Carbon *vs.* Nitrogen Acylation in Reactions of Organolithium–Pyridine Adducts with Acid Chlorides and Esters

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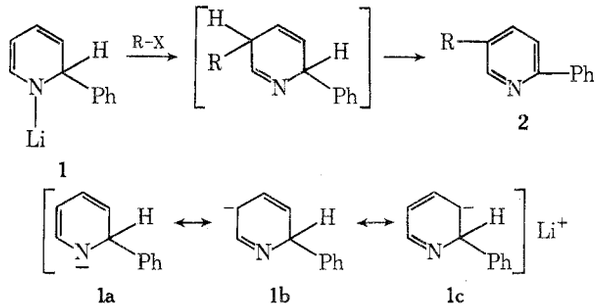
Received April 9, 1974

Acylation of the ambident anion, 1-lithio-2-phenyl-1, 2-dihydropyridine (1), has been investigated. Acetylation with acetyl chloride occurred preferentially at nitrogen to yield *N*-acetyl-2-phenyl-1,2-dihydropyridine (**4a**) and some C-substitution product, 2-phenyl-5-acetylpyridine (**5a**). In contrast, reaction of **1** with trifluoroacetyl chloride gave primarily C rather than N substitution to give 2-phenyl-5-trifluoroacetyl-1,2-dihydropyridine (**6**), 2-phenyl-5-trifluoroacetylpyridine (**5b**), and some *N*-trifluoroacetyl-2-phenyl-1,2-dihydropyridine (**4b**). Reaction of **1** with para-substituted benzoyl chlorides gave rise to **4** and **5**; however, with *p*-ethoxybenzoyl chloride the disubstituted product **7** (R = *p*-$EtOC_6H_4$) was also obtained. The mechanism for the formation of **7** is discussed. The use of organolithium pyridine adducts other than **1** is described.

There are few methods available for the direct acylation of pyridines and related systems particularly since Friedel–Crafts acylation is not possible with such π-deficient molecules.[3] Recent examples involve carboxylation[4] of the adduct **1** and reaction of pyridine derivatives[5] with ethyl chloroformate and Grignard reagent. We now report[6] a useful method of effecting acylations of pyridines which has wide utility and affords compounds which are otherwise hard to prepare.[7]

Recently, we reported that the highly reactive and versatile intermediate, 1-lithio-2-phenyl-1,2-dihydropyridine (**1**),[8] isolated from the reaction of phenyllithium with pyridine, reacted with alkyl halides to give 2-phenyl 5-substituted pyridines **2**; however, no N-alkylation product could

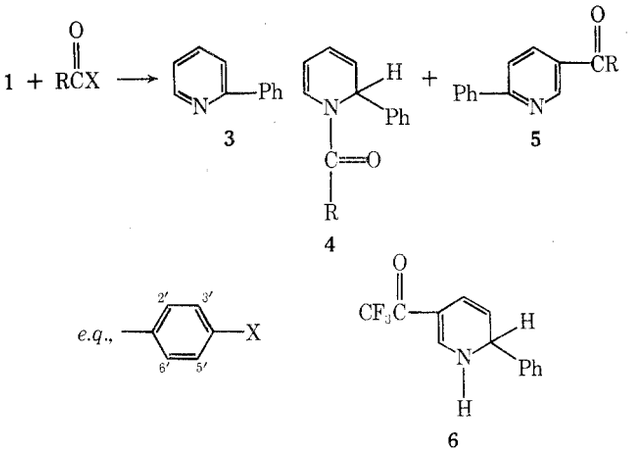


1 **2** **1a** **1b** **1c**

be detected.[9] The mesomeric structures **1a–c** strongly suggest that electrophilic attack may occur either at carbon or nitrogen or both. C- *vs.* N-substitution in this or other structurally related dienamines has not been reported. In contrast to substitution at a saturated carbon atom, very little is known regarding the behavior of ambident anions in substitution reactions at an unsaturated carbon atom or at heteroatoms.[10,11] It was therefore of interest to study the electronic influence of substituents in the acylating agent upon the site of substitution. We now have evidence for both N- and C-acylation as well as N,C-diacylation in the reaction of **1** with acid chlorides and esters. In subsequent papers we shall consider reactions with other electrophiles.

The yellow crystalline adduct **1**, prepared by the dropwise addition of pyridine to an ether solution of phenyllithium, was isolated,[8] washed with anhydrous ether, and taken up in dry THF,[12] followed by the addition of the acid chloride or ester at −65°. A number of other conditions were investigated and the results are summarized in Table I.

Treatment of **1** with 1 equiv of acetyl chloride resulted in almost exclusive N-acylation to yield *N*-acetyl-2-phenyl-



a, R = Me
b, R = CF_3
c, R = OEt
d, *p*-$CF_3C_6H_4$
e, *p*-$O_2NC_6H_4$
f, *p*-HC_6H_4
g, *p*-$EtOC_6H_4$

1,2-dihydropyridine (**4a**, 34.2%) and some C-substitution product 2-phenyl-5-acetylpyridine (**5a**, 1.7%). Addition of lithium chloride to a solution of **1** did not alter the yields of **4a** and **5a** significantly. However, when an excess of acetyl chloride was used a much higher yield of **4a** was obtained (68.5%), but **5a** could not be detected. Similarly, compounds **4** can also be prepared using other reagents. For example, treatment of **1** with acetic anhydride, ethyl acetate, and ethyl chloroformate resulted in exclusive N-acylation to give high yields of **4a** and 1-carbethoxy-2-phenyl-1,2-dihydropyridine (**4c**, 77%), respectively. On the other hand reaction of **1** with trifluoroacetyl chloride gave primarily C- rather than N-acylation to yield **6** (13.2%), **5b** (5%), and some N-substituted product **4b** (1.1%). The unusual stability of the dihydro product **6** is likely due to the stabilizing effect of the trifluoroacetyl group.[13] Although **6** did undergo partial aromatization to **5b** at 197° in the vpc (retention time 15 min), it could be recrystallized and was stable on storage. The structures of the products **4** and **5** were established mainly on the basis of uv,[14,15] ir,[15,16] nmr,[8,15,17] and mass spectral[18] data. Compounds **5** also exhibited spectral data[9] consistent with a 2,5-disubstituted pyridine structure.

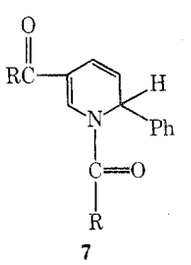
The results obtained show that the relative amount of

Table I
Per Cent Yield of Products from Reaction of Acylation Reagent with 1-Lithio-2-phenyl-1,2-dihydropyridine

Acylation reagent	Registry no.	Temp, C	Ratio 1:acylation reagent	R	3	4	5	6	7	8
Acetyl chloride	73-36-5	−65	1:1	CH_3	7.1	34.2[b]	1.7[c]			
Acetyl chloride		0	1:1	CH_3	11.9[d]	31.6	1.0			
Acetyl chloride		−65	1:2	CH_3	13.0	68.5				
Acetyl chloride		−65	1:10	CH_3	13.3	63.7				
Acetyl chloride[a]		−65	1:1	CH_3	37.2	31.0	0.6			
Acetic anhydride	108-24-7	−65	1:1	CH_3	6.8	31.6				
Acetic anhydride		0	1:1	CH_3	28.9	12.4				
Ethyl acetate	141-78-6	−65	1:1	CH_3	11.9	55.6				
Trifluoroacetyl chloride	354-32-5	−65	1:1	CF_3	17.1	1.1[e]	13.2[f]	5.0[g]		
Ethyl chloroformate	541-41-3	−65	1:1	OC_2H_5	7.1	77.0[h]				
Ethyl chloroformate		0	1:1	OC_2H_5	15.9	63.0				
Benzoyl chloride	98-88-4	−65	1:1	C_6H_5	16.5	26.6[i]	8.9			
Ethyl benzoate	93-89-0	−65	1:1	C_6H_5	5.95	34.2	24.2[j]			
Ethyl benzoate		0	1:1	C_6H_5	18.4	41.7	34.4			
p-Trifluoromethylbenzoyl chloride	329-15-7	−65	1:1	*p*-$CF_3C_6H_4$	11.0	15.9[k]	1.5[l]			
p-Nitrobenzoyl chloride	122-04-3	−65	1:1	*p*-$O_2NC_6H_4$	37.2	5.9[m]				3.4[n]
p-Ethoxybenzoyl chloride	16331-46-7	−65	1:1	*p*-$EtOC_6H_4$	16.3	14.8[o]			60.00[p]	
1-Adamantyl acid chloride	2094-72-6	−65	1:2	1-ada					11.8[q]	

[a] LiCl added to the reaction. [b] Registry no. 35022-78-7. [c] 35022-79-8. [d] 1008-89-5. [e] 52358-12-0. [f] 35022-82-3. [g] 35022-81-2. [h] 35022-83-4. [i] 35022-80-1. [j] 30091-51-1. [k] 52358-13-1. [l] 52358-16-4. [m] 52358-14-2. [n] 52358-19-7. [o] 52358-15-3. [p] 52358-17-5. [q] 52358-18-6.

N-substitution dropped significantly in going from the weakly electrophilic acetyl chloride to the more strongly electrophilic trifluoroacetyl chloride. This observation prompted us to study the reaction of **1** with a series of para-substituted benzoyl chlorides to determine the electronic effect of the substituent on the relative amounts of C- and N-substitution without the interference of steric factors. Reaction on **1** with *p*-trifluoromethylbenzoyl chloride gave primarily the N-substituted product **4d** (15.9%) and some **5d** (1.5%). Considerable intractable tar was obtained in this and the reaction below. When **1** was allowed to react with *p*-nitrobenzoyl chloride a low yield of the N-substituted product **4e** (5.9%) was isolated but none of the C-substitution product **5e** was detected; instead, an unexpected dimeric product which exhibits spectral data consistent with structure **8** (3.4%) was obtained. Its mass spectrum exhibited a parent ion peak at *m/e* 308 (100). The most abundant fragment arose from cleavage of dimer to give an ion at *m/e* 154 (13.5). The nmr spectrum characteristic of a 2-phenyl 5-substituted pyridine,[9] exhibited a 1 H doublet ($J_{2',4'}$ = 2 Hz) at δ 9.42 attributed to the $C_2{}^1$–H, a 1 H doublet ($J_{4',5'}$ = 8 Hz) of doublets ($J_{2',4'}$ = 2 Hz) at δ 8.54 due to the $C_4{}^1$–H and a complex 14 H multiplet at 7.3–8.3 due to the C_{3-5}–H, $C_{5'}$–H and phenyl hydrogens. The dimer **8** may result from nucleophilic attack at the 6 position of 2-phenylpyridine[3] by the organolithium–pyridine intermediate **1b**.[9]



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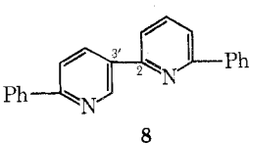

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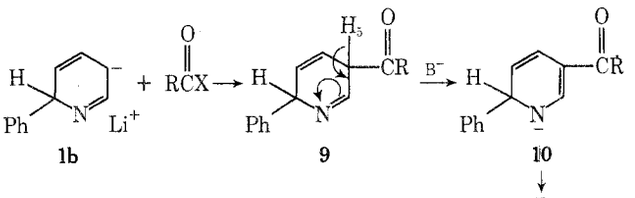
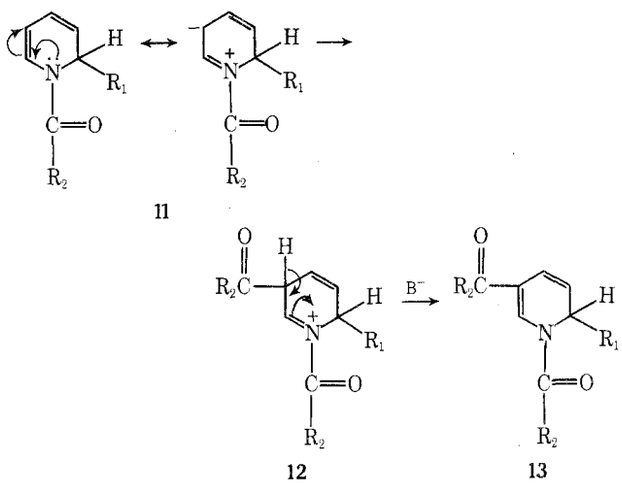
Treatment of **1** with benzoyl chloride or ethyl benzoate afforded in good yields (Table I) both the N- and C-substitution products **4f** and **5f**, respectively. In contrast, reaction of **1** with *p*-ethoxybenzoyl chloride gave the unexpected 1,5-di(*p*-ethoxybenzoyl)-2-phenyl-1,2-dihydropyridine (**7**, R = *p*-$EtOC_6H_4$) (60%) together with **4g** (14.8%). None of the C-substitution product **5g** was detected. One possible pathway for the formation of **7** may involve reaction of the acid chloride with **1b** to give the dihydro intermediate **9**. Abstraction of the active C-5 proton by base such as 2-phenylpyridine (some of which is always obtained) could give rise to **10** which on further reaction with acid chloride could yield the disubstituted product **7**. On the other hand,

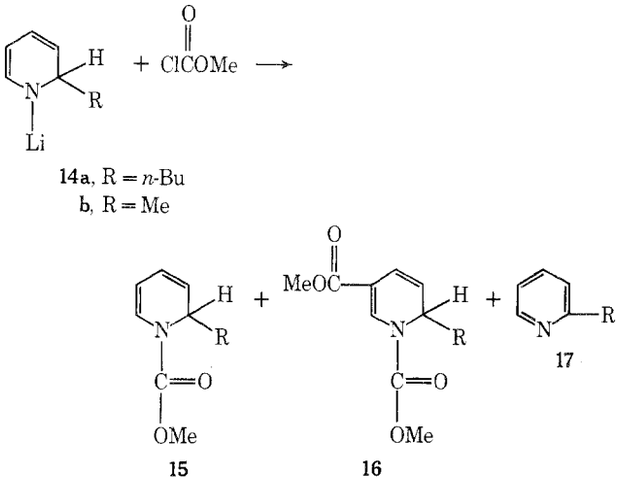


one could envisage[14] the reaction of **11** (R_1 = Ph, R_2 = *p*-$EtOC_6H_4$) with acid chloride forming the 2,5-dihydro intermediate **12** which in the presence of base may give **13**. However, this mechanism appears doubtful since treatment of 2-butyl-1-carbomethoxy-1,2-dihydropyridine **11** (R_1 = *n*-Bu, R_2 = OMe) with methyl chloroformate and then 2-butylpyridine failed to yield any of the disubstituted product **13** (R_1 = *n*-Bu, R_2 = OMe). When **1** was reacted with 1-adamantanecarbonyl chloride the disubstituted product **7** (R = 1-adamantyl) was obtained (11.8%) as the sole material isolated. Although the overall yield of isolable products was low in some reactions, the ratio of N/C-



substitution appears to be dependent on the relative electrophilicities of the acylation agents. The ratio of N/C-substitution[19] dropped significantly in going from the less reactive acetyl chloride (20:1) to the more reactive benzoyl chloride (3:1) and then to the most reactive trifluoroacetyl chloride (1:16).

The reaction of other organolithium–pyridine compounds[8,20] was also studied with the view of determining the effect of the 2-substituent upon the site of further substitution. When *N*-lithio-2-butyl-1,2-dihydropyridine (**14a**) was treated with 1 equiv of methyl chloroformate the N-substituted product **15a** (43%) was obtained as well as the 1,5-disubstituted product **16a** (25%) and 2-butylpyridine **17a** (5%). With 5 equiv of the acid chloride yields of 35, 34, and 6%, respectively, were obtained. Similarly, reaction of 1-lithio-2-methyl-1,2-dihydropyridine (**14b**), with methyl chloroformate gave rise to **15b** (7%), the disubstitution product **16b** (10%), and some **17b** (7.3%). None of the C-substitution product 2-alkyl-5-carbomethoxypyridine was obtained in either of these reactions.



Further studies of organolithium–pyridine adducts and their derivatives are in progress in these laboratories.

Experimental Section

Melting points were determined with a Büchi capillary apparatus and are uncorrected. Nmr spectra were determined for solutions of $CDCl_3$ unless otherwise noted with $SiMe_4$ as internal standard with a Varian HA-100 spectrometer. Infrared spectra (in KBr unless otherwise noted) were taken on a Beckman IR-8 or Unicam SP-1000 spectrometer. Untraviolet spectra (in 95% EtOH) were measured using a Cary-14 spectrometer. Mass spectra were measured with a CEC-21-110 or AEI-MS-9 mass spectrometer. Quantitative analysis were effected with a Hewlett-Packard 5750 or a Varian Aerograph 1520 dual column gas chromatograph.

1-Lithio-2-phenyl-1,2-dihydropyridine (1). To an ice-cold solution of 8.4 g (0.1 mol) of PhLi in 200 ml of anhydrous ether was slowly added 7.9 g (0.1 mmol) of pyridine under a N_2 atmosphere. The resulting yellow precipitate was redissolved by repeated shaking. Upon cooling to 0° the adduct **1** was obtained as a yellow crystalline solid which was washed with 30 ml of dry ether and taken up in 100 ml of dry THF. A 2-ml aliquot of the above solution was hydrolyzed with 10 ml of water and the concentration determined by titration with hydrochloric acid.

***N*-Acetyl-2-phenyl-1,2-dihydropyridine (4a) and 2-Phenyl-5-acetylpyridine (5a). General Procedure. (a) −65°.** To a solution of 0.94 g (5.77 mmol) of **1** in 10 ml of dry THF was added 0.45 g (5.77 mmol) of AcCl with stirring at −65° under N_2. The resulting yellow solution was allowed to stand at room temperature for 1 hr, and 10 ml of water was added. Extraction with $CHCl_3$ (5 × 5 ml), drying (Na_2SO_4), and removal of the solvent gave a yellow oil. Vpc analysis on a 5 ft × ⅛ in. column packed with 10% UCW-98 on Anakrom ABS (60/80 mesh) with a He flow rate of 60 ml/min and a column temperature of 170° gave 0.064 g (7.1%) of **3** (retention time 1.33 min); 0.394 g (34.2%) of **4a** (3.75 min). The latter had bp 118° (1.5 mm): uv 303 nm (ε 4300); ir 1640 cm^{-1} (C=O); nmr δ 7.38 (m, 5, phenyl), 6.53 [d ($J_{5,6}$ = 7.5 Hz) of d ($J_{4,6}$ = 0.75), 1, C_6-H], 6.26 [d ($J_{2,3}$ = 5.5), 1, C_2-H)], 6.08 [(d ($J_{3,4}$ = 8.75) of d ($J_{4,5}$ = 5.75), 1, C_4-H], 5.79 [d ($J_{3,4}$ = 8.75) of d ($J_{2,3}$ = 5.5) of d ($J_{3,5}$ = 1.5), 1, C_3-H], 5.36 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75) of d ($J_{3,5}$ = 1.5), 1 C_5-H], 2.17 (s, 3, CH_3); mass calcd for $C_{13}H_{13}NO$, 199.099705; found, 199.099245. Continued elution gave 0.019 g (1.7%) of **5a** (6.0 min): mp 118°; ir 1660 cm^{-1} (C=O); nmr δ 9.24 [d ($J_{4,6}$ = 2 Hz), 1, C_6-H], 8.31 [d ($J_{3,4}$ = 8.75) of d ($J_{4,6}$ = 2), 1, C_4-H], 8.1 (m, 2, phenyl ortho H), 7.84 [d ($J_{3,4}$ = 8.75), 1, C_3-H], 7.5 (m, 3, phenyl meta and para H), 2.64 (s, 3, CH_3); mass calcd for $C_{13}H_{11}NO$, 197.084055; found, 197.084408.

(b) Ion Effect. Acetyl chloride (0.135 g, 1.73 mmol) was added to a solution of 0.282 g (1.73 mmol) of **1** in 10 ml of dry THF to which 1.15 g of LiCl was added. The reaction was completed and the vpc analysis effected as in (a) to yield 0.099 g (37.2%) of **3**, 0.106 g (31%) of **4a**, and 0.002 g (0.6%) of **5a**.

(c) −65°. Acetic anhydride (0.52 g, 5.1 mmol) was added to a solution of 0.83 g (5.1 mmol) of **1** in 10 ml of dry THF as under (a). Vpc analysis on a 5 ft × ¼ in. column packed with 10% Se-30 on Anakrom ABS (60/80 mesh) with a He flow rate of 60 ml/min and a column temperature of 175° afforded 0.054 g (6.8%) of **3** (retention time 5.1 min), and 0.32 g (31.6%) of **4a** (13.1 min).

(d). Addition of EtOAc (0.31 g, 3.54 mmol) to a solution of 0.58 g (3.54 mmol) of **1** in 10 ml of dry THF as in (a) and then vpc analysis on a 5 ft × ¼ in. column packed with 10% Se-30 on Anakrom ABS (60/80 mesh) with a He flow rate of 60 ml/min and a column temperature of 172° afforded 0.065 g (11.9%) of **3** (retention time 4.2 min), and 0.392 g (55.6%) of **4a** (9.3 min).

***N*-Trifluoroacetyl-2-phenyl-1,2-dihydropyridine (4b), 2-Phenyl-5-trifluoroacetylpyridine (5b), and 2-Phenyl-5-trifluoroacetyl-1,2-dihydropyridine (6).** To a solution of 1.2 g (7.4 mmol) of **1** in 10 ml of dry THF was added a solution of CF_3COCl in THF until the reddish brown color of **1** was discharged and the reaction mixture turned yellow. The reaction was completed as under (a) above and the reaction mixture was chromatographed on a 2.5 × 20 cm SiO_2 column. Elution with 300 ml of C_6H_{14}-PhH (1:1 v/v) gave 0.020 g (1.0%) of **4b:** ir 1700 cm^{-1} (C=O); nmr (CCl_4) δ 7.22–7.50 (m, 5, phenyl), 6.68 [d ($J_{5,6}$ = 7.5 Hz), 1, C_6-H], 6.02–6.24 (m, 2, C_2-H, C_4-H), 5.86 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H], 5.5 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75), 1, C_5-H]; mass calcd for $C_{13}H_{10}NOF_3$, 253.07138; found, 253.070866. Further elution with 500 ml of the same solvent gave 0.196 g (17.1%) of **3.** Continued elution (200 ml) afforded 0.093 g (5.0%) of **5b:** mp 72–73°, ir 1700 cm^{-1} (C=O); nmr δ 9.36 [d ($J_{4,6}$ = 2 Hz), 1, C_6-H], 8.42 [d ($J_{3,4}$ = 8.5) of d ($J_{4,6}$ = 2), 1, C_4-H], 8.14 (m, 2, ortho phenyl H), 7.92 [d ($J_{3,4}$ = 8.5), 1, C_3-H], 7.54 (m, 3, meta and para phenyl H); mass calcd for $C_{13}H_8NOF_3$; 251.05574; found, 251.055082. Elution with PhH (400 ml) gave 0.247 g (13.2%) of **6:** mp 121–123° (from PhH); ir 1600 cm^{-1} (C=O); nmr δ 7.74 [d ($J_{1,6}$ = 7.5 Hz), 1, C_6-4],[21] 7.4 (m, 5, phenyl), 6.7 [broad d ($J_{1,6}$ = 7.5), 1, –NH],[22] 6.56 [d ($J_{3,4}$ = 9.75), 1, C_4-H], 5.41 [d ($J_{2,3}$ = 5.5), 1, C_2-H], 5.36 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H].

Anal. Calcd for $C_{13}H_{10}NOF_3$: C, 61.67; H, 3.98; N, 5.53. Found: C, 61.69; H, 3.85; N, 5.51.

1-Carbethoxy-2-phenyl-1,2-dihydropyridine (4c), −65°. Ethyl chloroformate (0.54 g, 5.1 mmol) was added to a solution of 0.83 g (5.1 mmol) of **1** in 10 ml of dry THF at −65° as under (a)

above. Vpc analysis as described under (c) at 175° gave 0.061 g (7.7%) of **3** and 1.12 g (77%) of **4c** (retention time 14.9 min): bp 118° (0.6 mm); uv 281 nm (ϵ 2600); ir (film) 1690 cm^{-1} (C=O); nmr (CCl_4) δ 7.14–7.50 (m, 5, phenyl), 6.82 [d ($J_{5,6}$ = 7.5 Hz), 1, C_6-H], 5.50–6.12 (m, 3, C_4-H, C_2-H, C_3-H), 5.20 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75) of d ($J_{3,5}$ = 1.3), 1, C_5-H], 4.16 [q (J = 7), 2, $-OCH_2-$], 1.22 [t (J = 7), 3, $-CH_3$]; mass calcd for $C_{14}H_{15}NO_2$, 229.110265; found, 229.109650.

***N*-(*p*-Trifluoromethylbenzoyl)-2-phenyl-1,2-dihydropyridine (4d) and 2-Phenyl-5-(*p*-trifluoromethylbenzoyl)pyridine (5d).** To a solution of 0.94 g (5.77 mmol) of **1** in 10 ml of dry THF was added 1.2 g (5.77 mmol) of *p*-$CF_3C_6H_4COCl$ as under (a) above. Vpc analysis as under (c) at 175° afforded 0.098 g (11%) of **3**, and at 246° gave 0.31 g (15.9%) of **4d** (retention time 5.5 min): bp 103° (0.5 mm); ir 1620 cm^{-1} (C=O); nmr δ 7.26–7.76 (m, 9, phenyl H), 6.22–6.50 (m, 2, C_6-H, C_2-H), 6.14 [d ($J_{3,4}$ = 9.75 Hz) of d ($J_{4,5}$ = 5.75), 1, C_4-H], 5.86 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H], 5.36 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75), 1, C_5-H]; mass calcd for $C_{19}H_{14}NOF_3$, 329.10266; found, 329.103311. This was followed by 0.029 g (1.5%) of **5d** (retention time 10.6 min): mp 183–184° (from MeOH); ir 1640 cm^{-1} (C=O); nmr δ 9.08 [d ($J_{4,6}$ = 2 Hz), 1, C_6-H], 7.72–8.30 (m, 8, ortho phenyl H, $C_{2',3',5',6'}$-H, C_4-H, C_5-H), 7.44–7.62 (m, 3, meta and para phenyl H); mass calcd for $C_{19}H_{12}NOF_3$, 327.08702; found, 327.086866.

***N*-(*p*-Nitrobenzoyl)-2-phenyl-1,2-dihydropyridine (4e) and 6,6'-diphenyl-2,3'-dipyridyl (8).** A solution of *p*-$O_2NC_6H_4COCl$ (1.07 g, 5.77 mmol) in 2 ml of dry THF was added to a solution of 0.94 g (5.77 mmol) of **1** in 10 ml of dry THF. The reaction was completed as under (a) above and the reaction mixture chromatographed on a 2.5 × 15 cm Al_2O_3 column. Elution with 1300 ml of PhH and then 200 ml of PhH–Et_2O (2:1 v/v) gave 0.333 g (37.2%) of **3**. Further elution with 300 ml of the latter solvent gave an orange viscous oil which was subjected to preparative tlc on 0.5 mm SiO_2 G plates using PhH–Et_2O (7:1 v/v) as the development solvent. Extraction of the fraction R_f 0.5–0.6 afforded 0.03 g (3.4%) of **8**: mp 131–131.5°; mass calcd for $C_{22}H_{16}N_2$, 308.131340; found, 308.131953. Extraction of the fraction R_f 0.6–0.8 gave rise to 0.104 g (5.9%) of **4e**:[23] ir 1650 cm^{-1} (C=O); nmr δ 8.28 [d ($J_{2',3'}$ = $J_{5',6'}$ = 8.75 Hz), 2, C_3-H, $C_{5'}$-H], 7.64 [d ($J_{2',3'}$ = $J_{5',6'}$ = 8.75), 2, $C_{2'}$-H, $C_{6'}$-H], 7.26–7.56 (m, 5, phenyl), 6.24–6.44 (m, 2, C_6-H, C_2-H), 6.18 [d ($J_{3,4}$ = 9.75), of d ($J_{4,5}$ = 5.75), 1, C_4-H], 5.9 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H], 5.52 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75), 1, C_5-H]; mass calcd for $C_{18}H_{14}N_2O_3$, 306.100420; found, 306.101075.

***N*-Benzoyl-2-phenyl-1,2-dihydropyridine (4f) and 2-Phenyl-5-benzoylpyridine (5f). Method A.** To a solution of 0.58 g (3.546 mmol) of **1** in 10 ml of dry THF was added 0.50 g (3.546 mmol) of C_6H_5COCl as under (a). Vpc analysis was effected as under (c) at 172° to give 0.091 g (16.5%) of **3**, and at 260° to yield 0.246 g (26.6%) of **4f** (retention time 4.6 min): bp 170° (1.0 mm); ir 1615 cm^{-1} (C=O); nmr δ 7.1–7.6 (m, 10, phenyl H), 6.46 [d ($J_{5,6}$ = 7.5 Hz), 1, C_6-H], 6.25 [d ($J_{2,3}$ = 5.5), 1, C_2-H], 6.09 [d ($J_{3,4}$ = 9.75) of d ($J_{4,5}$ = 5.75) of d ($J_{4,6}$ = 0.90) of d ($J_{2,4}$ = 0.75), 1, C_4-H], 5.82 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5) of d ($J_{3,5}$ = 1.30) of d ($J_{3,6}$ = 1.10), C_3-H], 5.26 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75) of d ($J_{3,5}$ = 1.3), 1, C_5-H]; mass calcd for $C_{18}H_{15}NO$, 261.11498; found, 261.114179. 0.082 g (8.9%) of **5f** was also found: mp 84–85° (lit.[24] mp 89.5°); ir 1620 cm^{-1} (C=O); nmr δ 9.1 [d ($J_{4,6}$ = 2 Hz), 1, C_6-H], 7.8–8.3 (m, 6, C_4-H, C_3-H, 4 ortho phenyl H), 7.4–7.7 (m, 6, meta and para phenyl H); mass spectrum M^+ 259.

Method B. PhCOOEt (0.867 g, 5.77 mmol) was added to a solution of 0.94 g (5.77 mmol) of **1** in 10 ml of dry THF at −65°. The reaction was completed and the analysis effected as under (a) at 160° to give 0.053 g (6.0%) of **3** (retention time 1.9 min) and at 220° to give 0.515 g (34.2%) of **4f** (2.1 min) and 0.362 g (24.2%) of **5f** (8.6 min).

***N*-(*p*-Ethoxybenzoyl)-2-phenyl-1,2-dihydropyridine (4g) and 1,5-Di-(*p*-ethoxybenzoyl)-2-phenyl-1,2-dihydropyridine (7, R = *p*-$EtOC_6H_4$).** To a solution of 0.45 g (2.764 mmol) of **1** in 10 ml of dry THF was added 0.51 g (2.764 mmol) of *p*-EtO-C_6H_4COCl as under (a) above. The reaction mixture was chromatographed on a 2.5 × 15 cm SiO_2 column. Elution with 700 ml of C_6H_{14}–PhH (1:1 v/v) afforded 0.071 g (16.3%) of **3**. Elution with 300 ml of PhH gave 0.125 g (14.8%) of **4g**: bp 115° (0.8 mm) dec; ir (film) 1620 cm^{-1} (C=O); nmr (CCl_4) δ 7.10–7.54 (m, 7, phenyl, $C_{2'}$-H, $C_{6'}$-H), 6.78 [d ($J_{2',3'}$ = $J_{5',6'}$ = 8.75 Hz), 2, $C_{3'}$-H, $C_{5'}$-H], 6.48 [d ($J_{5,6}$ = 7.5) of d ($J_{4,6}$ = 0.75), 1, C_6-H], 6.12 [d ($J_{2,3}$ = 5.5), 1, C_2-H], 6.06 [d ($J_{3,4}$ = 9.75) of d ($J_{4,5}$ = 5.75), 1, C_4-H], 5.74 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H], 5.19 [d ($J_{5,6}$ = 7.5) of d ($J_{4,5}$ = 5.75), 1, C_5-H], 3.96 [q (J = 7), 2, $-OCH_2-$], 1.35 [t (J = 7), 3, $-OCH_2CH_3$]; mass calcd for $C_{20}H_{19}NO_2$, 305.141565; found, 305.140686. Further elution with 1100 ml of PhH gave rise to 0.376 g (60%) of **7** (R = *p*-$EtOC_6H_4$): bp 116° (0.6 mm) dec; ir (film) 1620 cm^{-1} (C=O); nmr (CCl_4) δ 7.20–7.62 (m, 10, phenyl, C_6-H, $C_{2'}$-H, $C_{6'}$-H), 6.68–6.90 (m, 5, C_4-H, $C_{3'}$-H, $C_{5'}$-H), 6.16 [d ($J_{2,3}$ = 5.5 Hz), 1, C_2-H], 5.84 [d ($J_{3,4}$ = 9.75) of d ($J_{2,3}$ = 5.5), 1, C_3-H], 3.97 [q (J = 7), 4, $-OCH_2-$], 1.37 [t (J = 7), 6, $-OCH_2CH_3$]; mass calcd for $C_{29}H_{27}NO$, 453.193985; found, 453.192659.

1-Carbomethoxy-2-butyl-1,2-dihydropyridine (15a) and 1,5-Dimethoxycarbonyl-2-butyl-1,2-dihydropyridine (16a). To a solution of *N*-lithio-2-butyl-1,2-dihydropyridine[8] (0.0275 mol) in dry ether was added a solution of MeOCOCl (2.6 g, 0.0275 mol) in dry ether. The reaction was completed as under (a). Vpc analysis on a 6 ft × ¼ in. column packed with 3% OV-17 on Chrom W (80–100 mesh) with a He flow rate of 50 ml/min and a column temperature of 155° gave 0.19 g (5%) of **17a** (retention time 1 min) and at 205° 2.30 g (43%) of **15a** (1.12 min): ir (film) 1718 cm^{-1} (C=O); nmr δ 6.72 [1 H, d ($J_{5,6}$ = 7.5 Hz), C_6-H], 5.95 [1 H, d ($J_{3,4}$ = 8.75) of d ($J_{4,5}$ = 5.5), C_4-H], 5.68 [1 H, d ($J_{2,3}$ = 5), C_3-H], 5.26 (1 H, m, C_5-H), 4.75 (1 H, m, C_2-H), 3.78 (3 H, s, $-OCH_3$), 0.7–1.9 (9 H, m, *n*-Bu); mass calcd for $C_{11}H_{17}NO_2$, 195.1259; found, 195.1266. 0.87 g (25%) of **16a** was also found (retention time 3.25 min): ir (film) 1712 and 1734 cm^{-1} (C=O); nmr δ 7.92 (1 H, s, C_6-H), 6.46 [1 H, d ($J_{3,4}$ = 9.75 Hz), C_4-H], 5.62 [1 H, d ($J_{3,4}$ = 9.75 Hz) of d ($J_{2,3}$ = 5.5), C_3-H], 4.78 [1 H, d ($J_{2,3}$ = 5.5), C_2-H], 3.86 (3 H, s, $-OCH_3$), 3.78 (3H, s, $-OCH_3$), 0.65–1.65 (9 H, m, *n*-Bu); mass calcd for $C_{13}H_{19}NO$, 253.1314; found, 253.1310.

1-Carbomethoxy-2-methyl-1,2-dihydropyridine (15b) 1,5-Dimethoxycarbonyl-2-methyl-1,2-dihydropyridine (16b). To a solution of *N*-lithio-2-methyl-1,2-dihydropyridine[8] (0.0846 mol) in dry ether (85 ml) was added a solution of MeOCOCl (7.99 g, 0.0846 mol) in 10 ml of dry ether. The reaction was completed as under (a). Vpc analysis on a 5 ft × ¼ in. column packed with 3% OV-101 on Chrom W (80–100 mesh) with a He flow rate of 55 ml/min and a column temperature of 130° gave 0.58 g (7.3%) of **17b** (retention time 0.88 min) and at 180° gave 0.85 g (7%) of **15b** (2 min): ir 1718 cm^{-1} (C=O); nmr δ 6.65 [1 H, d ($J_{5,6}$ = 7.5 Hz), C_6-H], 5.91 [1 H, d ($J_{3,4}$ = 8.75) of d ($J_{4,5}$ = 5.5), C_4-H], 5.63 [1 H, d ($J_{2,3}$ = 5), C_3-H], 5.30 (1 H, m, C_5-H), 4.86 (1 H, m, C_2-H), 3.78 (3 H, s, $-OCH_3$), 1.14 [3 H, d (J = 6.5), $-CH_3$]; mass calcd for $C_8H_{11}NO_2$, 153.0789; found, 153.0787. 0.85 g (10%) of **16b** was also found (6.0 min); ir 1712 and 1734 cm^{-1} (C=O); mass calcd for $C_{10}H_{13}NO_4$, 211.0845; found, 211.0837.

Acknowledgments. We are grateful to the Robert A. Welch Foundation and the Medical Research Council of Canada (Grant No. MA-4888) for financial support of this work.

Registry No.—**1**, 24724-75-2; **14a**, 20180-25-0; **14b**, 52358-20-0; **15a**, 52358-21-1; **15b**, 52358-22-2; **16a**, 52358-23-3; **16b**, 52358-24-4; PhLi, 591-51-5; pyridine, 110-86-1.

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