Rearrangement of a 16α,17α-Epoxy-16β-methylandrostane-17β-carbothioic Acid to a 17β-Mercapto-16β-methylandrostane-17α,16α-carbolactone

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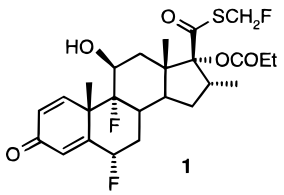
The 16α,17α-epoxy-16β-methylandrostane-17β-carbothioic acid **2b** rearranges in solution at ambient temperature to the 17β-mercapto-16β-methylandrostane-17α,16α-carbolactone **6a**, possibly via the spirocyclic α-thiolactone **5**.

Fluticasone propionate **(1)** is a potent, locally active



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antiinflammatory steroid used in the treatment of asthma and rhinitis by inhalation. Systemic side effects are low, as any swallowed drug is either poorly absorbed or rapidly deactivated by metabolism.[1] During early synthetic studies, it was necessary to prepare some 16-methylene analogues for biological screening.[2] In these studies, the 16α,17α-epoxy-16β-methylandrostane-17β-carbothioic acid **2b** was envisioned as a key intermediate and was synthesized from the corresponding carboxylic acid (**2a**) by reaction with 2-fluoro-*N*-methylpyridinium tosylate (FMPT)[3] and triethylamine, followed by hydrogen sulfide. Compound **2b** was recognized as an unstable compound, and we describe here some experiments which reveal its ability to undergo facile rearrangement to the 17β-mercapto-17α,16α-carbolactone **6a** (Scheme 1).

The labile thioacid (**2b**) was isolated in 88% yield from **2a** after carboxyl activation with FMPT and an excess of triethylamine, followed by reaction with H_2S at 0 °C. In the solid state, **2b** could be stored at ca. 4 °C without decomposition at least for several days, but the structural integrity of **2b** was first established by trapping it in the reaction mixture by the addition of MeI to give the stable *S*-methyl thiolester (**3**) in 62% yield. Ester **3** was also obtained directly when MeSH was used as the nucleophile instead of H_2S, and it was subsequently reacted with trifluoroacetic acid (TFA) to give the 16-methylene-17α-alcohol (**4**) in 59% yield from **2a**.

A freshly prepared chloroform solution of the thioacid (**2b**) was seen by TLC to undergo slow transformation to a less polar product, and this was also observed in the NMR solution in Me_2SO-d_6. When **2b** was kept in solution in $CHCl_3$−MeOH (19:1) at room temperature for 3.5 h or in TFA for 3 h, the 17β-mercapto-17α,16α-carbolactone (**6a**) was isolated, in 66% and 50% yields, respectively. Compound **6a** had highly characteristic spectra: a strong band at 1820 cm^{-1} in the IR spectrum resulted from the β-lactone carbonyl group, whereas in the ^1H NMR spectrum, a singlet at 3.85 ppm, which exchanged with D_2O, arose from the SH group. Field desorption (FD) mass spectrometry revealed peaks from both the molecular ion and from the expected fragment ion resulting from loss of CO_2; electron impact (EI) studies showed only the latter. Further evidence for the structure of **6a** was provided by methylation to its methyl sulfide (**6b**), propionylation to the dipropionate (**6c**), and oxidation to the disulfide (**6d**), all under mild conditions and without loss of the β-lactone function, according to IR evidence (1810−1829 cm^{-1}) on **6b**−**d** and by FDMS for **6b** and **6d**. Chemical evidence for the thiol group in **6a** came from the decolorization of the I_2−NaN_3 spray reagent[4] by the compound on a TLC plate; **6b**−**d** did not react positively in this sensitive test for thiols. Treatment of **6a** with trichloroacetyl isocyanate in $CDCl_3$ in an NMR tube[5] resulted in rapid and slower conversions of the 11β-hydroxy and 17β-thiol groups, respectively, to the corresponding bis(trichloroacetyl)carbamate (**6e**) as indicated by the appearance of two low-field NH singlets at 9.02 and 9.66 ppm. ^1H NMR (on **6a**−**d** and ^{13}C NMR (on **6a**−**c**) were consistent with the proposed structures.

Finally, when a sample of **6a** was reexamined after prolonged storage in the solid state at ambient temperature in the dark, it was found to have undergone almost complete decomposition to a mixture containing two major, closely separated components by analytical HPLC. Purification by preparative reverse-phase HPLC gave a

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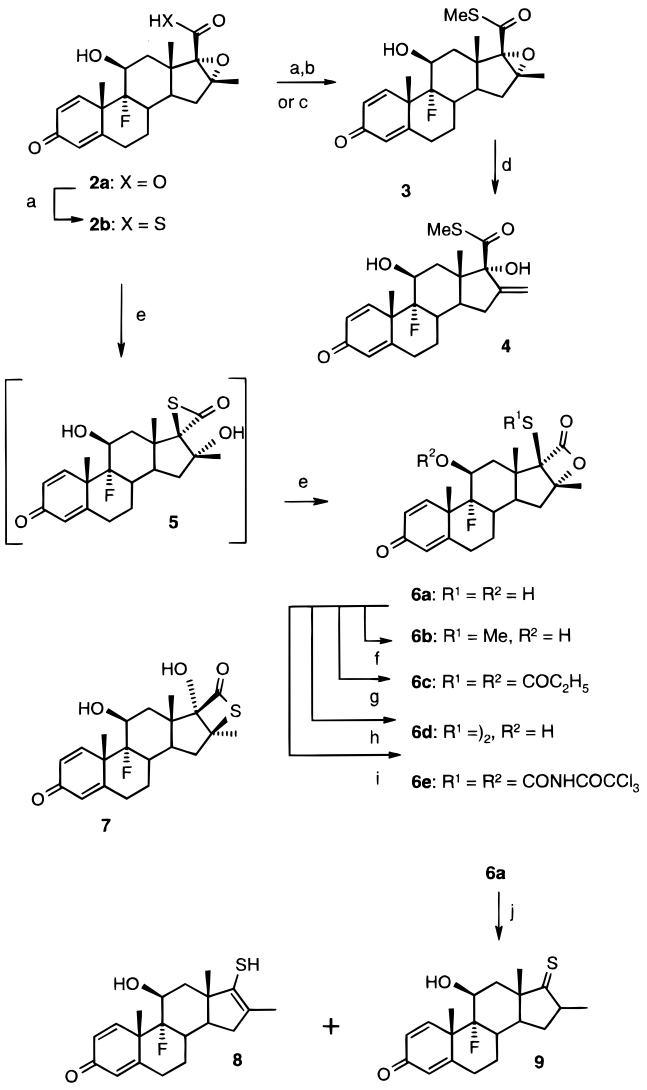
Scheme 1[a]



[a] Reagents: (a) on **2a**, FMPT, NEt_3, CH_2Cl_2, 0 °C, then H_2S, 0 °C to rt (88%); (b) MeI, 0 °C to rt (62.5% overall from **2a**); (c) on **2a**, FMPT, NEt_3, CH_2Cl_2, 0 °C, then MeSH, 0 °C (86%); (d) CF_3CO_2H, rt (59% overall from **2a**); (e) on **2b**, $CHCl_3$-MeOH, rt (66%) or CF_3CO_2H, rt (50%); (f) MeI, $NaHCO_3$, $MeCONMe_2$, rt (97%); (g) $EtCO_2H$, $(CF_3CO)_2O$, *p*-TsOH, rt, (20%); (h) I_2 or air, $NaHCO_3$, $MeCONMe_2$, rt (58% or 29%); (i) $Cl_3CCONCO$, $CDCl_3$, rt; (j) storage, rt, dark.

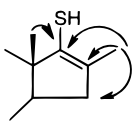
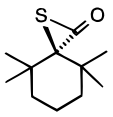


Figure 1. Key $^1H-^{13}C$ correlations in compound **8**.

mixture (ca. 1.4:1) of the enethiol (**8**) and thione (**9**) tautomers as defined by IR and ^1H and ^{13}C NMR, including COSY, heteronuclear multiple quantum correlation (HMQC), and heteronuclear multiple bond correlation (HMBC) experiments. The presence of the thiocarbonyl group at C17 was established by the highly characteristic signal at 277.9 ppm in the ^{13}C NMR spectrum of **9**, whereas the HMBC spectrum confirmed the structure of the enethiol tautomer **8**. Key ^1H-to-^{13}C correlations are summarized in Figure 1. LCMS (electrospray, positive and negative ions) revealed the expected molecular ions, as did MS (thermospray, positive ion), and these were confirmed by HRMS (electrospray, positive ion). Thione **9** was a single diastereoisomer; however, the configuration at C16 was not investigated further.

It seems likely that **6a** could result from intramolecular attack of the sulfur in the thioacid (**2b**) on the β-face of the 16α,17α-epoxide ring concomitant with or after its acid-catalyzed opening. This would result in the intermediate spirocyclic α-thiolactone (**5**) which would, in turn, be susceptible to opening by the generated proximal 16α-hydroxy group, giving the β-lactone ring and the thiol group in the observed product (**6a**). The alternative attack of sulfur at C16 of the epoxide ring to give the β-thiolactone (**7**) would not be compatible with the spectral and chemical evidence. α-Thiolactones appear to be very rare,[6,7,8] but one, the spirocyclic α-thiolactone (**10**), has been described in which X-ray studies have



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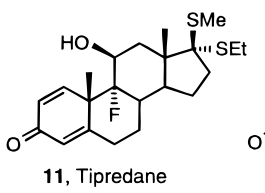
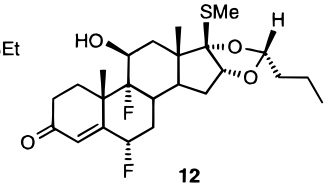
revealed a very long spirocarbon−sulfur bond (191.6 pm) with a small bond angle (46.9°) at the sulfur atom.[6] This compound (**10**) reacted with methanol to give the corresponding methyl α-mercapto ester, an intermolecular reaction analogous to the proposed intramolecular conversion of **5** to **6a**.

In conclusion, apart from the mechanism of its formation, **6a** can now be considered as an easily accessible compound with some potential as an intermediate in the synthesis of C17-alkylthio analogues, related to the C17-thioketals (e.g., **11** and **12**) reported[9] to have topical antiinflammatory activity.



11, Tipredane



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Experimental Section[10]

16α,17α-Epoxy-9α-fluoro-11β-hydroxy-16β-methyl-3-oxoandrosta-1,4-diene-17β-carbothioic Acid (2b). A mixture of 16α,17α-epoxy-9α-fluoro-11β-hydroxy-16β-methyl-3-oxoandrosta-1,4-diene-17β-carboxylic acid (**2a**)[11] (377 mg, 1.0 mmol) and 2-fluoro-*N*-methylpyridinium tosylate (340 mg, 1.2 mmol) in dry CH_2Cl_2 (7 mL) was stirred, cooled in ice, and

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(10) For general experimental information, see ref 2. ^1H NMR spectra were measured at 90 MHz in Me_2SO-d_6, IR spectra in Nujol (mulls) and KBr for FTIR, and UV spectra in ethanol; optical rotations were in dioxan, unless stated otherwise. Melting points were determined on a Kofler block and are uncorrected.
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treated for 1 min with NEt_3 (0.42 mL, 3.0 mmol). After 1 h, H_2S was passed through the mixture for 30 min, which was then allowed to warm to room temperature for a further 30 min. Next, 2 M HCl was added and the product was extracted with EtOAc and then back extracted into 5% sodium carbonate. The aqueous extracts were acidified with 6 M HCl and extracted with EtOAc; the organic phase was washed with water, dried, and concentrated. Refrigeration gave off-white crystals (347 mg, 88%) of **2b**. A solution of **2b** in $CHCl_3$ underwent almost complete decomposition (by TLC) within ca. 24 h to the 17*β*-mercapto-*β*-lactone (**6a**). The same transformation was observed by ^{1}H NMR in Me_2SO-d_6 and confirmed by TLC.

***S*-Methyl 16α,17α-Epoxy-9α-fluoro-11*β*-hydroxy-16*β*-methyl-3-oxoandrosta-1,4-diene-17*β*-carbothioate (3).** A mixture of the carboxylic acid (**2a**) (376 mg, 1.0 mmol) and 2-fluoro-*N*-methylpyridinium tosylate (340 mg, 1.2 mmol) in dry CH_2Cl_2 (3.5 mL) was stirred, cooled in ice, and treated for 0.5 min with NEt_3 (0.7 mL, 5.0 mmol). After 1 h, H_2S was passed through the mixture for 15 min and stirring was continued at 0 °C for a further 45 min. CH_3I (0.12 mL, 2.0 mmol) was then added, and the temperature was allowed to rise to room temperature over 2.5 h. The mixture was diluted with EtOAc and washed successively with 2 M HCl, 5% $NaHCO_3$ and water; dried; and evaporated to a solid (345 mg). Preparative layer chromatography (PLC) ($CHCl_3$−Me_2CO, 9:1) gave a white crystalline solid (265 mg, 62%); recrystallization from acetone gave **3** (206 mg): mp 301−309 °C (dec); $[\alpha]^{19}_D$ +122 (*c* 0.57); UV λ_{max} 240 nm (ϵ 20 060); IR 1670 cm^{-1}; ^{1}H NMR δ 1.39 (s, 3H), 1.53 (s, 3H), 1.55 (s, 3H), 2.25 (s, 3H), 4.16 (m, 1H), 5.50 (m, 1H), 6.08 (bs, 1H), 6.27 (dd, J = 10 and 2 Hz, 1H), 7.35 (d, J = 10 Hz, 1H). Anal. Calcd for $C_{22}H_{27}FO_4S\cdot 0.25H_2O$: C, 64.3; H, 6.8; S 7.9. Found: C, 64.5, H, 6.7; S, 8.2.

***S*-Methyl 9α-Fluoro-11*β*,17α-dihydroxy-16-methylene-3-oxoandrosta-1,4-diene-17*β*-carbothioate (4).** A mixture of the carboxylic acid (**2a**) (3.00 g, 7.96 mmol) and 2-fluoro-*N*-methylpyridinium tosylate (2.71 g, 9.55 mmol) in dry CH_2Cl_2 (28 mL) was stirred and treated dropwise at 0 °C with NEt_3 (3.33 mL, 28.87 mmol). After 1 h at 0 °C, CH_3SH was passed through the suspension for 0.5 h; the resulting yellow solution was stirred further at 0 °C for 1.5 h. The mixture was diluted with EtOAc, washed successively with 1 M HCl, 5% $NaHCO_3$, and water, dried and evaporated to a pale yellow solid (2.78 g) whose major component was equipolar with the epoxythiolester (**3**) on TLC ($CHCl_3$−Me_2CO, 4:1). The solid was dissolved in TFA (110 mL) and kept at room temperature for 4.5 h. The solvent was removed, and the residue was redissolved in EtOAc, washed with 5% $NaHCO_3$ and water, dried, and evaporated to a solid (2.92 g). PLC in $CHCl_3$−Me_2CO (6:1) gave the major product (1.92 g, 59%). Two recrystallizations of a portion (200 mg) from acetone gave colorless crystals (153 mg) of **4**: mp 259−274 °C (dec); $[\alpha]^{20}_D$ +75 (*c* 0.95); UV λ_{max} 238.5 nm (ϵ 19,510); IR 1698 cm^{-1}; ^{1}H NMR δ 0.90 (s, 3H), 1.54 (s, 3H), 2.20 (s, 3H), 4.21 (m, 1H), 4.97 (bs, 1H), 5.20 (bs, 1H), 5.28 (m, 1H), 6.09 (bs, 1H), 6.28 (dd, J = 10 and 2 Hz, 1H), 7.34 (d, J = 10 Hz, 1H). Anal. Calcd for $C_{22}H_{27}FO_4S$: C, 65.0; H, 6.7; S, 7.9. Found: C, 64.9; H, 6.9; S, 8.0.

9α-Fluoro-11*β*-hydroxy-17*β*-mercapto-16*β*-methyl-3-oxoandrosta-1,4-diene-17α,16α-carbolactone (6a). The 17*β*-carboxylic acid (**2a**) (2.00 g, 5.31 mmol) was converted to the thioacid (**2b**) (vide supra), and the freshly prepared product was dissolved in TFA (70 mL). After 3 h at room temperature, most of the TFA was removed under reduced pressure at ca. 30 °C and 5% $NaHCO_3$ was added. Extraction with EtOAc, followed by washing with water and brine, drying, and solvent removal, gave the crude product (1.863 g). Chromatography on silica gel (100 g), eluting with $CHCl_3$−Me_2CO (19:1), gave the 17*β*-mercapto-*β*-lactone (**6a**) (1.038 g, 50%). Recrystallization of a portion (200 mg) twice from acetone gave colorless crystals (131 mg); mp 240−257 °C (dec); $[\alpha]^{22}_D$ +83 (*c* 0.48); UV λ_{max} 238 nm (ϵ 15,940); IR 2560, 1820 cm^{-1}; ^{1}H NMR δ 1.05 (s, 3H), 1.56 (s, 3H), 1.64 (s, 3H), 3.85 (s, 1H), 4.27 (m, 1H), 5.60 (m, 1H), 6.13 (bs, 1H), 6.31 (dd, J = 10, 2 Hz, 1H), 7.38 (d, J = 10 Hz, 1H); ^{13}C NMR δ 186.3, 170.9, 167.3, 153.5, 130.4, 125.6, 102.6, 91.6, 73.9, 71.3, 49.2, 45.6, 44.6, 38.1, 37.1, 34.6, 31.5, 28.5, 24.3, 21.2, 17.8; FDMS *m/e* 393 [(M + H)$^+$, 32%], 348 [(M − CO_2)$^+$, 100%]; EIMS *m/e* 348 [(M − CO_2)$^+$, 38%]. Anal. Calcd for $C_{21}H_{25}FO_4S$: C, 64.25; H, 6.4; S, 8.2. Found: C, 64.0; H, 6.6, S, 8.4. In a similar reaction on the same scale, the freshly prepared thioacid (**2b**) (2.15 g) was dissolved in $CHCl_3$−MeOH (9:1, 100 mL). After 3.5 h at room temperature, the solution was concentrated to a low volume then refrigerated to give crystals of **6a** (1.377 g, 66%). ^{1}H NMR ($CDCl_3$ + $Cl_3CCONCO$) showed rapid conversion of the 11*β*-hydroxy group and slow conversion of the SH group of **6a** to give the 11*β*,17*β*-bis(trichloroacetyl)carbamate (**6e**), complete within 3 days: ^{1}H NMR δ 1.18 (s, 3H), 1.41 (s, 3H), 1.72 (s, 3H), 5.58 (m, 1H), 6.17 (bs, 1H), 6.38 (dd, J = 10, 2 Hz, 1H), 6.88 (d, J = 10 Hz, 1H), 9.02 (s, 1H), 9.66 (s, 1H).

9α-Fluoro-11*β*-hydroxy-16*β*-methyl-17*β*-methylthio-3-oxoandrosta-1,4-diene-17α,16α-carbolactone (6b). A solution of the 17*β*-mercapto-*β*-lactone (**6a**) (434 mg, 1.11 mmol) in dimethylacetamide (2 mL) was stirred, treated with $NaHCO_3$ (186 mg, 2.2 mmol) and CH_3I (0.14 mL, 2.22 mmol), and then stirred at room temperature for an additional 3.5 h. The mixture was diluted with EtOAc (100 mL), washed with 5% $NaHCO_3$ and water, dried, and evaporated to a pale yellow solid (439 mg, 97%). Two recrystallizations from acetone gave colorless crystals (223 mg, 49%) of the methyl sulfide (**6b**): mp 274−276 °C; $[\alpha]^{22}_D$ +62 (*c* 0.40); UV λ_{max} 238 nm (ϵ 15,940); IR 1810 cm^{-1}; ^{1}H NMR δ 1.07 (s, 3H), 1.54 (s, 3H), 1.64 (s, 3H), 2.23 (s, 3H), 4.23 (m, 1H), 5.55 (m, 1H), 6.11 (bs, 1H), 6.27 (dd, J = 10, 2 Hz, 1H), 7.34 (d, J = 10 Hz, 1H); FDMS *m/e* 407 [(M + H)$^+$, 58%], 362 [(M − CO_2)$^+$, 100%], 363 [(M + H − CO_2)$^+$, 35%]; EIMS *m/e* 362 [(M − CO_2)$^+$, 100%]. Anal. Calcd for $C_{22}H_{27}FO_4S$: C, 65.0, H, 6.7; S, 7.9. Found: C, 65.35; H, 6.8; S, 8.4.

9α-Fluoro-16*β*-methyl-3-oxo-11*β*-propionyloxy-17*β*-propionylthioandrosta-1,4-diene-17α,16α-carbolactone (6c). A mixture of the 17*β*-mercapto-*β*-lactone (**6a**) (400 mg, 1.02 mmol), propionic acid (4 mL), trifluoroacetic anhydride (1.2 mL), and dry toluene-*p*-sulfonic acid (8 mg) was stirred at room temperature for 5 days. The reaction mixture was treated with 5% $NaHCO_3$ and extracted with EtOAc, and the combined extracts were washed with water, dried, and evaporated to a brown gum (542 mg). PLC on silica in $CHCl_3$−Me_2CO (19:1) gave the major product as a colorless foam (160 mg, 20%) which crystallized from acetone as colorless needles (76 mg) of the dipropionate (**6c**): mp 167−169 °C, $[\alpha]^{22}_D$ +55 (*c* 0.49); UV λ_{max} 234.5 nm (ϵ 19,030), IR 1809, 1740, 1698 cm^{-1}; ^{1}H NMR δ 0.98 (s, 3H), 1.09 (t, J = 7 Hz, 3H), 1.12 (t, J = 7 Hz, 3H), 1.42 (s, 3H), 1.60 (s, 3H), 2.49 (q, J = 7 Hz, 2H), 2.74 (q, J = 7 Hz, 2H), 4.18 (m, 1H), 6.11 (bs, 1H), 6.28 (dd, J = 10, 2 Hz, 1H), 6.85 (d, J = 10 Hz, 1H). Anal. Calcd for $C_{27}H_{33}FO_6S\cdot 0.25H_2O$: C, 63.7; H, 6.6; S, 6.3. Found: C, 63.8; H, 6.6; S, 6.7.

Disulfide (6d) from 6a. A mixture of 9α-fluoro-11*β*-hydroxy-17*β*-mercapto-16*β*-methyl-3-oxoandrosta-1,4-diene-17α,16α-carbolactone (**6a**) (250 mg, 0.64 mmol), iodine (162 mg, 0.64 mmol), $NaHCO_3$ (108 mg, 1.23 mmol), and dimethylacetamide (2.5 mL) was stirred at room temperature for 1.5 h. The reaction mixture was diluted with 10% sodium thiosulfate, and the product was extracted with EtOAc. The combined extracts were washed with water, dried, and evaporated to a white solid (210 mg). PLC in $CHCl_3$−Me_2CO (4:1) gave **6d** (146 mg, 58%), which was recrystallized twice from acetone to give colorless crystals (64 mg): mp 264−268 °C (dec); $[\alpha]^{20}_D$ +271 (*c* 0.53, DMSO); UV λ_{max} 238 nm (ϵ 33,530); IR 1829, 1818 cm^{-1}; ^{1}H NMR δ 1.03 (s, 3H), 1.51 (s, 3H), 1.61 (s, 3H), 4.18 (m, 1H), 5.46 (m, 1H), 6.02 (bs, 1H), 6.21 (dd, J = 10, 2 Hz, 1H), 7.26 (d, J = 10 Hz, 1H); FDMS *m/e* 694 [(M − 2CO_2)$^+$, 100%], 696 [(M + 2H − 2CO_2)$^+$, 21%]. Anal. Calcd for $C_{42}H_{48}F_2O_8S_2\cdot 1.5H_2O$: C, 62.3; H, 6.35; S, 7.9. Found: C, 62.5; H, 6.0; S, 8.0.

9α-Fluoro-11*β*-hydroxy-17-mercapto-16-methylandrosta-1,4,16-trien-3-one (8) and 9α-Fluoro-11*β*-hydroxy-3-oxo-16-methylandrosta-1,4-diene-17-thione (9). A sample of the 17*β*-mercapto-*β*-lactone (**6a**), which had been stored in the dark at ambient temperature for ca. 17 years, was shown

by TLC, HPLC, LCMS, IR, and ^{1}H NMR to have mainly decomposed to a mixture of two significant products. The remaining material (140 mg) was dissolved in MeCN (14 mL) and ethanol (4 mL) and then purified by reverse-phase HPLC on a Dynamax column (5 × 30 cm). Isocratic elution with 80% MeCN−H_2O revealed a double peak (retention time 10−11 min). The MeCN was removed under reduced pressure, and the residue was extracted with EtOAc. The solution was washed with brine, dried, and evaporated to a cream-colored solid (50 mg), a mixture of the title enethiol (**8**) and thione (**9**). Analytical HPLC on a Phenomenex Prodigy ODS-2 (15 × 0.46 cm) column, eluting with 0.05% aqueous TFA−MeCN using a gradient (15−95% MeCN over 16 min) with a flow rate of 1.5 mL min^{-1}, showed two peaks at t_R = 11.82 (41.6%) and 12.14 min (58.4%), detected at 230 nm. LCMS on Supelcosil LCABZ Plus (3 × 0.46 cm column), eluting with 0.01% aqueous formic acid−MeCN, initially isocratically (0% MeCN for 0.7 min), then using a gradient (0−95% MeCN over 3.5 min), and finally isocratically (95% MeCN for 3.6 min), showed single peaks at t_R = 4.98 min (electrospray, positive ion) {*m*/*e* 349 [(M + H)$^+$, 100%], 697 [(2M + H)$^+$, 80%]} and t_R = 4.94 min (electrospray, negative ion) {*m*/*e* 347 [(M − H)$^-$, 100%]}; IR (KBr) 3304, 1662 cm^{-1}. ^{1}H NMR (400 MHz) for **8**: δ 1.08 (s, 3H), 1.51 (s, 3H), 1.64 (s, 3H), 3.47 (s, 1H), 4.09 (m, 1H), 5.46 (d, J = 4 Hz, 1H), 6.00 (s, 1H), 6.22 (d, J = 10 Hz, 1H), 7.32 (d, J = 10 Hz, 1H); ^{13}C NMR (100 MHz) δ 15.2, 17.1, 22.7, 26.7, 30.1, 33.0, 36.0, 40.2, 48.0, 48.2, 48.3, 70.8, 102.1, 124.3, 129.1, 133.8, 134.2, 152.7, 166.9, 185.2. ^{1}H NMR (400 MHz) for **9**: δ 1.06 (s, 3H), 1.33 (d, J = 7.5 Hz, 3H), 1.52 (s, 3H), 4.17 (m, 1H), 5.52 (d, J = 4 Hz, 1H), 6.03 (s, 1H), 6.22 (d, J = 10 Hz, 1H), 7.29 (d, J = 10 Hz, 1H); ^{13}C NMR (100 MHz) δ 19.6, 21.3, 22.9, 26.9, 30.1, 32.3, 33.6, 40.2, 45.1, 48.2, 55.0, 58.8, 70.6, 101.5, 124.3, 129.1, 152.5, 185.2, 166.6, 277.9; MS (thermospray, positive ion) *m*/*e* 349 [(M + H)$^+$, 100%]; HRMS (electrospray, positive ion) calcd for $C_{20}H_{26}FO_2S$ (M + H)$^+$ 349.1638, found 349.1626. Anal. Calcd for $C_{20}H_{25}FO_2S$·0.25 EtOAc: C, 68.1; H, 7.35; S, 8.65. Found: C, 67.9; H, 7.3, S, 8.7.

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Supporting Information Available: ^{1}H NMR data (Table 1) for compounds **6a**−**d**, ^{13}C NMR data (Table 2) for compounds **6a**−**c**, and IR data (Table 3) for compounds **3**, **4**, **6a**−**d**, **8**, and **9** (3 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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