On the Oxidation of Hydrazones by Lead Tetra-acetate

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The oxidation of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate gave, after acetylation, 3β-acetoxylanost-7-ene and, as major product, 3β,7α-diacetoxylanostane. The corresponding oxidation of 3β-hydroxylanost-24-en-7-one hydrazone gave 3β-hydroxylanosta-7,24-diene and, as main product, 3β-hydroxy-7α-acetoxylanost-24-ene. The corresponding reactions of benzophenone hydrazone, dicyclohexyl ketone hydrazone, and camphor hydrazone were also investigated in order to examine the mechanism of the oxidation.

The related oxidations of benzophenone hydrazone and 3β-hydroxylanostan-7-one hydrazone with perbenzoic acid are also described.

The lead tetra-acetate oxidation of hydrazones is, in certain cases, a synthetically useful reaction.

THE removal of the C-14 methyl group of lanosterol during cholesterol biogenesis involves a stepwise oxidation of the methyl group terminating in decarboxylation.[1] Relevant syntheses of lanosterol derivatives with the C-14 methyl group in various oxidation states have recently been reported.[2,3] Such syntheses all require the prior introduction of a 7α-hydroxy-group into the

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[1] (*a*) F. Gautschi and K. Bloch, *J. Biol. Chem.*, 1958, **233**, 1343; (*b*) J. A. Olson, jun., M. Lindberg, and K. Bloch, *ibid.*, 1957, **226**, 941.

[2] (*a*) J. Fried, J. W. Brown, and M. Applebaum, *Tetrahedron Letters*, 1965, 489; (*b*) J. Fried, J. W. Brown, and L. Borkenhagen, *ibid.*, p. 2499; (*c*) C. W. Shoppee, J. C. Coll., N. W. Hughes, and R. E. Lack, *ibid.*, p. 3249; (*d*) J. Fried and J. W. Brown, *ibid.*, 1966, 1677; (*e*) C. W. Shoppee, N. W. Hughes, and R. E. Lack, *J. Chem. Soc.* (*C*), 1966, 2359.

[3] (*a*) T. J. Bentley, J. F. McGhie, and D. H. R. Barton, *Tetrahedron Letters*, 1965, 2497; (*b*) D. H. R. Barton, A. Hameed, and J. F. McGhie, *ibid.*, p. 4343.

lanosterol system. We have recently reported [4] a novel method for the preparation of 7α-acetoxy-derivatives *via* lead tetra-acetate oxidation of the corresponding 7-*ketone* hydrazones. We now present a full report of our investigations of the scope and mechanism of this reaction.

3β-Hydroxylanostan-7-one [5] (prepared by the improved procedure given in the Experimental section) (Ia) was converted into the hydrazone (IIa). This was characterised as the *N*-acetyl derivative. The hydrazone (IIa) reacted with lead tetra-acetate in methylene chloride at room temperature with rapid evolution of nitrogen. Acetylation of the product followed by chromatography gave 3β-acetoxylanost-7-ene (20%) (IIIa; $R^1 = Ac$) and 3β,7α-diacetoxylanostane (68%) (IVa; $R^1 = Ac$). Both compounds were characterised by comparison with authentic samples.[5]

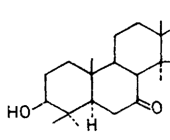
Similarly 3β-hydroxylanost-24-en-7-one (Ib) gave the hydrazone (IIb) which reacted with lead tetra-acetate in methylene chloride to give 3β-hydroxylanosta-7,24-diene (IIIb; $R^1 = H$) (20%) and 3β-hydroxy-7α-acetoxylanost-24-ene (IVb; $R^1 = H$) (68%).

With the knowledge that this reaction constituted a useful method for the preparation of 7α-acetoxylanostanes, particularly when unsaturated in the side chain, we investigated the variation in yields of the olefin and acetate in different solvents. The results are shown in Table 1. Except in the case of methanol, little variation of yield with solvent was observed. In the case of methanol a third non-crystalline compound was obtained. By analogy with the work of Norman [6] on the lead tetra-acetate oxidation of substituted hydrazones in alcoholic solvents it seems likely that this product is a 7-methoxy-compound (V).

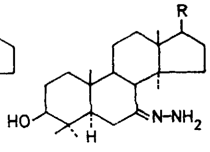
TABLE 1

Solvent		Yield of olefin (IIIa; $R^1 = Ac$) (%)	Yield of acetate (IVa; $R^1 = Ac$) (%)
Acetic acid		13	70
Benzene		15	70
Methylene chloride	0°C	18	70
	20°C	18	68
	40°C	20	68
Light petroleum (b.p. 40—60°C)		14	75
Methanol		18	45
Dimethylacetamide		15	63

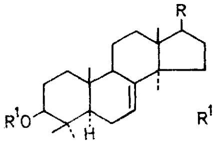
There appear to be two distinct pathways which could explain the formation of the products from the oxidation of hydrazones with lead tetra-acetate. Iffland and his co-workers [7] have shown that substituted hydrazones react with lead tetra-acetate to give α-acetoxy-azo-compounds. The reaction has been interpreted as involving a cyclic mechanism [6,8] (VI) ⟶ (VIII). By analogy it is conceivable that in the reaction of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate both the olefin (IIIa) and the acetate (IVa) are formed *via* pathway A. The known preference for attack on the α-face of the sterol molecule, coupled with the large steric requirements of the intermediate (IX) would explain the formation of the 7α-acetoxy-derivatives. Indeed, such considerations were the basis of our original conception of this improved 7α-acetoxy-group synthesis.



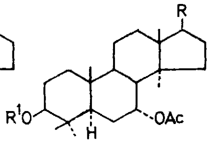
(I) a; $R=C_8H_{17}$
b; $R=C_8H_{15}$



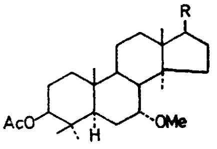
(II) a; $R=C_8H_{17}$
b; $R=C_8H_{15}$



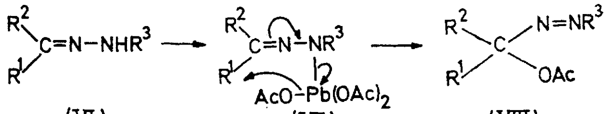
(III) a; $R=C_8H_{17}$
b; $R=C_8H_{15}$



(IV) a; $R=C_8H_{17}$
b; $R=C_8H_{15}$



(V) $R=C_8H_{17}$



(VI) (VII) (VIII)

An alternative mechanism involves initial oxidation of the hydrazone to the diazo-compound (XII) (a ready reaction observed with many simple oxidising agents [9]) followed by reaction of the diazo-compound with acetic acid formed in the primary oxidation step. This could lead to formation of either the acetate or the olefin as shown in pathway B. Protonation of the diazo-compound on the carbon atom from the α side would be expected to give an intermediate (XIII) identical with that obtained in the diazotization of the corresponding ' equatorial ' 7β-amine. Such diazotizations are known to give considerable amounts of products formed with retention of configuration.[10] Although we have not found any substantial quantity of the 7β-acetate, this fact alone is insufficient evidence for us to ignore this route as a reasonable reaction mechanism. The olefin (as III) in this reaction sequence is formally derivable from either the diazo-compound (XII) or its protonated form, the diazonium ion (XIII). Loss of nitrogen from the diazo-compound would yield a carbene (XIV), from which the olefin would form as a result of a 1,2-hydrogen

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[4] D. H. R. Barton, P. L. Batten, and J. F. McGhie, *Chem. Comm.*, 1969, 450.

[5] D. H. R. Barton and B. R. Thomas, *J. Chem. Soc.*, 1953, 1842.

[6] M. J. Harrison, R. O. C. Norman, and W. A. F. Gladstone, *J. Chem. Soc.* (*C*), 1967, 735.

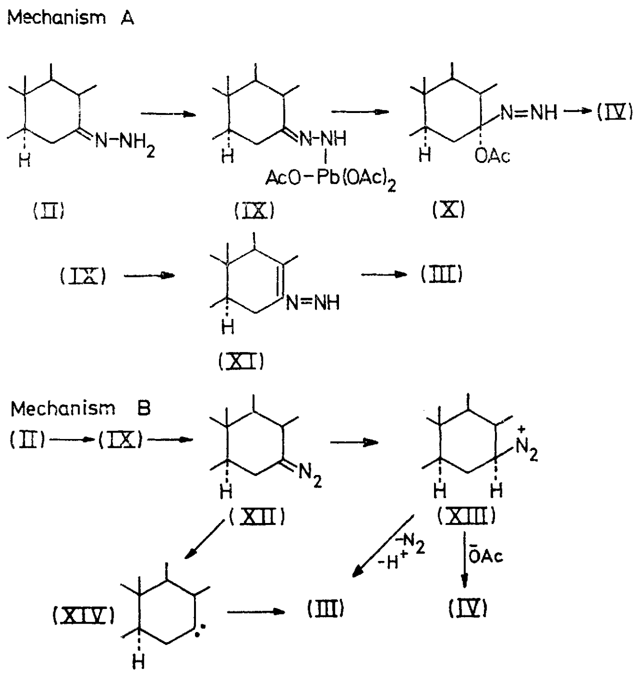
[7] D. C. Iffland and E. Gerda, *J. Amer. Chem. Soc.*, 1961, **83**, 747; *J. Org. Chem.*, 1963, **28**, 2769.

[8] R. N. Butler, *Chem. and Ind.*, 1968, 437.

[9] P. A. S. Smith, ' Open-chain Nitrogen Compounds,' Benjamin, New York, 1966, p. 165; T. L. Gilchrist and C. W. Rees, ' Carbenes, Nitrenes and Arynes,' Nelson, London, 1969, p. 12

[10] D. N. Kirk and M. P. Hartshorn, ' Steroid Reaction Mechanisms,' Elsevier, London, 1968, pp. 314—319.

shift. Alternatively, loss of nitrogen from the diazonium ion (XIII) would lead to a carbonium ion which, on proton loss, would give the olefin.



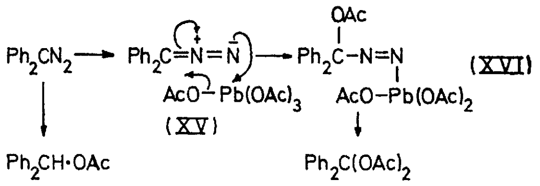
In an attempt to distinguish between these two mechanisms the lead tetra-acetate oxidation of benzophenone hydrazone was investigated. In this case, the corresponding diazo-compound, diphenyldiazomethane, is stable. Oxidation of benzophenone hydrazone with lead tetra-acetate (2 mol.) in methylene chloride immediately produced a red colouration. Disappearance of this red colouration was accompanied by evolution of nitrogen. The reaction was much slower than in the case of 3β-hydroxylanostan-7-one hydrazone. Hydrolysis of the crude reaction mixture with alkali followed by chromatographic separation afforded benzophenone (36%) and benzhydrol (52%). The corresponding oxidation of diphenyldiazomethane with lead tetra-acetate was slower. Alkaline hydrolysis followed by chromatography established the products to be benzophenone (84%) and benzhydrol (7%). This result is in agreement with the work of Hensel,[11] who found that oxidation of diphenyldiazomethane with lead tetra-acetate gave benzophenone acetal diacetate, which on alkaline hydrolysis would afford benzophenone. The reactions of benzophenone hydrazone and diphenyldiazomethane with lead tetra-acetate in the presence of varying amounts of acetic acid was also studied and the results are shown in Table 2. Increases in the molar ratio of acetic acid to lead tetra-acetate resulted in increased yields of benzhydrol from either benzophenone hydrazone or diphenyldiazomethane as substrate. Conversely, in the presence of excess of lead tetra-acetate higher yields of benzophenone resulted. Experiments were also performed in which acetate ion, in the form of tetramethylammonium acetate, was added to the reaction mixture. Although it was at first anticipated that this would result in greater yields of benzhydrol, in fact the opposite effect was observed. This can be ascribed to a reduction in the concentration of protons by displacement of the dissociation equilibrium for acetic acid. Effectively this gives a greater ratio of lead tetra-acetate to acetic acid and consequently enhanced yields of the ketone. These results are all consistent with rapid oxidation of benzophenone hydrazone to diphenyldiazomethane, followed by a slower step in which the diazo-compound is partitioned between reaction with acetic acid to give, after hydrolysis, benzhydrol, and reaction with lead tetra-acetate to give, ultimately, benzophenone. The sequence of these transformations is depicted in (XV), (XVI), and related formulae, and is consistent with pathway B.

TABLE 2

Reactions of benzophenone hydrazone and of diphenyldiazomethane with lead tetra-acetate

	$Ph_2C\colon N\cdot NH_2$		Ph_2CN_2	
Addenda (mol.)	Ph_2CO (%)	$Ph_2CH\cdot OH$ (%)	Ph_2CO (%)	$Ph_2CH\cdot OH$ (%)
$2Pb(OAc)_4$	36 (24)	52(41)	85 (63)	7 (6)
$5Pb(OAc)_4$	61 (45)	29 (21)		
$10Pb(OAc)_4$	67 (50)	18 (14)		
$2Pb(OAc)_4$–2AcOH	25 (16)	57 (49)	44 (25)	51 (36)
$2Pb(OAc)_4$–5AcOH	16 (10)	68 (52)	26 (18)	61 (47)
$2Pb(OAc)_4$–10AcOH	14 (6)	75 (58)	18 (11)	68 (52)
$2Pb(OAc)_4$–AcOH (solvent)	10 (6)	85 (65)		
$2Pb(OAc)_4$–$10Me_4\overset{+}{N}\overset{-}{O}Ac$	53 (31)	28 (22)		

Yields in parentheses are those of the corresponding 2,4-dinitrophenylhydrazone or 3,5-dinitrobenzoate.

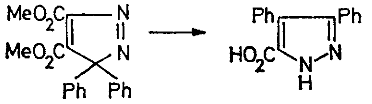


Confirmation that all the hydrazone was oxidised to the diazo-compound was forthcoming from a trapping experiment. Trial experiments with diphenyldiazomethane and various possible trapping reagents indicated that dimethyl acetylenedicarboxylate was the most efficient. Reaction of benzophenone hydrazone with lead tetra-acetate in the presence of a large excess of this ester at −20°C followed by the usual alkaline work-up gave 3,4-diphenylpyrazole-5-carboxylic acid (XVIII) in 84% yield (as estimated by u.v. spectroscopy on the crude product). The initial adduct between diphenyldiazomethane and the acetylenic ester [dimethyl 3,3-diphenyl-3*H*-pyrazole-4,5-dicarboxylate (XVII)] rearranged during alkaline hydrolysis.[12] Crystallisation of the crude product gave the pyrazole (XVIII) in 71%

[11] R. H. Hensel, *Chem. Ber.*, 1955, **88**, 257.

[12] J. Van Alphen, *Rec. Trav. chim.*, 1943, **62**, 485, 491.

yield. In a blank experiment with diphenyldiazomethane and dimethyl acetylenedicarboxylate at −20°C the yield of pyrazole (XVIII) isolated after crystallisation was 64%.



(XVII) (XVIII)

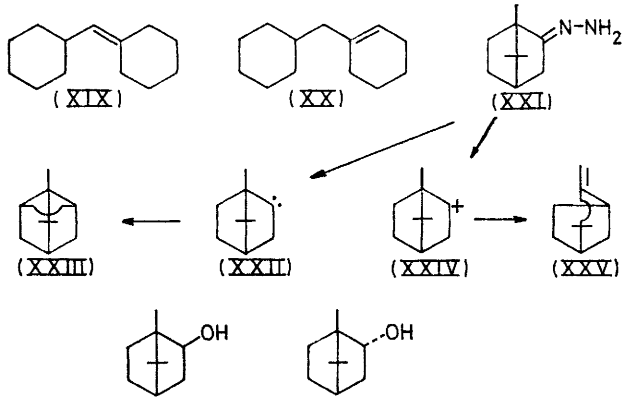
The mechanism of lead tetra-acetate oxidation of benzophenone hydrazone having been established, we returned to the triterpenoid hydrazone. The effect of changes in the concentration of lead tetra-acetate, acetic acid, and acetate ion on the oxidation of 3β-hydroxylanostan-7-one hydrazone was investigated. The results are shown in Table 3. In sharp contrast to the corresponding reactions of benzophenone hydrazone, the yields of both olefin and acetate were virtually unaffected by changes in any of the three variables. Moreover, when the reaction was conducted in the presence of a large excess of lead tetra-acetate (20 mol.), and was followed by the appropriate alkaline hydrolysis, none of the ketone, 3β-hydroxylanostan-7-one, could be detected. The same result was observed with a large excess both of lead tetra-acetate and of acetate ion. Attempts to oxidise the hydrazone to the 7-diazo-compound failed, and since it was apparent that in this case the detection and isolation of minor components of the reaction would prove difficult, we sought a simpler alicyclic system for further mechanistic studies.

TABLE 3

Reaction of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate followed by acetylation

Addenda (mol.)	Olefin (IIIa; R^1 = Ac) (%)	Acetate (IVa; R^1 = Ac) (%)
$2Pb(OAc)_4$	17	72
$2Pb(OAc)_4$–$5AcOH$	14	68
$2Pb(OAc)_4$–$10AcOH$	17	70
$2Pb(OAc)_4$–$AcOH$ (solvent)	17	70
$2Pb(OAc)_4$–$10Me_4\overset{+}{N}\overset{-}{O}Ac$	11	69
$20Pb(OAc)_4$	13	64
$20Pb(OAc)_4$–$10Me_4\overset{+}{N}\overset{-}{O}Ac$	13	62

Dicyclohexyl ketone hydrazone was suitable. It offered the advantage that the products of lead tetra-acetate oxidation were amenable to g.l.c. analysis, thus simplifying the detection and identification of trace amounts. The parent dicyclohexyl ketone was prepared by reaction of cyclohexylmagnesium chloride with ethyl formate,[13] to give dicyclohexylmethanol. Oxidation with chromium trioxide in glacial acetic acid afforded dicyclohexyl ketone, which was converted into the hydrazone. Oxidation of this hydrazone with lead tetra-acetate under the previously described conditions gave a mixture of dicyclohexylmethyl acetate (43%), dicyclohexyl ketone (2%), and the two olefins (XIX) and (XX) in yields of 46 and 8% as shown by g.l.c. analysis. The parent hydrazone contained (g.l.c. analysis) slightly less than 1% of the parent ketone. Authentic specimens of the olefins (XIX) and (XX) were prepared by the following procedures.



(XIX) (XX) (XXI)

(XXIII) (XXII) (XXIV) (XXV)

(XXVI) (XXVII)

The olefin (XIX) was obtained by a Wittig reaction. Cyclohexyl iodide and triphenylphosphine, when heated together without a solvent at 140°C for 7 hr., gave cyclohexyltriphenylphosphonium iodide.[14] This on treatment with butyl-lithium afforded the corresponding ylide,[14] which reacted smoothly with cyclohexanecarbaldehyde to furnish the required olefin (XIX) in low yield. Treatment of the olefin with boron trifluoride effected 96% isomerisation of the double bond to the endocyclic position, affording the other olefin (XX). The olefins were not interconvertible under the reaction or work-up conditions employed in the lead tetra-acetate oxidations.

The effects of changes in the concentration of lead tetra-acetate, acetic acid, and tetramethylammonium acetate on the reaction of dicyclohexyl ketone hydrazone with lead tetra-acetate were investigated. The results are given in Table 4. These results are similar to those obtained in the corresponding reactions of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate, in that little variation in yields of the products occurs upon changing the reaction conditions. Even under condi-

TABLE 4

Reaction of dicyclohexyl ketone hydrazone with lead tetra-acetate

Addenda (mol.)	Olefins (%) (XIX)	(XX)	Ketone (%)	Acetate (%)
$2Pb(OAc)_4$	46	8	2	43
$5Pb(OAc)_4$	45	9	3	42
$10Pb(OAc)_4$	49	8	1	41
$2Pb(OAc)_4$–$2AcOH$	47	9	3	41
$2Pb(OAc)_4$–$5AcOH$	48	10	2	40
$2Pb(OAc)_4$–$10AcOH$	45	10	2	43
$2Pb(OAc)_4$–$2Me_4\overset{+}{N}\overset{-}{O}Ac$	45	8	3	43
$2Pb(OAc)_4$–$5Me_4\overset{+}{N}\overset{-}{O}Ac$	44	8	4	44
$2Pb(OAc)_4$–$10Me_4\overset{+}{N}\overset{-}{O}Ac$	43	6	4	47

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[13] P. Sabatier and A. Maihle, *Compt. rend.*, 1904, **139**, 343.
[14] A. Maercker, *Org. Reactions*, 1965, **14**, 270.

tions of high lead tetra-acetate concentration the yield of dicyclohexyl ketone was negligible. The results obtained with both 3β-hydroxylanostan-7-one hydrazone and dicyclohexyl ketone hydrazone are compatible with the cyclic mechanism depicted in pathway A, since it would be predicted that changes in concentration of lead tetra-acetate, acetic acid, or acetate ion would have no effect upon the product distribution from such a reaction mechanism.

However, in order to examine the reaction further it became expedient to prepare dicyclohexyldiazomethane. This we accomplished by the diazo-transfer method described recently by Anselme.[15] The hydrazone in tetrahydrofuran was converted into the anion by butyl-lithium. Treatment of this anion with toluene-*p*-sulphonyl azide at −78°C gave dicyclohexyldiazomethane. In practice it was found necessary to use an excess of butyl-lithium in order to convert all the hydrazone into the anion. The exclusion of air was mandatory, since subsequent g.l.c. analysis of the products of reactions conducted in the presence of traces of oxygen revealed considerable amounts of dicyclohexyl ketone.

Treatment of the diazo-compound in tetrahydrofuran with acetic acid (3 mol.) in methylene chloride at −78°C followed by the usual work-up and g.l.c. analysis revealed the presence of dicyclohexylmethyl acetate (26%), and the olefins (XIX) and (XX) in 25 and 5% yield respectively. Dicyclohexyl ketone, formed by aerial oxidation, was present to the extent of 10%. In a duplicate run the yields of dicyclohexylmethyl acetate and of (XIX) and (XX) were 28, 28, and 5% respectively, the ketone content being 14%. The remainder of the reaction mixture consisted of compounds with much longer g.l.c. retention times than either the acetate or the two olefins. Although we have not identified these products it seems probable that they are formed by reaction of the diazo-compound with excess of butyl-lithium. The ratio of olefin to acetate formed in the reaction of the diazo-compound with acetic acid was 1·18 : 1. In the corresponding reaction of dicyclohexyl ketone hydrazone with lead tetra-acetate in tetrahydrofuran and methylene chloride at −78°C the product composition was acetate (46%), ketone (1%), and the two olefins (XIX) and (XX) (45 and 8% respectively), the ratio of olefin to acetate being 1·15 : 1.

The identity of the ratios of olefin to acetate in the reaction of the hydrazone with lead tetra-acetate, and in that of the diazo-compound with acetic acid support a mechanism involving primary oxidation of the hydrazone to the diazo-compound.

Although our results at first appeared to indicate that the oxidation of benzophenone hydrazone proceeded by a mechanism different from that of dicyclohexyl ketone hydrazone or 3β-hydroxylanostan-7-one hydrazone, we are inclined to the view that the mechanism in all cases involves preliminary oxidation of the hydrazone to the diazo-compound (mechanism B). However, we do have reservations. It is surprising that the addition of large excesses of lead tetra-acetate to the alicyclic hydrazones causes no appreciable increase in yield of the corresponding ketones, whereas in the aromatic series the effect is so large. If diazo-compounds be accepted as the intermediates in all oxidations of hydrazones with lead tetra-acetate, then in the alicyclic cases these compounds must be so reactive towards acetic acid, even when buffered, that they cannot be trapped by excess of lead tetra-acetate.

Our final experiments on the lead tetra-acetate oxidation were aimed to discover whether the olefinic precursor is the carbene or the corresponding carbonium ion. For this purpose we employed camphor hydrazone (XXI) as a model compound. Reaction *via* the carbene (XXII) would result in the formation of tricyclene (XXIII) in accordance with the classical work of Meerwein on the mercury(II) oxide oxidation of camphor hydrazone.[16] On the other hand the formation of the carbonium ion (XXIV) would yield camphene (XXV) by a Wagner–Meerwein rearrangement. In the event, oxidation of camphor hydrazone with lead tetra-acetate afforded a mixture of camphene (60%) and isoborneol (XXVI) and borneol (XXVII) acetates, as well as other, unidentified products. After alkaline hydrolysis the yields of isoborneol and borneol were established as 7 and 1% respectively. No tricyclene could be detected. The olefin is thus formed *via* a carbonium ion.

Finally we briefly studied the oxidation of hydrazones with perbenzoic acid. 3β-Hydroxylanostan-7-one hydrazone (IIa) on treatment with perbenzoic acid (2 mol.) in methylene chloride at room temperature gave, in a slower reaction, 3β-hydroxylanost-7-ene (IIIa; $R^1 = H$) (15%) and 7α-benzoyloxy-3β-hydroxylanostane (67%). Similarly, reaction of benzophenone hydrazone with perbenzoic acid (2 mol.) followed by alkaline hydrolysis afforded benzophenone (70%) together with benzhydrol (19%). The addition of perbenzoic acid to benzophenone hydrazone was accompanied by an immediate red colouration. Although we have not conducted any further experiments on this oxidation it appears possible that the mechanism is similar to that postulated for lead tetra-acetate oxidation of hydrazones. The formation of benzophenone and benzhydrol is envisaged as occurring by attack of perbenzoic acid or benzoic acid respectively on the intermediate diphenyldiazomethane.

Recently, a brief study has been reported on the oxidation of 17β-acetoxy-5α-androstan-3-one hydrazone by lead tetra-acetate.[17] The yield of acetate (3α to 3β *ca.* 2 : 1) was 52% and of olefin 25%; the results are in general agreement with those of our own investigations.

EXPERIMENTAL

Specific rotations were measured at 25°C for solutions in chloroform (0·1%) with a Perkin-Elmer 141 digital read-out

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[15] J. P. Anselme and W. Fisher, *Tetrahedron*, 1969, **25**, 89.

[16] (*a*) H. Meerwein and K. V. Emster, *Ber.*, 1920, **53**, 1915; (*b*) W. Reusch, M. W. Di Carlo, and L. Traynor, *J. Org. Chem.*, 1961, **26**, 1711.

[17] M. Debono and R. M. Molloy, *J. Org. Chem.*, 1969, **34**, 1454.

polarimeter. I.r. spectra are for Nujol mulls unless otherwise stated, and were determined with a Perkin-Elmer 257 i.r. spectrophotometer. The n.m.r. spectra were recorded with a Varian A60 spectrometer for solutions in deuteriochloroform containing tetramethylsilane as internal standard. U.v. spectra are for solutions in ethanol, and were recorded with a Perkin-Elmer 137 spectrophotometer. G.l.c. analyses were performed with a Pye 104 chromatograph [10% E30 column (4 mm. × 5 ft.) with nitrogen as carrier gas]. The peak areas were integrated with a Honeywell 5530 integrator.

The course of column chromatographs and the progress of reactions were followed by t.l.c. on silica gel G with light petroleum–ethyl acetate (85 : 15) as eluant. Development was effected by spraying with 50% sulphuric acid and heating at 110°. Alumina was Spence type O or H as specified and light petroleum refers to the fraction b.p. 40—60°.

The phrase ' worked up in the usual way ' refers to dilution of the reaction mixture with water followed by extraction with ether. The ethereal extracts were combined, washed with dilute hydrochloric acid (or sodium hydroxide), as, or when, appropriate, then with water. After drying ($MgSO_4$) the solvent was removed under vacuum.

All reactions were at 20°C unless otherwise specified.

3β-*Acetoxylanosta*-7,9(11)-*diene*.—3β-Acetoxylanost-8-ene (70 g.) in chloroform (200 ml.) was treated with a solution of perbenzoic acid in chloroform (240 ml., 1 : 1 equiv.). The mixture was left overnight at 0—5°C, then washed successively with sodium hydroxide (2N) and water. The chloroform layer was then shaken with hydrobromic acid (48%; 30 ml.) for 15—30 min. The chloroform solution was removed and washed with cold water until acid-free. Removal of the solvent followed by crystallisation of the residue from chloroform–methanol gave 3β-acetoxylanosta-7,9(11)-diene (60 g.), m.p. 164—166°C, $[\alpha]_D$ +85°, $\lambda_{max.}$ 235, 242, and 251 mμ (ε 14,500, 17,500, and 11,000) (lit.,[18] m.p. 165—166°C, $[\alpha]_D$ +87°).

3β-*Acetoxylanost*-8-*en*-7-*one*.— 3β-Acetoxylanosta-7,9(11)-diene (50 g.) in chloroform (100 ml.) was treated with perbenzoic acid in chloroform (200 ml., 1·1 equiv.) dropwise with stirring at 0°C. The solution was set aside overnight at 0°C and then washed with sodium hydroxide (2 × 150 ml.) and water (2 × 150 ml.). After removal of the solvent, the product in glacial acetic acid (100 ml.) was treated with methanesulphonic acid (2 ml.) under reflux for 3 min., then cooled, and methanol (200 ml.) was cautiously added. The crude product separated on washing and was crystallised from acetone–methanol to give 3β-acetoxylanost-8-en-7-one (35 g.), m.p. 147—148°C, $[\alpha]_D$ +20°, $\nu_{max.}$ 1735 and 1242 (OAc), 1650 (C=O), and 1580 (C=C) cm.$^{-1}$, $\lambda_{max.}$ 252 mμ (log ε 4·01) (lit.,[19] m.p. 151—152°C, $[\alpha]_D$ +21·3°).

3β-*Hydroxylanostan*-7-*one*.—3β-Acetoxylanost-8-en-7-one (20 g.) in dry tetrahydrofuran (200 ml.) was slowly added to lithium (1 g.) in dry liquid ammonia (200 ml.) with stirring. The mixture was then stirred for a further 2 hr. The excess of lithium was destroyed by the cautious addition of methanol, after which the mixture was left overnight. Water and ether were then added to form a two-phase system, and the mixture was worked up in the usual way. The ethereal solution was dried (Na_2SO_4) and evaporated to give a white solid. Crystallisation from methanol gave 3β-hydroxylanostan-7-one (15 g.), m.p. 164—165°C, $[\alpha]_D$ +26°, $\nu_{max.}$ 3200br (OH), and 1705 and 1680 (C=O) cm.$^{-1}$ (lit.,[5] m.p. 171—173°C, $[\alpha]_D$ +28°).

3β-*Hydroxylanostan*-7-*one Hydrazone*.— 3β-Hydroxylanostan-7-one (506 mg.) in anhydrous diethylene glycol (20 ml.) and hydrazine hydrate (5 ml.) was refluxed for 2 hr. and then cooled and poured into water. The hydrazone was extracted with ether (3 × 10 ml.). The combined extracts were washed with water (3 × 15 ml.) and dried ($MgSO_4$). Removal of the solvent gave 3β-*hydroxylanostan*-7-*one hydrazone* as a white solid, m.p. 187—193°C, $[\alpha]_D$ +68° (tetrahydrofuran), $\nu_{max.}$ 3440br (OH), 3380 and 3260 (NH), and 1640 (C=N) cm.$^{-1}$ (Found: C, 78·85; H, 11·6; N, 5·95. $C_{30}H_{54}N_2$ requires C, 78·55; H, 11·85; N, 6·1%).

The hydrazone (100 mg.) was acetylated with pyridine (5 ml.) and acetic anhydride (1 ml.) overnight at room temperature. The usual work-up gave 3β-*acetoxylanostan*-7-*one acetylhydrazone*, m.p. 219—220°C (from methanol), $[\alpha]_D$ +50° (tetrahydrofuran), $\nu_{max.}$ 3290 and 3200 (NH), 1740 and 1240 (OAc), and 1665 (CO·NH) cm.$^{-1}$ (Found: C, 74·9; H, 10·7; N, 5·25. $C_{34}H_{58}N_2O_3$ requires C, 75·25; H, 10·75; N, 5·15%).

3β-*Acetoxylanosta*-7,9(11)-*diene* 24,25-*Dibromide*.—' Lanosterol acetate dibromide A' [20] (50 g.) was dissolved in chloroform (200 ml.) and treated with a solution of perbenzoic acid in chloroform (152 ml.; 1 ml. containing 0·0125 g. of available oxygen) at 0°C overnight. The solution was then washed with aqueous sodium hydroxide (2N; 2 × 150 ml.) and water (2 × 150 ml.) and then shaken with aqueous hydrobromic acid (48%; 30 ml.) for 15—30 min. After removal of the acid layer the solution was washed with water (2 × 150 ml.) and the solvent was removed to give a yellowish solid. Crystallisation from chloroform–methanol gave 3β-acetoxylanosta-7,9(11)-diene 24,25-dibromide [20] (40 g.), m.p. 183—184°C, $[\alpha]_D$ +97°, $\lambda_{max.}$ 234, 243, and 255 mμ (ε 14,800, 17,200, and 11,300).

3β-*Acetoxylanost*-8-*en*-7-*one* 24,25-*Dibromide* (with Dr. D. A. Lewis).—3β-Acetoxylanosta-7,9(11)-diene 24,25-dibromide (25 g.) in chloroform (50 ml.) was treated with perbenzoic acid in chloroform (61 ml.; 1 ml. containing 0·0117 g. of available oxygen) dropwise at 0°C. After 2 hr. at 0—5°C the solution was washed with aqueous sodium hydroxide (2N; 2 × 150 ml.) and water (2 × 150 ml.). Removal of the solvent left an off-white solid which, in hot glacial acetic acid (100 ml.), was refluxed with methanesulphonic acid (2 ml.) for 3 min. Methanol was added to the cooled solution until crystallisation commenced. The mixture was allowed to cool to room temperature and the product was filtered off and recrystallised from chloroform–methanol to give 3β-*acetoxylanost*-8-*en*-7-*one* 24,25-*dibromide* (13 g.), m.p. 187—188°C, $[\alpha]_D$ −19°, $\nu_{max.}$ 1735 and 1245 (OAc), 1652 (C=O), and 1590 (C=C) cm.$^{-1}$ (Found: C, 60·0; H, 7·5; Br, 23·2. $C_{32}H_{50}Br_2O_3$ requires C, 59·8; H, 7·8; Br, 24·9%).

3β-*Acetoxylanosta*-8,24-*dien*-7-*one* (with Dr. D. A. Lewis). 3β-Acetoxylanost-8-en-7-one 24,25-dibromide (10 g.) (see before) in benzene (400 ml.) and methanol (100 ml.) was refluxed with AnalaR zinc dust (10 g.). Further zinc dust (2 g.) was added at hourly intervals. After a total of 4 hr. heating the solution was decanted and the residual zinc was refluxed twice with further portions of benzene (100 ml.). The combined organic solvents were washed with warm water and the solvent was removed. The residue was crystallised from chloroform–methanol to give 3β-*acetoxy*-

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[18] D. H. R. Barton, J. S. Fawcett, and B. R. Thomas, *J. Chem. Soc.*, 1951, 3147.

[19] D. H. S. Horn and D. Ilse, *J. Chem. Soc.*, 1957, 2280.

[20] D. A. Lewis and J. F. McGhie, *Chem. and Ind.*, 1956, 550.

lanosta-8,24-*dien*-7-*one* (3·7 g.), m.p. 195—196°C, $[\alpha]_D$ +20°, $\nu_{max.}$ 1738 and 1245 (OAc), 1650 (C=O), and 1580 (C=C) cm.$^{-1}$ (Found: C, 79·1; H, 10·3. $C_{32}H_{50}O_3$ requires C, 79·6; H, 10·4%).

3β-*Hydroxylanost*-24-*en*-7-*one* (with Dr. T. J. Bentley).—3β-Acetoxylanosta-8,24-dien-7-one (10 g.) in dry tetrahydrofuran (150 ml.) was added slowly with stirring to lithium (500 mg.) in liquid ammonia (100 ml.). The solution was stirred for a further 2 hr. and then methanol was added to destroy the excess of lithium. The mixture was left overnight, then ether and water were added to give a two-phase system. Work-up in the usual way and crystallisation from methanol gave 3β-*hydroxylanost*-24-*en*-7-*one* (7·7 g.), m.p. 163—164°C, $[\alpha]_D$ +27°, $\nu_{max.}$ 3500 and 3350 (OH), and 1700 and 1685 (C=O) cm.$^{-1}$ (Found: C, 79·4; H, 11·15. $C_{30}H_{50}O_2,0{\cdot}5CH_3OH$ requires C, 79·85; H, 11·4%).

3β-*Hydroxylanost*-24-*en*-7-*one Hydrazone*.—3β-Hydroxylanost-24-en-7-one (904 mg.) was treated with hydrazine hydrate (3 ml.) in refluxing diethylene glycol (20 ml.) for 2 hr. The cooled solution was poured into water and the product was extracted with ether. The extract was washed well with water, dried ($MgSO_4$), and evaporated to give 3β-*hydroxylanost*-24-*en*-7-*one hydrazone*, indefinite m.p., $\nu_{max.}$ 3440br (OH), 3380 and 3255 (N–H), and 1640 (C=N) cm.$^{-1}$ (Found: N, 6·1. $C_{30}H_{52}N_2O$ requires N, 6·15%).

The hydrazone (297 mg.) was acetylated with acetic anhydride (3 ml.) in pyridine (10 ml.) overnight. The usual work-up gave 3β-*acetoxylanost*-24-*en*-7-*one acetylhydrazone*, m.p. 187—188°C (from methanol), $[\alpha]_D$ +43°, $\nu_{max.}$ 3190 and 3090 (N–H), 1740 and 1245 (OAc), and 1670 (CO·NH) cm.$^{-1}$ (Found: C, 75·75; H, 10·2; N, 5·1. $C_{34}H_{56}N_2O_3$ requires C, 75·5; H, 10·45; N, 5·2%).

Preparation of Dicyclohexyl Ketone Hydrazone.—Dicyclohexyl ketone[13] (5 g.) was treated with anhydrous hydrazine (5 g.) in refluxing absolute ethanol (40 ml.) for 24 hr. The solvent was removed on a steam-bath under reduced pressure, and ether was added to bring the mixture back to its original volume. The lower, hydrazine layer was run off, and the ethereal layer was dried (KOH), filtered, and evaporated at the pump to give dicyclohexyl ketone hydrazone. The product was purified by distillation at 148°/1·5 mm. to give the *hydrazone* (2·8 g.), m.p. 46—47°C, $\nu_{max.}$ 3340 and 3200 (NH) and 1640 and 1610 (C=N) cm.$^{-1}$ (Found: C, 74·9; H, 11·55; N, 13·35. $C_{23}H_{24}N_2$ requires C, 74·95; H, 11·5; N, 13·5%).

Acetylation of the hydrazone (500 mg.) with acetic anhydride (5 ml.) in pyridine (10 ml.) overnight followed by the usual work-up gave *dicyclohexyl ketone acetylhydrazone*, m.p. 167—168°C (from aqueous ethanol), $\nu_{max.}$ 3180 and 3080 (NH) and 1660 (CO·NH) cm.$^{-1}$ (Found: C, 71·9; H, 10·3; N, 11·1. $C_{15}H_{20}N_2O$ requires C, 71·95; H, 10·45; N, 11·2%).

Dicyclohexylmethyl Acetate.—Dicyclohexylmethanol[13] (10 g.) in pyridine (125 ml.) was heated on a steam-bath with acetic anhydride (10 ml.) for 4 hr. The product was poured on ice, worked up in the usual way, and purified by distillation to give *dicyclohexylmethyl acetate* (11 g.), b.p. 111—114°C/0·4 mm., n_D^{25} 1·4752, $\nu_{max.}$ 1735 and 1240 cm.$^{-1}$ (OAc). The analytical sample was purified by preparative g.l.c. (Found: C, 75·25; H, 10·75. $C_{15}H_{26}O_2$ requires C, 75·6; H, 11·0%).

Cyclohexylmethylenecyclohexane.—Triphenylphosphine (19 g.) and cyclohexyl iodide (16 g.) were heated together at 160°C for 12 hr. A solid began to crystallise out and eventually the mixture became almost completely solid. The crude product was washed with ether and then crystallised from methanol at −20°C to give cyclohexyltriphenylphosphonium iodide (27 g.), m.p. 220—221°C. This iodide (23·8 g.) was stirred with butyl-lithium in ether[20] (42 ml.; 1 ml. containing 77 mg. of butyl-lithium) in ether (180 ml.) for 6 hr. at room temperature to give a red solution of the ylide. A solution of cyclohexanecarbaldehyde (5·1 g.) in ether (50 ml.) was added dropwise to the solution at room temperature and the red colour was rapidly discharged. The solution was filtered to remove triphenylphosphine oxide and then washed with sodium bisulphite (40 g.) in water (100 ml.), and finally with water (100 ml.). It was dried ($MgSO_4$) and evaporated, and the resultant oil was distilled to give *cyclohexylmethylenecyclohexane*, b.p. 76—77°/1 mm., $\nu_{max.}$ (film) 1450, 990, 890, and 840 cm.$^{-1}$, τ 5·1 (1H, d), M^+ 178, n_D^{25} 1·4935, g.l.c. retention time * 570 sec. The analytical sample was prepared by g.l.c. (Found: C, 87·45; H, 12·25. $C_{13}H_{22}$ requires C, 87·55%; H, 12·45%).

Cyclohex-1-*enylcyclohexylmethane*.— Boron trifluoride–ether complex (40 ml.) was added to a solution of cyclohexylmethylenecyclohexane (1·045 g.) in ether (20 ml.) and the mixture was left overnight at room temperature. It was then poured into ice–water and worked up in the usual way to give a dark brown oil. Distillation under reduced pressure gave *cyclohex*-1-*enylcyclohexylmethane*, b.p. 77—79°/1 mm., $\nu_{max.}$ (film) 1670 (C=C), 1450, 920, and 805 cm.$^{-1}$ τ 4·65 (1H, complex m), M^+ 178, n_D^{25} 1·4902. The analytical sample was prepared by g.l.c. (retention time 600 sec.) (Found: C, 87·3; H, 12·2. $C_{13}H_{22}$ requires C, 87·55; H, 12·45%).

Table 5

Oxidation of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate in various solvents (at 20°C unless otherwise specified)

Solvent		Hydrazone (mg.)	Lead tetra-acetate (mg.)	Time
Acetic acid (25 ml.)		349	659 (2 mol.)	24 hr.
Benzene (25 ml.)		344	677	5 min.
Dichloromethane	(0°C; 40 ml.)	346	672	5 min.
	(20°C; 20 ml.)	232	440	5 min.
	(40°C; 40 ml.)	349	660	5 min.
Light petroleum (100 ml.)		344	666	10 days
Dimethylacetamide (40 ml.)		326	622	12 hr.

Table 6

Oxidation of 3β-hydroxylanostan-7-one hydrazone with lead tetra-acetate in the presence of acetic acid and excess of lead tetra-acetate or tetramethylammonium acetate in methylene chloride at 20°C

Solvent (ml.)	Hydrazone (mg.)	Lead tetra-acetate (mg.)	Acetic acid (mg.)	Acetate ion (mg.)	Time
40	232	440 (2 mol.)			5 min.
40	332	660 (2 mol.)	223 (5 mol.)		5 min.
40	346	672 (2 mol.)	442 (10 mol.)		5 min.
40	347	676 (2 mol.)		997 (10 mol.)	5 min.
60	346	6660 (20 mol.)			5 min.
40	225	4426 (20 mol.)		625 (10 mol.)	5 min.

Oxidation of 3β-*Hydroxylanostan*-7-*one Hydrazone with Lead Tetra-acetate in Various Solvents*.—The general procedure is exemplified by the use of methylene chloride as

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* G.l.c. retention time was measured (conditions A) at a nitrogen flow rate of 60 ml. min.$^{-1}$ on a programmed run between 100 and 200° at a rate of increase of temperature of 8 deg. min.$^{-1}$.

solvent. Other results are shown in Tables 5 and 6. The hydrazone (232 mg.) in dichloromethane (20 ml.) was treated at 20°C with lead tetra-acetate (440 mg.; 2 mol.). There was immediate precipitation of lead diacetate and evolution of nitrogen. When nitrogen evolution was complete the mixture was poured into water, and then filtered through Celite. The organic layer was separated and the aqueous layer was extracted with ether (3 × 20 ml.). The combined solutions were washed with aqueous sodium carbonate (2 × 20 ml.) and water (2 × 20 ml.), dried ($MgSO_4$), and evaporated. The white solid obtained, in pyridine (25 ml.) and acetic anhydride (2 ml.), was left overnight at room temperature. The mixture was poured into water and the product was extracted with ether in the usual way. The crude product in benzene was chromatographed over alumina type H (10 g.). Elution with light petroleum (b.p. 40—60°) gave 3β-acetoxylanost-7-ene [5] (43 mg., 18%). Further elution, with light petroleum–benzene (99 : 1), gave $3\beta,7\alpha$-diacetoxylanostane [5] (188 mg., 68%). The results obtained with other solvents are reported in Table 1. The reaction in methanol needs special mention.

The hydrazone (288 mg.) in methanol (100 ml.) was treated with lead tetra-acetate (449 mg.) at 20°C. The product was worked up and chromatographed in the usual way. Elution with light petroleum gave 3β-acetoxylanost-7-ene (53 mg., 18%), followed by a second compound (28 mg.), which did not crystallise. Further elution with benzene–light petroleum (1 : 99) gave $3\beta,7\alpha$-diacetoxylanostane (152 mg., 45%).

Oxidation of Benzophenone Hydrazone with Lead Tetra-acetate in the Presence of Acetic Acid or Tetramethylammonium Acetate.—The general procedure is exemplified by the oxidation of benzophenone hydrazone with lead tetra-acetate (2 mol.). The other results are given in Table 7.

The hydrazone (487 mg., 2·5 mmoles) in dry methylene chloride (40 ml.) was treated with lead tetra-acetate (2·23 g., 5 mmoles) at 20°C. After the red colouration had disappeared the mixture was poured into water and filtered through Celite. The organic layer was removed and the aqueous layer was extracted with methylene chloride (20 ml.). The combined organic extracts were washed with aqueous sodium hydroxide (2N) and water, and the solvent was removed to give a yellowish oil. This, in sodium hydroxide (2 g.) in ethanol (25 ml.), was left overnight. The product was poured into water and extracted with ether in the usual way, and the solvent was removed to give a yellow solid. This in the minimum of light petroleum was chromatographed over alumina type H (15 g.). Elution with light petroleum gave benzophenone (163 mg., 36%), characterised as its 2,4-dinitrophenylhydrazone (216 mg., 24%). Elution with benzene–light petroleum (1 : 99) gave benzhydrol (238 mg., 52%), characterised as its 3,5-dinitrobenzoate (385 mg., 41%).

Reaction of Diphenyldiazomethane with Lead Tetra-acetate and Acetic Acid.—The general procedure is exemplified by oxidation with lead tetra-acetate (2 mol.). The other results are shown in Table 7.

Diphenyldiazomethane (996 mg.) in methylene chloride (40 ml.) was treated with lead tetra-acetate (4·44 g., 2 mol.). Work-up as for the oxidation of benzophenone hydrazone gave benzophenone (790 mg., 85%) [1161 mg. of 2,4-dinitrophenylhydrazone (63%)] and benzhydrol (65 mg., 7%) [115 mg. of 3,5-dinitrobenzoate (6%)].

TABLE 7

Oxidation of benzophenone hydrazone and of diphenyldiazomethane with lead tetra-acetate at 20°C

Solvent (ml.)	Benzophenone hydrazone (mg.)	Lead tetra-acetate (g.)	Acetic acid	Tetramethylammonium acetate (g.)
Dichloromethane (40)	425	5·55 (5 mol.)		
(40)	309	7·39 (10 mlo.)		
(40)	477	2·215 (2 mol.)	291 mg. (2 mol.)	
(40)	494	2·216	745 mg. (5 mol.)	
(40)	487	2·217	1·500 g. (10 mol.)	
Acetic acid (40)	462	2·22		
Dichloromethane (150)	501	2·22		3·320

Dichloromethane (ml.)	Diphenyldiazomethane (mg.)	Lead tetra-acetate (g.)	Acetic acid
40	996	4·44 (2 mol.)	
15	476	2·22 (2 mol.)	294 mg. (2 mol.)
40	497	2·22 (2 mol.)	748 mg. (5 mol.)
40	499	2·22 (2 mol.)	1·501 g. (10 mol.)

Reaction of Benzophenone Hydrazone with Lead Tetra-acetate in the Presence of Dimethyl Acetylenedicarboxylate.—The hydrazone (489 mg.) in methylene chloride (40 ml.) containing dimethyl acetylenedicarboxylate (18 g., 20 mol.) was cooled to −20°C, and lead tetra-acetate (2·22 g., 2 mol.) was added. The mixture was left overnight at −20°C and then allowed to warm to room temperature. The mixture was poured into water and filtered through Celite, and the organic phase was removed. The aqueous layer was extracted with methylene chloride (2 × 20 ml.) and the combined solutions were washed with aqueous 2N-sodium hydroxide (2 × 20 ml.) and water (2 × 20 ml.). The solvent was removed at room temperature and the resultant yellow oil in ethanol (50 ml.) at 0°C was cautiously treated with sodium hydroxide (15 g.) in absolute ethanol (100 ml.). The mixture was set aside at room temperature for 2 days and then poured into water. Extraction with ether gave a yellowish oil (38 mg.) which contained some benzophenone and benzhydrol (t.l.c.). The aqueous layer was then acidified to pH 5—6 and extracted with methylene chloride (3 × 50 ml.). The combined extracts were washed well with water to remove acetylenedicarboxylic acid, and evaporated to dryness to give a white solid (626 mg.), $\lambda_{max.}$ 229 and 256 mμ (ε 15,500 and 11,800). The product was crystallised from aqueous methanol to give 3,4-diphenylpyrazole-5-carboxylic acid (465 mg., 71%) [m.p. (see later) and mixed m.p.], $\lambda_{max.}$ 229 and 254 mμ (ε 18,000 and 13,500), $\nu_{max.}$ 3300—3040 (OH) and 1710 (C=O) cm.$^{-1}$. The crude product was estimated by u.v. comparison with an authentic sample to be 87% pure, indicating that 84% of the diphenyldiazomethane had been trapped.

Reaction of Diphenyldiazomethane with Dimethyl Acetylenedicarboxylate.—Diphenyldiazomethane (1·94 g.) in methylene chloride (40 ml.) and dimethyl acetylenedicarboxylate (1·42 g.) were left overnight at −20°C. Work-up as described in the preceding experiment gave 3,4-diphenylpyrazole-5-carboxylic acid, m.p. 265—266° (from aqueous methanol) (64%), $\nu_{\text{max.}}$ 3300—3040 and 1710 cm.$^{-1}$, $\lambda_{\text{max.}}$ 229 and 254 mμ (ε 17,500 and 13,000).

Reaction of Dicyclohexyl Ketone Hydrazone with Lead Tetra-acetate.—The general procedure is exemplified by the reaction of the hydrazone with 2 mol. of oxidant. The other results are shown in Table 8.

The hydrazone (210 mg., 1 mmole) in methylene chloride (10 ml.) was treated with lead tetra-acetate (887 mg., 2 mol.) in methylene chloride (20 ml.) at 25°C for 10 min. The mixture was poured into water and filtered through Celite. The organic layer was separated and the aqueous layer was extracted with methylene chloride (20 ml.). The combined solutions were washed with aqueous sodium hydroxide (2N; 20 ml.) and water (20 ml.), and the solvent was removed to give a colourless oil. This, in ether, was analysed by g.l.c. (conditions A). The products were dicyclohexylmethyl acetate (43%) (retention time 900 sec.), dicyclohexyl ketone (2%) (retention time 732 sec.), cyclohexylmethylenecyclohexane (46%), and cyclohex-1-enylcyclohexylmethane (8%).

TABLE 8

Oxidation of dicyclohexyl ketone hydrazone with lead tetra-acetate at 20° in methylene chloride

Hydrazone (mg.)	Lead tetra-acetate (mg.)	Acetic acid (mg.)	Tetramethylammonium acetate (mg.)
211	2·215 (5 mol.)		
210	4·433 (10 mol.)		
210	884 (2 mol.)	117 (2 mol.)	
210	886	301 (5 mol.)	
206	886	601 (10 mol.)	
212	897		279 (2 mol.)
216	885		675 (5 mol.)
214	885		1·352 (10 mol.

Preparation of Dicyclohexyldiazomethane.—Dicyclohexyl ketone hydrazone (49 mg.) in dry redistilled tetrahydrofuran (10 ml.) under nitrogen was treated with butyl-lithium in ether (0·50 ml.; 1 ml. containing 96 mg. of butyl-lithium; 3 mol.) with stirring. The solution was cooled to −78°C and tosyl azide (2 mol.) was injected through a septum. The solution was stirred at −78°C for a further 2—3 min. (dark yellow colour).

Acetic acid (110 ml.) in methylene chloride (10 ml.) was added and the solution was stirred for a further 5 min. The mixture was poured into water after it had warmed to room temperature. The product was extracted with methylene chloride in the usual way. G.l.c. analysis of the crude product showed it to contain dicyclohexylmethyl acetate (26%), dicyclohexyl ketone (10%), (XIX) (25%), and (XX) (5%).

Oxidation of Dicyclohexyl Ketone Hydrazone with Lead Tetra-acetate In Methylene Chloride–Tetrahydrofuran.—The hydrazone (104 mg.) in tetrahydrofuran (10 ml.) was cooled to −78°C. Lead tetra-acetate (446 mg.) in methylene chloride (20 ml.) was added. After the evolution of nitrogen had ceased the mixture was worked up in the usual way. G.l.c. analysis revealed the presence of dicyclohexylmethyl acetate (46%), dicyclohexyl ketone (1%), (XIX) (45%), and (XX) (8%).

Camphor Hydrazone.—D-Camphor hydrazone, prepared from camphor by the method of Reusch,[16b] had b.p. 118°C/13 mm., m.p. 54—55°C, $\nu_{\text{max.}}$ 3350 and 3200 (NH), and 1670 and 1600 (C=N) cm.$^{-1}$.

Oxidation of Camphor Hydrazone with Lead Tetra-acetate.—The hydrazone (411 mg.) in methylene chloride (40 ml.) was treated with lead tetra-acetate (2·238 g., 2 mol.). After the evolution of nitrogen had ceased the mixture was poured into water and filtered through Celite, and the organic layer was removed. The aqueous layer was extracted with methylene chloride and the combined methylene chloride solutions were washed with sodium hydroxide (2N; 30 ml.) and water (2 × 20 ml.). Removal of the solvent under reduced pressure afforded a pale yellow oil (255 mg.). G.l.c. analysis of the mixture * revealed the presence of camphene (60%) (retention time 216 sec.), a second unidentified hydrocarbon (16%) (retention time 186 sec.), and two other compounds (each 9%).

The product was refluxed in ethanolic sodium hydroxide (10%; 20 ml.) under nitrogen for 3 hr. The mixture was poured into water, and the product was extracted with ether and re-analysed by g.l.c. (conditions B). The two compounds initially thought to be present in 9% yield were resolved into several components, two of which were identified as borneol (1%) and isoborneol (7%), retention times 590 and 570 sec., respectively.

Oxidation of 3β-Hydroxylanostan-7-one Hydrazone with Perbenzoic Acid.—The hydrazone (349 mg.) in methylene chloride (10 ml.) was cooled to 0°C while a solution of perbenzoic acid in chloroform (1·2 ml., 1·1 mol.) was added. After the effervescence had ceased the solution was washed with aqueous sodium hydroxide (2N; 2 × 25 ml.) and then with water (2 × 25 ml.). Removal of the solvent left an off-white solid which was dissolved in benzene and chromatographed over alumina type H (10 g.). Elution with light petroleum–benzene (1 : 1) gave 3β-hydroxylanost-7-ene (39 mg., 11%), m.p. 156—158°C (from methanol), $[\alpha]_D$ +9°, $\nu_{\text{max.}}$ 3360 and 3310 cm.$^{-1}$ (OH) (lit.,[21] m.p. 162—163°C, $[\alpha]_D$ +10°).

Further elution with light petroleum–ethyl acetate (19 : 1) gave 7α-benzoyloxy-3β-hydroxylanostane (50%), m.p. 207—208°C (from methanol), $[\alpha]_D$ −26°, $\nu_{\text{max.}}$ 3550 (OH) and 1700 and 1285 (OBz) cm.$^{-1}$ (Found: C, 80·45; H, 10·6. $C_{37}H_{58}O_3$ requires C, 80·65; H, 10·6%).

Oxidation of Benzophenone Hydrazone with Perbenzoic Acid.—Benzophenone hydrazone (491 mg.) in methylene chloride (10 ml.) and perbenzoic acid in methylene chloride (7·5 ml.; 1 ml. containing 0·011 g. of available oxygen) were left at room temperature until the red colour had disappeared. The mixture was washed with aqueous sodium hydroxide (2N) and water, and the solvent was removed to give a yellowish oil, which was hydrolysed overnight with ethanolic 2N-sodium hydroxide. The product was chromatographed as described for the lead tetra-acetate oxidation of benzophenone hydrazone. Elution with light petroleum

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* G.l.c. retention time was measured (conditions B) at a nitrogen flow rate of 60 ml. min.$^{-1}$ on a programmed run between 80 and 200° at a rate of temperature increase of 4 deg. min.$^{-1}$.

[21] R. B. Woodward, A. A. Patchett, D. H. R. Barton, D. A. J. Ives, and R. B. Kelly, *J. Chem. Soc.*, 1957, 1131.

gave benzophenone (325 mg., 70%) [465 mg. of 2,4-dinitrophenylhydrazone (51%)].

Further elution with light petroleum–ethyl acetate (99 : 1) gave benzhydrol (87 mg., 19%) [104 mg. of 3,5-dinitrobenzoate (11%)].

Oxidation of 3β-*Hydroxylanost*-24-*en*-7-*one Hydrazone with Lead Tetra-acetate*.—3β-Hydroxylanost-24-en-7-one hydrazone (603 mg.) in methylene chloride (10 ml.) was treated with lead tetra-acetate (1·2 g., 2 mol.) in methylene chloride (30 ml.). The mixture was poured into water after the cessation of effervescence and filtered through Celite. The methylene chloride solution was removed and the aqueous layer was extracted with methylene chloride. The combined organic extracts were washed with water (2 × 20 ml.) and the solvent was removed to leave a yellowish oil which was dissolved in light petroleum–benzene (1 : 3; 60 ml.) and chromatographed over alumina type H (18 g.). Elution with light petroleum–benzene (3 : 2) gave 3β-*hydroxylanosta*-7,24-*diene* (50 mg.), m.p. 150—151°C (from methanol), $[\alpha]_D$ +9°, $\nu_{max.}$ 3370—3300 cm.$^{-1}$ (OH) (Found: C, 84·2; H, 12·05. $C_{30}H_{50}O$ requires C, 84·45; H, 11·8%). Acetylation with acetic anhydride–pyridine followed by the usual work-up gave 3β-*acetoxylanosta*-7,24-*diene*, m.p. 155—156° (from methanol), $[\alpha]_D$ +30°, $\nu_{max.}$ 1740 and 1245 cm.$^{-1}$ (OAc) (Found: C, 81·75; H, 11·35. $C_{32}H_{52}O_2$ requires C, 82·0; H, 11·2%).

Further elution with ethyl acetate–light petroleum (1 : 19) gave 7α-*acetoxy*-3β-*hydroxylanost*-24-*ene* (180 mg.), m.p. 188—189° (from methanol), $[\alpha]_D$ −14° (Found: C, 78·95; H, 11·2. $C_{32}H_{54}O_3$ requires C, 78·95; H, 11·2%).

7α-*Acetoxylanost*-24-*en*-3-*one*.— 7α-Acetoxy-3β-hydroxylanost-24-ene (1·09 g.) in acetone (15 ml.) was treated with an excess of Kiliani's chromic acid. After shaking for 5 min. the excess of oxidising agent was destroyed with sodium bisulphite, and the product was extracted with ether in the usual way. This gave 7α-*acetoxylanost*-24-*en*-3-*one* (700 mg.), m.p. (from methanol) 136—137°, $[\alpha]_D$ −40°, $\nu_{max.}$ 1710 (C=O), and 1730 and 1250 (OAc) cm.$^{-1}$ (Found: C, 79·1; H, 10·75. $3_{32}H_{52}O_3$ requires C, 79·3; H, 10·8%).

3β,7α-*Dihydroxylanostane*.— 7α-Benzoyloxy-3β-hydroxylanostane (59 mg.) was heated under reflux with sodium hydroxide (2 g.) in ethanol (25 ml.) under nitrogen for 5 hr. The usual work-up gave 3β,7α-dihydroxylanostane (24 mg.), m.p. (from methanol) 164—166°C, $[\alpha]_D$ +4°, $\nu_{max.}$ 3290 cm.$^{-1}$ (OH).

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