Studies on Anticoccidial Agents. III. Selective Esterification and Acyl Transfer in α^4-Norpyridoxol

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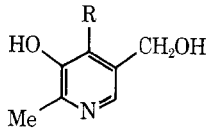
Acyl and aroyl substituents attached to the ring hydroxyl group of α^4-norpyridoxol have been found to transfer to the side-chain hydroxyl at the α^5 position. This intermolecular rearrangement takes place on heating 3-*O*-acyl-α^4-norpyridoxol in pyridine. The mechanism of this rearrangement has been studied and could be explained by a two-stage intermolecular transesterification via the 3,α^5 diester. Some α^5 aromatic esters have also been prepared by selective hydrolysis of 3-*O*-acetyl-α^5-*O*-aroyl-α^4-norpyridoxol.

4-Deoxypyridoxol (**1**) and α^4-norpyridoxol (**2**) have been shown to exhibit coccidiostatic effects and the latter compound was found to be the more desirable drug.[1,2] In the



1, R = Me
2, R = H

present study, the selective esterification of **2** has been examined in order to obtain derivatives for evaluation as potential anticoccidial agents. Perez-Medina et al.[3] prepared **5a** hydrochloride from **2** by refluxing in acetyl chloride. We have prepared a series of diesters **5** by treating **2** with excess acid chloride or anhydride in pyridine.

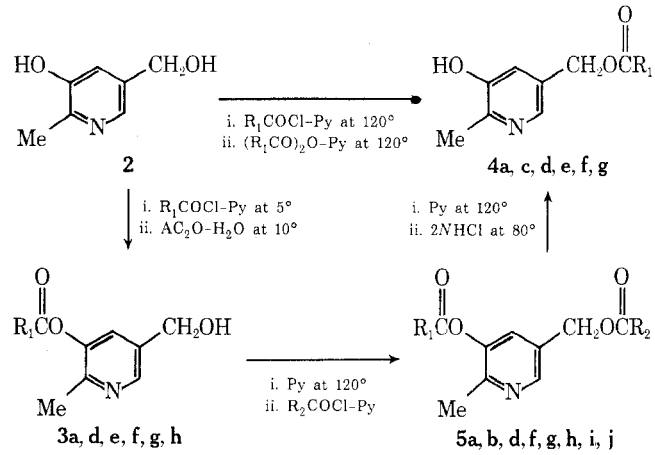
We obtained 3-*O*-monoesters **3** by treating **2** with 1 equiv of an acid chloride at 5°. 3-*O*-Acetoxy-5-hydroxymethyl-2-methylpyridine (**3a**) was prepared by treating **2** with acetic anhydride in water under vigorous stirring. These monoesters gave a negative ferric chloride test, indicating substitution of the phenolic hydroxyl group.

In an attempt to obtain 3-hexanoyloxy-5-hydroxymethyl-2-methylpyridine, we treated **2** with 1 mol of *n*-hexanoic anhydride in pyridine at about 120° for 10 hr. The resulting monohexanoate was not the same as the product obtained from **2** and *n*-hexanoyl chloride in pyridine under cooling and gave a positive ferric chloride test, indicating the presence of a phenolic hydroxyl group as could be expected from the rearranged product (**4**). The ir spectrum of the monoester **4e** on comparison with that of 3-*O*-monohexanoate **3e** confirmed the structural assignment. The carbonyl absorption band of the ring-substituted hexanoyl group appeared at 1770 cm^{-1} while that of the α^5-*O*-hexanoyl group appeared at 1730 cm^{-1}. The α^5-*O*-hexanoate **4e** was in fact obtained by heating a pyridine solution of the hydrochloride of 3-*O*-*n*-hexanoate **3e.**

Analogous rearrangements were shown to occur in other aliphatic, alicyclic, and aromatic esters, namely 3-*O*-acetyl, 3-*O*-valeryl, 3-*O*-pivaloyl, 3-*O*-cyclohexanecarbonyl, and 3-*O*-benzoyl esters of **2.** The sterically hindered pivaloyl moiety in the 3-*O*-pivaloate **3d** migrated more slowly than the unhindered hexanoyl function in 3-*O*-hexanoate **3e.** The transfer of 3-*O*-benzoate **3g** was effected only under the prolonged reaction conditions. The reason for this difficulty for rearrangement may be related to the greater stability of the aromatic esters as compared with the corresponding aliphatic esters.

Korytnyk et al.[4-6] observed the intramolecular acyl rearrangement via an ortho acid in the synthesis of α^4-O-acylpyridoxols. Now we observed the acyl transfer in the synthesis of α^5-*O*-acyl-α^4-norpyridoxols.

To clarify the mechanism of these acyl rearrangements, we examined the behavior of 3-*O*-pivaloate **3d** in pyridine at about 120°. Heating a pyridine solution of **3d** at 120° for 10 hr produced 3,α^5-*O*-pivaloate **5d**, α^5-*O*-pivaloate **4d**, and **2** together with some starting material (**3d**). The 3,α^5-*O*-pivaloate hydrochloride (**5d**) obtained was again heated in pyridine at 120° for 10 hr, which resulted in partial hydrolysis to α^5-*O*-pivaloate **4d** (12.8%). When the diester hydrochloride (**5d**) was heated in the presence of **2** under the same conditions, the transfer of the 3-*O*-pivaloyl group of **5d** to the 5-hydroxymethyl group of **2** was very effective (58.3%). On the other hand, heating the pyridine solution of the α^5-*O*-pivaloate **4d** in the absence as well as in the presence of **2** at 120° for 10 hr afforded only unchanged starting material. Thus the chemical evidences described above have shown that the 3-*O*-acyl transfer to the α^5-O position can be explained by a two-stage intermolecular transesterification via the 3,α^5-*O*-diester **5.**



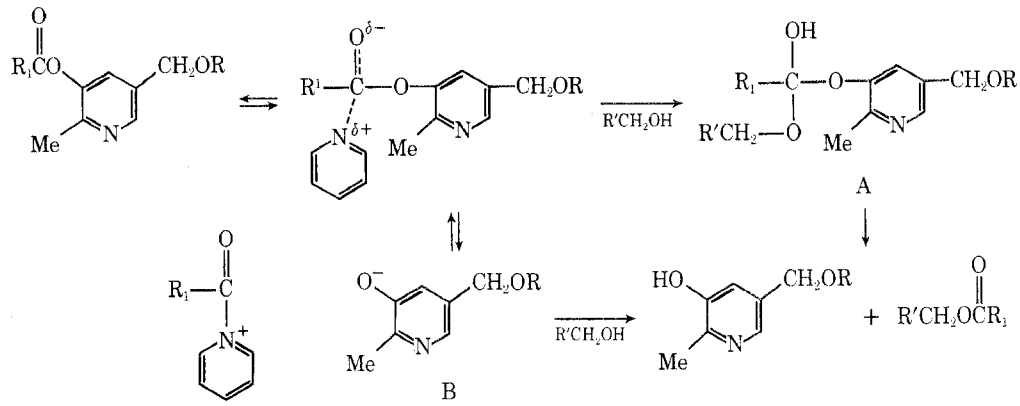
2 **4a, c, d, e, f, g**

3a, d, e, f, g, h **5a, b, d, f, g, h, i, j**

a, R_1 = Me
b, $R_1 = R_2$ = iso-C_3H_7
c, R_1 = *n*-C_4H_9
d, $R_1 = R_2$ = *t*-C_4H_9
e, R_1 = *n*-C_5H_{11}
f, R_1 = cyclohexyl
g, $R_1 = R_2$ = Ph
h, $R_1 = R_2$ = *p*-PhOMe
i, R_1 = Me; R_2 = Ph
j, R_1 = Me; R_2 = *p*-PhOMe

In the acyl shift from 3 to α^5, participation of pyridine molecule precedes an attack of the α^5-hydroxyl on the 3-*O*-ester carbonyl, since the transfer has not been observed in toluene but in pyridine as well as in toluene containing a trace of pyridine at 120° for 10 hr. So the acyl transfer may proceed by way of the ortho acid (A) or the pyridinium salt (B).

In addition α^5-O-monoaromatic esters (**4**) have been obtained by the interaction of 3-*O*-acetate **3a** with aroyl chlorides to produce the corresponding esters (**5**), followed by selective hydrolysis with 2 *N* HCl. The α^5-*O*-acetate **4a** was



also prepared from **2** via 5-bromomethyl-3-hydroxy-2-methylpyridine under conditions essentially identical with those applied to the synthesis of 5-acetoxymethyl-3-hydroxy-2,4-dimethylpyridine.[7] All the esters prepared were found to be active against *Eimeria acervulina*, and 3-*O*-monoacetate **3a** and α^5-O-monoacetate **4a** have almost the same activity as **2** HCl.

Experimental Section

Melting points are uncorrected. Ir spectra were determined using a Perkin-Elmer 221 and Jasco IRA-2 spectrometers. NMR spectra were taken on a Varian A-60 spectrometer using tetramethylsilane as an internal standard. Typical experimental procedures are described for the preparation of the ester derivatives.

3,α^5-*O*-Dibenzoyl-α^4-norpyridoxol. **2** HCl (0.9 g, 5.13 mmol) was dissolved in pyridine (5 ml) and cooled at 5° and benzoyl chloride (1.5 g, 10.66 mmol) was added. The solution was stirred at room temperature overnight, poured into water, and extracted with chloroform. The extract was dried and the solvent was removed, leaving a crystalline material which was recrystallized from ethyl acetate–*n*-hexane to give 1.6 g (90%) of the dibenzoate: mp 85–86°; ir (Nujol) 1738, 1722 cm^{-1}.

Anal. Calcd for $C_{21}H_{17}NO_4$: C, 72.61; H, 4.93; N, 4.03. Found: C, 72.63; H, 4.83; N, 4.23.

3,α^5-*O*-Dianisoyl-α^4-norpyridoxol (prepared by the above procedure) had mp 135–136° from ethyl acetate–*n*-hexane (92% yield): ir (Nujol) 1730, 1715 cm^{-1}.

Anal. Calcd for $C_{23}H_{21}NO_6$: C, 67.80; H, 5.20; N, 3.44. Found: C, 67.75; H, 5.15; N, 3.43.

3,α^5-*O*-Diisobutyryl-α^4-norpyridoxol hydrochloride (prepared by the above procedure) had mp 134–136° from ethanol–ethyl acetate (95% yield): ir (Nujol) 1762, 1738 cm^{-1}.

Anal. Calcd for $C_{15}H_{22}ClNO_4$: C, 57.10; H, 6.97; N, 4.43; Cl, 11.25. Found: C, 57.14; H, 6.94; N, 4.45; Cl, 11.27.

3-*O*-Acetyl-α^4-norpyridoxol Hydrochloride (3a). An aqueous solution (15 ml) of **2** HCl (3.5 g) was neutralized with $NaHCO_3$ and to this solution acetic anhydride (2.5 g) was added at 15° under vigorous stirring. After addition was completed, the solution was stirred for 20 min and then extracted with ethyl acetate. The extract was dried (Na_2SO_4) and concentrated to a small volume and addition of ethanol containing 15% hydrogen chloride afforded **3a** (3.4 g, 86.8%): mp 134–135°; ir (Nujol) 3300, 1786 cm^{-1}; NMR (D_2O) 2.52 (s, 3, OCOMe), 2.72 (s, 3, C_2 Me), 4.91 (s, 2, C_5 CH_2OH), 8.42 (d, 1, J = 2.0 Hz, C_4 H), 8.61 ppm (d, 1, J = 2.0 Hz, C_6 H).

Anal. Calcd for $C_9H_{12}ClNO_3$: C, 49.61; H, 5.56; N, 6.48. Found: C, 49.82; H, 5.62; N, 6.58.

3-*O*-Cyclohexanecarbonyl-α^4-norpyridoxol Hydrochloride (3f). A solution of cyclohexanecarbonyl chloride (1.47 g, 10 mmol) in pyridine (10 ml) was added dropwise in 15 min at 5° into a solution of **2** HCl (1.76 g, 10 mmol) in pyridine (20 ml). The mixture was stirred at 10° for 16 hr, diluted with ice–water, and extracted with chloroform. The extract was washed with water and dried and the solvent was removed to leave an oil, which was again dissolved in ethyl acetate, and addition of ethanol containing 15% hydrogen chloride yielded 1.9 g (66.7%) of **3f**: mp 148–150°; ir (Nujol) 3250, 1770 cm^{-1}; NMR (CF_3COOH) 7.6–8.9 (m, 11), 7.18 (s, 3, C_2 Me), 4.84 (s, 2, CH_2OH), 1.54 (broad s, 1, C_4 H), 1.28 (broad s, 1, C_6 H).

Anal. Calcd for $C_{14}H_{20}ClNO_3$: C, 58.75; H, 7.05; N, 4.90; Cl, 12.40. Found: C, 59.00; H, 7.10; N, 4.96; Cl, 12.64.

The following four derivatives were prepared by the above procedure.

3-*O*-*n*-Hexanoyl-α^4-norpyridoxol hydrochloride (3e) had mp 127–129° on recrystallization from ethanol–ethyl acetate (59.1%); ir (Nujol) 3260, 1770 cm^{-1}; NMR (D_2O) 0.93 (t, 3, J = 6 Hz), 1.2–2.0 (m, 6), 2.67 (s, 3, C_2 Me), 2.83 (t, 3, J = 7.5 Hz), 4.90 (s, 2, C_5 CH_2OH), 8.38 (d, 1, J = 1.5 Hz, C_4 H), 8.63 ppm (d, 1, J = 1.5 Hz, C_6 H).

Anal. Calcd for $C_{13}H_{20}ClNO_3$: C, 57.00; H, 7.31; N, 5.12; Cl, 12.97. Found: C, 57.28; H, 7.40; N, 5.32; Cl, 12.99.

3-*O*-Pivaloyl-α^4-norpyridoxol hydrochloride (3d) had mp 162–163° as recrystallized from ethanol–ethyl acetate (64.0%); ir (Nujol) 3240, 1765 cm^{-1}; NMR (D_2O) 1.38 (s, 9, CMe_3), 2.68 (s, 3, C_2 Me), 4.88 (s, 2, C_5 CH_2OH), 8.38 (d, 1, J = 1.5 Hz, C_4 H), 8.63 ppm (d, 1, J = 1.5 Hz, C_6 H).

Anal. Calcd for $C_{12}H_{18}ClNO_3$: C, 55.50; H, 6.98; N, 5.38; Cl, 13.65. Found: C, 55.65; H, 7.08; N, 5.48; Cl, 13.57

3-O-Benzoyl-α^4-norpyridoxol (3g) had mp 81–82° on recrystallization from ethyl acetate–*n*-hexane (86.5%); ir (Nujol) 3180, 1740 cm^{-1}.

Anal. Calcd for $C_{14}H_{13}NO_3$: C, 69.12; H, 5.38; N, 5.76. Found: C, 69.08; H, 5.36; N, 5.60.

3-*O*-*p*-Anisoyl-α^4-norpyridoxol (3h) had mp 103–104° on recrystallization from ethyl acetate–*n*-hexane (81%); ir (Nujol) 3200, 1730 cm^{-1}.

Anal. Calcd for $C_{15}H_{15}NO_4$: C, 65.92; H, 5.53; N, 5.13. Found: C, 65.77; H, 5.50; N, 5.01.

α^5-*O*-Valeryl-α^4-norpyridoxol (4c). A mixture of **2** HCl (0.88 g, 5 mmol) and *n*-valeryl chloride (0.66 g, 5.57 mmol) in pyridine (5 ml) was stirred at 120° for 20 hr, diluted with water, and extracted with chloroform. The extract was washed with water and dried (Na_2SO_4) and the solvent was removed to leave an oily product, which gradually solidified. Recrystallization from ethyl acetate–*n*-hexane gave **4c** (0.73 g, 65%): mp 114–115°; ir (Nujol) 2600, 2500, 1730 cm^{-1}; NMR ($CDCl_3$) 0.88 (t, 3, J = 6.0 Hz), 1.1–1.8 (m, 4), 2.35 (t, 2, J = 7.5 Hz), 2.59 (s, 3, C_2 Me), 5.09 (s, 2, C_5 CH_2), 7.26 (d, 1, J = 1.5 Hz, C_4 H), 8.03 ppm (d, 1, J = 1.5 Hz, C_6 H).

Anal. Calcd for $C_{12}H_{17}NO_3$: C, 64.55; H, 7.68; N, 6.27. Found: C, 64.64; H, 7.68; N, 6.35.

α^5-*O*-Hexanoyl-α^4-norpyridoxol (4e). To a solution of **2** HCl (0.88 g, 5 mmol) in pyridine (10 ml), *n*-hexanoic anhydride (1.07 g, 5 mmol) was added dropwise. The mixture was stirred at 120° for 10 hr and worked up as described above to give a crystalline residue, which was recrystallized from ethyl acetate–*n*-hexane to afford **4e** (0.73 g, 61.3%): mp 111–112°; ir (Nujol) 2630, 2500, 1730 cm^{-1}.

Anal. Calcd for $C_{13}H_{19}NO_3$: C, 65.80; H, 8.07; N, 5.90. Found: C, 65.79; H, 7.92; N, 5.82.

Rearrangement of 3-*O*-Pivaloyl-α^4-norpyridoxol (3d). A. A solution of 3-*O*-pivaloate **3d** (1.6 g) in pyridine (6 ml) was stirred at 120° for 10 hr. After removal of pyridine, the residue was diluted with water, neutralized with aqueous $NaHCO_3$, and extracted with ethyl acetate. The resulting oil after evaporation of the solvent was chromatographed on dry silica gel, eluting with benzene–ethyl acetate (1:1).

The major product (0.48 g) was the starting material. The second product (0.38 g, oil) was identified as 3,α^5-*O*-dipivaloyl-α^4-norpyridoxol (**5d**), which was converted into a hydrochloride: mp 142–143°; ir (Nujol) 1765, 1730 cm^{-1}; NMR (D_2O) 1.17 (s, 9), 1.37 (s, 9), 2.68 (s, 3, C_2 Me), 5.34 (s, 2, C_5 CH_2), 8.38 (d, 1, J = 2 Hz, C_4 H), 8.63 ppm (d, 1, J = 2 Hz, C_6 H).

Anal. Calcd for $C_{17}H_{26}ClNO_4$: C, 59.30; H, 7.62; N, 4.07; Cl,

10.62. Found: C, 59.15; H, 7.60; N, 4.11; Cl, 10.54.

The third product (0.17 g) was α^5-*O*-pivaloyl-α^4-norpyridoxol (**4d**), which was recrystallized from ethyl acetate–*n*-hexane: mp 170°; ir (Nujol) 2650, 1715 cm^{-1}; NMR ($CDCl_3$) 1.14 (s, 9), 2.56 (s, 3, C_2 Me), 5.05 (s, 2, C_5 CH_2), 7.21 (d, 1, J = 2 Hz, C_4 H), 7.98 ppm (d, 1, J = 2 Hz, C_6 H).

Anal. Calcd for $C_{12}H_{17}NO_3$: C, 64.55; H, 7.68; N, 6.27. Found: C, 64.80; H, 7.80; N, 6.46.

The aqueous layer after extraction with ethyl acetate was concentrated and again extracted with a large quantity of hot ethyl acetate. The extract was dried and concentrated and addition of anhydrous ethanol–HCl gave **2** HCl (0.047 g).

B. A solution of **3d** (1.0 g) in dry toluene (15 ml) containing pyridine (0.3 ml) was heated at 120° for 10 hr and worked up as described above to give **3d** (0.89 g) and **5d** (0.015 g).

Conversion of 3,α^5-*O*-Dipivaloate (5d) to α^5-*O*-Pivaloate (4d) in Pyridine. A. A solution of 3,α^5-*O*-dipivaloate hydrochloride (**5d,** 0.300 g) in pyridine (1.5 ml) was stirred at 120° for 10 hr, diluted with water, and extracted with chloroform. The extract was washed with water and dried and the solvent was removed to leave a semisolid. Chromatography on silica gel with benzene–ethyl acetate (1:1) gave the starting material (**5d,** 0.234 g) and α^5-*O*-pivaloate (**4d,** 0.025 g).

B. A solution of 3,α^5-*O*-dipivaloate hydrochloride (**5d,** 0.69 g, 2 mmol) and **2** (0.280 g, 2 mmol) in pyridine (3 ml) was stirred at 120° for 10 hr and woked up as described above. The starting material (0.34 g) and α^5-*O*-pivaloate **4d** (0.26 g), mp 169–170°, were obtained.

Heating of α^5-*O*-Pivaloate (4d) with α^4-Norpyridoxol in Pyridine. A solution of **4d** (0.250 g) and **2** HCl (0.192 g) in pyridine (5 ml) was heated at 120° for 10 hr and the solvent was removed, diluted with water, neutralized with aqueous $NaHCO_3$, and extracted with ethyl acetate. The extract, after being dried over Na_2SO_4, was concentrated and addition of *n*-hexane gave **4d** (0.23 g). The aqueous layer was again extracted with a large quantity of hot ethyl acetate. The extract was concentrated and addition of anhydrous ethanol–HCl gave **2** HCl (0.187 g).

Rearrangement of 3-*O*-Cyclohexanecarbonyl-α^4-norpyridoxol (3f). A solution of **3f** (0.47 g) in pyridine (1.5 ml) was heated at 120° for 10 hr and worked up as described above. The crystalline residue obtained was chromatographed on a dry silica gel column. Elution with benzene–ethyl acetate (1:1) gave 3,α^5-*O*-dicyclohexanecarboxylate **5f** (0.12 g) and α^5-*O*-cyclohexanecarboxylate **4f** (0.22 g).

5f was an oil, which was converted to a hydrochloride: mp 150–151°; ir (Nujol) 1765, 1735 cm^{-1}.

Anal. Calcd for $C_{21}H_{30}ClNO_4$: C, 63.73; H, 7.68; N, 3.54; Cl, 8.95. Found: C, 63.91; H, 7.67; N, 3.75; Cl, 8.99.

4f melted at 175–177°; ir (Nujol) 2650, 1720 cm^{-1}.

Anal. Calcd for $C_{14}H_{19}NO_3$: C, 67.44; H, 7.68; N, 5.62. Found: C, 67.51; H, 7.77; N, 5.78.

When the reaction was continued for 22 hr, the only product was α^5-*O*-cyclohexanecarboxylate **4f.**

α^5-*O*-Acetyl-α^4-norpyridoxol (4a). A. 3-*O*-Acetate hydrochloride (**3a,** 0.2 g) was converted to α^5-*O*-acetate **4a** (0.1 g) in pyridine (1 ml) under heating at 120° for 10 hr: mp 170–172°; ir (Nujol) 2634, 2500, 1757 cm^{-1}; NMR (DMF-d_7) 2.08 (s, 3, OAc), 2.40 (s, 3, C_2 Me), 5.08 (s, 2, CH_2OAc), 7.21 (d, 1, J = 2.0 Hz, C_4 H), 8.00 (d, 1, J = 2.0 Hz, C_6 H).

Anal. Calcd for $C_9H_{11}NO_3$: C, 59.66; H, 6.12; N, 7.73. Found: C, 59.73; H, 6.03; N, 7.78.

B. **2** HCl (2.0 g) was dissolved in 47% hydrobromic acid and the solution was refluxed for 30 min, cooled, and made alkaline with aqueous $NaHCO_3$ to give 5-bromomethyl-3-hydroxy-2-methylpyridine (1.2 g), mp 282–285° dec.

Anal. Calcd for C_7H_8BrNO: C, 41.60; H, 3.99; N, 6.93; Br, 39.58. Found: C, 41.70; H, 4.05; N, 6.89; Br, 39.70.

A mixture of the bromomethyl compound (1.2 g), AgOAc (3.5 g), and KOAc (22 g) in AcOH (80 ml) was stirred at 130° for 1.5 hr. After evaporation of the solvent, the residue was extracted with ethyl acetate. The extract was washed with water, dried, and concentrated into a small volume to afford **4a** (0.2 g), mp 170–172°.

3-*O*-Acetyl-α^5-*O*-benzoyl-α^4-norpyridoxol (5i). To a solution of 3-*O*-acetate **3a** (1.1 g) in pyridine (10 ml), benzoyl chloride (0.8 g) was added dropwise at 5°. The mixture was diluted with ice–water and extracted with ethyl acetate. The extract was washed with water, dried (Na_2SO_4), and concentrated to dryness to give an oil. Crystallization from ethyl acetate–*n*-hexane afforded **5i** (1.37 g): mp 57°; ir (Nujol) 1760, 1720 cm^{-1}.

Anal. Calcd for $C_{16}H_{15}NO_4$: C, 67.36; H, 5.30; N, 4.91. Found: C, 67.36; H, 5.17; N, 4.82.

3-*O*-Acetyl-α^5-*O*-anisoyl-α^4-norpyridoxol (5j) was prepared by a similar procedure: mp 65–66°; ir (Nujol) 1765, 1705 cm^{-1}.

Anal. Calcd for $C_{17}H_{17}NO_5$: C, 64.75; H, 5.43; N, 4.44. Found: C, 64.65; H, 5.38; N, 4.29.

α^5-*O*-Benzoyl-α^4-norpyridoxol (4g). A. A solution of **5i** (0.5 g) in 2 *N* HCl (25 ml) was stirred at 80° for 1 hr, cooled, and neutralized with aqueous $NaHCO_3$. A colorless product (0.2 g) separated. Recrystallization from ethanol gave **4g:** mp 221–223°; ir (Nujol) 2500, 1720 cm^{-1}.

Anal. Calcd for $C_{14}H_{13}NO_3$: C, 69.12; H, 5.39; N, 5.76. Found: C, 69.18; H, 5.30; N, 5.65.

B. 3-*O*-Benzoate hydrochloride (**3g,** 0.5 g) was heated in pyridine at 120° (5 ml) for 60 hr and chromatographed on silica gel to give α^5-*O*-benzoate **4g** (0.085 g) together with 3,α^5-*O*-dibenzoate **5g** (0.070 g) and the starting material **3g** (0.210 g).

α^5-*O*-Anisoyl-α^4-norpyridoxol hydrochloride (4h) was prepared from **5j** by the above procedure and isolated as a hydrochloride: mp 224–225° dec; ir (Nujol) 2500, 1715 cm^{-1}.

Anal. Calcd for $C_{15}H_{16}ClNO_4$: C, 58.16; H, 5.20; N, 4.51; Cl, 11.44; Found: C, 58.09; H, 5.10; N, 4.40; Cl, 11.56.

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Registry No.—**2** HCl, 3816-44-2; **3a,** 54193-37-2; **3a** HCl, 53054-35-6; **3d,** 54193-38-3; **3d** HCl, 54193-39-4; **3e** HCl, 53123-11-8; **3f,** 54293-21-9; **3f** HCl, 54193-40-7; **3g,** 53054-39-0; **3g** HCl, 54193-41-8; **3h,** 53054-40-3; **4a,** 53054-46-9; **4c,** 53054-48-1; **4d,** 54193-42-9; **4e,** 54193-43-0; **4f,** 54193-44-1; **4g,** 53054-52-7; **4h** HCl, 53054-69-6; **5b** HCl, 53054-23-2; **5d,** 54193-45-2; **5d** HCl, 54193-46-3; **5f,** 53054-59-4; **5f** HCl, 54193-47-4; **5g,** 53054-72-1; **5h,** 54193-48-5; **5i,** 53054-56-1; **5j,** 53054-57-2; benzoyl chloride, 98-88-4; anisoyl chloride, 100-07-2; isobutyryl chloride, 79-30-1; acetic anhydride, 108-24-7; cyclohexanecarbonyl chloride, 2719-27-9; hexanoyl chloride, 142-61-0; pivaloyl chloride, 3282-30-2; *n*-valeryl chloride, 638-29-9; *n*-hexanoic anhydride, 2051-49-2; 5-bromomethyl-3-hydroxy-2-methylpyridine, 54193-49-6.

References and Notes

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