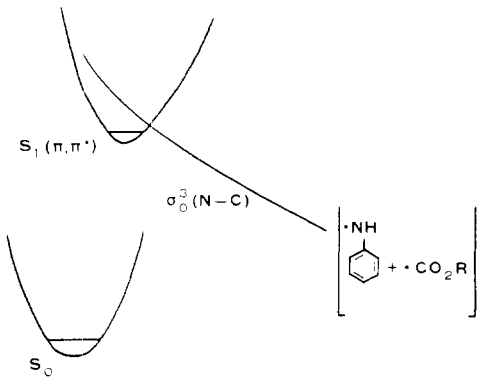

Figure 2. Surface diagram for photolysis of urethanes.

amines, such as aniline, on the wavelength of the exciting source.[21,22] Thus the photoprocesses of aromatic amines are wavelength dependent.

Proposed Mechanism for Alkyl *N*-Arylcarbamates in Solution. A lucid picture for the photodegradation of alkyl *N*-arylcarbamates in solution may now be presented from our results and from studies reported in the literature. Each phase or step of the photodegradation process will be considered with respect to Scheme II.

1. Excited State and Primary Reaction Processes. The absorption process of aromatic urethanes, as discussed previously, results in the formation of an excited molecule in the $S_1(\pi,\pi^*)$ energy level regardless of the exciting wavelength. From this state, the carbamate molecule can then dissociate to give a radical pair in a solvent cage or return to the ground state by a nonradiative or a radiative (fluorescence) decay process. The formation of a solvent-caged radical pair consisting of an aminyl radical and an alkoxycarbonyl radical arises from the surface crossing of the $S_1(\pi,\pi^*)$ excited state with the σ_0^3(N–C) repulsive surface (Figure 2), leading to a homolytic cleavage of the N–C bond (Scheme II, path 1a). A similar surface crossing of the $S_1(\pi,\pi^*)$ state with the σ_0^3(C–O) repulsive state leads to the formation of an alkoxyl and *N*-phenylformamoyl radical pair in a solvent cage (Scheme II, path 1b).

2. Formation of Primary Products. Primary reaction products are subsequently formed from reactions of the solvent-caged radical pair. As shown in Scheme II, path 2a, the radical pair can recombine to give the ground-state carbamate. Concurrently, the radical pair may combine to give photo-Fries rearrangement products (Scheme II, path 2b). These latter products are judged to be relatively photostable when compared to others that may form. Decomposition of the alkoxycarbonyl radical or the *N*-phenylformamoyl radical by decarboxylation and decarbonylation, respectively, can also occur (Scheme II, paths 2c and 2d). In the latter case this leads to a "free" anilinyl radical. These radicals also arise from disruption of the cage radical pair. It is the reactions of these anilinyl radicals that subsequently may account for most of the remaining primary reaction products. On the basis of our findings, the parent arylamine (e.g., aniline) is one of these products (except in the case of **5a**). It forms via hydrogen abstraction (Scheme II, path 2e). The fact that the sum of quantum efficiencies (Φ_{total}) for the parent amine and rearrangement products fails to coincide with the quantum efficiencies (Φ_D) for carbamate disappearance can be rationalized by postulating that the anilinyl radical can undergo reactions other than hydrogen abstraction.

Acknowledgment. We are grateful to Professor D. Swern, Temple University, for helpful suggestions in preparing the manuscript and to Dr. R. M. Fantazier for stimulating discussions bearing on this study. Our appreciation is also extended to Mr. G. K. Echterling for his assistance in carrying out some of the experimental work and to Mr. A. G. Geigley for recording the NMR spectra.

Registry No. **1a**, 101-99-5; **1b**, 62-53-3; **1c**, 87-25-2; **1d**, 94-09-7; **2a**, 73262-65-4; **2b**, 95-53-4; **2c**, 73262-66-5; **2d**, 73274-30-3; **3a**, 63379-16-8; **3b**, 106-49-0; **3c**, 73262-67-6; **4a**, 73262-68-7; **4b**, 87-62-7; **5a**, 73262-69-8; **5b**, 88-05-1.

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(22) Perichet, G.; Pouyet, B., *C. R. Hebd. Seances Acad. Sci., Ser. C* **1973**, *276*(1), 37.

Influence of Fluorine and Oxygen Atoms at C-19 on the Previtamin D-Vitamin D Interconversion

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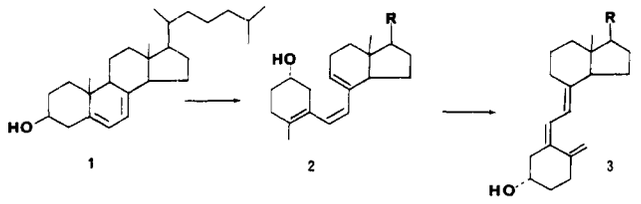
19,19-Difluorocholesteryl acetate (**6**), prepared by fluorination of 19-oxocholesteryl acetate (**5**), was converted to the respective 5,7-diene (**7**) which, on irradiation, gave both 19,19-difluoroprevitamin D_3 (**8**) and 19,19-difluorotachysterol (**9**). On the fluorinated previtamin did not rearrange to the corresponding vitamin D derivative (**4**) but isomerized, in part, to the tachysterol derivative **9**. On the other hand, 19-acetoxyprevitamin D_3 acetate (**11**), described previously by Moriarty et al.,[13] proved to be unstable, rearranging irreversibly to 19-acetoxyvitamin D_3 acetate (**12**).

The biogenetic route to vitamin D_3 (**3**) involves a photochemical conversion of 7-dehydrocholesterol (**1**) to previtamin D_3 (**2**) (Scheme I), followed by a thermal isomerization.[1] A similar route is commonly used for chemical synthesis of vitamin D_3 and its analogues since their respective 7-dehydrocholesterol derivatives are easily accesible.[1,2] However, the thermal isomerization of previtamin D_3 (**2**) to vitamin D_3 (**3**), which is shifted predominantly to the latter (20:80 at 80 °C), is sensitive to conformational and substitutional changes in the vicinity of the triene system,[3] which may thus preclude the formation of the

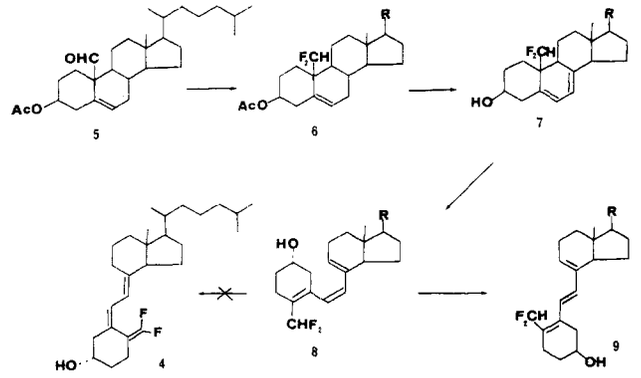
(1) (a) Fieser, L. F.; Fieser, M. "Steroids"; Reinhold: New York, 1959; pp 90–160. (b) Holick, M. F.; Richtand, N. M.; McNeil, S.; Holick, S. A.; Formmer, J. E.; Henley, J. W.; Potts, J. T., Jr. *Biochemistry* **1979**, *18*, 1003.
(2) Georghiou, P. E. *Chem. Soc. Rev.* **1977**, *6*, 83.

0022-3263/80/1945-2201$01.00/0

Scheme I



Scheme II



desired vitamin D analogues.

We have recently shown that substitution at C-1 by an oxo group, or at C-6 by a methyl group, also interferes with this equilibrium, shifting it completely toward the previtamin system.[4]

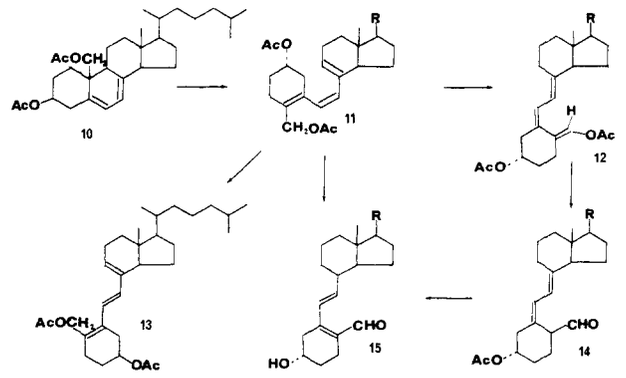
In continuation of our studies on previtamin D equilibria, we investigated the influence of fluorine and oxygen atoms at C-19, the terminal position of the triene system.

We have attempted to prepare 19,19-difluorovitamin D_3 (**4**), starting from the known 19-oxocholesteryl acetate (**5**)[5] (Scheme II). This compound was converted to the 19,19-difluorocholesteryl acetate (**6**) with (diethylamino)sulfur trifluoride.[6] Allylic bromination with 1,3-dibromo-5,5-dimethylhydantoin followed by dehydrobromination with trimethyl phosphite in xylene and hydrolysis led to the 19,19-difluorocholesta-5,7-dien-3β-ol acetate (**7**).

Irradiation of the diene **7** with 300-nm light at 0 °C resulted in 19,19-difluoroprevitamin D_3 (**8**; 20%) and its 6,7 *E* isomer, the 19,19-difluorotachysterol[3] (**9**; 10%).[7]

The structure of the previtamin derivative **8** was assigned from its spectroscopic properties: its triene chromophore absorbed at λ_{max} 256 nm (ϵ 10 000),[8] and in the ^1H NMR the presence of signals of the cis-vicinal vinylic protons at C-6 and C-7 (broad signal at δ 5.86) and of the vinylic proton at C-9 (q, δ 5.58, J = 2.5 and 3.5 Hz) was observed. In addition, the C=C(R)CHF_2 group was recognized from both the ^1H NMR and ^{19}F NMR spectra (H triplet and F doublet with J = 55.5 Hz). Its mass spectrum indicated a molecular ion peak (*m/e* 420) and a base peak assigned to the $M^+ - H_2O - CHF_2$ fragment. In addition, ion peaks were observed due to the cleavage of ring C (across the 9,11 and 8,14 bonds), characteristic of the previtamin D_3 system.[9]

Scheme III



The second compound isolated, 19,19-difluorotachysterol (**9**), absorbed at λ_{max} 278 nm, 270 (sh), and 288 (sh) (ϵ 18 000, 17 500, and 17 000).[10] Its ^1H NMR spectrum in the vinylic region displayed signals due to the vicinal trans protons at C-6 and C-7 (δ 6.60 and 6.25, J = 16 Hz) and a proton at C-9 (q, δ 5.75, J = 2.5 and 3.5 Hz). The C=C(R)CHF_2 moiety was identified, as in the case of the previtamin D_3 derivative **8**, by the characteristic ^1H triplet and ^{19}F doublet (J = 55.5 Hz).

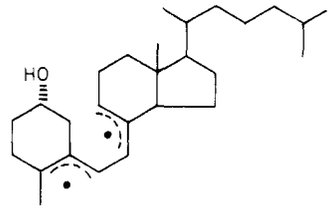
The mass spectral pattern of the 6,7 *E* triene **9** was almost superimposable on that of its 6,7 *Z* isomer **8**, differing only by the relative intensities of some fragmentation peaks.[11]

As expected, the 6,7 *Z* triene **8** isomerized completely to the 6,7 *E* isomer **9** when its solution, containing traces of iodine, was exposed for a short time to sunlight.[12] However, no thermal isomerization of 6,7 *Z* triene **8** to the respective vitamin D_3 derivative **4** could be detected.

After the reaction mixture was heated for 2 h, during which the reaction was monitored by TLC and UV spectroscopy, a slow formation of a new product was observed, the UV shifting to longer wavelengths. After the mixture was heated for 5 h, we isolated, in addition to the starting material, a product which proved to be identical to 6,7 *E* triene **9**. This thermal *Z*/*E* isomerization also took place in alcoholic solution, but it was suppressed on addition of traces of hydroquinone.

The fact that 19,19-difluoroprevitamin D_3 (**8**) does not isomerize may be explained by the strong inductive effect of the two fluorine atoms which prevent the hydrogen migration.[13]

The thermal 6,7 *Z* → *E* isomerization may be rationalized by the intermediacy of a diradical of the following formula:



(3) Sanders, G. M.; Pot, J.; Havinga, E. *Fortschr. Chem. Org. Naturst.* **1969**, *28*, 131. Havinga, E. *Experientia* **1973**, *29*, 1181. Schlatmann, J. L. M. A.; Pot, J.; Havinga, E. *Recl. Trav. Chim. Pays-Bas* **1964**, *83*, 1173. Takken, H. J. Thesis, University Leiden, Holland, 1971.

(4) Sheves, M.; Mazur, Y. *J. Chem. Soc., Chem. Commun.* **1977**, 21.

(5) Akhtar, M.; Barton, D. H. R. *J. Am. Chem. Soc.* **1964**, *86*, 1528.

(6) von Halasz, S. P.; Glemser, O. *Chem. Ber.* **1970**, *103*, 594; **1971**, *104*, 1247.

(7) In addition, a number of other products were formed which have not yet been investigated.

(8) This λ_{max} value is shifted by ca. 5 nm as compared to that of previtamin D_3 [λ_{max} 261 nm (ϵ 10 000)[4]].

(9) Zaretskii, Z. V. I. *Biomed. Mass Spectrom.* **1978**, *5*, 576.

(10) The parent tachysterol adsorbs at longer wavelength and with higher intensity [λ_{max} 282 nm (ϵ (ϵ 25 000)[4]].

(11) The ratio of the intensities of the molecular ion peak and the main fragmentation ion peak is significantly higher in **9** than in **8**. A similar intensity relationship was observed in the mass spectra of tachysterol and previtamin D_3 (Zaretskii, Z. V. I., unpublished results). These data may be indicative of the higher stability of the 6,7 *E* triene than of the 6,7 *Z* triene.

(12) This 6,7 *Z*/6,7 *E* iodine-induced photoisomerization is characteristic of the previtamin D_3 system.[1a]

(13) It is plausible that a localized positive charge on the terminal carbon atom of the triene system is involved in the transition state of the 1,7 hydrogen migration. Cf.: Breslow, R.; Hoffman, J. H.; Perchonock, C. *Tetrahedron Lett.* **1973**, 3723.

Contrary to the stability of 19,19-difluoroprevitamin D_3 (**8**), 19-acetoxyprevitamin D_3 (**11**) proved to be thermally unstable. The formation of this compound by irradiation of 3β,19-diacetoxycholesta-5,7-diene (**10**) and its isomerization to 19-acetoxyvitamin D_3 (**12**) (see Scheme III) were previously reported by Moriarty et al.[14] On attempting to purify previtamin D_3 derivative **11**, whose presence was indicated by the formation of the tachysterol derivative **13** on addition of I_2 (λ_{max} 267, 278, 290 nm), we have observed that it is exceptionally unstable. Thus **11** isomerized completely to 19-acetoxyvitamin D_3 acetate (**12**) [λ_{max} 219 nm (ε 27 000), 267 (18 000); and on addition of I_2, λ_{max} 271 nm] after having been kept at 50 °C for 2 h. In contrast, the vitamin derivative **12** was thermally stable, being recovered unchanged after overnight heating at 70 °C.

Hydrolysis of 19-acetoxyvitamin D_3 acetate (**12**) with traces of base (0.01 N NaOH in MeOH) gave a mixture of the doubly unsaturated 19-epimeric aldehydes **14** (λ_{max} 242, 252, 257 nm[15]) which on standing with stronger base (0.1 N NaOH in MeOH) rearranged to the doubly conjugated aldehyde **15** (λ_{max} 298 nm). Attempts to hydrolyze 19-acetoxyprevitamin D_3 acetate (**11**), in order to obtain its 19-hydroxy analogue, proved unsuccessful: it rearranged to the conjugated aldehyde **15**.

The nonreversible formation of 19-acetoxyvitamin D_3 acetate (**12**) from the corresponding previtamin D_3 **11** indicates the remarkable stability of the former. This stability may be explained by the electron-donating property of the oxygen atom of the enol acetate system which changes the electron distribution in the triene system, thus inhibiting the [1,7] sigmatropic H migration. An alternative explanation may involve a steric effect: the acetoxy group at C-19 destabilizes the s-cis 6,7 conformation of 19-acetoxyvitamin D_3 acetate (**12**) and prevents in this way its reconversion to the corresponding previtamin D_3 (**11**).

Experimental Section

^1H NMR spectra were recorded on a Bruker WH-90 spectrometer using CCl_4 as a solvent and cyclohexane-*d* as an internal lock. All chemical shifts are reported in δ values relative to tetramethylsilane as a standard. The ^{19}F NMR spectra were recorded on the same spectrometer, operating at 84.66 MHz and using $CDCl_3$ as an internal lock. The ultraviolet spectra were taken on a Cary 118 spectrophotometer with ether as a solvent. Mass spectra were recorded on Varian MAT 731 high-resolution mass spectrometer.

19,19-Difluorocholesteryl Acetate (6). 19-Oxocholesteryl acetate (**5**, 1.0 g) was treated with (diethylamino)sulfur trifluoride (2 mL) and then left for 15 h at 70 °C under N_2. The reaction mixture was extracted with CH_2Cl_2 and washed with $NaHCO_3$ and H_2O. The organic layer was dried with $MgSO_4$. Evaporation under reduced pressure gave a solid which was chromatographed on silica gel (100 g) by using CH_2Cl_2–hexane (70:30) to give 0.5 g of the title compound: mp 104–105 °C; ^1H NMR ($CDCl_3$) δ 0.70 (s, 3 H, HC-18), 0.83 (s, 3 H, HC-19), 0.86, 0.90 (s, 6 H, HC-26, HC-27), 4.61 (m, 1 H, HC-3), 5.70 (br s, 1 H, HC-5), 5.87 (t, 1 H, J = 56 Hz, HC-19); mass spectrum, m/e (relative intensity) 406 (5), 405 (32), 404 (100), 353 (27), 291 (44), 261 (15), 260 (25), 249 (31), 247 (12), 149 (19), 147 (25), 145 (14), 143 (31). Anal. ($C_{29}H_{46}O_2F_2$) C, H.

19,19-Difluorocholesta-5,7-dien-3β-ol (7). A solution of 19,19-difluorocholesteryl acetate (**6**, 1.0 g) in dry hexane (50 mL) was heated under reflux, and the hot solution was treated with 1,5-dibromo-5,5-dimethylhydantoin (0.4 g). The reflux was continued for an additional 20 min, and the cooled reaction mixture was filtered. The filtrate was evaporated to dryness under reduced pressure, and the residue was dissolved in xylene (10 mL), added during 10 min to a boiling solution of trimethyl phosphite in xylene (10 mL), and boiled for 2 h, followed by evaporation of the solvent under high vacuum. The residue (yellow oil) was dissolved in ether (100 mL) and treated with KOH in MeOH (5%, 10 mL). After being left for 2 h at room temperature under N_2, the product was extracted with ether and purified on a column of Sephadex LH20 with a mixture of $CHCl_3$ and hexane (65/35). The material obtained consisted, according to the ratio of the optical densities of its UV bands at λ_{max} 236, 240, 249, 271, 281, and 292 nm, of a mixture of 5,7-diene **7** and its 4,6 isomer.

19,19-Difluoroprevitamin D_3 (8) and 19,19-Difluorotachysterol (9). A solution containing 19,19-difluorocholesta-5,7-dien-3β-ol **7** (50 mg) in dry ether (250 mL) was irradiated with 300-nm light at 0 °C under N_2 for 1 h. The solvent was evaporated to dryness and the residue separated on a preparative thin-layer chromatographic plate, with a mixture of ether and hexane (70:30) as an eluent. One of the fractions (10 mg) consisted of **8**: UV (ether) λ_{max} 256 nm (ε 10 000); ^1H NMR ($CDCl_3$) δ 0.68 (s, 3, HC-18), 0.83, 0.90 (d, 6 H, HC-26, HC-27), 3.5 (m, 1 H, HC-3), 5.58 (q, 1 H, J = 2.5, 35 Hz, HC-9), 5.86 (br s, 2 H, HC-6, HC-7), 6.39 (t, 1 H, J = 55.5 Hz, HC-19); mass spectrum, m/e (relative intensity) 420 (M^+, 34), 351 (100), 307 (32), 289 (19), 247 (10), 235 (11), 212 (36), 161 (44), 143 (30), 133 (33). Anal. ($C_{27}H_{44}OF_2$) C, H.

Another fraction (5 mg) consisted of **9**: UV (ether) λ_{max} 278 nm (ε 18 000), 270 (sh, 17 500), 288 (sh, 17 000); ^1H NMR (CCl_4) δ 0.68 (s, 3 H, HC-18), 0.83, 0.90 (s, 6 H, HC-26, HC-27), 3.88 (m, 1 H, HC-3), 5.75 (q, 1 H, HC-9), 6.60 and 6.23 (2 d, 2 H, J = 16 Hz, HC-6, HC-7), 6.65 (d, 1 H, J = 55.5 Hz, HC-19); mass spectrum, m/e (relative intensity) 420 (M^+, 76), 351 (87), 307 (32), 289 (21), 247 (11), 235 (14), 212 (35), 161 (41), 143 (25), 133 (45). Anal. ($C_{27}H_{44}OF_2$) C, H.

Isomerization of 19,19-Difluoroprevitamin D_3 (8). A. The title compound (**8**, 10 mg) was dissolved in isooctane and heated at 70 °C for 5 h under N_2. The solvent was evaporated, and the product was separated on a TLC preparative plate with chloroform–hexane (65:35) to give the starting material (8 mg) and 19,19-difluorotachysterol (**9**, 1 mg) identical with product obtained by irradiation (see above). When **9** was heated under identical conditions it was recovered unchanged.

B. Compound **8** (1 mg) was heated for 2 h at 70 °C in 10 mL of ethanol (solution 1), ethanol in the presence of hydroquinone (0.005 mg), (solution 2), and isooctane (solution 3), whereupon the UV spectra were determined. No change was observed in the spectra of solution 2. However, solutions 1 and 3 showed a shift in the λ_{max} of 12 nm (λ_{max} 268 nm). The three solutions were evaporated to dryness, and the residues were separated on analytical TLC plates. The solutions 1 and 3 gave the starting material and **9** (ca. 1 mg, λ_{max} 278 nm). Solution 2 gave the starting material and only traces (less then 0.5%) of **9**.

C. An ether solution of **8** (15 mg in 10 mL) was treated with 1 drop of I_2 solution in ether and left for 2 min in sunlight. The resulting material (λ_{max} 278 nm, **9**) was identical with the product of the thermal reaction.

3β,19-Diacetoxycholesta-5,7-diene (10). A solution of cholest-5-ene-3β,19-diol diacetate (2 g) in dry hexane (100 mL) was heated under reflux with 1,5-dibromo-5,5-dimethylhydantoin (0.8 g). After being refluxed for 20 min, the reaction mixture was cooled and filtered and the filterate evaporated to dryness. The residue was dissolved in xylene (10 mL) and added during 10 min to a boiling solution of trimethyl phosphite in xylene (10 mL). The solvent was evaporated to dryness under high vacuum, and the residue was purified on a silica gel column to give a material (0.4 g) absorbing at λ 230, 240, 248, 271, and 291 nm, whose optical densities ratios indicated a 1:1 mixture of **11** and 3β,19-diacetoxycholesta-4,6-diene.

19β-Acetoxyvitamin D_3 Acetate (12). The mixture of the two dienes (500 mg) from the above experiment was irradiated with 300-nm light at 0 °C under N_2 for 1 h. The solvent was evaporated to dryness, and the residue was separated by flash chromatography with ether–hexane (30:70). One of the fractions (λ_{max} 236, 240, and 249 nm) gave material (0.2 g) identical with 3β,19-diacetoxycholesta-4,6-diene. Another fraction gave **12** [400 mg; λ_{max} 219 nm (ε 27 000), 267 (18 000)] and was assigned the structure of 19-acetoxyvitamin D_3 (**12**): ^1H NMR ($CDCl_3$) δ 0.54 (s, 3 H, HC-19), 0.82, 0.90 (s, 6 H, HC-26, HC-27), 2.03 (s, 3 H,

(14) Moriarty, R. M.; Paaren, H.; Gilmore, J. *J. Chem. Soc., Chem. Commun.* **1974**, 927.

(15) This UV spectrum is characteristic of the dicyclohexylidene–ethane system.

AcC-3), 2.17 (s, 3, AcC-19), 4.90 (heptet, 1 H, J = 3.8 Hz, HC-3), 5.99 and 6.30 (AB q, 2 H, J = 11 Hz, HC-6, HC-7), 7.04 (s, 1 H, HC-19); mass spectrum, m/e (relative intensity) 484 (M^+, 5), 364 (100), 351 (17), 349 (12), 259 (251), 251 (42), 197 (25), 157 (26), 156 (23), 147 (22), 145 (17), 143 (24). Anal. ($C_{31}H_{48}O_4$) C, H. A third fraction consisted of a material for which we assigned the structure 11 on the basis of its UV (λ_{max} 260 nm) which shifted to λ_{max} 278 nm on addition of traces of I_2 and exposure to sunlight, forming the tachysterol derivative 13. When purification of 11 was attempted on a TLC plate, it isomerized to 12, as was evident from its it UV (λ_{max} 219, 267 nm) and NMR spectra.

An isooctane solution of 11 (5 mg, 5 mL) was heated for 2 h at 50 °C, whereupon the UV changed (λ_{max} 219, 267 nm). The isolated material was identical (NMR) with 12.

Hydrolysis of 19-Acetoxyvitamin D_3 Acetate (12) and of 19-Acetoxyprevitamin D_3 Acetate (11). A solution of 12 (10 mg) in methanolic KOH (5 mL, 0.05%) was left at room temperature, its UV being monitored. A change in the UV was observed after only 5 min, the bands at 267 and 219 decreasing in intensity while new ones with λ_{max} between 240 and 260 appeared. After 2 h these (λ_{max} 242, 252, and 257 nm) reached their maximum value, indicating the formation of 14. The solution was then brought to neutral pH, and the solvent was evaporated to dryness at room temperature. The residue showed in the NMR signals at δ 9.50 and 9.55 due to the aldehydic protons.

On being left for a longer time, the UV maximum of 14 decreased, and a new band appeared at 298 nm. The same λ_{max} value was obtained when a solution of 12 in methanolic KOH (5 mL, 0.5%) was left for 5 min. This UV band was assigned to the structure 15.

Similar hydrolysis (0.5% KOH in MeOH) of 11 also resulted in 15 (UV λ_{max} 298 nm).

Acknowledgment. The authors are grateful to Dr. Z. I. V. Zaretskii for mass spectra and their interpretation. Thanks are due to Mr. Mircea Grinberg for recording NMR spectra.

Registry No. 5, 1107-90-0; 6, 73197-94-1; 7, 73197-95-2; 8, 73197-96-3; 9, 73197-97-4; 10, 13640-06-7; 11, 55105-86-7; 12, 73245-72-4; 13, 73210-06-7; 14, 73197-98-5; 15, 73197-99-6; 3β,19-diacetoxycholesta-4,6-diene, 73198-00-2.

Asymmetric Synthesis of (-)-3β-Hydroxy-17-methoxy-*D*-homo-18-nor-5α-androsta-13,15,17-triene

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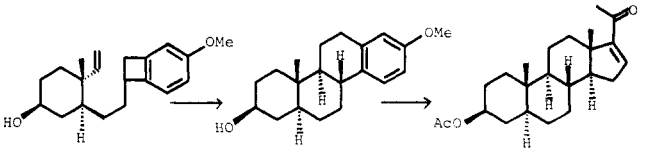
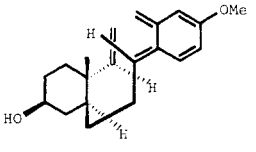
A stereoselective synthesis of (-)-3β-hydroxy-17-methoxy-*D*-homo-18-nor-5α-androsta-13,15,17-triene (2), an important intermediate in the synthesis of 20-oxo-5α-Δ^{16}-pregnen-3β-ol acetate (3), has been achieved by thermolysis of optically active 1-ethenyl-4-hydroxy-2-[2-(4-methoxybenzocyclobutenyl)ethyl]-1-methylcyclohexane (1).

There have appeared many reports[1-3] on the stereocontrolled synthesis of steroid hormones, a class of compounds which show pharmaceutically interesting activities as sex hormones, and recently attention has been focussed on the development of asymmetric syntheses[4-9] of this type of compound. Although synthetic approaches to the A-ring aromatic and 19-nor steroid nuclei, based on novel BC ring construction via intramolecular cycloaddition to *o*-quinodimethanes derived from benzocyclobutenes or other precursors, have proved to be effective methods,[10-16] none of these provides a synthetic route to the pregnane-type steroids in either racemic or optically active form. Pregnane-type steroids constitute an important class of steroid hormones and could also be key intermediates in the synthesis of other classes of steroid hormones.[1] In this paper we wish to report an efficient synthesis of optically active 3β-hydroxy-17-methoxy-*D*-homo-18-nor-5α-androsta-13,15,17-triene (2) [which has already been transformed into 20-oxo-5α-Δ^{16}-pregnen-3β-ol acetate (3) in its *dl* form[17]] by a stereoselective reaction. The synthesis is based on the chiral cyclohexane derivative 1 which un-

Scheme I





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