2b was independently prepared by *tert*-buxoxide-catalyzed addition of nitromethane to **1b** in *t*-BuOH, according to a method previously described for other olefins.[10] The product obtained (33%) had mp 140–141 °C (from ethyl alcohol).

Under similar conditions, **1a** (0.88 g, 3.9×10^{-3} mol) gave 1,3-dinitro-2,2-diphenylpropane (**2a**): 0.28 g (51%); mp 198 °C (from ethyl alcohol); mass spectrum, 286 *m/e* (M^+); NMR δ ($CDCl_3$) 5.6 (s, 4 H, CH_2NO_2), 6.8–7.9 (m, 10 H, Ar H). Anal. Calcd for $C_{15}H_{14}N_2O_4$: C, 62.93; H, 4.93; N, 9.78. Found: C, 62.37; H, 5.08; N, 9.64.

Reaction of a Secondary Amine with 9-(Dinitromethylene)fluorene (3). Diethylamine or di-*n*-butylamine (1.4×10^{-3} mol) was added to a solution of **3** (0.16 g, 0.6×10^{-3} mol) in acetonitrile (3 mL) at room temperature. The mixture was stirred for 0.5 min, during which time all the olefin dissolved, and the bis onium salt **4** precipitated: NMR (Me_2SO-d_6) of the diethylammonium salt δ 1.42 (t, 12 H), 3.21 (q, 8 H), 6.1 (s, 4 H), 7.5–8.2 (m, 8 H); mass spectrum, *m/e* 374 ($M^+ - 2Et_2NH$). The salt rapidly decomposed on standing. The reaction mixture was extracted with ether and aqueous NaOH. Fluorenone (0.03 g, 56%) was recovered from the ethereal extract. The aqueous solution was acidified and extracted with ether. The crude product recovered from the ethereal solution was crystallized to give 9,9-bis(dinitromethyl)fluorene (**5**): 0.10 g (90%); mp 156–157 °C (from chloroform); mass spectrum, *m/e* 374; NMR (CD_3CN) δ 7.6–7.1 (m, 8 H, Ar), 7.75 (s, 2 H, $CH(NO_2)_2$). Anal. Calcd for $C_{15}H_{10}N_4O_8$: C, 48.1; H, 2.7; N, 14.9. Found: C, 48.22; H, 2.7; N, 14.77.

Kinetic Measurements. Kinetic rate measurements of the reaction of **1a** with CN^- were carried out in Me_2SO (refluxed over CaH_2 and vacuum distilled),[11] using a 2400 Gilford spectrophotometer. The consumption of the olefinic starting material was monitored at 330 nm. The reaction was conducted under pseudo-first-order conditions (with respect to **1a**). Cyanide ion concentration ranged from 5×10^{-4} to 5×10^{-3} M. Substrate concentrations were ca. 10^{-5} M. The spectrophotometer was interfaced directly to a PDP 11/40 minicomputer for data aquisition and analysis. Correlation coefficients were better than 0.999 (eight determinations).

Registry No. **1a**, 5670-69-9; **1b**, 75700-13-9; **2a**, 75700-14-0; **2b**, 75700-15-1; 3, 25945-85-1; 4 bis(diethylamine) salt, 75700-17-3; 5, 75700-16-2; 4-methoxybenzophenone, 611-94-9.

(10) Schechter, H.; Ley, D. E.; Zeldin, L. *J. Am. Chem. Soc.* **1952**, *74*, 3664.

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Trifluoromethylated Steroidal C-17 Spirofuranones

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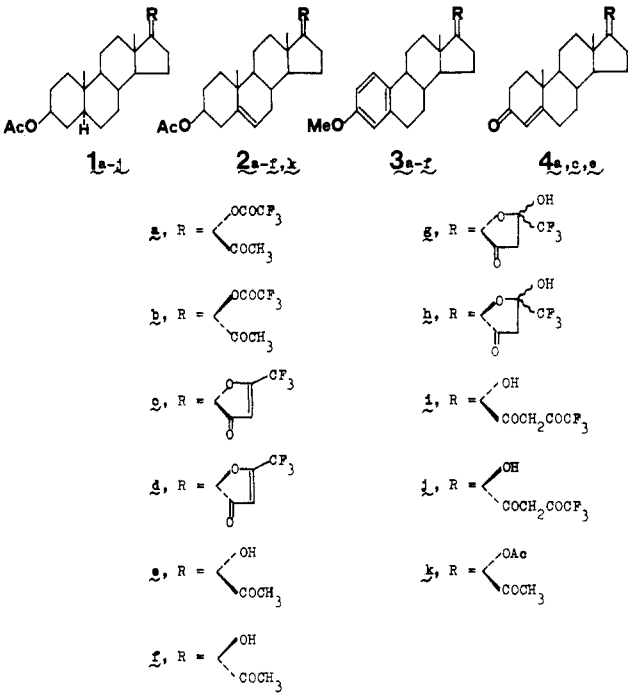
The development of new, relatively inexpensive methods for the introduction of a trifluoromethyl group into the steroid system is of considerable interest from both synthetic and pharmaceutical standpoints.[1]

In this context we describe here a simple, yet effective preparation of potentially useful 5′-(trifluoromethyl)spiro[steroid-17,2′(3′*H*)-furan]-3′-ones, the fluorinated analogues of a class of bioactive C-17 spirosteroids.[2]

(1) J. Fried and N. A. Abraham in "Organic Reactions in Steroid Chemistry", J. Fried and J. A. Edwards, Eds., Van Nostrand-Reinhold Co., 1972, Vol. 1, Chapter 8; G. H. Rasmusson, A. Chen, and G. E. Arth, *J. Org. Chem.*, **38**, 3670 (1973), and references therein; G. H. Rasmusson, R. D. Brown, and G. E. Arth, *J. Org. Chem.*, **40**, 672 (1975).

Chart I



The requisite substrates **1a,b**, **2a,b**, **3a,b**, and **4a** were all, except for **4a**,[3] readily prepared from the corresponding alcohols **1e,f**, **2e,f**, and **3e,f** with trifluoroacetic anhydride–pyridine at room temperature.

Treatment of **1a,b**–**4a** with a catalytic amount of 1,5-diazabicyclo[5.4.0]undec-5-ene (DBU) in refluxing benzene (Dean–Stark apparatus) afforded the spiro derivatives **1c,d**, **2c,d**, **3c,d**, and **4c** in 78–90% yields. The only isolable byproducts were the original alcohols **1e,f**–**4e** (see Chart I for structures).

The structure of all the C-17 spirofuranones followed from their analytical and spectral data.

Thus, both elemental analyses and mass spectra were consistent with the assumed composition. The IR spectra exhibited a band at 1705–1720 cm^{-1} characteristic of similar five-membered α,β-unsaturated ketones.[4] The ^1H NMR spectra showed a singlet[5] near δ 5.9 for one vinylic proton.

The above reaction conditions were found to be the most suitable ones to drive to completion the desired condensations and minimize hydrolytic cleavage of the labile trifluoroacetoxy group.

Substitution of potassium *tert*-butoxide for DBU gave, in the case of **1a**, the intermediate aldol-type product **1g** (vide infra) as the major component (62% yield) but no trace of **1c**.

Acidic catalysts proved to be completely inefficient since **1a**, when azeotropically refluxed in benzene in the presence of *p*-toluenesulfonic acid for 48 h, was recovered practically unchanged.

In contrast to the smooth conversion of **1a,b**–**4a**, the less electrophilic[6] 17-acetoxy derivative **2k** failed to undergo

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(3) B. R. Samant and F. Swet, *J. Org. Chem.*, **42**, 1981 (1977).

(4) P. Margaretha, *Tetrahedron Lett.*, 4891 (1971); C. Venturello and R. D' Aloisio, *Synthesis*, 754 (1977).

(5) C-4′ H could be occasionally observed by careful sweep-width expansion as a partially resolved quartet with $J_{H,F} = 0.7$ Hz.

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any DBU-catalyzed condensation.

Intramolecular Claisen condensations of 17-acetoxypregnan-20-ones were instead reported to occur in the presence of Wittig reagents to give, inter alia, spiro ethers structurally related to the intermediates in the condensations of **1a,b–4a**.[7]

The nature of these intermediates, which were observed by TLC during the course of the reaction, was investigated in detail in the case of **1a** and **1b** by stopping the reactions after 5 h. Chromatographic resolution of residues afforded compounds **1g** or **1h** in 29 or 39% yield, respectively, together with starting material (for **1b** only), spiro derivatives **1c** or **1d**, and alcohols **1e** or **1f**.

The presence of a single carbonyl absorption at 1750 cm^{-1} (in addition to the acetate band at 1720 cm^{-1}) in the solution ($CHCl_3$) IR spectra and the absence of signals apart from 3α-H and OH protons downfield of δ 3.1 in the ^1H NMR spectra recorded in different solvents indicated that **1g** and **1h** existed in solution exclusively in the cyclohemiketal form. Furthermore, the ^1H NMR spectra exhibited a pair of singlets each for the 13-Me group, two broad signals for the OH proton, and two partially overlapping AB quartets for the C-4′ methylene protons, suggesting that each product was a mixture of the C-5′ epimers in ~2.3:1 and 1.2:1 ratios for **1g** and **1h**, respectively.

The presence of the open-chain tautomeric forms **1i** and **1j** was ruled out in the solid state as well, in spite of the complexity of the IR spectra as KBr disks, which showed four bands each in the carbonyl-stretching region at 1755, 1740, 1725, and 1705 cm^{-1}. There were no absorption bands which could be attributed to enolic structures, while β-dicarbonyl compounds of the form CF_3COCH_2COR are reported to be largely enolic and possess strong bands in the region 1680–1605 cm^{-1}.[6,8]

The major epimers, isolated in fairly pure form by two crystallizations of crude **1g** and **1h** from acetone–hexane, exhibited exclusively the bands at 1755 and 1705 cm^{-1}. The mother liquors showed conversely a pronounced and parallel enhancement of the bands at 1740 and 1725 cm^{-1}, which could be thus conceivably assigned to the minor epimers.

These could not be isolated from the mother liquors, owing to the facility of epimerization and the fact that the major ones had lower solubility.

Spectral data in our hands did not permit an unambiguous assignment of configuration at C-5′ to the two pairs of epimers.

The composition of the reaction mixtures after 5 h (see the Experimental Section) indicated that the rate-limiting step was in both cases the dehydration of intermediates **1g** and **1h** and that this process was faster for **1g**.

1g and **1h** (as the ~1.9:1 and 1:1 epimeric mixtures) were found to be the major products (76 and 57% yield, respectively) of the treatment of **1a** and **1b** with hexamethylphosphotriamide (HMPT) in the presence of sodium azide. Alcohols **1e** and **1f** were the only byproducts. No trace of 17-azido derivatives could be detected.

The well-known accelerating effect of an α-carbonyl group toward an S_N2 process[9] appeared to be completely outweighed by steric hindrance factors, even in the more favorable **1b** case.

For comparative purpose it may be recalled that in a previous study on the solvolyses of tertiary C-17 trifluoroacetates, an 11% yield of 17α-azido derivative was obtained from a 17β-trifluoroacetate.[10]

Substitution of sodium acetate for sodium azide gave again **1g** (from **1a**) as the main product (80% yield). No **1c** was detected.

Experimental Section

Melting points were determined on a Kofler hot-stage apparatus and are uncorrected. Optical rotations were measured with a Schmidt-Haensch polarimeter (1-dm cell) in 1% $CHCl_3$ solutions. IR spectra were recorded on a Perkin-Elmer 521 spectrophotometer by using KBr pellets, unless otherwise specified. ^1H NMR spectra were run on a Varian EM-390 spectrometer, using $CDCl_3$ as solvent, unless otherwise indicated, and Me_4Si as internal standard. Mass spectra were taken with an Hewlett-Packard 5930 A spectrometer. HMPT was distilled in vacuo over sodium hydride. Benzene was dried over sodium. DBU (Aldrich) was used as received.

General Procedure for Preparation of Trifluoroacetates 1a,b–3b. 3β,17α-Dihydroxy-5α-pregnan-20-one 3-Acetate 17-Trifluoroacetate (1a). A solution of 3β,17α-dihydroxy-5α-pregnan-20-one 3-acetate (**1e**;[11] 1.13 g, 3 mmol) in pyridine (5 mL) was treated with trifluoroacetic anhydride (2.1 mL) at 0 °C and allowed to stand at room temperature for 3 h. Then cold 1 N HCl (35 mL) was added and the mixture was extracted with ether. The ether layers were washed to neutrality with water, dried (Na_2SO_4), and evaporated. The residue (1.41 g) was passed through a short silica gel column with benzene. Evaporation of the solvent and recrystallization of the white solid from hexane gave pure **1a** (1.10 g): mp 166.5–167.5 °C; $[\alpha]_D$ −8°; IR 1780, 1725, 1715 cm^{-1}; ^1H NMR δ 0.63 (3 H, s, 13-Me), 0.80 (3 H, s, 10-Me), 1.97 (3 H, s, 3β-OAc), 2.03 (3 H, s, COMe), 4.7 (1 H, m, 3α-H). Anal. Calcd for $C_{25}H_{35}F_3O_5$ (mol wt 472.5): C, 63.54; H, 7.46; F, 12.06. Found: C, 63.65; H, 7.54; F, 12.00.

The following trifluoroacetates were prepared and isolated in a similar manner from the corresponding alcohols **1f**,[12] **2e**,[13] **2f**,[14] **3e**,[15] and **3f**.[16]

3β,17β-Dihydroxy-5α-pregnan-20-one 3-acetate 17-trifluoroacetate (1b): mp 139–140 °C; $[\alpha]_D$ −8°; IR 1790, 1730, 1710 cm^{-1}; ^1H NMR δ 0.80 (3 H, s, 10-Me), 1.00 (3 H, s, 13-Me), 1.98 (3 H, s, 3β-OAc), 2.07 (3 H, s, COMe), 4.7 (1 H, m, 3α-H). Anal. Calcd for $C_{25}H_{35}F_3O_5$ (mol wt. 472.5): C, 63.54; H, 7.46; F, 12.06. Found: C, 63.57; H, 7.53; F, 12.00.

3β,17β-Dihydroxypregn-5-en-20-one 3-acetate 17-trifluoroacetate (2a): mp 153–155 °C; $[\alpha]_D$ −59°; IR 1770, 1720, 1705 cm^{-1}; ^1H NMR δ 0.68 (3 H, s, 13-Me), 1.02 (3 H, s, 10-Me), 2.00 (3 H, s, 3β-OAc), 2.08 (3 H, s, COMe), 4.6 (1 H, m, 3α-H), 5.4 (1 H, m, C-6 H). Anal. Calcd for $C_{25}H_{33}F_3O_5$ (mol wt 470.5): C, 63.82; H, 7.07; F, 12.11. Found: C, 63.80; H, 7.04; F, 12.01.

3β,17β-Dihydroxypregn-5-en-20-one 3-acetate 17-trifluoroacetate (2b): mp 134–135 °C; $[\alpha]_D$ −54°; IR 1785, 1730, 1710 cm^{-1}; ^1H NMR δ 1.01 (3 H, s, 10-Me or 13-Me), 1.03 (3 H, s, 13-Me or 10-Me), 2.00 (3 H, s, 3β-OAc), 2.07 (3 H, s, COMe), 4.6 (1 H, m, 3α-H), 5.4 (1 H, m, C-6 H). Anal. Calcd for $C_{25}H_{33}F_3O_5$ (mol wt 470.5): C, 63.82; H, 7.07; F, 12.11. Found: C, 63.80; H, 7.12; F, 12.04.

17α-Hydroxy-3-methoxy-19-norpregna-1,3,5(10)-trien-20-one trifluoroacetate (3a): mp 110.5–111 °C; $[\alpha]_D$ +34°; IR 1780, 1730 cm^{-1}; ^1H NMR δ 0.70 (3 H, s, 13-Me), 2.10 (3 H, s, COMe), 3.77 (3 H, s, 3-OMe), 6.63–7.25 (3 H, aromatic protons). Anal. Calcd for $C_{23}H_{27}F_3O_4$ (mol wt 424.5): C, 65.08; H, 6.41; F, 13.43.

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(14) C. W. Shoppee and D. A. Prins, *Helv. Chim. Acta*, **26**, 201 (1943).
(15) Prepared from estrone methyl ether, following the same procedure as used by J. Bastard, M. Fetizon, and J. C. Gramain, *Tetrahedron*, **29**, 2867 (1973), on 5α-androstan-17-one.
(16) K. Prezewowsky, R. Wiechert, and W. Hohlweg, *Justus Liebigs Ann. Chem.*, **752**, 68 (1971).

Found: C, 65.01; H, 6.48; F, 13.48.

17β-Hydroxy-3-methoxy-19-norpregna-1,3,5(10)-trien-20-one trifluoroacetate (3b): mp 141–142 °C; $[\alpha]_D$ +45°; IR 1775, 1715 cm^{-1}; ^1H NMR δ 1.06 (3 H, s, 13-Me), 2.11 (3 H, s, COMe), 3.74 (3 H, s, 3-OMe), 6.63–7.21 (3 H, aromatic protons). Anal. Calcd for $C_{23}H_{27}F_3O_4$ (mol wt 424.5): C, 65.08; H, 6.41; F, 13.43. Found: C, 65.13; H, 6.42; F, 13.28.

Trifluoroacetate **4a** was prepared from **4e** by a literature procedure.[3]

General Procedure for Preparation of Spirofuranones 1c,d–4c. **5′-(Trifluoromethyl)-(17*R*)-spiro[3β-acetoxy-5α-androstane-17,2′(3′*H*)-furan]-3′-one (1c).** A solution of **1a** (0.47 g, 1 mmol) and DBU (75 mg, 0.5 mmol) in benzene (10 mL) was stirred at reflux under a Deans–Stark trap for 24 h, after which time TLC analysis indicated that all the intermediate **1g** (see later) had disappeared. The reaction mixture was concentrated and chromatographed on silica gel (7 g). Elution with benzene gave **1c** (0.41 g, 90%): mp 127–128 °C (from hexane); $[\alpha]_D$ + 147°; IR 1725, 1710, 1630 cm^{-1}; ^1H NMR δ 0.81 (3 H, s, 10-Me), 0.89 (3 H, s, 13-Me), 1.97 (3 H, s, 3β-OAc), 4.7 (1 H, m, 3α-H), 5.97 (1 H, s, C-4′ H); mass spectrum, *m/e* (relative intensity) 454 (M^+, 15), 394 (M^+ – 60, 15), 379 (M^+ – 75, 5). Anal. Calcd for $C_{25}H_{33}F_3O_4$ (mol wt 454.5): C, 66.06; H, 7.32; F, 12.54. Found: C, 66.01; H, 7.20; F, 12.44.

Elution with benzene–ether (9:1) gave the alcohol **1e** (26 mg, 7%).

The following spirofuranones were prepared and isolated in a similar manner from the corresponding trifluoroacetates **1b**, **2a**, **2b**, **3a**, **3b**, and **4a**.

5′-(Trifluoromethyl)-(17*S*)-spiro[3β-acetoxy-5α-androstane-17,2′(3′*H*)-furan]-3′-one (1d, 83%): mp 185–186 °C; $[\alpha]_D$ –154°; IR 1730, 1710, 1630 cm^{-1}; ^1H NMR δ 0.80 (3 H, s, 10-Me), 0.98 (3 H, s, 13-Me), 1.98 (3 H, s, 3β-OAc), 4.7 (1 H, m, 3α-H), 5.86 (1 H, s, C-4′ H); mass spectrum, *m/e* (relative intensity) 454 (M^+, 6), 394 (M^+ – 60, 5), 379 (M^+ – 75, 2). Anal. Calcd for $C_{25}H_{33}F_3O_4$ (mol wt 454.5): C, 66.06; H, 7.32; F, 12.54. Found: C, 66.16; H, 7.31; F, 12.59.

5′-(Trifluoromethyl)-(17*R*)-spiro[3β-acetoxyandrost-5-ene-17,2′(3′*H*)-furan]-3′-one (2c, 85%): mp 131.5–132.5 °C; $[\alpha]_D$ + 113.5°; IR 1725, 1715, 1630 cm^{-1}; ^1H NMR δ 0.93 (3 H, s, 13-Me), 1.02 (3 H, s, 10-Me), 2.00 (3 H, s, 3β-OAc), 4.6 (1 H, m, 3α-H), 5.4 (1 H, m, C-6 H), 5 .97 (1 H, s, C-4′ H); mass spectrum, *m/e* (relative intensity) 393 (M^+ – 59, 24), 392 (M^+ – 60, 87), 377 (M^+ – 75, 19). Anal. Calcd for $C_{25}H_{31}F_3O_4$ (mol wt 452.5): C, 66.36; H, 6.90; F, 12.59. Found: C, 66.47; H, 6.94; F, 12.37.

5′-(Trifluoromethyl)-(17*S*)-spiro[3β-acetoxyandrost-5-ene-17,2′(3′*H*)-furan]-3′-one (2d, 82%): mp 178.5–179 °C; $[\alpha]_D$ –202°; IR 1725, 1705, 1625 cm^{-1}; ^1H NMR δ 1.00 (3 H, s, 13-Me or 10-Me), 1.01 (3 H, s, 10-Me or 13-Me), 2.00 (3 H, s, 3β-OAc), 4.6 (1 H, m, 3α-H), 5.4 (1 H, m, C-6 H), 5.87 (1 H, s, C-4′ H); mass spectrum, *m/e* (relative intensity) 393 (M^+ – 59, 25), 392 (M^+ – 60, 92), 377 (M^+ – 75, 18). Anal. Calcd for $C_{25}H_{31}F_3O_4$ (mol wt 452.5): C, 66.36; H, 6.90; F, 12.59. Found: C, 66.43; H, 6.89; F, 12.57.

5′-(Trifluoromethyl)-(17*R*)-spiro[3-methoxyestra-1,3,5-(10)-triene-17,2′(3′*H*)-furan]-3′-one (3c, 78%): mp 110.5–111.5 °C; $[\alpha]_D$ +212°; IR 1705, 1625 cm^{-1}; ^1H NMR δ 0.95 (3 H, s, 13-Me), 3.76 (3 H, s, 3-OMe), 5.99 (1 H, s, C-4′ H), 6.63–7.25 (3 H, aromatic protons); mass spectrum, *m/e* (relative intensity) 407 (M^+ + 1, 19), 406 (M^+, 71). Anal. Calcd for $C_{23}H_{25}F_3O_3$ (mol wt 406.4): C, 67.97; H, 6.20; F, 14.02. Found: C, 67.99; H, 6.17; F, 14.11.

5′-(Trifluoromethyl)-(17*S*)-spiro[3-methoxyestra-1,3,5-(10)-triene-17,2′(3′*H*)-furan]-3′-one (3d, 80%): mp 124–125 °C; $[\alpha]_D$ –147°; IR 1705, 1625 cm^{-1}; ^1H NMR δ 1.02 (3 H, s, 13-Me), 3.75 (3 H, s, 3-OMe), 5.88 (1 H, s, C-4′ H), 6.62–7.22 (3 H, aromatic protons); mass spectrum, *m/e* (relative intensity), 407 (M^+ + 1, 25), 406 (M^+, 100). Anal. Calcd for $C_{23}H_{25}F_3O_3$ (mol wt 406.4): C, 67.97; H, 6.20; F, 14.02. Found: C, 68.05; H, 6.17; F, 13.76.

5′-(Trifluoromethyl)-(17*R*)-spiro[androst-4-ene-17,2′-(3′*H*)-furan]-3,3′-dione (4c, 80%): mp 157–158 °C; $[\alpha]_D$ +265°; IR 1720, 1675, 1625 cm^{-1}; ^1H NMR δ 0.97 (3 H, s, 13-Me), 1.18 (3 H, s, 10-Me), 5.74 (1 H, br s, C-4 H), 5.98 (1 H, s, C-4′ H); mass spectrum, *m/e* (relative intensity) 409 (M^+ + 1, 25), 408 (M^+, 100), 393 (M^+ – 15, 7), 366 (M^+ – 42, 9). Anal. Calcd for $C_{23}H_{27}F_3O_3$ (mol wt 408.5): C, 67.63; H, 6.66; F, 13.95. Found: C, 67.80; H, 6.70; F, 13.81.

The procedure was repeated on **1a** as described above, except that the reaction was stopped after 5 h. The mixture was chromatographed on silica gel (12 g). Elution with benzene gave **1c** (258 mg, 57%). Elution with benzene–ether (95:5) gave **1g** (138 mg, 29%) as an approximately 2.3:1 mixture of the two C-5′ epimers. Two crystallizations from acetone–hexane afforded the major epimer: mp 206–208 °C; $[\alpha]_D$ +99°; IR 3260, 1755, 1705 cm^{-1}; ^1H NMR δ 0.77 (3 H, s, 13-Me), 0.81 (3 H, s, 10-Me), 1.98 (3 H, s, 3β-OAc), 2.57 and 2.79 (2 H, AB q, J = 19.5 Hz, C-4′ H_2), 4.7 (1 H, m, 3α-H), 4.93 (1 H, br s, OH); ^1H NMR (C_6D_6/$CDCl_3$, 2:1)[17] δ 0.64 (10-Me), 0.75 (13-Me), 1.80 (3β-OAc), 2.42 and 2.60 (J = 19.5 Hz, C-4′ H_2), 4.24 (OH); ^1H NMR (CD_3COCD_3) δ 0.77 (13-Me), 0.83 (10-Me), 1.92 (3β-OAc), 2.52 and 2.92 (J = 18 Hz, C-4′ H_2), 6.52 (OH); mass spectrum, *m/e* (relative intensity) 472 (M^+, 8), 412 (M^+ –60, 77), 397 (M^+ – 75, 34). Anal. Calcd for $C_{25}H_{35}F_3O_5$ (mol wt 472.5): C, 63.54; H, 7.46; F, 12.06. Found: C, 63.51; H, 7.53; F, 12.10.

That the crude product was a mixture of the two C-5′ epimers was apparent from the following relatively less intense ^1H NMR signals ascribed to the minor epimer: δ 2.63 and 2.92 (AB q, J = 19.5 Hz, C-4′ H_2), 5.11 (br s, OH); ^1H NMR (C_6D_6–$CDCl_3$, 2:1) δ 0.67 (10-Me), 0.73 (13-Me), 1.82 (3β-OAc), 2.47 and 2.78 (J = 19.5 Hz, C-4′ H_2), 4.50 (OH); ^1H NMR (CD_3COCD_3) δ 0.76 (13-Me), 2.30 and 2.63 (J = 18 Hz, C-4′ H_2), 6.77 (OH).

Elution with benzene–ether (9:1) gave **1e** (52 mg, 14%).[18]

Repetition of the above procedure on **1b** gave by elution with benzene a mixture of **1b** and **1d** (194 mg, relative yields 9 and 31%). Elution with benzene–ether (95:5) gave **1h** (186 mg, 39%) as an ~1.2:1 mixture of the two C-5′ epimers. Two crystallizations from acetone–hexane gave the major epimer: mp 225–227 °C; $[\alpha]_D$ –112.5°; IR 3280, 1755, 1705 cm^{-1}; ^1H NMR δ 0.80 (3 H, s, 10-Me), 0.88 (3 H, s, 13-Me), 1.98 (3 H, s, 3β-OAc), 2.58 and 2.83 (2 H, AB q, J = 18 Hz, C-4′ H_2), 3.92 (1 H, br s, OH), 4.7 (1 H, m, 3α-H); ^1H NMR (C_6D_6/$CDCl_3$, 2:1) δ 0.65 (10-Me), 0.83 (13-Me), 1.79 (3β-OAc), 2.42 and 2.65 (J = 18 Hz, C-4′ H_2), 3.02 (OH); ^1H NMR (CD_3COCD_3) δ 0.83 (10-Me), 0.90 (13-Me), 1.90 (3β-OAc), 2.53 and 2.93 (J = 18 Hz, C-4′ H_2), 6.53 (OH); mass spectrum, *m/e* (relative intensity) 472 (M^+, 13), 412 (M^+ – 60, 83), 397 (M^+ –75, 40). Anal. Calcd for $C_{25}H_{35}F_3O_5$ (mol wt 472.5): C, 63.54; H, 7.46; F, 12.06. Found: C, 63.28; H, 7.55; F, 11.86.

The following relatively less intense ^1H NMR signals in the crude product are attributable to the minor epimer: δ 2.62 and 2.92 (AB q, J = 19.5 Hz, C-4′ H_2), 4.28 (br s, OH); ^1H NMR (C_6D_6/$CDCl_3$, 2:1) δ 2.45 and 2.73 (J = 19.5 Hz, C-4′ H_2), 3.31 (OH); ^1H NMR (CD_3COCD_3) δ 0.93 (13-Me), 2.63 and 2.97 (J = 18 Hz, C-4′ H_2), 6.67 (OH).

Elution with benzene–ether (9:1) gave **1f** (64 mg, 17%).

Substitution of potassium *tert*-butoxide (0.23 g, 2 mmol) for DBU resulted, after 5 h, in the formation of **1g** (62%) and **1e** (38%) from **1a**.

Reaction of 1a in HMPT in the Presence of NaN_3. **1a** (0.47 g, 1 mmol) and NaN_3 (0.65 g, 10 mmol) in 5 mL of HMPT were stirred at 65 °C for 2.5 h. The mixture was poured into water and extracted with ether. The extract was washed repeatedly with water and dried (Na_2SO_4). The residue (0.46 g) was chromatographed on silica gel (12 g). Elution with benzene–ether (95:5) gave starting material (23 mg, 5%) followed by **1g** (359 mg, 76%) as an ~1.9:1 epimeric mixture. Elution with benzene–ether (9:1) gave **1e** (56 mg, 15%).

Repetition of the above procedure on **1b** gave **1h** (283 mg, 60%) as an ~1:1 epimeric mixture and **1f** (109 mg, 29%).

In the same manner the reaction of **1a** in HMPT was carried out in the presence of sodium acetate to give **1g** and **1e** in 80 and 20% yield, respectively.

Registry No. 1a, 75522-19-9; **1b**, 75557-07-2; **1c**, 75522-20-2; **1d**, 75557-08-3; **1e**, 5456-44-0; **1f**, 75557-09-4; **1g** (epimer 1), 75522-21-3; **1g** (epimer 2), 75522-22-4; **1h** (epimer 1), 75557-10-7; **1h** (epimer 2), 75557-11-8; **2a**, 75522-23-5; **2b**, 75557-12-9; **2c**, 75522-24-6; **2d**, 75557-13-0; **2e**, 1863-39-4; **2f**, 41906-06-3; **3a**, 75522-25-7; **3b**, 75557-14-1; **3c**, 75522-26-8; **3d**, 75557-15-2; **3e**, 1624-58-4; **3f**, 34965-67-8; **4a**, 560-10-1; **4c**, 75522-27-9.

(17) Here and later only those signals which were found to be solvent dependent are reported.

(18) The higher yield of **1e** in comparison with that after reaction completion may be due to hydrolysis of residual **1a** on the column.