for 24 h with stirring. The mixture was then cooled to room temperature, 10 mL of ether was added, and after the mixture was stirred for another 5 min, the inorganic residue was separated by filtration through Celite. This residue was washed several times with ether, after which the filtrates were combined, dried over anhydrous magnesium sulfate, and evaporated to yield 0.37 g (2.1 mmol, 84%) of crude di-*n*-butyl sulfone, mp 35–44 °C. Recrystallization from petroleum ether (bp 30–60 °C) gave 0.34 g (1.9 mmol, 76%) of purified di-*n*-butyl sulfone [mp 42–44 °C (lit.[8] mp 43–44 °C)] which exhibited no melting point depression when mixed with an authentic sample of this compound.

Acknowledgment. We are grateful to the Natural Sciences and Engineering Research Council of Canada and the Carus Chemical Co. for financial assistance.

Registry No. 2-Butanol, 78-92-2; 2-nonanol, 628-99-9; 2-decanol, 1120-06-5; 5-decanol, 5205-34-5; cyclohexanol, 108-93-0; 3-methylcyclohexanol, 591-23-1; norborneol, 1632-68-4; menthol, 1490-04-6; borneol, 507-70-0; benzhydrol, 91-01-0; 1-octen-3-ol, 3391-86-4; 1-phenyl-1-buten-3-ol, 17488-65-2; 1-phenyl-1-penten-3-ol, 34862-94-7; 1-phenyl-1-hexen-3-ol, 22596-38-9; 1-phenyl-1-butyn-3-ol, 5876-76-6; 1-decanol, 112-30-1; benzyl alcohol, 100-51-6; benzaldehyde, 100-52-7; di-*n*-butyl sulfide, 544-40-1.

(8) Barnard, D. *J. Chem. Soc.* **1957**, 4547.

Pyrido[1,2-*a*]azepines. A Correction

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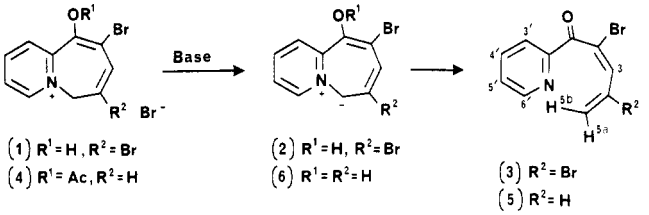
Received January 18, 1982

The only example of a pyrido[1,2-*a*]azepine in the literature is that reported by one of us,[1] as formed when the salt **1** was treated with aqueous base, and given the formula **2**. A renewed interest in pyridoazepines prompted us to



repeat the preparation of compound **2** and submit it to ^{13}C NMR and to the higher resolving power of 100-MHz Fourier transform ^1H NMR. The ^1H NMR spectrum now reveals that the signals at δ 5.5, 5.79, and 6.92 (assigned to protons 6, 8, and the *O*H in formula **2**) are in fact a doublet, a quartet, and a doublet and that the coupling constants are 1.8 and 1.2 Hz. More crucially, the ^{13}C NMR spectrum of the compound previously formulated as **2** shows signals at δ ($CDCl_3$) 121.2 (s, C4)[3], 123.2 (s, C2), 123.6 (t, C5), 123.7 (d, C3′), 127.5 (d, C5′), 134.3 (d, C3), 137.0 (d, C4′), 149.5 (d, C6′), 151.2 (s, C2′), and 185 (s, Cl). The most notable signals are at δ 123.6 triplet in off resonance, and a carbonyl signal at δ 185. Our original IR determination in Nujol showed no strong band higher than 1620 cm^{-1}; a determination on the chloroform extract after basification of the salt **1** shows bands at 1690, 1620, and 1610 cm^{-1}. The three new pieces of evidence establish the structure of the compound as a pyridoylbutadiene **3**. Further, treatment of compound **4** (also reported in our earlier paper[1]) with cold aqueous bases gave a red, unstable compound (characterized as its picrate) whose spectral characteristics establish it as the pyridoylbutadiene **5**. Apart from the signals due to the pyridine protons, the free base **5** showed signals at δ 5.25 (1 H, d of d, J = 9 and 2 Hz, H5a), 5.4 (1 H, d of d, J = 15 and 2 Hz, H5b), 5.9–6.7 (1 H, m, H4), 7.05 (1 H, d, J = 10 Hz, H3). We have established previously that salt **1** is bicyclic, and the ^1H NMR (Me_2SO-d_6) of the salt **4** confirmed its bicyclic nature, with signals at δ 5.1 (2 H, broad, unresolved at room temperature, d of d at −40 °C, H_6), 6.1 (1 H, d of t, H7), and 6.9 (1 H, d, J = 9.5 Hz, H8). We thus assume that the pyrido[1,2-*a*]azepines **2** and **6** have only transient existence, being unstable relative to the pyridoylbutadienes **3** and **5**; we cannot rule out the possibility that traces of the pyridoazepines are present (though undetected by NMR), since the deep red color associated with compounds **3** and **5** is hard to explain on the basis of a pyridoylbutadiene chromophore. Attempts to generate the pyridoazepine **6** by treatment of salt **4** with nonnucleophilic bases in nonprotonating solvents gave red colors, but no NMR spectra could be obtained even after prolonged accumulation.

Experimental Section[2]

1-Bromo-1-(2-pyridoyl)-1,3-butadiene (5). A solution of the salt **4** in the minimum of water was treated with a few drops of a saturated sodium bicarbonate solution (sodium carbonate and pyridine were also used successfully). A deep red color was produced, and extraction with dichloromethane gave, after drying and evaporation, a red oily solid. The ^1H NMR spectrum showed this to be almost pure diene **5**, characterized as its **picrate**: mp 152–154 °C; ^1H NMR ($CDCl_3$) δ 5.25 (1 H, d of d, J = 9 and 2 Hz), 5.4 (1 H, d of d, J = 15 and 2 Hz), 5.9–6.7 (1 H, m), 7.05 (1 H, d, J = 10 Hz), 7.4 (1 H, m), 7.9 (2 H, m), 8.7 (1 H, d of d, J = 4 and 1 Hz). Anal. Calcd for $C_{16}H_{11}BrN_4O_8 \cdot C_2H_5OH$: C, 42.4; H, 3.3; N, 10.9. Found: C, 42.5; H, 3.0; N, 11.15.

Registry No. **1**, 1532-74-7; **3**, 81625-42-5; **4**, 1532-75-8; **5**, 81625-43-6; **5** picrate, 81625-44-7.

(1) A. Fozard and G. Jones, *J. Org. Chem.*, **30**, 1523 (1965).

(2) NMR spectra were determined on a JEOL FX100 FT spectrometer.

(3) Off-resonance multiplicities are given in parentheses.

Synthesis of Allolaurinterol

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Received February 11, 1982

Metalation of phenolic methoxymethyl ethers is an effective means of controlling the regiochemistry of substitution in complex systems and affords a convenient entry into a class of marine sesquiterpenes from *Aplysia* species and *Laurencia* species such as allolaurinterol **1**,[1] laurinterol **2**,[2] aplysin **3**,[3] and laurene **4**.[4] These com-

(1) Kazlauskas, R.; Murphy, P. T.; Quinn, R. J.; Wells, R. J. *Aust. J. Chem.* **1976**, *29*, 2533–2539.

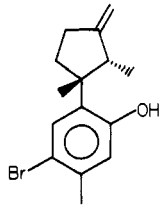
(2) (a) Irie, T.; Suzuki, M.; Kurosane, E.; Masamune, T. *Tetrahedron Lett.* **1966**, 1837–40; *Tetrahedron* **1970**, *26*, 3271–7. (b) Feutrill, G. I.; Mirrington, R.; Nichols, R. *Aust. J. Chem.* **1973**, *26*, 345–55.

(3) (a) Yamada, K.; Toda, M.; Hirata, Y. *Chem. Commun.* **1968**, 1432. Yamada, K.; Clemura, D.; Toda, M.; Hirata, Y. *Tetrahedron* **1969**, *25*, 3509–20. (b) Ronald, R. C.; Gewali, M. B.; Ronald, B. P. *J. Org. Chem.* **1980**, *45*, 2224.

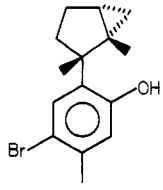
(4) McMurray, J. E.; VonBeroldingen, L. *Tetrahedron* **1974**, *30*, 2027–32.

0022-3263/82/1947-2792$01.25/0

pounds were among the first halogenated natural products to have been isolated from marine sources. In this report we demonstrate the use of metalated phenyl methoxymethyl ethers, previously employed in our synthesis of aplysin **3**,[3b] for the synthesis of phenolic sesquiterpenes, represented in this case by allolaurinterol **1**, a constituent of *Laurincia filoformis*.



1



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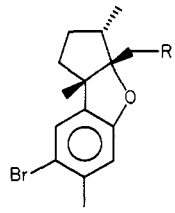
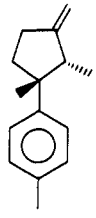
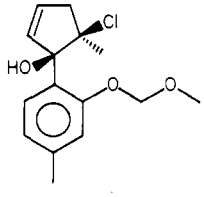


3, R = H
3a, R = OH

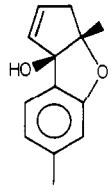


4

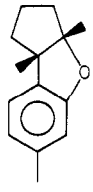
Treatment of 3-(methoxymethoxy)toluene with 1.1 equiv of *t*-BuLi in pentane resulted in regioselective formation of the 4-lithio derivative as an off-white precipitate.[5] Addition of an ether solution of the anion to 5-chloro-5-methyl-2-cyclopentenone[6] at −78 °C afforded the sensitive *cis*-chlorohydrin **5** in modest yield. Solvolysis of **5** in refluxing, basic methanol afforded the key tricyclic carbinol **6**. The hydroxyl group of **6** was replaced by a methyl group by conversion first to the chloride with PCl_3, followed immediately by alkylation of the highly reactive and sensitive tricyclic chloride with methylmagnesiuim bromide.[3b] The resulting olefin **7** was then hydrogenated over platinum to afford the tricyclic ether **8** that has the aplysin-type skeleton.



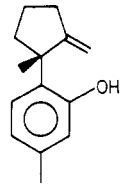
5



6

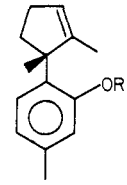


8

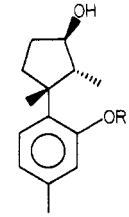


9

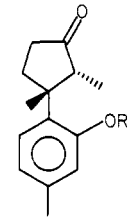
Elaboration of the tricyclic ether **8** to cyclopentyl phenolic structures of the *Laurencia* sesquiterpenes required cleavage of the furanoid ring and introduction of functionality at C-3 in the cyclopentane ring. We envisioned that this might be accomplished by base-catalyzed elimination of the phenolic oxygen induced by attack of a hindered, strong base on the methyl group of the tertiary ether to afford **9**. Elimination in this direction would have enabled convenient formation of the hydroxymethyl function of aplysinol **3a**. However, upon treatment with a solution of lithium diisopropylamide in refluxing THF only the isomeric endocyclic olefin **10** could be obtained. After investigating a variety of bases for this elimination (LDA,*n*-BuLi, *t*-BuLi, KO-*t*-Bu), we found that the best procedure was to employ 2 equiv of lithium tetramethylpiperidide added in portions to **8** in refluxing THF. Only this very strong base induced clean elimination to the phenolic olefin **10**. With the other bases either the conversion was poor, or as in the case of *t*-BuLi a Wagner–Meerwein shift occurred, affording a styrene-type product. It is not clear whether or not the exocyclic olefin is formed in this elimination; the only phenolic products obtained being **10** or the rearranged products from methyl migration, e.g., structures that are related to the cuparenes.[7]



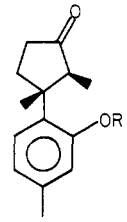
10, R = H
10a, R = *t*-BDMS



11, R = *t*-BDMS

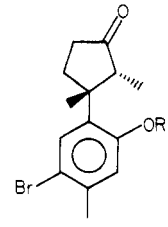


12, R = *t*-BDMS

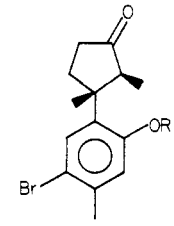


13, R = *t*-BDMS

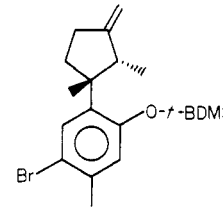
Hydroboration of the *tert*-butyldimethylsilyl ether of **10** afforded a secondary alcohol **11** in 86% yield, which was immediately oxidized to the ketone **12** with pyridinium dichromate. This ketone appeared to be at least 95% of the isomer **12**, as shown by the distinctive methyl resonance at δ 0.7, which suggests that the siloxy derivative **10** is hydroborated with considerably greater selectivity than had been previously observed in electrophilic olefin additions in related systems for laurene[4] and laurinterol.[2b] By gas chromatography the selectivity of the hydroboration appears to be about 96:4 for the alcohol **11**. Bromination of **12** in propylene oxide afforded exclusively the para bromo isomer **14** without loss of the silyl protecting group.



14, R = *t*-BDMS
14a, R = H



15, R = *t*-BDMS
15a, R = H



16

To establish that the stereochemical assignment of the secondary methyl group was as assigned, we treated a sample of **14** with NaOMe in MeOH to epimerize the methyl group. Under these conditions the silyl protecting group was also removed; however, the NMR of spectrum of the resulting keto phenol showed a new methyl doublet at δ 1.1 as well as the original signal at δ 0.7, indicating the epimerized product was a mixture of **14a** and **15a**. By NMR the bromo ketone **14** can be contaminated with no more than 5% of the isomeric compound **15**.

Bromo ketone **14** was surprisingly resistant to nucleophilic addition. While it was necessary to avoid strongly

(5) Ronald, R. C. *Tetrahedron Lett.* **1975**, 3973–4; **1976**, 4413–16.
(6) Martin, G. J.; Daviaud, G. *Bull. Soc. Chem. Fr.* **1970**, 3098–102.
(7) Gonzales, A. G.; Darias, J.; Diaz, A.; Foureron, J. D.; Martin, J. D.; Parez, C. *Tetrahedron Lett.* **1976**, 3051–3054. For synthetic approaches to the cuparenes, see Bird, C. W.; Yeong, Y. C.; Hudec, J. *Synthesis* **1974**, 27.

basic epimerizing conditions, which precluded the use of the more typical olefination procedures (Wittig-type reagents), the lack of reactivity of the cyclopentyl carbonyl group rendered most of the other olefination procedures useless in this case ($Me_2^+SCH_2^-$, PPh_3,[8] Me_3SiCH_2MgCl, KH;[9] $CH_2(MgBr)_2$[10]). However, **14** could be readily methylenated in high yield by treatment with CH_2Br_2/Zn[11] in the presence of $TiCl_4$ without epimerization of the α-methyl group. The resulting olefin **16** on desilation with n-Bu_4NF in THF afforded (±)-allolaurinterol **1** that was spectrally identical with the natural material. To our knowledge this work constitutes the first synthesis of allolaurinterol.

Experimental Section

General Procedures. Melting point determinations were made in seated evacuated capillaries with a Thomas-Hoover Unimelt apparatus and are uncorrected. IR spectra were obtained on a Beckman Acculab 1 spectrophotometer, using films for liquid samples and KBr mulls for solids unless otherwise noted. NMR spectra were obtained in CCl_4 or $CDCl_3$ containing Me_4Si on either a Varian Associates Model EM360 or a Nicolet Technology Corporation NT 200 instrument. Gas chromatograms were obtained on a Packard-Becker Model 417 chromatograph using 3 mm × 2.6 m glass columns packed with 3% OV-17 on 80/100 Chromosorb W-HP. Analytical thin-layer chromatograms were run with E. Merck 250-μm precoated silica gel plates. Preparative chromatograms were run with 1.6-mm layers of E. Merck silica gel PF-254. Column chromatography was run with J. T. Baker 60–200-mesh silica gel. Combustion analyses were performed by Galbraith Laboratories.

5-Chloro-5-methyl-1-[2-(methoxymethoxy)-4-methylphenyl]cyclopent-2-en-1-ol (5). A solution of 3-(methoxymethoxy)toluene[5] (7.0 g, 46.0 mmol) in pentane (5 mL) was metalated at 0 °C with t-BuLi (32 mL, 1.5 M, 47 mmol) in a 500-mL round-bottomed flask maintained under an argon atmosphere. The lithio derivative settled as an off-white precipitate. After 3 h the supernatant was removed, and the precipitate was washed with three portions of pentane and then dissolved in ether (150 mL). The mixture was cooled to −78 °C, and then a solution of 5-chloro-5-methyl-2-cyclopenten-2-one[6] (5.9 g, 47 mmol) in ether (100 mL) was added dropwise over a 1-h period. After 6 h the mixture was quenched with water and filtered through a pad of Celite to remove an orange, polymeric residue. The filtrate was poured into water and extracted with ether. The combined extracts were washed with 10% aqueous NaOH, water, and brine, dried with anhydrous $MgSO_4$ and concentrated. The crude product was chromatographed on a 12 mm × 40 cm column of silica gel eluted with 5% ether in petroleum to afford **5**, 3.5 g (27% yield), as a viscous oil: IR 3500 (OH), 3075–2810, 1600, 1560, 1495, 1240, 800, 770 cm^{-1}; NMR δ 6.6–7.3 (3 H, m) 6 (2 H, d), 5.2 (2 H, d), 3.45 (CH_3, s), 3.2–2.7 (2 H, m), 2.2 (CH_3, s), 1.25 (CH_3, s). The chlorohydrin was sufficiently unstable that it was used immediately in the subsequent cyclization.

8b-Hydroxy-3a,8b-dihydro-3a,6-dimethyl-3*H*-cyclopenta[*b*]benzofuran (6). A solution of KOH (1.1 g) in methanol (80 mL) was added to the chlorohydrin **5** (3 g, 10.6 mmol) and the mixture heated to reflux for 24 h. The mixture was cooled, poured into water, and extracted with ether. The combined ether extracts were washed with 10% aqueous NaOH, water, brine, dried with anhydrous $MgSO_4$ and concentrated. The crude product was chromatographed on a 1.2 mm × 30 cm column of silica gel eluted with 20% ether in petroleum ether to afford 1.07 g (50% yield) of **5** as a white powder, mp 80–82 °C. An analytical sample was obtained by sublimation as white filamentous needles: mp 86–87 °C; IR 3360 (OH), 3040–2910, 1610, 1600, 1090, 1020, 800, 750 cm^{-1}; NMR δ 6.6–7.3 (3 H, m), 5.8 (2 H, s), 2.7 (2 H, s), 2.3 (CH_3, s), 1.5 (CH_3, s). Anal. Calcd for $C_{13}H_{14}O_2$: C, 77.23; H, 6.93. Found: C, 77.19; H, 7.00.

3a,8b-Dihydro-3a,6,8b-trimethyl-3*H*-cyclopenta[*b*]benzofuran (7). To a solution alcohol **5** (200 mg, 0.99 mmol) in ether (5 mL) at 0 °C was added PCl_3 (84 μL, 0.99 mmol). After 2 min the mixture became cloudy and GC (200 °C) showed that **5** (t_R 3.1 min) had all reacted to form a new product (t_R 4.1 min). A solution of MeMgBr in ether (2 mL, 1.5 M, 3 mmol) was added over a 30-min period. GC after the addition showed complete conversion to a new product (t_R 2.3 min). The reaction mixture was poured into water and extracted with ether. The combined ether extracts were washed with 10% aqueous NaOH, water, and brine, dried with anhydrous $MgSO_4$, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 1% ether in petroleum ether to afford 170 mg (86% yield) of **7**: IR 3020–2810, 1610, 1600, 1500, 950, 800, 710 cm^{-1}; NMR δ 6.6–7.3 (3 H, m), 5.7 (2 H, s), 2.7 (2 H, d), 2.3 (CH_3, s), 1.4 (CH_3, s), 1.3 (CH_3, s). Anal. Calcd for $C_{14}H_{16}O$: C, 84.00; H, 8.00. Found: C, 84.12; H, 8.18.

1,2,3a,8b-Tetrahydro-3a,6,8b-trimethyl-3*H*-cyclopenta[*b*]benzofuran (8). The tricyclic olefin **7** (250 mg, 1.25 mmol) was hydrogenated over Adams' catalyst (9 mg) in EtOH (2 mL) in a small flask fitted with a balloon filled with H_2. After 6 h the mixture was filtered and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 1% ether in petroleum ether to afford 210 mg (83% yield) of **8**: IR 3010–2860, 1610, 1590, 1490, 1300, 880, 850 cm^{-1}; NMR δ 6.4–6.9 (3 H, m), 2.5 (CH_3, s), 1.5–2.0 (6 H, m), 1.3 (CH_3, s), 1.25 (CH_3, s). Anal. Calcd for $C_{14}H_{18}O$: C, 83.16; H, 8.91. Found: C, 83.47; H, 9.14.

2,3-Dimethyl-3-(2-hydroxy-4-methylphenyl)cyclopent-1-ene (10). A solution of *N*-lithio-2,2,6,6-tetramethylpiperidide was prepared from the amine (167 μL, 0.99 mmol) and n-BuLi (0.5 mL, 2.0 M, 1.0 mmol) in THF (1 mL). One-half of this solution was added to the tricyclic ether **8** (100 mg, 0.5 mmol) in THF (1 mL) and the mixture heated to reflux under argon. After 6 h the remaining amide solution was added. After 18 h the reaction mixture was poured into water and extracted with ether. The combined extracts were washed with water and brine, dried with anhydrous $MgSO_4$, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 10% ether in petroleum ether to afford 65 mg (65% yield) of **10**: IR 3420, 3010–2810, 1610, 1560, 1500, 1150, 1000, 940, 790, 720 cm^{-1}; NMR δ 7.2–6.4 (3 H, m), 6.05 (1 H, s), 5.55 (1 H, s), 2.2 (CH_3, s), 1.9–2.3 (4 H, m), 1.5 (CH_3, s), 1.3 (CH_3, s). Phenol **10** proved to be a highly sensitive compound and was used immediately without further handling.

2,3-Dimethyl-3-[2-(*tert*-butyldimethylsiloxy)-4-methylphenyl]cyclopent-1-ene (10a). The phenol **10** (360 mg, 1.78 mmol), *tert*-butyldimethylsilyl chloride (801 mg, 5.3 mmol) and imidazole (434 mg, 7.1 mmol) were mixed in DMF (5 mL), and the mixture was stirred at 40 °C for 48 h. The mixture was poured into water and extracted with ether. The combined extracts were washed with water and brine, dried with anhydrous $MgSO_4$, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 2% ether in petroleum ether to afford 540 mg (96%) of **10a**: IR 3050, 2960–2850, 1610, 1500, 1350, 850, 840, 760 cm^{-1}; NMR δ 7.3–6.7 (3 H, m), 5.55 (1 H, s), 2.3 (CH_3, s), 1.9–2.5 (4 H, m), 1.75 (CH_3, s), 1.55 (CH_3, s), 1.0 (9 H, s), 0.3 (6 H, s). Anal. Calcd for $C_{20}H_{32}OSi$: C, 75.94; H, 10.12. Found: C, 75.88; H, 10.21.

***trans*-2,3-Dimethyl-3-[2-(*tert*-butyldimethylsiloxy)-4-methylphenyl]cyclopentanol (11).** A solution of BH_3·THF (1.54 mL, 0.65 M, 1.0 mmol) was added at 0 °C to the silyl ether **10a** (316 mg, 1 mmol) in THF (2 mL). After 4 h the boranes were oxidized with H_2O_2 (1 mL, 30%) in aqueous NaOH (1 mL, 30% w/v). After 1 h the mixture was extracted with ether; the combined ether extracts were washed with water and brine, dried with anhydrous $MgSO_4$, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 10% ether in petroleum ether to afford 290 mg (86% yield) of **11**: IR 3380 (OH, br), 3010–2820, 1600, 1510, 1160, 1110, 790; NMR δ 7.2–6.5 (3 H, m), 4.1 (1 H, br), 2.9–1.6 (4 H, m), 2.2 (CH_3, s), 1.3 (CH_3, s), 1.1 (9 H, s), 0.5 (3 H, d), 0.3 (6H, s). GC analysis

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(240 °C) showed two peaks 4.35 and 4.65 min in the ratio of about 96:6. Anal. Calcd for $C_{20}H_{34}O_2Si$: C, 71.85; H, 10.17. Found: C, 71.81; H, 9.83.

***trans*-2,3-Dimethyl-3-[2-(*tert*-butyldimethylsiloxy)-4-methylphenyl]cyclopentanone (12).** A solution of alcohol 11 (100 mg, 0.29 mmol) in DMF (1 mL) was vigorously stirred with pyridinium dichromate (225 mg, 0.6 mmol) for 4 h at ambient temperature. At this time TLC indicated that the oxidation was complete. The mixture was diluted with water and extracted with ether. The combined extracts were washed with 10% aqueous NaOH, water, and brine, dried with anhydrous $MgSO_4$, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 10% ether in petroleum ether to afford 94 mg of 12 (94% yield): IR 2975–2875, 1740 (C=O), 1620, 1500, 1275, 850 cm^{-1}; NMR δ 7.3–6.7 (3 H, m), 2.8–1.9 (4 H, m), 2.2 (CH_3, s), 1.25 (CH_3, s), 1.0 (9 H, s), 0.75 (3 H, d, J = 7 Hz), 0.3 (6 H, s). Anal. Calcd for $C_{20}H_{32}O_2Si$: C, 72.28; H, 9.63. Found: C, 72.41; H, 10.02.

***trans*-2,3-Dimethyl-3-[5-bromo-2-(*tert*-butyldimethylsiloxy)-4-methylphenyl]cyclopentanone (14).** Bromine (13 μL, 0.25 mmol) was added to a solution of the ketone 12 (85 mg, 0.25 mmol) in propylene oxide (2 mL). After 5 min the entire reaction mixture was chromatographed on a silica gel preparative plate developed with 13% ether in petroleum ether to afford 102 mg of 14 (80% yield) as a viscous liquid. We were unable to induce this material to crystallize. 14: IR 2990–2860, 1740 (C=O), 1600, 1500, 1400, 1310, 850; NMR δ 7.15 (1 H, s), 6.55 (1 H, s), 2.3–1.9 (4 H, m), 2.2 (CH_3, s), 1.25 (CH_3, s), 1.0 (9 H, s), 0.72 (3 H, d), J = 7 Hz), 0.3 (6 H, s). Anal. Calcd for $C_{20}H_{31}BrO_2Si$: C, 58.39; H, 7.54. Found: C, 58.16; H, 7.41.

Allolaurinterol *tert*-Butyldimethylsilyl Ether (16). The methylenation procedure of Nozaki[11] was employed. To a suspension of powdered zinc (81 mg, 1.25 mmol) in THF (1 mL) was added CH_2Br_2 (88 μL, 1.25 mmol) and $TiCl_4$ (137 μL, 1.25 mmol). A vigorous, exothermic reaction took place with formation of a dark-blue color. After 20 min the bromo ketone 14 (100 mg, 0.25 mmol) was added in 2 mL THF. The reaction was allowed to proceed for 6 h and then poured into water and extracted with ether. The combined extracts were washed with 10% aqueous NaOH, water and brine, dried with anhydrous Na_2SO_4, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 1% ether in petroleum ether to afford 85 mg of 16 (84% yield) as a pale-yellow oil): IR 3080–2850, 1650, 1600, 1350, 1250, 870, 840 cm^{-1}; NMR δ 7.25 (1 H, s), 6.65 (1 H, s), 4.85 (2 H, s), 3.1 (1 H, q), 2.2 (CH_3, s), 1.25 (CH_3, s), 1.0 (H, s), 0.72 (3 H, d, J = 7 Hz), 0.3 (6 H, s).

(±)-Allolaurinterol (1). The silyl ether of 16 (85 mg, 0.20 mmol) was cleaved by treatment with a solution of *n*-Bu_4NF (431 μL, 1 M, 0.43 mmol) in THF (1 mL) for 2 min at room temperature. The reaction mixture was then diluted with water and extracted with ether. The combined extracts were washed with water and brine, dried with anhydrous Na_2SO_4, and concentrated. The crude product was chromatographed on a silica gel preparative plate developed with 8% ether in petroleum ether to afford 57 mg of 1 (93% yield): IR 3550, 30580–2880, 1655, 1618, 1495, 1450, 1255, 1075, 880 cm^{-1}; NMR δ 7.25 (1 H, s), 6.5 (1 H, s), 4.95 (1 H, s), 4.85 (1 H, s), 4.6 (1 H, s), 2.95 (1 H, q), 2.5–1.8 (4 H, m), 2.22 (CH_3, s), 1.18 (CH_3, s), 0.72 (3 H, d, J = 7 Hz). Anal. Calcd for $C_{15}H_{18}BrO$: C, 61.01; H, 6.44. Found: C, 60.85; H, 6.47. This material was spectrally identical with (–)-allolaurinterol.[1]

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Kinetic Studies and Stereochemical Considerations for the Rearrangement of 1-(*o*-Chlorophenyl)-2-bromo-2-chloro-1-propyl Trifluoroacetate

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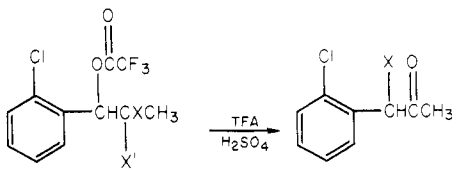
Neighboring group participation long has been considered a basic tenet of organic chemistry.[2] Demonstration of anchimeric assistance during the course of a reaction has come from rearrangement, rate acceleration, and stereochemical studies. Today a substantial number of groups and atoms are known to serve as important neighboring groups. For example, in a now classic publication Winstein et al.[3] invoked halogen participation and concomitant halonium ion formation to explain the rates of solvolysis of *cis*- and *trans*-2-halocyclohexyl esters. Like most investigations which followed, these authors examined the bridging capabilities of the individual halogens using similar but separate compounds containing iodine, bromine, or chlorine. Subsequently, it was necessary to show that the overall rate enhancement was a function of participation while allowing for the elements of induction, solvent influence, and the way the carbocation center was generated. For example, in Winstein's system the inductive effects of halogen was shown by calculation to result in substantial rate deceleration by as much as 10 000.[4]

Recent investigations[5] in our laboratories directed toward the rearrangement of aryldihalopropanols have utilized a similar approach. In previous experiments, NMR kinetic studies were conducted with 2,2-dichloro- and 2,2-dibromo-1-(*o*-chlorophenyl)-1-propyl trifluoroacetates in a trifluoroacetic acid–sulfuric acid mixture under identical conditions. A comparison of this type revealed a significant rate acceleration owing to halogen participation when the bromine-containing compound was compared with the analogous chloro derivative. This, as well as leaving group effects, implicated a halonium ion intermediate in the rearrangement of 1 to an α-halo ketone 2 (eq 1).



(1)

1a, X = X' = Cl
b, X = X' = Br
c, X = Br, X' = Cl

2a, X = Cl
b, X = Br

In our most recent system, the rearrangement of 1-(*o*-chlorophenyl)-2-bromo-2-chloro-1-propyl trifluoroacetate

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