over magnesium sulfate. Removal of the solvent under reduced pressure gave a yellow oily residue which solidified upon trituation with methanol. Crystallization of the residue from methanol afforded 2.83 g (69% yield) of pale yellow crystals, 1-pyrenyloxirane: mp 66–68 °C; IR (KBr) 3050 (m), 1220 (m), 1180 (m), 1030 (m), 880 (s), 840 (s), 820 (s), 735 (s), and 715 cm^{-1} (s); UV_{max} (methanol) 342 (48 900), 325 (31 300), 312 (12 600), 275 (52 800), 264 (26 400), 254 (11 400), 241 (80 700), and 232 nm (43 600); NMR δ_{Me_4Si} ($CDCl_3$) 2.88 (dd, 1 H, J = 6 and 3 Hz), 3.37 (dd, 1 H, J = 6 and 4 Hz), 4.70 (broad t, 1 H, J = 3 and 4 Hz), 7.88–8.13 (m, 8 H), and 8.27 (d, 1 H, J = 9 Hz).

Anal. Calcd for $C_{18}H_{12}O$: C, 88.50; H, 4.95. Found: C, 88.35; H, 4.84.

Method B. 1-Pyrenyloxirane. In a 500-mL round-bottomed flask were placed 5.915 g (25.7 mmol) of pyrene-1-carboxaldehyde and 0.676 g (1.83 mmol) of tetrabutylammonium iodide in 100 mL of dichloromethane. A layer (100 mL) of 50% (w/w) aqueous sodium hydroxide was introduced underneath this solution. Trimethylsulfonium iodide (6.067 g, 29.7 mmol) was then added and the whole mixture was warmed up to 60 °C with vigorous stirring under nitrogen atmosphere for 72 h until the originally undissolved sulfonium salt entered the solution.

The reaction mixture was next poured into 200 mL of an ice–water mixture, and the organic phase was separated, washed with water, and dried over magnesium sulfate. Dichloromethane was removed under reduced pressure to give an oily yellow residue. Crystallization of the oily residue from ethanol gave 5.15 g (82% yield) of pale yellow prisms of 1-pyrenyloxirane, mp 67–68 °C.

α-Bromo-2-acetyl-9,10-dimethylanthracene. Finely ground cupric bromide (1.165 g, 5.22 mmol) and 8 mL of ethyl acatate were placed in a 50-mL round-bottomed flask fitted with a reflux condenser and a magnetic stirrer. The solution was brought to reflux in an oil bath. 2-Acetyl-9,10-dimethylanthracene (0.619 g, 2.50 mmol) was dissolved in 8 mL of hot chloroform and introduced into the flask. The resulting reaction mixture was refluxed for 5 h with vigorous stirring to ensure complete exposure of the cupric bromide to the reaction medium. The completion of the reaction could be judged from the color change of the solution from green to amber, disappearance of all black solid, and cessation of hydrogen bromide evolution. After removal of cuprous bromide by filtration, the solution was treated with Norite A. Concentration of the filtrate under reduced pressure gave a greenish brown solid. Recrystallization from benzene afforded 0.521 g (64% yield) of a yellow compound, α-bromo-2-acetyl-9,10-dimethylanthracene: mp 176–178 °C dec; IR (KBr) 1665 (s), 1615 (m), 1290 (m), 1260 (s), 1020 (m), and 750 cm^{-1} (s); UV_{max} (methanol) 426 (3800), 375 (3690), 355 (3400), 338 (2480), 270 (36 700), and 245 nm (29 600); NMR δ_{Me_4Si} ($CDCl_3$) 3.09 (s, 3 H), 3.18 (s, 3 H), 4.61 (s, 2 H), 7.60 (m, 2 H), 7.98 (d, 1 H, J = 9 Hz), 8.36 (m, 3 H), and 9.07 (s, 1 H).

Anal. Calcd for $C_{18}H_{15}OBr$: C, 66.07; H, 4.62; Br, 24.42. Found: C, 66.11; H, 4.70; Br, 24.36.

Method C. 9,10-Dimethyl-2-anthryloxirane. A solution of 0.186 g (0.569 mmol) of α-bromo-2-acetyl-9,10-dimethylanthracene in 10 mL of ethanol was placed in a 25-mL round-bottomed flask with a magnetic stirrer and heated on an oil bath. Into the hot alcoholic solution was added dropwise a solution of 0.0245 g (0.648 mmol) of sodium borohydride in 1 mL of water. The resulting solution was allowed to reflux for 3–5 min and then filtered while still hot. When the volume of the solution was reduced by a gentle stream of nitrogen, light yellow crystals began to appear. The light yellow platelets were collected by filtration to give 0.116 g (82% yield) of 9,10-dimethyl-2-anthryloxirane: mp 134–135 °C; IR (KBr) 1380 (s), 1390 (s), 1250 (m), 870 (s), 815 (s), 800 (s), and 750 cm^{-1} (s); UV_{max} (methanol) 397 (7500), 376 (8200), 357 (5210), and 262 (191 000); NMR δ_{Me_4Si} ($CDCl_3$) 2.98 (dd, 1 H, J = 6 and 3 Hz), 3.08 (s, 3 H), 3.10 (s, 3 H), 3.26 (t, 1 H, J = 6 and 4 Hz), 4.11 (t, 1 H, J = 3 and 4 Hz), 7.32 (d, 1 H, J = 8 HZ(= 7/5[(dd, 2 H, J = 8 and 4 Hz), and 8.28–8.32 ppm (broad d, 4 H).

Anal. Calcd for $C_{18}H_{16}O$: C, 87.06; H, 6.49. Found: C, 86.63; H. 6.51.

Acknowledgment. The authors wish to acknowledge the National Cancer Institute (Grant CA-10220) and the National Institute of General Medical Sciences (Grant GM-20329) for the support of this work. They also wish to thank Professors J. A. Miller, E. C. Miller, and R. K. Boutwell of the McArdle Laboratory for Cancer Research, the University of Wisconsin, for their interest, encouragement, and biological essays of these oxiranes.

Registry No.—Pyrene-1-carboxaldehyde, 3029-19-4; anthracene-9-carboxaldehyde, 642-31-9; 1-naphthaldehyde, 66-77-3; 2-naphthaldehyde, 66-99-9; benz[a]anthracene-7-carboxaldehyde, 7505-62-6; chrysene-6-carboxaldehyde, 22138-85-8; 10-methyanthracene-9-carboxaldehyde, 7072-00-6; phenanthrene-9-carboxaldehyde, 4707-71-5; anthracene-9,10-dicarboxaldehyde, 7044-91-9; α-bromo-9,10-dimethyl-2-acetylanthracene, 66842-45-3; trimethylsulfonium iodide, 2181-42-2; tetrabutylammonium iodide, 311-28-4; 2-acetyl-9,10-dimethylanthracene, 15254-37-2; 9,10-dimethylanthracene, 781-43-1.

References and Notes

(1) For a review, see D. M. Jerina, etc., in "Origin of Human Cancer", H. H. Hiatt, J. D. Watson, and J. A. Winsten, Ed., Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y., 1977, Book B, pp 639–659; W. Levin, etc., *ibid.*, pp 659–682.
(2) (a) A. Borgen, H. Dawey, N. Castagnoli, T. T. Crocker, R. E. Rasmussen and I. Y. Wang, *J. Med. Chem.*, **16**, 503 (1973); (b) P. Sims, P. L. Grover, A. Swaisland, K. Pal, and A. Hewer, *Nature* (London), **252**, 326 (1974); (c) P. Daudel, M. Duquesne, P. Vigny, P. L. Grover, and P. Sims, *FEBS Lett.*, **57**, 250, (1975); (d) S. K. Yang, D. W. McCourt, P. P. Roller, and H. V. Gelboin, *Proc. Natl. Acad. Sci. U.S.A.*, **73**, 2594 (1976); (e) D. R. Thakker, H. Yagi, Y. H. Lu, W. Levin, A. H. Conney, and D. M. Jerina, *ibid.*, **73**, 3381 (1976).
(3) (a) I. B. Weinstein, A. M. Jeffrey, K. W. Jennette, S. H. Blobstein, R. G. Harvey, C. Harris, H. Autrup, H. Kasai, and K. Nakanishi, *Science*, **193**, 592 (1976); (b) K. M. Straub, T. Meehan, A. L. Burlingane, and M. Calvin, *Proc. Natl. Acad. Sci. U.S.A.*, **74**, 5285 (1977); (c) M. Koreeda, P. G. Wislocki, P. Moore, W. Levin, A. H. Conney, H. Yagi, and D. M. Jerina, *Science*, **199**, 778 (1978).
(4) (a) C. Malaveille, H. Bartsch, P. L. Grover, and P. Sims, *Biochem. Biophys. Res. Commun.*, **66**, 693 (1975); (b) E. Huberman, L. Sachs, S. K. Yang, and H. V. Gelboin, *Proc. Natl. Acad. Sci. U.S.A.*, **73**, 607 (1976); (c) R. F. Newbold and P. Brookes, *Nature* (*London*), **261**, 52 (1976); (d) A. W. Wood, P. G. Wislocki, R. L. Chang, W. Levin, H. Yagi, O. Hernandez, D. M. Jerina, and A. H. Conney, *Cancer Res.*, **36**, 3358 (1976); (e) T. J. Slaga, W. M. Bracken, A. Viaje, W. Levin, H. Yagi, D. M. Jerina, and A. H. Conney, *Ibid.*, **37**, 4130 (1977).
(5) R. G. Harvey, J. Pataki, R. N. Wilke, J. W. Flesher, and S. Soedigdo, *Cancer Lett.*, **1**, 339 (1976).
(6) E. J. Corey and M. Chaykovsky, *J. Am. Chem. Soc.*, **87**, 1353 (1965).
(7) A. Merz and G. Märkl, *Angew. Chem. Int. Ed. Engl.*, **12**, 845 (1973).
(8) L. F. Fieser and J. L. Hartwell, *J. Am. Chem. Soc.*, **60**, 2555 (1938); L. F. Fieser, J. L. Hartwell, and J. E. Jones, "Organic Syntheses", Collect. Vol. III, Wiley, New York, N.Y., 1955, p 98.
(9) (a) N. Drinkwater, J. A. Miller, E. C. Miller, and N. C. Yang, *Proc. Am. Assoc. Cancer Res.*, **19**, 97 (1978); (b) *Cancer Res.*, in press.
(10) K. Tanikawa, T. Ishizuka, K. Suzuki, S. Kusabayashi, and H. Mikawa, *Bull. Chem. Soc. Jpn.* **41**, 2719 (1968).
(11) N. P. Buu-Hoi, J. P. Hoeffinger, and P. Jacquignon, *Bull. Soc. Chim. Fr.*, 3808 (1968).
(12) M. W. Miller, R. W. Amidon, and P. O. Tawney, *J. Am. Chem. Soc.*, **77**, 2845 (1955).
(13) B. H. Klanderman, *J. Org. Chem.*, **31**, 2618 (1961).
(14) L. Van Hove, *Bull. Soc. Chim. Belg.*, **66**, 413 (1957).

A Unique Ring Contraction of 1,4-Dihydro-5*H*-1,3,4-benzotriazepin-5-ones to 1-Methyl-2-(methylamino)-4(1*H*)-quinazolinones via an Intermediate Dimroth Rearrangement[1]

Robert W. Leiby, Edward G. Corley, and Ned D. Heindel*

Department of Chemistry, Lehigh University, Bethlehem, Pennsylvania 18015

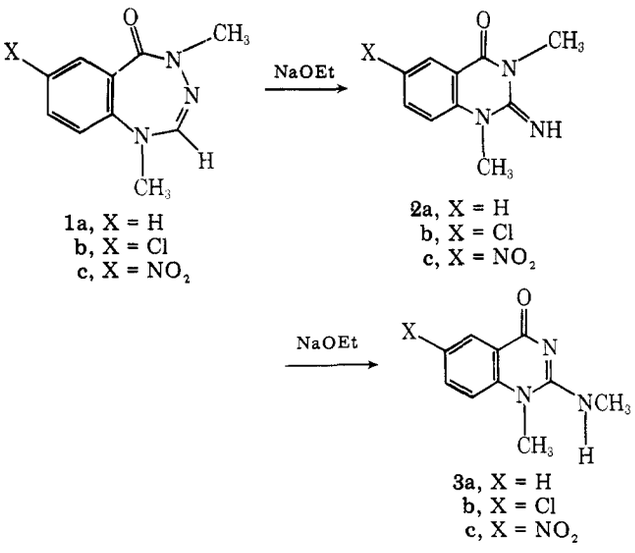
Received April 14, 1978

We have previously reported the synthesis of substituted 3,4-dihydro- and 1,4-dihydro-5*H*-1,3,4-benzotriazepin-5-ones[2] from *o*-aminobenzoyl hydrazides[3] and the discovery of a new alkoxide-induced ring contraction of the former compounds to 3-(methylamino)-4(3*H*)-quinazolinones.[4] We now wish to report a unique, base-catalyzed, ring contraction of the 1,4-dihydro-5*H*-1,3,4-benzotriazepin-5-ones in which the rearrangement takes place through a Dimroth-like intermediate (Scheme I).

The reaction is believed to proceed via abstraction of the C_2 proton by the ethoxide to yield the highly stable 2-cyanamidobenzamide anion (**4**). This anion then cyclizes by intramolecular attack of the amide nitrogen on the cyano carbon to give the 1,3-dimethyl-2-imino-4(3*H*)-quinazolinones (**2**) (Scheme II). These quinazolinones can be isolated from

0022-3263/78/1943-3427$01.00/0

Scheme I

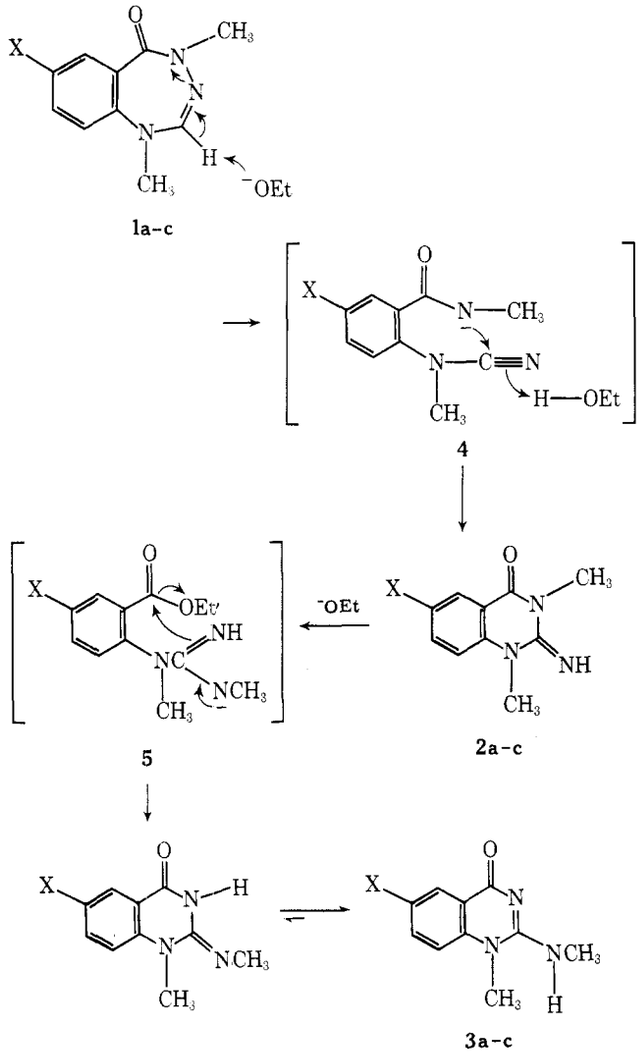


1a, X = H
b, X = Cl
c, X = NO_2

2a, X = H
b, X = Cl
c, X = NO_2

3a, X = H
b, X = Cl
c, X = NO_2

Scheme II



the reaction mixture or allowed to react further with the alkoxide. Attack of the alkoxide ion on the carbonyl carbon of **2** effects a Dimroth rearrangement,[5] presumably to yield a nonisolable 2-guanidinobenzoate (**5**) which spontaneously ring closes to the 1-methyl-2-(methylamino)-4(1*H*)-quinazolinones (**3**).

Compound **3a** has previously been reported by Doleschall and Lempert[6] in a multistep synthesis with 7% overall yield and had physical properties in agreement with that of the rearrangement product isolated herein.

The 2-imino- (**2a–c**) and 2-(methylamino)quinazolinones (**3a–c**) were easily distinguished on the basis of the *N*-methyl doublet in the ^1H NMR spectra of the methylamino compounds. The intermediate imino form was stable to acid and, indeed, **2b** and **2c** were each refluxed for 3 h in 1:1 glacial acetic acid/concentrated hydrochloric acid with recovery of the unchanged HCl salts of **2b** and **2c**. However, the imino form is base labile and will slowly rearrange, even in the solid state, if not completely free of base.

Compounds **1a, 2a,** and **3a** could readily be separated by TLC on silica gel plates (absolute ethanol, R_f 0.80, 0.39, and 0.54, respectively). However, it was found much easier to precipitate the imino form (**2a**) from the reaction medium as the hydrobromide salt, since **1a**·HBr and **3a**·HBr remained in solution. This was confirmed by the addition of aqueous HBr to pure solutions of **1a** and **3a.**

Solubility properties of **2b** and **3b** and of **2c** and **3c** were different enough to allow separation of the two isomers without the addition of HBr.

Experimental Section

Melting points, uncorrected, were determined on a Thomas-Hoover apparatus using open capillaries. Infrared spectra were recorded on a Perkin-Elmer Model 283 spectrometer using KBr disks. ^1H NMR were obtained on a Hitachi Perkin-Elmer R20A nuclear resonance spectrometer. Combustion analyses were provided by Dr. George I. Robertson, Florham Park, N.J.

1,3-Dimethyl-2-imino-4(1*H*,3*H*)-quinazolinone (2a). To a slurry of 7.00 g (0.037 mol) of **1a** in 50 mL of absolute ethanol was added a freshly prepared solution of 0.85 g (0.037 mol) of sodium in 30 mL of absolute ethanol. The solid completely dissolved upon heating to reflux. The solution was refluxed for 45 min and then cooled to room temperature for 20 min. A 35% aqueous solution of HBr was added dropwise, with stirring, to precipitate a white solid. The solid was collected on a filter and washed with ethanol. Recrystallization from 75% ethanol yielded 6.50 g (65%) of analytically pure **2a**·HBr: mp 294–295 °C; IR (KBr) 3320, 3220, 3060, 1712, 1655, 1619, 1578 cm^{-1}; NMR (Me_2SO-d_6) δ 3.50 (s, N_1-CH_3), 3.73 (s, N_3-CH_3), 7.35–8.20 (m, 4 H, Ar**H**), 9.15 (s, br, C=N^+H_2). Anal. Calcd for $C_{10}H_{12}BrN_3O$: C, 44.46; H, 4.48; N, 15.56. Found: C, 44.41; H, 4.52; N, 15.31.

Neutralization of the hydrobromide salt was accomplished by the addition of a 50% NaOH solution to an aqueous solution of the salt followed by extraction into chloroform. Removal of the dried (Na_2SO_4) chloroform in vacuo gave nearly quantitative amounts of **2a.** Recrystallization from water gave an analytically pure sample of **2a:** mp 131–132 °C; IR (KBr) 3355 (=NH), 1681 (C=O), 1605 (C=N) cm^{-1}; NMR (Me_2SO-d_6) δ 3.31 (s, N_3-CH_3), 3.43 (s,N_1-CH_3), 6.63 (s, br, =N**H**), 6.89–7.91 (m, 4 H, Ar**H**). Anal. Calcd for $C_{10}H_{11}N_3O$: C, 63.48; H, 5.86; N, 22.21. Found: C, 63.47; H, 5.76; N, 21.93.

1-Methyl-2-(methylamino)-4(1*H*)-quinazolinone (3a). **1a** (7.00 g, 0.037 mol) was treated as described above except that the reflux was continued for 15 h. Upon cooling, the reaction mixture yielded 2.85 g of an off-white solid. The solid was recrystallized from ethanol, yielding 2.30 g (32.8%) of **3a:** mp 323–324 °C (lit.[6] mp 324–326 °C); IR (KBr) 3220 (NH), 2960 (CH), 1625 (C=O) cm^{-1}; NMR (Me_2SO-d_6) δ 2.88 (d, J = 5 Hz, NHC**H**$_3$), 3.47 (s, NC**H**$_3$), 6.97–7.82 (m, 5 H, Ar**H**, N**H**). Anal. Calcd for $C_{10}H_{11}N_3O$: C, 63.48; H, 5.86; N, 22.21. Found: C, 63.61; H, 5.94; N, 21.91.

Similar treatment of **2a** with ethanolic ethoxide rearranged it to **3a.**

6-Chloro-1,3-dimethyl-2-imino-4(1*H*,3*H*)-quinazolinone (2b) and 6-Chloro-1-methyl-2-(methylamino)-4(1*H*)-quinazolinone (3b). To a slurry of 11.18 g (0.005 mol) of **1b** in 25 mL of absolute ethanol was added 25 mL of an anhydrous ethanolic solution of 0.115 g (0.005 mol) of sodium. The mixture was heated to reflux for 22 h, during which a solid formed. The mixture was cooled, and the solid was collected on a filter. The solid was washed twice in hot ethanol and filtered each time from the hot solution. The washings were set aside to cool. The solid that did not dissolve in the ethanol was recrystallized twice from glacial acetic acid. Pure **3b** (2.68 g, 24%) was obtained: mp 362–363 °C; IR (KBr) 3240 (NH), 1630 (C=O) cm^{-1}; NMR (TFA) δ 3.37 (d, J = 5 Hz, NHC**H**$_3$), 3.85 (s, NC**H**$_3$), 7.45–8.30 (m, Ar**H**, N**H**). Anal. Calcd for $C_{10}H_{10}ClN_3O$: C, 53.70; H, 4.51; N, 18.79. Found: C, 53.50; H, 4.73; N, 18.50.

The washings that were saved from above were chilled in an ice bath, causing colorless needles to crystallize. The needles were recrystallized three times from ethanol to yield 3.88 g (34.8%) of **2b:** mp 157–157.5 °C; IR (KBr) 3340 (=NH), 1680 (C=O), 1605 (C=N), cm^{-1}; NMR (Me_2SO-d_6) δ 3.32 (s, N_1-CH_3), 3.42 (s, N_3-CH_3), 6.78 (s, NH), 7.05–7.80 (m, 3 H, ArH). Anal. Calcd for $C_{10}H_{10}ClN_3O$: C, 53.70; H, 4.51; N, 18.79. Found: C, 53.45; H, 4.68; N, 18.49.

6-Nitro-1,3-dimethyl-2-imino-4(1*H*,3*H*)-quinazolinone (2c). To a slurry of 3.27 g (0.014 mol) of **1c** in 25 mL of ethanol was added a freshly prepared solution of 0.07 g (0.003 mol) of sodium in 25 mL of absolute ethanol. The slurry was heated to reflux, causing the solid to dissolve and the solution to turn a deep red color. The reflux was continued for 24 h and the solution was then cooled to room temperature. An olive-green solid crystallized from the cooled solution and was collected. Recrystallization from dioxane yielded 1.37 g (41.9%) of **2c** as golden-yellow crystals: mp 251–252 °C; IR (KBr) 3330 (=NH), 1680 (C=O), 1607 (C=N) cm^{-1}; NMR (TFA) δ 3.83 (s, N_1-CH_3), 4.00 (s, N_3-CH_3), 7.70–8.30 (m, 5 H, ArH, $=N^+H_2$). Anal. Calcd for $C_{10}H_{10}N_4O_3$: C, 51.28; H, 4.30; N, 23.92. Found: C, 51.18; H, 4.35; N, 23.70.

6-Nitro-1-methyl-2-(methylamino)-4(1*H*)-quinazolinone (3c). To 1.00 g (0.0043 mol) of **2c** was added 50 mL of absolute ethanol containing 0.10 g (0.0043 mol) of sodium. The solution was refluxed for 24 h and then allowed to stand overnight at room temperature. A solid crystallized in the reaction vessel and was filtered off. Analysis showed this solid to be starting material; 0.22 g (22%) was recovered. The reaction solution was then concentrated in vacuo to an oil which was induced to crystallize by scratching in a dioxane/ether solution. The crystals were collected and recrystallized from 50% ethanol to yield 0.30 g (30%) of **3c** as yellow crystals: mp >370 °C dec; IR (KBr) 3235 (NH), 1638 (C=O), 1603 (C=N) cm^{-1}; NMR (TFA) δ 3.45 (d, J = 4 Hz, $NHCH_3$), 3.95 (s, NCH_3), 7.85 (d, J = 10 Hz, H_8), 8.20 (br, NH_2^+), 8.84 (d, J = 10 Hz of d, J = 3 Hz, H_7), 9.23 (d, J = 3 Hz, H_5). Anal. Calcd for $C_{10}H_{10}N_4O_3$: C, 51.28; H, 4.30; N, 23.92. Found: C, 51.01; H, 4.52; N, 23.73.

Registry No.—**1a,** 59169-91-4; **1b,** 59169-92-5; **1c,** 59169-93-6; **2a,** 66809-70-9; **2a** HBr, 66809-71-0; **2b,** 66809-72-1; **2c,** 66809-73-2; **3a,** 5544-06-9; **3b,** 66809-74-3; **3c,** 66809-75-4.

References and Notes

(1) Presented at the 12th Middle Atlantic Regional Meeting of the American Chemical Society Medicinal Chemistry Division, Hunt Valley, Maryland, April 6, 1978.
(2) R. W. Leiby and N. D. Heindel, *J. Org. Chem.*, **41,** 2736 (1976).
(3) R. W. Leiby and N. D. Heindel, *Synth. Commun.*, **6,** 295 (1976).
(4) R. W. Leiby and N. D. Heindel, *J. Org. Chem.*, **42,** 161 (1977).
(5) A Dimroth rearrangement involving a similar compound was demonstrated by R. J. Grout and M. W. Partridge, *J. Chem. Soc.*, 3540 (1960).
(6) G. Doleschall and K. Lempert, *Acta. Chim. Acad. Sci. Hung.*, **45,** 357 (1965).

Communications

Deuterium Nuclear Magnetic Resonance. Evaluation of the Positional Distribution of Low Levels of Deuterium in the Presence of Eu(fod)$_3$

Summary: ^2H NMR spectroscopy, in conjunction with the shift reagent Eu(fod)$_3$, has been used to detect and quantify the positional incorporation of low levels of ^2H in catalytically deuterated saturated carboxylic acid esters.

Sir: While ^1H NMR can be used effectively to determine the extent of ^2H incorporation in organic molecules, it has severe limitations. First, ^1H NMR requires that the molecule under study contain high concentrations of ^2H, since this technique can evaluate ^2H only by difference. Secondly, when ^2H is largely dispersed throughout a molecule even in relatively high total concentration, analysis becomes very difficult because of insignificant changes observed in the area of each of the dispersed ^1H resonances. As an alternate method, mass spectrometry can furnish information concerning the total level of isotopic incorporation; however, in most instances it cannot define the positional distribution of ^2H owing to ^2H–^1H scrambling during the fragmentation process.

Although two orders of magnitude less sensitive in response to a magnetic field than ^1H, the ^2H nucleus is more amenable to Fourier transform methods.[1] Under complete proton decoupling conditions, ^2H resonances are normally observed as single resonances (no ^2H–^2H spin coupling is observed), having chemical shifts closely corresponding to their ^1H counterparts.[2] Also, because of their relatively short longitudinal relaxation time, T_1, multiple transients may be rapidly accumulated with short repetition times.[1] For example, a 100-mg sample of molecular weight of 200–300, containing 5% ^2H, which in magnetic response is equivalent to 0.05% ^1H, can yield an excellent quantitative spectrum within 0.5 h from 300 transients (repetition time only 5 s and a pulse angle of 60°).

^2H NMR in the presence[2,3] and absence[4,5] of lanthanide shift reagents can be used to examine positional substitution patterns in both static and rapidly exchanging ^1H, ^2H systems. Such a technique seemed amenable to our studies concerning the catalytic incorporation of ^2H into the saturated alkyl chains of carboxylic acids, since no other approach could quantify and evaluate the positional distribution of the low levels of widely dispersed ^2H. Typically, not more than a total of 29%, and in some cases as little as 2%, ^2H was incorporated into our representative samples. All ^2H spectra were obtained by use of a ^{31}P 10-mm probe of a JEOL FX-60Q NMR spectrometer,[6] which normally operates at 24 MHz with a ^2H lock channel of 9.2 MHz. By reversing the offset/rf power modules and exchanging the lock and observation lines, we could lock

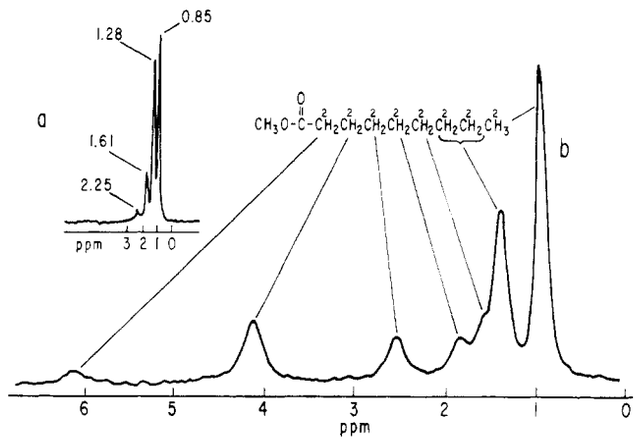


Figure 1. ^2H spectrum of: (a) methyl nonanoate, 255 transients, 4.4-s repetition rate, displayed spectral width = 500 Hz, 4K data points; (b) methyl nonanoate in the presence of Eu(fod)$_3$ shift reagent, molar ratio of Eu(fod)$_3$/substrate = 0.7, 200 transients, 4.4-s repetition rate, displayed spectral width = 62.5 Hz. Total ^2H content = 29%.

0022-3263/78/1943-3429$01.00/0