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INTRODUCTION OF THE AMINOOXY GROUP ON TO NITROAROMATIC AND HETEROCYCLIC RINGS

SYNTHESIS AND PROPERTIES OF O-(NITROARYL)HYDROXYLAMINES

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Abstract— The reaction of halonitrobenzenes with t-butyl N-hydroxycarbamate (**2**), gave t-butyl N(nitroaryloxy)carbamates (**3**), which yielded on acidolysis with trifluoroacetic acid, O-(nitroaryl)hydroxylamines (**4**). Compounds **4** were utilized for the amination of anionic nitrogens and of carbanions. Attempts to apply the method to the synthesis of hydroxylamines substituted on the oxygen by heterocyclic rings (pyridine, pyrimidine, pyrazine, triazine, purine and benzothiazole) yielded only the corresponding hydroxy compounds. However, the formation of a N,O-dipyridylhydroxylamine derivative (**22b**) indicates that O(5-nitro-2-pyridyl)hydroxylamine (**17**) existed as a highly reactive intermediate.

ALTHOUGH the chemistry of organic hydroxylamine derivatives has attracted great deal of attention,[1] very little work has been done on O-arylhydroxylamines. O-Phenylhydroxylamine was synthesized in low yields (15%) by two methods,[2,3] one of which also served for the synthesis of O-(*p*-tolyl)hydroxylamine (8% yield), O-(*m*-chlorophenyl)hydroxylamine (2%)[4] and O-(*m*-trifluoromethylphenyl)hydroxylamine (6·5%).[5] Another claimed synthesis of several derivatives[6] has been withdrawn.[7,8]

The synthetic approach we report here is based on the reaction of suitably activated aryl halides with N-hydroxycarbamates and subsequent removal of the carboalkoxy groups. This route was first attempted by Ilvaspaa and Marxer[9] who used mainly N-hydroxyurethane, but reported failure due to the sensitivity of the N—O bond towards the hydrolytic conditions employed. We have now found that on using t-butyl N-hydroxycarbamate (**2**)[10] the resulting t-butyl N-aryloxycarbamates (**3**) could be transformed in high yields to the desired O-arylhydroxylamines (**4**) by short treatment with trifluoroacetic acid.

$$\underset{\mathbf{1}}{ArX} + \underset{\mathbf{2}}{HONHCOOC(CH_3)_3} \xrightarrow{base} \underset{\mathbf{3}}{ArONHCOOC(CH_3)_3} \xrightarrow{CF_3COOH} \underset{\mathbf{4}}{ArONH_2}$$

The compounds prepared are listed in Table 1.

Compounds **4** were obtained as yellow-orange crystalline solids, and except for the picryl derivative **4e** were quite stable. Their structural assignments were confirmed by analyses, IR spectra and by the reaction with aldehydes or ketones which yielded O-aryloximes (**5**). (Identical with compounds obtained by reacting the corresponding oximes with halonitrobenzenes.)

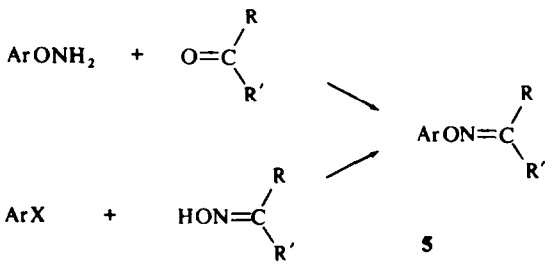
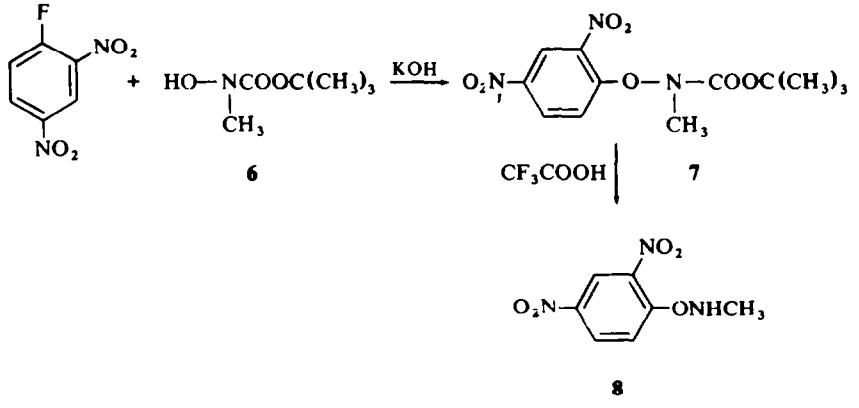


TABLE 1. YIELDS AND IR DATA FOR COMPOUNDS 3 AND 4

			3			4		
				ν(cm^{-1})				
NO	Ar	X	yield (%)	NH	C=O	yield (%)	ν(cm^{-1})NH$_2$	
a	2-nitrophenyl	F	25	3160	1715	83	3240,	3320
b	4-nitrophenyl	F	47	3240	1720	85	3235,	3310
c	2,4-dinitrophenyl	F[a]	80	3240	1725	95	3250,	3310
d	2,6-dinitrophenyl	Cl	60	3180	1700	92	3260,	3330
e	picryl	Cl	10	3375	1735	85	3310,	3425

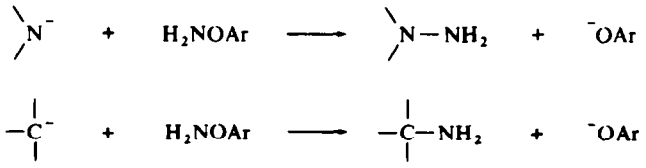
[a] We have previously reported (Ref 11) the synthesis of 3c from ArCl which was a much inferior method.

In a similar manner the reaction of 2,4-dinitrofluorobenzene with t-butyl N-hydroxy-N-methylcarbamate (**6**) yielded the aryloxycarbamate 7 which gave, on treatment with trifluoroacetic acid, O-(2,4-dinitrophenyl)-N-methylhydroxylamine (**8**). Compound **8** is the first known N-alkyl-O-arylhydroxylamine.

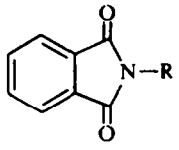


The most interesting structural feature of compounds **4** is the attachment of a good leaving group to a primary amino group. It is to be expected that the nitroaryloxy group would be easily displaced by nucleophiles, resulting in their amination. Inorganic amination reagents of this type such as chloramine and hydroxylamine-O-

sulphonic acid are well known but stability and solubility problems severely limit their use. O-Acyl-hydroxylamines are too unstable to be used as reagents, however, O-mesitoylhydroxylamine, has been shown to cause amination of anionic nitrogens.[12] We found that all compounds **4**, and particularly **4c** are highly suitable for this purpose and readily react with several types of anionic nitrogens or carbanions[13] in various solvents to give the corresponding hydrazines or amines respectively.



Representative examples of this type of amination (using **4c**) were the following: (1) Phthalimide (**9a**) to N-aminophthalimide (**9b**, 88% yield); (2) N-Tosylbenzylamine (**10a**) to 1-benzyl-1-tosylhydrazine (**10b**, 93%); (3) 2,4-Dimethyl-3,5-dicarbethoxypyrrole (**11a**) to 1-amino-2,4-dimethyl-3,5-dicarbethoxypyrrole (**11b**, 95%); (4) 9-Carbomethoxyfluorene (**12a**) to 9-amino-9-carbomethoxyfluorene (**12b**, 50%); (5) Diethyl phenylmalonate (**13a**) to diethyl α-amino-α-phenylmalonate (**13b**, 53%). The structures of the products were confirmed by spectral means and by preparation of benzal derivatives (of **10b** and **11b**) and acetyl derivatives (of **12b** and **13b**). Compound **13b** was hydrolyzed and decarboxylated to α-aminophenylacetic acid.



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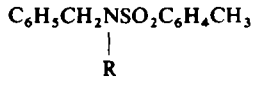

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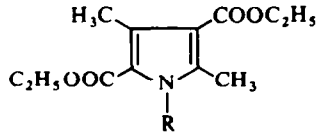

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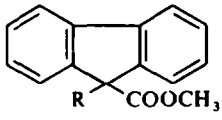

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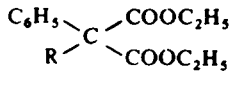

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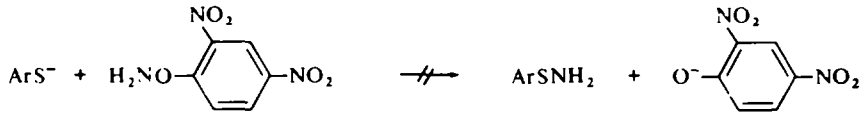
a: R = H
b: R = NH_2

The ability of compounds **4a, b, d**, to cause amination was checked by reacting them with the anion of **11a**. In all cases **11b** was obtained in high yields. However, attempts to cause methylaminations by **8** and diacetylaminations by O-(2,4-nitrophenyl)-N,N-diacetylhydroxylamine (prepared from **4c** and acetic anhydride) failed.

The reactions of **4c** with thiophenolate salts were also tried with the aim of obtaining the primary sulfenamides **14**. Starting with thiophenol, *p*-thiocresol and *p*-chloro-

thiophenol these reactions yielded two types of products which were identified as the corresponding sulfonamides **15** and sulfenimides **16**.



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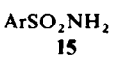

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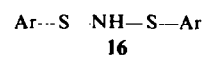

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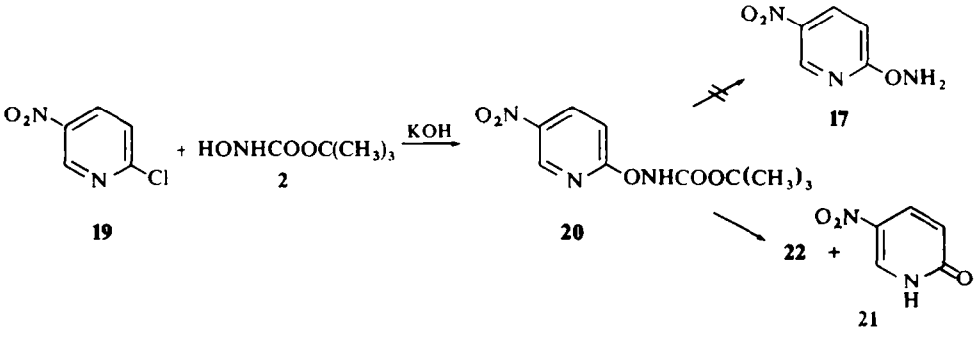
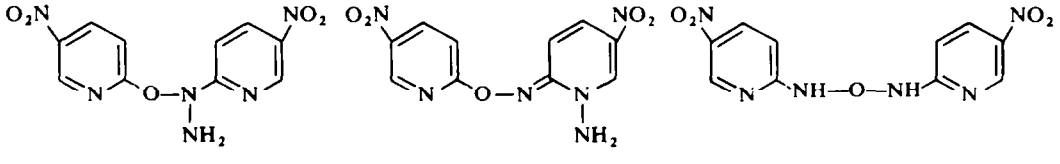
The formation of **15** and **16** which both contain N—S bonds indicates that the desired sulfenamides **14** were initially formed, but underwent either immediate oxidation to **15** or an intermolecular reaction to **16**. It should be noted that compound **16** have also been obtained on attempts to prepare **14** from sulfenyl chlorides and ammonia.[14]

Encouraged by the above results we next tried to extend the use of **2** for introduction of the aminooxy group on to electron deficient heteroaromatic rings. Thus, for the preparation of O-(5-nitro-2-pyridyl)hydroxylamine (**17**), **2** was reacted with 2-chloro-5-nitropyridine (**19**) to give t-butyl N-(5-nitro-2-pyridyloxy)carbamate (**20**). Treatment of **20** with excess trifluoroacetic acid or with formic acid yielded only 5-nitro-2-pyridone (**21**). However, on using only 1·2 equivalents of trifluoroacetic acid (diluted in nitromethane) we obtained besides **21** an additional product (**22**). Its elemental analyses and mass spectrum indicate the formula $C_{10}H_8N_6O_5$.



19 **2** **20** **17** **22** **21**

The NMR spectrum of **22** shows the presence of two different 2,5-disubstituted pyridine rings and its IR spectrum exhibits —NH_2 doublet at 3270 and 3320 cm^{-1}. The presence of a primary amino group was further confirmed by the easy formation of a Schiff base of **22** with acetone. These data exclude the symmetrical structure **22c** but are consistent with structures **22a** and **22b**.



22a **22b** **22c**

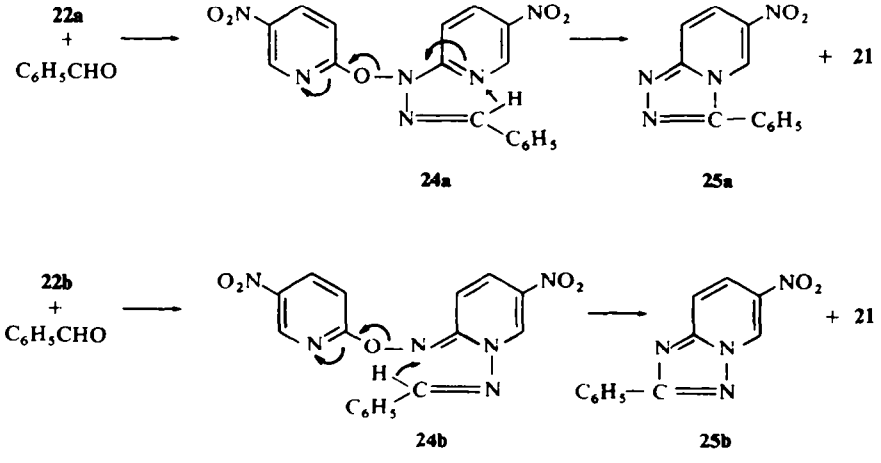
A close examination of the aromatic region of the NMR spectrum reveals that one set of peaks corresponds to that exhibited by 2-substituted-5-nitropyridines while the second one resembles that of 2-substituted-5-nitro-1,2-dihydropyridines. This is shown in Table 2, in which are compared the NMR spectra of **22** and of its N-phenylcarbamoyl derivative **23** (prepared from **22** and phenyl isocyanate) with those of 2-chloro-5-nitropyridine (**19**) and 5-nitro-2-pyridone (**21**).

TABLE 2. NMR CHEMICAL SHIFTS (δ, ppm) AND COUPLING CONSTANTS (H_z)

Compound	H^3(d)	$H^{3'}$(d)	H^4(dd)	$H^{4'}$(dd)	H^6(d)	$H^{6'}$(d)
22[a]	7·7	6·9	8·6	7·8	9·1	8·8
	$J_{3,4}$ = 9·0	$J_{3',4'}$ = 10·5	$J_{4,6}$ = 3·0	$J_{4',6'}$ = 2·25		
19	7·7		8·6		9·1	
	$J_{3,4}$ = 8·5		$J_{4,6}$ = 3·0			
21		6·5		8·1		8·7
		$J_{3',4'}$ = 10		$J_{4',6'}$ = 3		
23[b]	7·4	7·0	8·5	7·9	9·0	8·8

[a] Also a 2H singlet at 6·4(—NH_2), exchangeable with D_2O.
[b] Phenyl multiplet (5H) at *ca* 7·4.

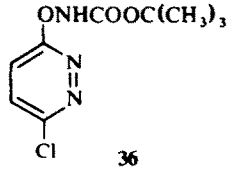
The NMR spectrum thus establishes the right structure as **22b**. Chemical evidence for the correctness of this assignment was obtained from the reaction of **22** with benzaldehyde which yielded a product (m.p. 204–205°) of the formula $C_{12}H_8N_4O_2$. This can result from elimination of 5-nitro-2-pyridone (**21**) (also isolated) from the benzylidene derivative of **22** (**24a** or **24b**). The most reasonable elimination process would involve a cyclization to a bicyclic system which would lead from **24a** to 6-nitro-2-phenyl-5-triazolo[4,3-a]pyridine (**25a**, lit[15] m.p. 208°) or from **24b** to 6-nitro-2-phenyl-5-triazolo[1,5-a]pyridine (**25b**, lit[16] m.p. 199°). Comparison with authentic samples proved that our product was indeed **25b**, which could have been obtained only from **22b**.



The formation of **22b** during the mild acidolysis of **20** indicates that the desired O-pyridyl-hydroxylamine **17** existed as an intermediate under these conditions. Its transformation to **22b** probably involves two separate reactions. One of them, which accounts for the N-amino group, resulted from the expected ability of **17** to cause N-amination of pyridine nitrogens (such aminations with hydroxylamine-O-sulfonic acid are known[17]). The other reaction involved is an intermolecular displacement at position 2 which accounts for the linkage between two pyridine rings.

On increasing the concentration or the amount of the acid, cleavage of the N—O bond predominates and **21** was the sole product. This instability most probably results from the tendency of hydroxypyridines to exist as pyridones, thus causing easy splitting of groups attached to the oxygen.

The same cleavage reaction has been observed on acidolysis of a series of pyrimidine derivatives bearing various substituents. A list of the t-butyl N-pyrimidyloxy-carbamates prepared (**26–35**) is given in Table 3. Additional carbamates derived from other heterocyclic systems were: t-butyl N-(3-chloro-6-pyridazyloxy)carbamate (**36**), t-butyl N-(2-benzothiazolyloxy)carbamate (**37**), t-butyl N-(4,6-diamino-1,3,5-triazyl-2-oxy)carbamate (**38**) and t-butyl N-(9-methyl-6-puryloxy)carbamate (**39**).



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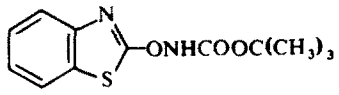

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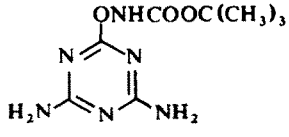

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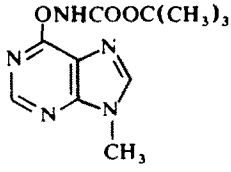

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Compounds **26**, **28–34**, **36–39** were prepared by reaction of the corresponding chloro derivatives with **2**. Compound **27** was obtained from 2-chloro-pyrimidine and **6**. Compound **35** was obtained by mild alkaline hydrolysis of **32**, as 4-chloro-6-hydroxypyrimidine did not react with **2**.

Most compounds in Table 3, as well as **36–39**, either yielded the corresponding hydroxy compounds or underwent decomposition on acidolysis attempts. The above results lead to the conclusion that materials bearing aminooxy groups on carbons adjacent to electron-withdrawing heterocyclic nitrogens, are either too unstable or too reactive to allow their isolation.

TABLE 3. t-BUTYL N-PYRIMIDYLOXYCARBAMATES

BAO = $-ONHCOOC(CH_3)_3$

BAMO = $-ONCOOC(CH_3)_3$ with CH_3 on the N

NO	Substitution on pyrimidine				Acidolysis products[a]
	2	4	5	6	
26	BAO	—	—	—	decomposition
27	BAMO	—	—	—	2-OH-pym
28	NH_2	Cl	—	BAO	2-NH_2-4-Cl-6-OH-pym
29	NH_2	BAO	—	—	2-NH_2-4-OH-pym
30	CH_3	Cl	—	BAO	2-CH_3-4-Cl-6-OH-pym
31	—	Cl	NH_2	BAO	decomposition
32	—	Cl	—	BAO	4-Cl-6-OH-pym
33	Cl	BAO	—	—	not identified
34	—	BAO	—	BAO	4,6-diOH-pym
35	—	OH	—	BAO	4,6-diOH-pym

[a] Excess trifluoracetic acid.
[b] pym = pyrimidine.

EXPERIMENTAL

M.ps were taken on a Fisher–Johns apparatus and are uncorrected. Spectra were recorded using the following instruments: IR (nujol mulls) on Perkin–Elmer 257, UV (Ethanol solutions) on Unicam SP-800 and NMR (DMSO-d_6 solns) on Varian HA-100.

t-Butyl N-(4-nitrophenoxy)carbamate (**3b**). A soln of 4-nitrofluorobenzene (3·52 g; 0·025 mole) in dry DMSO (35 ml) was added slowly to a cooled stirred soln of t-butyl N-hydroxycarbamate (3·32 g, 0·025 mole) and t-BuOK (2·8 g, 0·025 mole) in dry DMSO (35 ml). After stirring at room temp for 19 hr, the mixture was poured into ice–water and acidified (pH 5) with AcOH. The oil which was separated was taken up in ether and purified by chromatography on neutral alumina (elution with benzene) and crystallization from EtOAc–light petroleum to give 3 g (47%) of **3b** as yellow crystals, m.p. 108° (dec). (Found: C, 51·92; H, 5·54; N, 10·87. $C_{11}H_{14}N_2O_5$ requires: C, 51·97; H, 5·55; N, 11·02%).

t-Butyl N-(2-nitrophenoxy)carbamate (**3a**). Quantities and procedure as for **3b** above. The product precipitated as a solid on pouring the mixture into water and was collected by filtration and crystallized from EtOAc–light petroleum to give 1·6 g of **3a**, m.p. 90–91°. (Found: C, 51·54; H, 5·44; N, 11·00. $C_{11}H_{14}N_2O_5$ requires: C, 51·97; H, 5·55; N, 11·02%).

t-Butyl N-(2,4-dinitrophenoxy)carbamate (**3c**). 2,4-Dinitrofluorobenzene (18·6 g, 0·1 mole) was added dropwise to a cooled stirred soln of **2** (13·3 g, 0·1 mole) and KOH (5·6 g, 0·1 mole) in abs EtOH (200 ml). The soln, which turned deep red was stirred 1 hr and AcOH was added until the colour became pale yellow. Pouring into cold water (2000 ml) yielded a yellow solid which was collected by filtration and crystallized from EtOAc–light petroleum to give 25 g of **4c** as very pale yellow crystals, m.p. 74–75°. (Found: C, 43·99; H, 4·45; N, 14·21; $C_{11}H_{13}N_3O_7$ requires: C, 44·15; H, 4·38; N, 14·04%).

t-Butyl N-(2,6-dinitrophenoxy)carbamate (**3d**). The procedure employed was the same as for **3c** above, using 6·7 g of 2,6-dinitrochlorobenzene, 4·43 g of **2** and 1·86 g of KOH. The aryl halide was in this case added dissolved in EtOH and stirring was continued for 20 hr. Compound **3d** (6 g) was obtained as yellow crystals, m.p. 105–106°. (Found: C, 43·95; H, 4·37; N, 14·01. $C_{11}H_{13}N_3O_7$ requires: C, 44·15; H, 4·38; N, 14·04%).

t-Butyl N-(2,4,6-trinitrophenoxy)carbamate (**3e**). Preparation and work up as for **4c** yielded a red oil which partly solidified after chromatography on neutral alumina (elution with EtOAc). Crystallization yielded 10% of **3e**, m.p. 155–156° dec. (Found: C, 38·82; H, 3·86; N, 16·76. $C_{11}H_{22}N_4O_9$ requires: C, 38·38; H, 3·51; N, 16·28%).

O-(Nitroaryl)hydroxylamines (**4**). These were prepared by dissolving 2 g of **3** in 10 ml trifluoroacetic acid. Strong gas evolution was observed in all cases. After 30 min at room temp the solns were poured into cold water, neutralized ($NaHCO_3$) and the precipitated products were collected by filtration and crystallized from EtOH, yields are given in Table 1 and analytical data in Table 4.

TABLE 4. O-(NITROARYL)HYDROXYLAMINES

NO	M.p. (°C)	Formula	Found %			Required %			UV (nm) (log ε)
			C	H	N	C	H	N	
4a	90–91	$C_6H_6N_2O_3$	46·72	3·67	17·95	46·76	3·92	18·18	215(4·09), 261(3·60), 322(3·41)
4b	124–125	$C_6H_6N_2O_3$	46·48	4·15	17·98	46·76	3·92	18·18	226(3·87), 309(4·04)
4c	112–114	$C_6H_5N_3O_5$	36·45	2·49	20·84	36·14	2·53	21·10	216(4·06), 296(3·94)
4d	80–81	$C_6H_5N_3O_5$	36·63	2·84	20·80	36·14	2·53	21·10	320(4·01), 430(3·04)
4e	196–197	$C_6H_4N_4O_7$	30·77	1·61	23·47	29·52	1·65	22·95	239(4·20), 317(4·07), 410(3·89)

O-(Nitroaryl)oximes. An ethanolic soln containing equivalent amounts of **4** and the carbonyl compound and 1 drop of conc HCl was refluxed for 30 min. The products usually crystallized out on cooling. *O(2-Nitrophenyl-4-chlorobenzaldoxime* melted at 117°. (Found: C, 56·32; H, 3·15; N, 9·76. $C_{13}H_9N_2O_3Cl$ requires: C, 56·40; H, 3·25; N, 9·76%). *O-(4-nitrophenyl)-4-chlorobenzaldoxime* melted at 130–131°. (Found: C, 56·22; H, 3·54; N, 10·23). For further examples see Ref 18.

N,N-Diacetyl-O-(2,4-dinitrophenyl)hydroxylamine. A soln of **4c** (1 g) in Ac_2O (10 ml) was refluxed for 30 min. Addition of water, filtration and crystallization (EtOH) afforded 1·2 g of the product, m.p. 130°: IR ν_{max} 1720, 1740 cm^{-1} (C=O): NMR δ 2·55 (s, 6H $N(COCH_3)_2$). (Found: C, 42·32, H, 3·20: N, 14·88. $C_{10}H_9N_3O_7$ requires: C, 42·41; H, 3·20; N, 14·84%).

t-Butyl N-(2,4-dinitrophenoxy)-N-methylcarbamate (**7**). The reaction of 2,4-dinitrofluorobenzene and **6**[19] was carried out as described for the preparation of **3c** above. The mixture remained yellow and was worked up without acidification to give after crystallization from EtOAc–light petroleum, 94% of **7**, m.p. 94–95°: IR ν_{max} 1740 cm^{-1} (C=O). (Found: C, 45·85; H, 4·88; N, 13·46. $C_{12}H_{15}N_3O_3$ requires: C, 46·01; H, 4·83; N, 13·41%).

O-(2,4-Dinitrophenyl)-N-methylhydroxylamine (**8**). Acidolysis of **7** with trifluoroacetic acid (as described for **4**) gave **8** in 91% yield, m.p. 74°: IR ν_{max} 3280 cm^{-1} (—NH—). (Found: C, 39·18; H, 3·28; N, 19·39. $C_7H_7N_3O_5$ requires: C, 39·45; H, 3·31; N, 19·71%).

O-(2,4-Dinitrophenyl)-N-acetyl-N-methylhydroxylamine was prepared by acetylation of **8** in the usual manner, m.p. 102–103°: IR ν_{max} 1710 (C=O). (Found: C, 42·39; H, 3·33; N, 16·38: $C_9H_9N_3O_6$ requires: C, 42·36; H, 3·55; N, 16·47%).

Amination of N-tosylbenzylamine (**10a**). To a soln of the sodium salt of **10a** (prepared from 2·61 g of **10a** and 0·23 g of Na in MeOH and evaporation of the solvent) in dry DMF (30 ml), **4c** (1·99 g) was added in one portion. A very dark red colour developed immediately. After stirring for 20 min the mixture was poured into ice water and the ppt was collected and washed with water till the filtrate came out colourless. Crystallization from EtOH yielded 2·56 g (93%) of **10b**, m.p. 131–132°: IR ν_{max} 3320, 3380 (—NH_2). (Found: C, 60·96; H, 5·85; N, 9·95. $C_{14}H_{16}N_2O_2S$ requires: C, 60·85; H, 5·84; N, 10·14%).

The benzal derivative of **10b** prepared by reaction with benzaldehyde, melted at 115–116°. (Found: C, 69·36; H, 5·40; N, 7·78. $C_{21}H_{20}N_2O_2S$ requires: C, 69·22; H, 5·53; N, 7·69%).

Amination of **11a** was performed using **4c** in the same manner as that of **10a**, to give 95% yield of **11b**, m.p. 90–91°, IR ν_{max} 3220, 3320 cm^{-1} (—NH_2) 1740 cm^{-1} (C=O). (Found: C, 56·79; H, 7·25; N, 10·88. $C_{12}H_{18}N_2O_4$ requires: C, 56·68; H, 7·13; N, 11·02%). *The benzal derivative* melted at 75–77°. (Found: C, 66·73; H, 6·40; N, 8·05. $C_{19}H_{22}N_2O_4$ requires: C, 66·65; H, 6·48; N, 8·18%).

Amination of **9a**. Commercial potassium phthalimide was used. N-Aminophthalimide (produced in 88% yield) melted at 200–205°, resolidified and melted at 305°, as described in the literature.[20]

Diethyl-α-amino-α-phenylmalonate (**13b**). To a stirred soln of **13a** (2·36 g) in dry DMF (25 ml) NaH (0·48 g, 50% in paraffin) was added. After evolution of H_2 ceased paraffin was removed by extraction with light petroleum and a soln of **4c** (1·99 g) in DMF (10 ml) was added. The dark red soln was stirred for

additional hr and the solvent was evaporated. The residue was taken up in ether, filtered and evaporated to give a yellow oil. Distillation gave 1·34 g of **13b** as colourless oil, b.p. 155–160/7 mm. n_D^{22} −1·5067: IR ν_{max} 3250, 3315 cm^{-1} (—NH_2) 1735 cm^{-1} (C=O). (Found: C, 62·20: H, 6·73: N, 5·57. $C_{13}H_{17}NO_4$ requires: C, 62·14: H, 6·82: N, 5·57%).

The N-*acetyl derivative of* **12b** melted at 73°: IR: ν_{max} 3370 cm^{-1} (NH) 1740 (CO) 1685 (CNH). (Found: C, 61·05: H, 6·32: N, 4·44. $C_{15}H_{19}NO_5$ requires: C, 61·46: H, 6·53: N, 4·78%).

Basic hydrolysis of **13b** was carried out with two equivalent of KOH in 50% EtOH (1 hr reflux). Acidification (HCl) and evaporation yielded, after crystallization of the residue from water, a colourless material which melted at 270° (dec) and gave a positive ninhydrin test. It was identified as α-aminophenylacetic acid by comparison (IR spectra) with a commercial sample.

9-*Amino*-9-*carbomethoxyfluorene* (**12b**). 9-Carbomethoxyfluorene (2·24 g, 0·01 mole) was dissolved in 100 ml of 0·1N MeOK soln in benzene–MeOH (B.D.H) and 1·99 g of **4c** was added to the yellow soln. After stirring overnight the potassium dinitrophenolate which precipitated was filtered off and the solvent was evaporated. The residue was taken up in ether, additional quantity of salt was removed and dry HCl was bubbled through the soln. The hydrochloride of **12b**, m.p. 223–226 precipitated and was collected dissolved in 0·1N NaOH soln and extracted with ether. The ether afforded the free amine **12b** and crystallization from light petroleum (b.p. 60–80°) yielded 1·13 g (47%), m.p. 113°: IR ν_{max} 3295, 3390 cm^{-1} (—NH_2) 1730 (C=O). (Found: C, 74·94: H, 5·02: N, 5·78. $C_{15}H_{13}NO_2$ requires: C, 75·30: H, 5·48: N, 5·85%).

N-*Acetyl derivative of* **12b** m.p. 239–240°, IR ν_{max} 3230 cm^{-1} (—NH—) 1740 (C—O) 1650 (CNH). (Found: C, 72·40: H, 5·65: N, 4·81. $C_{17}H_{15}NO_3$ requires: C, 72·58: H, 5·37: N, 4·98%).

t-Butyl N-(5-*nitro*-2-*pyridyloxy*)*carbamate* (**20**). 2-Chloro-5-nitropyridine (10 g) in EtOH (185 ml) was added to a soln of **2** (8·4 g) and KOH (3·6 g) in 100 ml of EtOH. The soln was stirred for 4 hr, filtered and evaporated (<40°). The residue was triturated with water and after filtration was crystallized from EtOAc–light petroleum to give 12·6 g (78%) of **20**, m.p. 80–81°: IR ν_{max} 3240 cm^{-1} (—NH), 1765 (C=O). (Found: C, 47·21: H, 5·36: N, 16·41. $C_{10}H_{13}N_3O_5$ requires: C, 47·06: H, 5·13: N, 16·46%).

1-*Amino*-2-(5-*nitro*-2-*pyridoxylimino*)5-*nitro*-1,2-*dihydropyridine* (**22b**). To a soln of **20** (2 g) in nitromethane (15 ml) trifluoroacetic acid (2 ml) was added. After stirring for 9 hr and refrigerating overnight the ppt was collected by filtration and crystallized from n-BuOH to give 0·7 g of orange crystals, m.p. 189–190°: UV 214 nm (log ε 432) 370 (4·40). For additional spectral data see in the text. (Found: C, 41·22: H, 2·76; N, 28·73, M^+, *m/e* 292, $C_{10}H_8N_6O_5$ requires: C, 41·10; H, 2·76; N. 28·76%; Mol wt. 292).

Isopropylidene derivative of **22b** was obtained by refluxing **22b** in dry acetone containing a trace of HCl, m.p. 182°: UV 214 nm (log ε 4·38) 370 (4·22). No NH absorption in the IR. (Found: C, 47·30: H, 3·67: N, 25·02; M^+, *m/e* 332. $C_{13}H_{12}N_6O_5$ requires: C, 46·98: H, 3·61: N, 25·30%, Mol wt. 332).

N-*phenylcarbamoyl derivative of* **22b** was obtained from the reaction of **22b** and phenyl isocyanate in dry DMSO, m.p. 202–203°. (Found: C, 49·60: H, 3·31: N, 23·40. $C_{17}H_{14}N_7O_6$ requires: C, 49·63: H, 3·16: N, 23·84%).

6-*Nitro*-2-*phenyl*-5-*triazolo*[15-a]*pyridine* (**25b**). To a soln of **22b** (0·05 g) in dry DMSO (10 ml), benzaldehyde (0·1 g) and a drop of conc HCl were added. After heating on a water bath for 40 min, the soln was poured into water and the white ppt was collected and crystallized from EtOH to give 0·02 g of **25b**, m.p. 204–205°. (Found: C, 59·92: H, 3·58: N, 23·29, M^+, *m/e* 240. $C_{12}H_8N_4O_2$ requires: C, 60·00: H, 3·40: N, 23·30%, mol wt. 240).

6-*Nitro*-2(p-*chlorophenyl*)-5-*triazolo*[1,5a]*pyridine*. Prepared as **25b** above, using *p*-chlorobenzaldehyde, m.p. 254°. (Found: C, 52·37: H, 2·49: N, 20·27. $C_{12}H_7N_4O_2Cl$ requires: C, 52·45: H, 2·55: N, 20·40%).

Carbamates **26–34** *and* **36–39**. The procedure described above for the preparation of **20** was used. The starting halogeno compounds were obtained from commercial sources. Yields and analytical and spectral data are given in Table 5.

t-Butyl N-(4-*hydroxy*-6-*pyrimidyloxy*)*carbamate* (**35**). Compound **32** (1·74 g) was added to a soln of 1·3 g of KOH in EtOH (25 ml) and was heated at 40° for 3 hr. The soln was filtered and evaporated and the residue was dissolved in water and acidified with AcOH. The mixture was extracted with EtOAc and the extract yielded an oil which solidified on standing. Crystallization from EtOAc–light petroleum yielded 0·5 g of **35**, m.p. 120–121°. Spectral and analytical data are included in Table 5.

Acidolyses of carbamates **26–39**. A soln of the carbamate (1 g) in trifluoroacetic acid (2 ml) was left at

room temp for 30 min. The products usually precipitated on addition of ether. The hydroxy compounds were identified by comparison with authentic samples obtained by hydrolysis of the starting chloro compounds and with literature[21] physical and spectral data.

TABLE 5. CARBAMATES 26–39

NO	Yield (%)	M.p. (°C)	Formula	Found (required)			IR (cm^{-1})		UV nm (log ε)
				C	H	N	NH	C=O	
26	60	99–100	$C_9H_{13}N_3O_3$	51·25 (51·18)	6·50 (6·20)	19·79 (19·89)	3270	1720	260(3.56)
27	64	59–60	$C_{10}H_{15}N_3O_3$	53·42 (53·32)	7·04 (6·71)	18·50 (18·65)	—	1710	259(3.55)
28	81	163–164	$C_9H_{13}N_4O_3Cl$	41·20 (41·46)	5·04 (4·98)	21·57 (21·48)	3150	1770	231(4·12) 280(3·75)
29	70[a]	146–147	$C_9H_{14}N_4O_3$	47·52 (47·78)	6·16 (6·24)	24·76 (24·76)	3120	1755	228(4·11) 281(3·68)
30	50	76–77	$C_{10}H_{14}N_3O_3Cl$	46·73 (46·28)	5·16 (5·39)	16·37 (16·18)	3170	1755	251(3·60)
31	61	141–142	$C_9H_{13}N_4O_3Cl$	41·66 (41·46)	5·23 (4·98)	21·49 (21·48)	3210	1755	250(3·99) 291(3·84)
32	50	70–71	$C_9H_{12}N_3O_3Cl$	43·70 (44·00)	4·88 (4·93)	17·03 (17·10)	3160	1750	249(3·50)
33	60	97–99	$C_9H_{12}N_3O_3Cl$	44·20 (44·00)	5·07 (4·93)	16·85 (17·10)	3130	1750	254(3·68)
34	50	121–122	$C_{14}H_{22}N_4O_6$	48·87 (49·12)	6·44 (6·48)	16·38 (16·37)	3130 3190	1755	242(3·43)
35	31	120–121	$C_9H_{13}N_3O_4$	47·66 (47·57)	5·47 (5·77)	18·04 (18·49)	3180	1750	240(3·02)
36	61[a]	78–80	$C_9H_{12}N_3O_3Cl$	43·91 (44·00)	4·62 (4·93)	17·42 (17·10)	3140	1740	278(3·25)
37	65[a]	103–104	$C_{12}H_{14}N_2O_3S$	53·93 (54·13)	5·47 (5·30)	10·29 (10·52)	3100	1725	217(4·50) 247(3·90)
38	61[a]	>300	$C_8H_{14}N_6O_3$	39·61 (39·65)	5·92 (5·82)	34·97 (34·70)	3080	1770	214(4·24) 241(3·25)
39	56[a]	164–166	$C_{11}H_{15}N_5O_3$	49·74 (49·81)	5·48 (5·70)	26·32 (26·40)	3180	1755	251(4·02)

[a] Two equivalents of KOH were used and the mixture was acidified with AcOH before work-up.

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