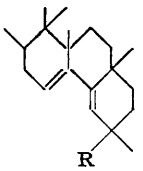
acid, giving the *diketo-ester*, m. p. 238—240°, which is now formulated as (IV). This compound had been obtained on a small scale by Bergmann and Bergmann (*Biochem. Z.*, 1933, **267**, 296) both by this method and

by the distillation of methyl glycyrrhetate with copper bronze, but its nature was apparently not realised. The diketo-ester is not reduced on heating with 50% hydrazine hydrate and sodium ethoxide, but undergoes hydrolysis and isomerisation; the *diketo-acid* still retains the system of conjugated double bonds originally present, as shown by its absorption spectrum, and is characterised by an *ester*, m. p. 232—234°, depressed by admixture of the original diketo-ester. The resistance of the carbonyl groups of the latter ester to reduction is only apparent and the diketo-ester is easily reduced by the Clemmensen method, giving *methyl deoxydeoxoglycyrrhetate*; this is hydrolysed by means of alkali under pressure to the *acid*, m. p. 303—306°, (V).

The acid forms solid films of good stability, withstanding a pressure of 14 dynes/cm. before collapse, and showing the phenomenon of spontaneous contraction. The value for the limiting area is 46 sq. A. and for μ 268 e.s.u. $\times 10^{-21}$; these constants are of the same order as those found for β- and γ-oleananic acids (Bilham and Kon, *loc. cit.*), hedraganic acid, ursanic acid, and dihydrobetulanic acid (Bilham, Kon, and Ross, this vol., p. 35). The small limiting area observed is incompatible with any formula such as (I) and suggests that in glycyrrhetic acid also the carboxyl group is situated in a terminal ring.

This cannot be ring A because glycyrrhetic acid is capable of forming a lactone (Ruzicka and Marxer, *loc. cit.*) and the carboxyl group must therefore be situated in reasonable proximity to the double bond. The only possible point of attachment for the carboxyl group becomes C_{20} in ring E, from which it follows that deoxydeoxoglycyrrhetic acid is epimeric with one of the oleananic acids (doubtless the γ-acid), and deoxoglycyrrhetic acid with oleanolic acid; the pairs of epimerides become identical when the carboxyl group is replaced by methyl.

It is hoped to obtain an independent proof of this important point by a chemical method, using a reaction which will destroy the configuration about C_{20}. One such reaction, analogous to the conversion of abietic acid into methyl abietin (Ruzicka, de Graaff, and Müller, *Helv. Chim. Acta*, 1932, **15**, 1300), is now being explored. An alternative method, though unsuccessful, has yielded results of some interest. Methyl acetyloleanolate gives on treatment with selenium dioxide a dehydro-ester, in which the new double bond is conjugated with that originally present, giving rise to an absorption spectrum with a maximum at 2500 A. (Ruzicka, Grob, and Sluys-Veer, *Helv. Chim. Acta*, 1939, **22**, 788).* The discoverers formulated this compound as having both double bonds in one ring, but there can be little doubt, from the position of the absorption maximum, that the double bonds must be distributed between two rings, as in the analogous compound derived from β-amyrin (Ruzicka, Müller, and Schellenberg, *ibid.*, p. 767). Dehydro-β-amyrin (amyradienol II) is formulated as (VII, R = Me) on the basis of the older structural formulæ (Picard and Spring, J., 1941, 35) and the dehydro-ester would then be (VII, R = CO_2Me). The elimination of the carbomethoxy-group from the latter compound will give rise to the compound (VIII), which should be identical with norechinocystadienol, recently obtained by Noller and Carson (*J. Amer. Chem. Soc.*, 1941, **63**, 2238) by the loss of carbon dioxide and water from echinocystic acid. The formation of this compound follows naturally from the formula (IX) put forward



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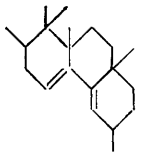
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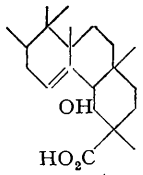
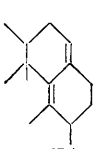
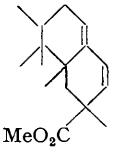


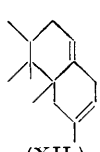
(IX.)

for echinocystic acid by Bilham and Kon (*loc. cit.*), and, in particular, the position of the second double bond. On the other hand, the new formulation (III) now adopted by us leads to the partial formula (X) for norechinocystadienol, the formation of which must involve a retropinacolic migration of an angular methyl group, whilst the dehydro-compounds formed with selenium dioxide will have the alternative structure (XI). A difference of structure is, indeed, made probable by an unmistakable difference in the absorption maxima: norechinocystadienol has a maximum at 2410 (Noller and Carson, *loc. cit.*, confirmed by us) or nearly 100 A. further from the visible end of the spectrum. Moreover, the spectra of the dehydro-dompounds have a distinct secondary maximum at *ca.* 2600 A. (see fig.).


(X.)



(XI.)

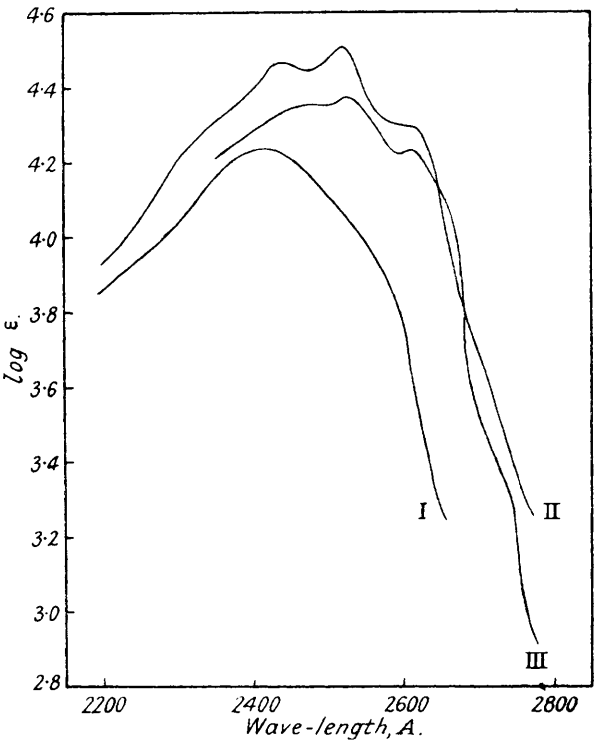

(XII.)

The dehydro-ester, now represented by the partial formula (XI), is easily hydrolysed to the corresponding *hydroxy-acid*, which has a similar absorption spectrum, and loses carbon dioxide on heating. The product,

* A curious discrepancy has been noted between the results reported in this paper and our own observations: the acetyl dehydro-ester is described as having a rotation of + 137°, whereas the other compounds of this type are lævorotatory, and this point receives comment. It is now found that the rotation of the acetyl ester prepared by the selenium dioxide method is — 133°, and a specimen with $[\alpha]_D$ — 130° has also been obtained from siaresinolic acid (Part XV).

oleadienol I, is evidently formed with a simultaneous shift of a double bond because it is optically transparent; the presence of two double bonds is shown by its reaction with perbenzoic acid. Oleadienol I probably has the structure (XII); the movement of the double bond towards the α-carbon is the rule in the decarboxylation of βγ-mono-olefinic acids (compare, *e.g.*, the formation of methylene*cyclo*hexane from Δ¹-*cyclo*hexenylacetic acid; Wallach, *Annalen*, 1907, **353**, 287), but we are not aware of its occurrence in diolefinic acids.

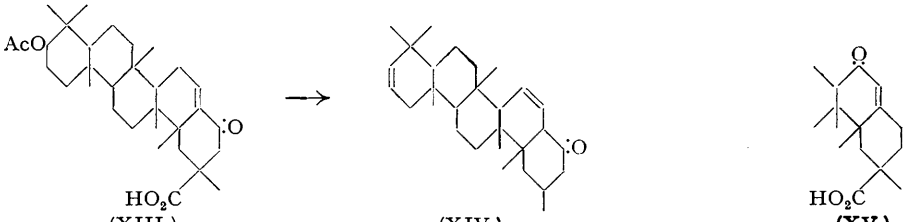
Now, if the movement of the double bond which destroys the original system of conjugated double bonds is correctly formulated above, it should be possible to obtain oleadienol I (XII) from glycyrrhetic acid. Methyl acetylglycyrrhetate is converted into the deoxo-ester (methyl acetyl*epi*oleanolate) by the Clemmensen method, which is simpler than the catalytic reduction originally used by Ruzicka, Leuenberger, and Schellenberg (*loc. cit.*) and gives an equally good yield. The deoxo-ester reacts with selenium dioxide to give a good yield of the *dehydro-ester*, which has an absorption spectrum indistinguishable from that of the ester (XI) (see fig.). The *hydroxy-dehydro-acid* is obtained from it on hydrolysis, but it does not lose the carboxyl group even on strong heating.



I. *Echinocystadienol.*
II. *Methyl acetyldehydrodeoxoglycyrrhetate.*
III. *Methyl acetyldehydro-oleanolate.*

A similar difficulty in removing the carboxyl group is experienced with deoxydeoxoglycyrrhetic acid and also with glycyrrhetic acid itself and appears to be characteristic of the whole series. This failure precluded the production of ketones (or alcohols) which could be used to determine the position of the carbonyl group of glycyrrhetic acid by the surface film method.

This has been successfully achieved with acetylketo-oleanolic acid. This acid is very similar to acetylglycyrrhetic acid; like the latter, it is an αβ-unsaturated ketone, it is produced by the oxidation of acetyloleanolic acid under the conditions used to convert acetyldeoxoglycyrrhetic acid into acetylglycyrrhetic acid (Ruzicka and Marxer, *loc. cit.*), and it has been suggested that the carbonyl group must occupy a similar position, β or γ with respect to the carboxyl, because the esters of glycyrrhetic and keto-oleanolic acids are equally readily hydrolysed (Ruzicka, Leuenberger, and Schellenberg, *loc. cit.*); in the light of the present work there is little doubt that these two acids are epimeric about C_{20} and are both represented by formula (XIII).



(XIII.) (XIV.) **(XV.)**

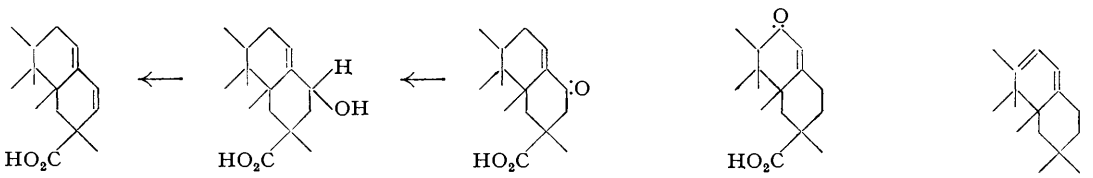
Acetylketo-oleanolic acid, on heating in a sealed tube, loses carbon dioxide and acetic acid (compare the formation of oleanylene II from acetyloleanolic acid; Kitasato, *Acta Phytochim.*, 1934—5, **8**, 207), forming *oleadienone II*. The change is evidently accompanied by the migration of a double bond because the ketone is optically transparent. It is probably represented by formula (XIV), although the position of the double bond cannot be regarded as certain.

The ketone does not form satisfactory films, but the *alcohol* obtained by reduction with sodium and alcohol (*oleadienol II*) gives solid films with a limiting area of 41 sq. A., which is the smallest area yet observed in a triterpene derivative; μ is 117 e.s.u. × 10^{-21}. This clearly indicates that the hydroxyl group, derived from the carbonyl group of acetylketo-oleanolic acid, occupies a position in one of the end rings of the polycyclic system; it appears to exclude a position in ring D, which could be derived from formula (III) by placing the carbonyl group as in the partial formula (XV).

The decarboxylation of acetylketo-oleanolic acid has already been carried out by boiling with quinoline, an acetoxyketone with an additional double bond being obtained (Ruzicka, Cohen, Furter, and Sluys-Veer, *Helv. Chim. Acta*, 1938, **21**, 1735). It was hoped that this compound would prove useful in the elucidation of

the structure of the dehydro-compounds. The *compound* obtained, however, melted higher than the required ketone and differed from it in being optically transparent; it is clear that the elimination of the carboxyl group had been accompanied by the movement of the double bond, destroying the conjugated system originally present, just as in the formation of oleadienone II, and a new double bond had not been introduced. The new ketone is evidently the 2-*acetoxy*-compound corresponding to oleadienone II.

Whilst it has not proved possible to obtain analogous compounds from glycyrrhetic acid owing to its resistance to decarboxylation, proof of the complete analogy in structure of this acid and keto-oleanolic acid was obtained by the following reactions: keto-oleanolic acid was reduced with sodium in alcoholic solution to the dehydro-acid, which is doubtless identical with the dehydro-acid already obtained by means of sodium amalgam reduction by Kitasato (*Acta Phytochim.*, 1934—5, **8**, 1; *loc. cit.*). This acid has also been found to be identical with the dehydro-oleanolic acid (XI) prepared by the selenium dioxide process, which has already been discussed above; the formation of it follows naturally from the formula (XIII) for the keto-acid, but would be difficult to interpret on the basis of the structure (XV); it also affords conclusive evidence of the position of the double bond adopted in that formula as against a position in the middle of the molecule, as in (II).



(XV.) (XVI.)

Glycyrrhetic acid was similarly reduced and gave a diene-acid which was isolated in the form of its *methyl* ester; the *acetyl* derivative of this proved to be identical with the acetyl dehydro-ester obtained by the selenium dioxide oxidation of deoxoglycyrrhetic ester. The behaviour of glycyrrhetic acid in this reaction is thus an exact parallel to that of keto-oleanolic acid and leaves little room for doubt that their structures are similar.

The formation of the diene acids from keto-oleanolic and glycyrrhetic acid described above is also analogous to the formation of dehydro-β-amyrin (amyradienol II) from keto-β-amyrin (Picard and Spring, *loc. cit.*) and appears to afford a proof that the double bond and the keto-group in all these compounds must be situated in different rings. The formation of the isomeric compound with two double bonds in one ring (amyradienol I), which is probably represented by the structure (XVI), still awaits a satisfactory explanation.

Experimental.

M. p.'s were determined in sealed capillaries and are uncorrected; unless otherwise stated, analysis specimens were dried for 2 hours at 100°/1—2 mm.; rotations were determined in chloroform solution; the technique of surface-film measurements was that described in Part XI (J., 1941, 552).

Methyl Glycyrrhetate.—50 G. of *Glycyrrhizinum ammoniacale* (British Drug Houses Ltd.) were refluxed with 300 c.c. of 3% methyl-alcoholic hydrogen chloride, the solution evaporated to dryness under reduced pressure, the residue extracted with ether, and the dark extract passed through a long column of activated alumina, on which a deep yellow band formed near the top. The methyl ester, m. p. 222—224°, was recovered from the filtrate and crystallised by solution in warm acetone and addition of water until a turbidity appeared.

Diketo-ester (V).—4·25 G. of methyl glycyrrhetate in 116 c.c. of AnalaR acetic acid were gradually treated with 12·3 c.c. of Kiliani's chromic acid solution at room temperature. After ½ hour methyl alcohol was added, and the solution warmed to destroy the excess of reagent, then diluted with its own volume of water. On cooling, the new *ester* (60% yield) crystallised; if more water was added to precipitate the product completely, a gum was obtained. The diketo-ester crystallised from methyl alcohol in plates, m. p. 238—240° (Found: C, 76·8; H, 9·5. $C_{31}H_{46}O_4$ requires C, 77·1; H, 9·6%).

500 Mg. of the diketo-ester were heated for 12 hours with 2·25 c.c. of 50% hydrazine hydrate and 400 mg. of sodium in 8 c.c. of alcohol in a sealed tube at 200°. The product was diluted (no precipitate formed at this stage), acidified, and extracted with ether. The *acid* crystallised from methyl alcohol and melted at 325° (Found: C, 77·1; H, 9·5. $C_{30}H_{44}O_4$ requires C, 76·9; H, 9·5%); the light absorption in ethyl alcohol showed a band with a maximum at 2440, log $\epsilon_{max.}$ 4·20; it was re-esterified with diazomethane and gave a *methyl* ester, m. p. 245—247° after crystallisation from methyl alcohol, depressed by admixture of the original diketo-ester (Found: C, 77·5; H, 9·6. $C_{31}H_{46}O_4$ requires C, 77·1; H, 9·6%).

Deoxydeoxoglycyrrhetic Acid.—1·3 G. of the diketo-ester were boiled for ½ hour with 140 c.c. of acetic acid, 35 c.c. of hydrochloric acid, and 60 g. of amalgamated zinc. The solution was diluted and extracted with light petroleum (b. p. 60—80°), the extract being percolated through a 15 cm. column of activated alumina, which was then washed with the pure solvent until no more crystalline material was eluted (yield, 520 mg.); the *methyl* ester formed sparkling plates, m. p. 182°, after two crystallisations from methyl alcohol (Found: C, 81·7; H, 11·2. $C_{31}H_{50}O_2$ requires C, 82·0; H, 11·2%). 520 Mg. of the ester were heated for 4 hours with 52 c.c. of 20% potassium hydroxide in 85% alcohol in two sealed tubes at 170°. The product was diluted, acidified, and extracted with ether, the acid re-extracted by repeated shaking with 10% sodium hydroxide solution, and the alkaline extract acidified and extracted with ether. The *acid* crystallised in contact with methyl alcohol and was recrystallised by solution in acetone–ether and evaporation of the ether; it formed iridescent plates, m. p. 303—305° (Found: C, 82·1; H, 10·9. $C_{30}H_{48}O_2$ requires C, 81·8; H, 11·0%).

Methyl Acetyldeoxyglycyrrhetate.—Crude methyl glycyrrhetate (13 g.) was boiled with 130 c.c. of acetic anhydride and 1 g. of fused sodium acetate for an hour, and the solution then gradually diluted with water, giving 3·7 g. of crystalline acetyl ester, m. p. above 280°; a little more could be recovered by further dilution of the mother-liquor.

The acetyl ester was reduced by the Clemmensen method as described above, only half the amounts of reagents being used; the product, purified in the same way and crystallised from acetone, had m. p. 254—255°, depressed by the starting material (lit., 265° corr.).

Methyl Acetyldehydrodeoxoglycyrrhetate.—1·25 G. of the above ester were boiled for 48 hours with 75 c.c. of acetic acid and 0·6 g. of selenium dioxide. The solution was evaporated to dryness under reduced pressure, the residue extracted with ether, and the solution filtered from selenium and again evaporated to dryness. The residue was dissolved in benzene and percolated through a short column of activated alumina. The recovered *ester* crystallised from chloroform–methyl alcohol in iridescent plates (600 mg.), m. p. 230—231°, $[\alpha]_D$ − 32° (c = 0·73) (Found: C, 77·9; H, 9·9. $C_{33}H_{50}O_4$ requires C, 77·6; H, 9·8%).

Dehydrodeoxoglycyrrhetic Acid.—The above acetyl ester was hydrolysed as described on p. 538. The *acid* formed needles from acetone, m. p. above 305° (Found: C, 79·5; H, 10·1. $C_{30}H_{46}O_3$ requires C, 79·3; H, 10·1%). All attempts to remove the carboxyl group of this acid by heating alone or with quinoline and copper powder were unsuccessful.

The same acid was also obtained when a boiling solution of glycyrrhetic acid in 200 vols. of alcohol was gradually saturated with sodium. The oily acid recovered by dilution, acidification, and extraction with ether crystallised in contact with methyl alcohol. It was esterified with diazomethane; the *methyl* ester formed small plates, m. p. 262—263° after two crystallisations from methyl alcohol, and gave a brown colour with tetranitromethane in chloroform (Found: C, 79·3; H, 10·5. $C_{31}H_{48}O_3$ requires C, 79·4; H, 10·3%). For identification the ester was dissolved in 20 parts of warm pyridine–acetic anhydride (1 : 1) and left at room temperature. After some hours the characteristic iridescent plates of the acetyl ester began to separate. Water was added, and the precipitated ester crystallised once from methyl alcohol. It had m. p. 229—230°, not depressed by the ester obtained as above.

Bromination of Methyl Acetylglycyrrhetate.—Methyl acetylglycyrrhetate (220 mg.) in 6·6 c.c. of acetic acid was kept at 85—95° while 2·35 c.c. of 3% bromine in acetic acid were added dropwise. The solid which separated on cooling was recrystallised from methyl alcohol, giving long needles, m. p. 210—215°. It contained halogen and was not the expected dehydro-compound. Attempts to debrominate it did not lead to crystalline products.

Dehydro-oleanolic Acid.—(1) Methyl acetyldehydro-oleanolate was prepared as described by Ruzicka, Grob, and Sluys-Veer (*loc. cit.*; compare also above). The acetyl ester had m. p. 225°, $[\alpha]_D$ − 133° (c = 1·53) (absorption spectrum in the fig.); it was hydrolysed under pressure as described above. The *hydroxy-acid* crystallised from methyl alcohol in hexagonal plates, m. p. 274—275° (Found: C, 79·0; H, 10·3. $C_{30}H_{46}O_3$ requires C, 79·3; H, 10·1%). (2) Keto-oleanolic acid (see below) was reduced with sodium and alcohol exactly as described above. The acid recovered had m. p. 270—271°, not depressed by the acid prepared by method (1); it gave an ester, m p. 164°, not depressed by the ester, m. p. 166—167°, prepared by mild hydrolysis of the acetyl ester obtained by method (1) (compare Ruzicka *et al.*, *loc. cit.*).

Oleadienol I.—The dehydro-acid was heated until it was just melted, dissolved in ether, freed from acid by shaking with alkali, and the ether evaporated. The residue was repeatedly crystallised from methyl alcohol, the m. p. gradually rising to 218—219°. The *compound* evidently contained methyl alcohol of crystallisation (compare norechinocystadienol; Noller and Carson, *loc. cit.*, and this paper), $[\alpha]_D$ + 97° (c = 2·19 in dioxan) (Found: C, 81·5, 81·8; H, 11·7, 11·2. $C_{29}H_{46}O,CH_4O$ requires C, 81·4; H, 11·3%). The substance was purified by chromatographic adsorption from a benzene solution, but its properties were not appreciably changed. Titration with perbenzoic acid indicated 1·85 double bonds, a specimen of oleanolic acid titrated at the same time showing 0·8 double bond. It was recovered unchanged after an alcoholic solution had been shaken with hydrogen and Adams's catalyst. The acetate prepared by means of acetic anhydride and pyridine in the cold crystallised from methyl alcohol in needles, m. p. 186—188°, $[\alpha]_D$ + 87° (c = 1·74 in dioxan).

Acetylketo-oleanolic Acid. The oxidation of acetyloleanolic acid was carried out according to Ruzicka, Cohen, Furter, and Sluys-Veer (*loc. cit.*). The acid recovered from the sodium salt and crystallised from methyl alcohol–ether had m. p. 288° (lit., 282—284° corr.), together with a more soluble fraction, m. p. 264°; the latter also had the characteristic absorption of an $\alpha\beta$-unsaturated ketone with a maximum at 2510 A., log $\varepsilon_{max.}$ 4·1.

Decarboxylation. The acid, m. p. 288°, was decarboxylated in boiling quinoline as described by Ruzicka *et al.* (*loc. cit.*). The *product* was crystallised from methyl alcohol; it sintered at 222°, but did not melt completely until 235—240°, and gave a yellow colour with tetranitromethane (Found: C, 79·6; H, 10·3. $C_{31}H_{48}O_3$ requires C, 79·4; H, 10·3%). The same product, evidently an acetoxy-ketone, was also obtained from the lower-melting specimen of the keto-acid. A small amount of the acetoxy-ketone was reduced with 90% hydrazine hydrate and sodium ethoxide as described on p. 538; the resulting compound crystallised from methyl alcohol in needles, m. p. 217—219°, depressed by oleanol (m. p. 220—222°).

Oleadienone II.—Acetylketo-oleanolic acid was kept in a sealed Pyrex tube at 340° for an hour (nitrate bath). *Oleadienone II* crystallised from methyl or ethyl alcohol in pearly plates, m. p. 209—210°, raised to 210—212° by a final crystallisation from light petroleum (b. p. 60—80°); it gave a yellow colour with tetranitromethane (Found: C, 85·2; H, 10·8. $C_{29}H_{44}O$ requires C, 85·3; H, 10·9%).

Oleadienol II.—The ketone was reduced with sodium and alcohol as described above. The *alcohol*, crystallised from methyl alcohol and finally from light petroleum, formed needles, m. p. 219—221° (Found: C, 84·7; H, 11·5. $C_{29}H_{46}O$ requires C, 84·8; H, 11·3%).

Norechinocystadienol.—Our preparation of this compound was completed before the appearance of the paper by Noller and Carson (*loc. cit.*) and our results agree well with theirs. The highest m. p. observed by us was 191°; we were unable to obtain good analytical figures for the pure compound, but the product containing methyl alcohol of crystallisation was satisfactorily analysed (Found: C, 81·7, 81·8; H, 11·1, 10·9. $C_{29}H_{46}O,CH_4O$ requires C, 81·4; H, 11·3%). The *acetate* formed plates from methyl alcohol, m. p. 175—177°, $[\alpha]_D$ + 46° (c = 1·63 in dioxan) (Found: C, 82·1; H, 10·9. $C_{31}H_{48}O_2$ requires C, 82·2; H, 10·7%).

The authors' thanks are due to Dr. R. H. Kerlogue for the absorption spectra, to the Royal Society for a grant, and to Messrs. Whiffen and Sons, Ltd., for a gift of residues from the manufacture of clove oil.

Laboratories of J. Lyons and Co., Ltd., 149 Hammersmith Road, London, W.14.
Imperial College of Science and Technology, London, S.W.7.

[*Received, April 27th,* 1942.]