one major product as over 80% of the volatile reaction mixture, and nmr analysis of the crude material showed essentially the same spectrum as glpc-collected product. This was identified as 2,5-dimethyl-4-isopropylidene-5-hydroxyhex-2-en-3-one (**17**): uv max (hexane), 218 mμ (ε 6900), 262 (390), and 340 (11); ir, 2.84 (OH), 6.04 (conjugated carbonyl) and 10.6 μ; nmr, τ 8.66 (s, 6), 8.52 (s, 3), 8.16 (m, 3), 8.08 (s, 3), 4.20 (m, 1), and 4.09 (m, 1).

Anal. Calcd for $C_{11}H_{18}O_2$: C, 72.49; H, 9.95. Found: C, 72.25; H, 9.98.

When the above reaction was conducted at room temperature for 30 min or for 24 hr at reflux with an excess of diethylamine, a mixture of **17** and a new substance possessing a diethylamino function was obtained. This material was purified by extraction from ethereal solution with 1% hydrochloric acid solution followed by careful neutralization with saturated sodium bicarbonate solution to give a 60% yield of 1-(N,N-diethylamino)-2,5-dimethyl-4-isopropylidene-5-hydroxyhexan-3-one (**18**), the Michael addition product of diethylamine and **17**. Compound **18** displays the following spectral data: ir, 3.0, 5.92, 7.95, 8.4, 9.3, and 10.7 μ; 100 MHz nmr, τ 8.98 (d, 6, J = 6.1 Hz), 8.98 (t, 6, J = 6.6 Hz), 8.60 (s, 3), 8.51 (s, 3), 8.43 (s, 3), 8.24 (s, 3), 7.46 (apparent overlapping quartets, 4), 7.09 (m, 2), and 7.80 (m, 1). Examination of the nmr spectrum of the crude reaction product showed about a 6:1 ratio of **18** and **17**.

Stirring 100 mg of **18** in 25 ml of 20% potassium hydroxide solution for 2 hr followed by extraction with ether gave 45 mg (62%) of **17**.

Catalytic Hydrogenation of 17.—A solution of 0.30 g of **17** in 50 ml of 20% potassium hydroxide in methanol was hydrogenated at atmospheric pressure using 5% palladium-on-charcoal as catalyst. Exhaustive hydrogenation resulted in the uptake of 1 equiv of hydrogen. The resulting mixture was filtered to remove the catalyst, and the filtrate was poured into 100 ml of water and extracted several times with 25-ml portions of ether. The ethereal extracts were combined and dried, and the ether was removed to give 0.29 g (97%) of keto alcohol **19** which was further purified by glpc: ir, 2.95 (OH), 5.95 (conjugated carbonyl), and 6.10 μ (conjugated C=C); 100 MHz nmr, τ 8.95 (d, 6, J = 6.9 Hz), 8.55 (s, 6), 8.48 (s, 3), 8.21 (s, 3), 7.46 (s, 1), and 7.28 (septet, 1, J = 6.9 Hz).

Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.70; H, 10.94. Found: C, 71.46; H, 10.95.

Catalytic Hydrogenation of 18.—Catalytic hydrogenation of 3.0 g of **18** in the same manner as the hydrogenation of **19** gave **14** in 85% yield.

Dehydration of 2,5-Dimethyl-4-isopropylidene-5-hydroxyhexan-3-one (19).—An 0.29-g sample of **19** was stirred in 25 ml of glacial acetic acid containing ten drops of concentrated sulfuric acid for 30 min. The reaction mixture was poured into 50 ml of water and extracted with three 25-ml portions of pentane. The combined pentane extracts were washed with 50 ml of saturated sodium bicarbonate solution and dried, and the pentane was removed to give 0.24 g of crude **20** which was purified by glpc and shown to be identical with an authentic sample.[2]

Acid-Catalyzed Rearrangement of 17.—The reaction was carried out on an 0.180-g sample in essentially the same manner as the acid-catalyzed rearrangement of **3**. The crude product (0.140 g) was shown by glpc to be 94% one compound. Glpc purification gave 2,4,4-trimethyl-5-isopropylidenecyclopent-2-enone (**21**): ir, 5.92 and 6.16 μ; nmr, τ 8.72 (s, 6), 8.28 (d, 3, J = 1.5 Hz), 8.04 (s, 3), 7.74 (s, 3) and 3.39 (s, 1, J = 1.5 Hz).

Anal. Calcd for $C_{11}H_{16}O$: C, 80.44; H, 9.82. Found: C, 80.36; H, 9.88.

Catalytic Hydrogenation of 21.—A solution of 140 mg of **21** in 50 ml of methanol was exhaustively hydrogenated at atmospheric pressure using 5% palladium-on-charcoal as catalyst. The reaction mixture was filtered to remove the catalyst, and the filtrate was poured into 100 ml of water and extracted several times with 50-ml portions of pentane. The pentane extracts were combined and dried, and the pentane was removed to give 120 mg of crude product. Glpc analysis showed three compounds as 63, 18, and 19% of the volatile reaction product. The 19% product was isolated by glpc collection and the other two products were collected together since they could not be effectively separated by preparation glpc.

The 19% product is tentatively assigned as 2,4,4-trimethyl-5-isopropylidenecyclopentanone (**23**) on the basis of the following spectroscopic evidence: ir, 5.85 and 6.16 μ; nmr, τ 8.98 (d, 3, J = 6.5 Hz), 8.77 (s, 3), 8.69 (s, 3), 8.09 (s, 3), and 7.82 (s, 3). The methylene and methine protons are obscured by the olefinic methyl resonances.

The other two products are assigned as the *cis* and *trans* isomers of 2,4,4-trimethyl-5-isopropylcyclopentanone (**22**): ir, 5.77 μ (strong, cyclopentanone).[4] The 100-MHz nmr spectrum of this mixture was very complicated in the methyl region as expected for a mixture of the two isomers of **18**.

Registry No.—**3**, 16980-16-8; **5**, 16980-17-9; **6**, 16980-18-0; **15**, 16980-19-1; **17**, 16980-20-4; **18**, 16980-21-5; **19**, 16980-22-6; **21**, 16980-23-7; **23**, 16980-24-8.

A One-Step Procedure for the Preparation of Tertiary α-Ketols from the Corresponding Ketones

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Received February 27, 1968

Steroidal ketones having a tertiary α-hydrogen react at −25° with oxygen and a trialkyl phosphite in the presence of a strong base to yield the corresponding α-ketols. The method is especially useful for the introduction of a 17α-hydroxyl group into 20-keto steroids, yields of 65% being obtained in many cases. The scope and limitations of the reaction are discussed.

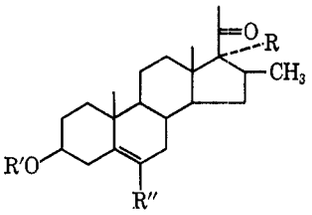
The preparation of 17α-hydroperoxypregnan-20-ones and their reduction to the corresponding 17α-hydroxy compounds has been reported by Barton and coworkers.[2] The introduction of the 17α-hydroperoxy function was accomplished by treatment of the pregnan-20-one with oxygen in the presence of *t*-alkoxide in the corresponding *t*-alkyl alcohol, and, after isolation, the hydroperoxide was reduced to the alcohol, zinc dust in acetic acid being the preferred reagent.

Some years ago we employed this procedure to introduce a 17α-hydroxyl into compound **1** and obtained **2** in only 22% yield.[3] We encountered two difficulties in the conversion. Preparation of the hydroperoxide at ambient temperature, as advocated in the original procedure, gave yields of less than 50% on a 0.5-g scale, and on a 50 to 100 g scale none of the desired product could be isolated. Secondly, the yield of **2** (46%) on zinc dust reduction of the hydroperoxide was disappointing, and the product always contained traces of an impurity that was hard to

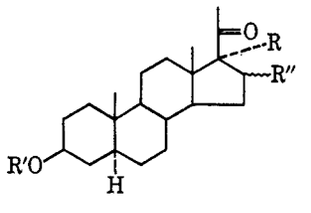
(1) Author to whom correspondence should be addressed at Hoffmann-La Roche Inc., Nutley, N. J. 07110.

(2) E. J. Bailey, D. H. R. Barton, J. Elks, and J. F. Templeton, *J. Chem. Soc.*, 1578 (1962).

(3) J. N. Gardner, F. E. Carlon, C. H. Robinson, and E. P. Oliveto, *Steroids*, **7**, 234 (1966).



1, R = H; R′ = Ac; R″ = CH_3
2, R = OH; R′ = H; R″ = CH_3
5, R = H; R′ = Ac; R″ = H
6, R = OH; R′ = H; R″ = H



3, R = H; R′ = Ac; R″ = β-CH_3
4, R = OH; R′ = H; R″ = β-CH_3
7, R = H; R′ = Ac; R″ = H
8, R = OH; R′ = H; R″ = H
17, R = H; R′ = Ac; R″ = α-CH_3
18, R = OH; R′ = Ac; R″ = α-CH_3
19, R = OH; R′ = Ac; R″ = β-CH_3

remove. These difficulties prompted us to seek an alternative system for the autoxidation which would permit operation at low temperatures, and an improved reducing agent.

In the period since the completion of our work, the autoxidation of pregnan-20-ones at 0° in tetrahydrofuran–*t*-butyl alcohol has been described,[4] as has reduction of hydroperoxides with trialkyl phosphites.[5] The nature of the difficulty in autoxidations at ambient temperature has been indicated also by demonstration of the ease of degradation of 17α-hydroperoxypregnan-20-ones to androstan-17-ones on warming with alkali.[6]

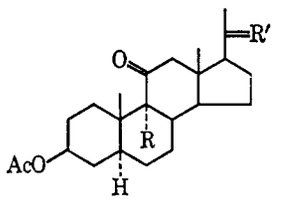
Our initial investigations quickly established that treatment of the 17α-hydroperoxide derived from **1** in an inert solvent with triethyl phosphite leads to a high yield of **2**. The triethyl phosphate formed in the reduction is easily removed from the steroid by washing with water. We then turned our attention to the search for an improved solvent system for the autoxidation, and decided to try the dimethylformamide–*t*-butyl alcohol mixture which has been used for the autoxidation of picolines.[7] A few experiments sufficed to reveal that down to approximately −25° rapid autoxidation occurred, and hydroperoxides could be isolated in high yield. Furthermore, the yields were not diminished if the reactions were allowed to continue for several hours, or were run on a 50 to 100 g scale, and because of the low temperature a 3β-acetoxy group could be preserved during the reaction. The experimental details for this procedure have been reported.[8]

As it is known that trialkyl phosphites are not rapidly oxidized by molecular oxygen at ambient temperature,[9] we decided to try to combine the autoxidation and reduction into a one-step procedure. When **1** was allowed to react with oxygen and a slight excess of triethyl phosphite in sodium *t*-butoxide–*t*-butyl alcohol–dimethylformamide and the product was subjected to hydrolysis, the desired alcohol **2** was obtained in 65% yield. Likewise, **3** gave **4** in 62% yield, and we were thus led to investigate the range of suitable experimental conditions, and the limitations imposed by the structure of the substrate on the procedure.

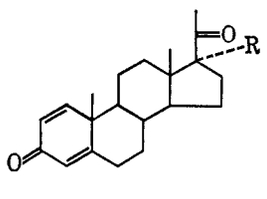
Dimethylformamide–*t*-butyl alcohol was found to be the solvent of choice as it results in the shortest reaction times, but tetrahydrofuran–*t*-butyl alcohol can be employed, although in this solvent it takes about twice as long for the hydroxylation of **3** to go to completion. Dimethyl sulfoxide–*t*-butyl alcohol can be used also, but temperatures below 0 to 15° result in crystallization of the solvent, and at these higher temperatures lower yields are obtained. The need for a solvent with a low freezing point (our best results have been obtained in the temperature range of −20 to −25°) imposes a considerable limitation on the range of materials one might employ, but any inert polar liquid which meets this criterion is potentially satisfactory.

Using the dimethylformamide–*t*-butyl alcohol–*t*-butoxide system, 17α-hydroxyl groups were introduced into compounds **1**, **3**, **5**, and **7**, the yields being in the 60–70% range. In the case of **7**, the concentration of *t*-butoxide employed was double that used in the first three examples. This reflects the fact that the rate of the reaction is sensitive to the concentration of base and the best results with **7** were obtained using the higher concentration. It is significant that **7** does not contain a 16β-methyl group which has been reported to promote formation of the 17α-hydroperoxide.[2]

That this method of hydroxylation is not restricted to the 17 position is shown by the formation of **10** from **9**, where the more hindered position of the entering



9, R = H; R′ = $-OCH_2CH_2O-$
10, R = OH; R′ = O



11, R = H
12, R = OH

hydroxyl group may well account for the reduced yield (30%). The obtention of **12**[10-13] from **11** shows that the $\Delta^{1,4}$-3-keto system can survive the reaction conditions, but this is not true of the Δ^4-3-keto moiety. When an attempt was made to prepare 17α-hydroxyprogesterone from progesterone, the gummy product was found by thin layer chromatography to contain several materials, and the ultraviolet spectrum[14] indicated that at least partial oxidation of the A ring had occurred.

Despite their instability, the isolation of secondary α-hydroperoxy ketones has been described.[15] How-

(4) G. V. Baddeley, H. Carpio, and J. A. Edwards, *J. Org. Chem.*, **31**, 1026 (1966).
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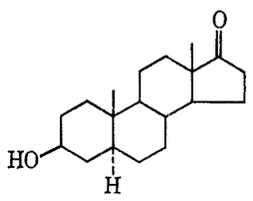
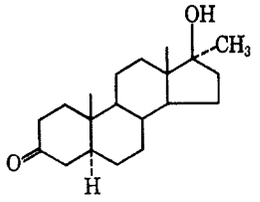
(6) J. B. Siddall, G. V. Baddeley, and J. A. Edwards, *Chem. Ind.* (London), 25 (1966).
(7) W. Bartok, D. D. Rosenfeld, and A. Schriesheim, *J. Org. Chem.*, **28**, 410 (1963).
(8) J. N. Gardner, F. E. Carlon, and O. Gnoj, *ibid.*, **33**, 1566 (1968).
(9) K. Smeykal, H. Baltz, and H. Fisher, *J. Prakt. Chem.*, **22**, 186 (1963).
(10) There is some conflict in the literature[11-13] regarding the physical constants of **12**. We have prepared an authentic sample from 17α-hydroxyprogesterone, as described in the Experimental Section.
(11) M. Nishikawa and K. Morita, German Patent 1,079,630 (1960); *Chem. Abstr.*, **55**, 23600 (1961).
(12) S. Wada, *Yagugaku Zasshi*, **79**, 120 (1959); *Chem. Abstr.*, **53**, 10296 (1959).
(13) G. Rosenkranz, J. Pataki, St. Kaufmann, J. Berlin, and C. Djerassi, *J. Amer. Chem. Soc.*, **72**, 4081 (1950).
(14) B. Camerino, B. Patelli, and R. Sciaky, *Gazz. Chim. Ital.*, **92**, 693 (1962).
(15) See references cited in ref 2.

ever, when hydroxylation of **13** and **14** was attempted, no reaction could be detected. The same was true of

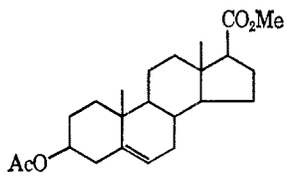


13

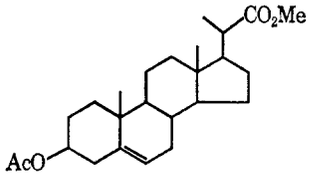


14

the esters **15** and **16**, but we do not know if this results



15



16

from a failure to enolize, or a failure of the hydroperoxide to form.

The original workers failed[2] to obtain a 17α-hydroperoxide from a 16α-methylpregnan-20-one. We attempted the hydroxylation of **17** under various conditions and were able, almost always, to detect traces of **18** by thin layer chromatography. We were not able, however, to obtain more than a very small conversion into products and **18** was isolated in only 1% yield. This result is very probably due to steric hindrance by the 16α-methyl group.

In conclusion, it may be noted that the principle of autoxidation and reduction occurring sequentially in the one reaction requires only that the reducing agent be stable in the presence of oxygen under the specified conditions. For reasons of solubility and ease of removal, the lower trialkyl phosphites are particularly favorable for use with steroids. However, another example of a suitable reducing agent is sodium methylsulfinate. Using this, salt **19** was obtained from **3** in 45% yield, using the solvent system dimethylformamide–tetrahydrofuran–dimethyl sulfoxide–*t*-butyl alcohol. This choice of solvents was necessitated by the poor solubility of the sodium salt.

Experimental Section

Ultraviolet data refer to solutions in methanol, and rotations to approximately 1% solutions in the solvents indicated. Melting points were determined on a Kofler hot-stage microscope except where another instrument is specified. With the exception of compound **10**, all the products reported were identified unambiguously by comparison (thin layer chromatography, infrared spectrum, and rotation) with authentic samples. (For many of these materials the melting point is an unreliable means of identification as it varies greatly with the apparatus used for the determination.)

Sodium hydride refers to the 50% suspension in oil. The course of the hydroxylation reactions was conveniently monitored by thin layer chromatography on silica gel coated microscope slides. Prior to development, the slides were dried for 10 min at 60° in a current of air to free them of dimethylformamide. In most instances, the system benzene–methanol (99:1) was used to develop the slides.

3β,17α-Dihydroxy-6,16β-dimethyl-5-pregnen-20-one (2).—Sodium hydride (0.15 g) was dissolved in *t*-butyl alcohol (2 ml) and dimethylformamide (3 ml), and to the solution were added dimethylformamide (5 ml) and triethyl phosphite (0.5 ml). The mixture was cooled to −25°, oxygen was passed through it, and a solution of **1** (1.09 g) in tetrahydrofuran (8 ml) was added. Passage of oxygen was continued for 22 hr, when a solution of sodium hydroxide (0.5 g) in methanol–water (2:1, 15 ml) was added; the mixture was stirred at ambient temperature for 1 hr. After acidification with acetic acid, the product was precipitated by addition of water, isolated by filtration, and dried. Crystallization from methanol–ethyl acetate gave **2** (662 mg), mp 175–182°. A second crop of 104 mg had mp 170–178° (lit.[3] mp 180–186°).

3β,17α-Dihydroxy-16β-methyl-5α-pregnan-20-one (4).—Sodium hydride (7.5 g) was dissolved in a mixture of *t*-butyl alcohol (100 ml) and dimethylformamide (150 ml) at ambient temperature, approximately 1 hr being taken to effect solution. Dimethylformamide (100 ml) and triethyl phosphite (25 ml) were added and, after cooling the solution to −25°, oxygen was passed through it. A solution of **3** (50 g) in tetrahydrofuran (120 ml) was added over 5 to 10 min and the passage of oxygen was continued for a further 45 min while maintaining −25°. The oxygen was then replaced by nitrogen and a solution of sodium hydroxide (5 g) in methanol (100 ml) and water (50 ml) was added. After agitation for 70 min at ambient temperature, followed by addition of acetic acid (10 ml), the mixture was poured into water (4000 ml). The precipitate was isolated by filtration, washed with water, and dried in an air draft at 100° to yield crude **4** (47 g). This material was dissolved in methanol (1500 ml) and ethyl acetate (500 ml) and the solution was concentrated to half its initial volume. Ethyl acetate (500 ml) was added and the solution was cooled to yield **4** (29.4 g): mp 255–260° (Kofler hot bench); $[\alpha]_D$ +45.6° (dioxane) (lit.[2] mp 214–216°; $[\alpha]_D$ +44° (dioxane)).

3β,17α-Dihydroxy-16β-methyl-5-pregnen-20-one (6).—Compound **5** (5 g) was hydroxylated as described for compound **3** (reaction time 2.5 hr) to yield **6** (3.15 g), $[\alpha]_D$ −20.4° (tetrahydrofuran) (lit.[16] $[\alpha]_D$ −33° (dioxane)).

3β,17α-Dihydroxy-5α-pregnan-20-one (8).—Compound **7** (15 g) was hydroxylated as described for compound **3** except that the amount of sodium hydride was doubled. Crystallization of the crude product gave **8** (10.1 g): mp 250–258°; $[\alpha]_D$ +36.3° (ethanol) (lit.[2] mp 251–256°; $[\alpha]_D$ +35° (ethanol)).

3β-Acetoxy-9α-hydroxy-5α-pregnane-11,20-dione (10).—Sodium hydride (0.3 g) was dissolved in *t*-butyl alcohol (1 ml) and dimethylformamide (5 ml) at ambient temperature. Triethyl phosphite (0.5 ml) was added, the mixture was cooled to −25°, and oxygen was passed through it. A solution of **9**[17] (0.5 g) in tetrahydrofuran (4 ml) was added and the passage of oxygen was continued for 50 min. After addition of sodium hydroxide (2 g) in water (10 ml) and methanol (20 ml), the mixture was stirred at ambient temperature for 1 hr, then poured into dilute acetic acid. The precipitate was isolated, dried, and acetylated in excess pyridine–acetic anhydride at 100° for 20 min. The product was precipitated with water and adsorbed on Florisil (15 g) in hexane. Elution with hexane–ether mixtures yielded 3β-acetoxy-5α-pregnane-11,20-dione (100 mg) followed by crude **10** (109 mg). The latter was purified by preparative thin layer chromatography on silica gel in the system chloroform–ethyl acetate (3:1) and two crystallizations from acetone–hexane to yield pure material (58 mg): mp 208–211; $[\alpha]_D$ +101 (chloroform) (lit.[18] mp 209–211°; $[\alpha]_D$ +105° (acetone)).

Anal. Calcd for $C_{23}H_{34}O_5$: C, 70.74; H, 8.78. Found: C, 70.70; H, 8.70.

17α-Hydroxy-1,4-pregnadiene-3,20-dione (12). A. From 11.—Sodium hydride (0.3 g) was dissolved in *t*-butyl alcohol (1 ml) and dimethylformamide (4 ml). To the solution were added dimethylformamide (4 ml) and triethyl phosphite (0.5 ml). After cooling the mixture to −20°, oxygen was bubbled through it and **11** (0.5 g) in dimethylformamide (5 ml) was added. After 45 min the reaction mixture was acidified with acetic acid and poured into water, and the precipitate was isolated. This material was dried and chromatographed in ligroin–toluene–propylene glycol on Chromosorb W (50 g), the proportion of toluene in the eluent being slowly increased from 0 to 100%. Compound **12** was detected in almost all the fractions. These were combined and crystallized from dichloromethane–acetone to

(16) R. Sciaky, *Gazz. Chim. Ital.*, **91**, 562 (1961).

(17) C. Djerassi, E. Batres, J. Romo, and G. Rosenkranz, *J. Amer. Chem. Soc.*, **74**, 3634 (1952).

(18) D. H. R. Barton, R. M. Evans, J. C. Hamlet, P. G. Jones, and T. Walker, *J. Chem. Soc.*, 747 (1954).

yield pure material (90 mg). A second crystallization gave an analytical sample: mp 240–260°; $[\alpha]_D$ +31° (chloroform).

Anal. Calcd for $C_{21}H_{28}O_3$: C, 76.78; H, 8.59. Found: C, 76.61; H, 8.34.

B. From 17α-Hydroxy-4-pregnene-3,20-dione.—17α-Hydroxy-4-pregnene-3,20-dione (1 g) and 2,3-dichloro-5,6-dicyanobenzoquinone (0.81 g) in dioxane (50 ml) were heated at reflux for 18 hr. A further 0.2 g of the quinone was added and heating was continued for 20 hr. The reaction mixture was diluted with dichloromethane and washed twice with 1 *N* sodium hydroxide and successively with saturated sodium bisulfite, 1 *N* sodium hydroxide, and water. The solution was dried over magnesium sulfate, and the solvent was evaporated. The residue on crystallization from dichloromethane–acetone gave **12** (472 mg), mp 220–256°. Two further crystallizations gave an analytical sample: mp 245–262°; λ_{max} 244 mμ (ε 15,000) with a slight shoulder at 295 mμ (presumably due to the presence of a trace of the $\Delta^{1,4,6}$-3-ketone); $[\alpha]_D$ +29° (chloroform).

Anal. Calcd for $C_{21}H_{28}O_3$: C, 76.78; H, 8.59. Found: C, 77.04; H, 8.30.

3β-Acetoxy-17α-hydroxy-16α-methyl-5α-pregnan-20-one (18).—Compound **17** (5 g) was hydroxylated as for compound **3**. The crude product was acetylated with excess pyridine–acetic anhydride at ambient temperature and chromatographed on Florisil (175 g) in hexane, eluting with gradually increasing proportions of ether. Hexane–ether (3:2) eluted material (58 mg) which, on crystallization from acetone–hexane, gave **18** (33 mg), mp 169–173° (lit.[19] mp 180–181°).

3β-Acetoxy-17α-hydroxy-16β-methyl-5α-pregnan-20-one (19).—Sodium hydride (0.2 g) was dissolved in dimethylformamide (4 ml) and *t*-butyl alcohol (3 ml) at ambient temperature. Dimethylformamide (4 ml) was added, the mixture was cooled on ice, and oxygen was passed through it. Solutions of sodium methylsulfinate (1 g) in dimethyl sulfoxide (5 ml) and **3** (1 g) in tetrahydrofuran (5 ml) were added simultaneously over 5 min, a slight precipitate forming in the reaction mixture. Passage of oxygen was continued for a further 30 min; the mixture was neutralized with acetic acid and poured into water. The product was extracted with ethyl acetate and crystallized from acetone–hexane to yield **19** (0.5 g), mp 152–155° (lit.[20] mp 161–163°).

Registry No.—**2**, 5618-40-6; **4**, 2543-24-0; **6**, 13900-61-3; **8**, 570-54-7; **10**, 16980-65-7; **12**, 2477-61-4; **18**, 16980-67-9; **19**, 2543-25-1.

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(20) R. Mickova and K. Syhora, *Collect. Czech. Chem. Commun.*, **30**, 2771 (1965).

Fluoroalkylquinonemethides

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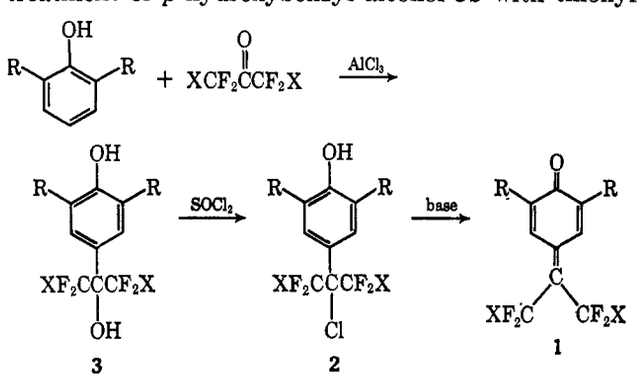
2,6-Dialkyl-7,7-bis(fluoroalkyl)quinonemethides were prepared in several steps from fluorinated ketones and 2,6-dialkylphenols. The quinonemethides, stabilized by the fluoroalkyl substituents at C-7, can be isolated and characterized, but they are reactive to nucleophilic attack, 1,6 polymerization, and addition of dienes and electron-rich olefins. *o*-Quinonemethides with 7,7-bis(fluoroalkyl) substituents were also prepared but could not be isolated pure; they were characterized by spectral properties and as the Diels–Alder adducts with styrene.

Quinonemethides, or 6-methylene-2,4-cyclohexadien-1-ones and 4-methylene-2,5-cyclohexadien-1-one, have long been of interest. Unfortunately, *p*-benzoquinonemethides are too unstable to isolate and characterize unless highly substituted both in the 2,6 and C-7 positions.[2] Recently, 2,6-di-*t*-butyl-7,7-dimethylquinonemethide,[3a] 2,6-di-*t*-butyl-7,7-dialkylquinonemethides,[3b] and 2,6-dimethyl-7,7-dicyanoquinonemethide[3c] were prepared and shown to be stable (but highly reactive) because of the sterically large or electronegative substituents. However, 2,6-di-*t*-butylquinonemethide with no C-7 substituents could be prepared only in dilute solution[2,4] and dimerized on attempted isolation. *o*-Benzoquinonemethides are less stable than the *para* isomers;[5] they have not been isolated[2b] but are proposed as intermediates in some reactions of substituted *o*-hydroxybenzyl alcohols.

Results and Discussion

A. *p*-Benzoquinonemethides. Synthesis.—Stable 2,6-dialkyl-7,7-bis(fluoroalkyl)quinonemethides, **1a**, **1b**, and **1c**, have been prepared in high yield (60–90%) by hydrogen chloride elimination from the *p*-hydroxybenzyl chlorides **2a** and **2c** with aqueous base or by treatment of *p*-hydroxybenzyl alcohol **3b** with thionyl chloride in pyridine. Benzyl chlorides **2a** and **2c** are readily prepared by condensation of fluorinated ketones with 2,6-disubstituted phenols to give the hydroxybenzyl alcohols **3a** and **3c**[6] which are then treated with thionyl chloride.



a, R = CH_3; X = F
b, R = $C(CH_3)_3$; X = F
c, R = CH_3; X = Cl
d, R = Br; X = F

(1) This work was presented at the Fourth International Fluorine Symposium, Estes Park, Colo., July 1967.

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