Cyclic Hydroxamic Acids. Part I. Synthesis and Reactions of 1,2-Dihydro-1-hydroxy-4,6-dimethyl-2-oxopyridine-3-carbonitrile

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1,2-Dihydro-1-hydroxy-4,6-dimethyl-2-oxopyridine-3-carbonitrile has been prepared, hydrolysed to the corresponding amide and acid, decarboxylated, halogenated, and nitrated.

1,2-DIHYDRO-1-HYDROXY-4,6-DIMETHYL-2-OXOPYRIDINE-3-CARBONITRILE (Ia) was synthesised in 20% yield by direct condensation of ethyl cyanoacetate, hydroxylamine, and acetylacetone, with piperidine as catalyst, in an example of the Hantzsch–Knoevenagel reaction. Since compound (Ia) had the same hydroxamic acid grouping as the antibacterial aspergillic acid,[1,2] it was tested as a bacteriocide; the results are reported in Table 1. Tests as an insecticide, fungicide, viruscide, or herbicide which proved negative were so up to the highest concentration given.

Compound (Ia) was identified by its n.m.r. spectrum (see Experimental section) and its i.r. data, which indicated the presence of a 2-pyridone carbonyl group,[3] a nitrile, and an intramolecularly hydrogen-bonded hydroxy-groups;[4] its properties were characteristic of hydroxamic acids.[1,2,4,5] Attempted reduction with zinc dust in acetic acid gave the zinc salt (Ib). Compound (Ia) was easily acylated and alkylated, and the products (Ic—g) were all reduced to 1,2-dihydro-4,6-dimethyl-2-oxopyridine-3-carbonitrile (IIj).[6] The acyl derivatives (Ic and d) were hydrolysed back to compound (Ia) by acid, but the alkyl derivatives were stable under these conditions. The corresponding amide (IIa) was obtained from compound (Ia) by acid hydrolysis, and converted into the acid (IId) with nitrous acid. Decarboxylation of the acid gave 4,6-dimethyl-1-hydroxy-2(1*H*)-pyridone (IIg) (69·8%), which was methylated and reduced to 4,6-dimethyl-2(1*H*)-pyridone (IIh).[7] The methyl ester (IIi) obtained from the acid (IId) was hydrolysed back to this acid even during crystallisation from polar solvents. The isomeric 1-methoxy-acid (IIe) was prepared by hydrolysis of the nitrile ether (Ie) by way of the corresponding amide (IIb). Compounds (IIb) and (IIe) were reduced to the pyridones (IIc) [7,8] and (IIf),[8] respectively.

Halogenation of the hydroxamic acid (Ia) with chlorine, bromine, or iodine chloride afforded the 5-halogeno-derivatives (IIIa; X = Cl, Br, or I). The position of the halogen atoms was established by reduc-

[1] E. Shaw, *J. Amer. Chem. Soc.*, 1949, **71**, 67.
[2] W. A. Lott and E. Shaw, *J. Amer. Chem. Soc.*, 1949, **71**, 70.
[3] I. E. El-Kholy, F. K. Rafla, and G. Soliman, *J. Chem. Soc.*, 1961, 4490.
[4] J. N. Gardner and A. R. Katritzky, *J. Chem. Soc.*, 1957, 4375.
[5] K. G. Cunningham, G. T. Newbold, F. S. Spring, and J. Stark, *J. Chem. Soc.*, 1949, 2091.
[6] U. Basu, *J. Indian Chem. Soc.*, 1930, **7**, 481.
[7] U. Basu, *J. Indian Chem. Soc.*, 1930, **7**, 815.
[8] E. Knoevenagal and W. Cremer, *Ber.*, 1902, 239.

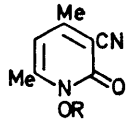
TABLE 1

Effect of compound (Ia) on bacteria *

Bacteria	Concn.	Results	Concn.	Results	Concn.	Results	Concn.	Results
Escherichia coli	64	0	32	0	16	0	8	0
Haemorphilus gallinarum	64	100	32	0	16	0	8	0
Staphylococcus aureus	64	100	32	100	16	50	8	0
Streptococcus faecalis	64	100	32	0	16	0	8	0
Salmonella cholerasuis	64	50	32	0	16	0	8	0
Salmonella gallinarum	64	0	32	0	16	0	8	0
Pseudomonas phaseolicola	1200	0	600	0	300	0	150	0

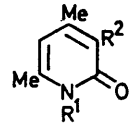
* Concentrations are in parts per million.

tion of the benzoates (IIIb; X = Cl or Br) to the pyridones (IIIc; X = Cl) [9] and (IIIc; X = Br).[10] Reduction of the benzoate (IIIb; X = I) resulted in loss of the iodo-substituent to give the pyridone (IIj). The 5-bromo-1-methoxy-compound (IIId; X = Br) was prepared either by methylation of compound (IIIa; X = Br) or bromination of the methyl ether (Ie). The 5-halogenohydroxamates (IIIa; X = Cl, Br, or I) were hydrolysed stepwise to the corresponding amides (IIIe; X = Cl, Br, or I) and acids (IIIh; X = Cl, Br, or I). Similarly, the methyl ether (IIId; X = Br) gave the amide (IIIg; X = Br) and the acid (IIIj; X = Br). Compounds (IIIe, g, h, and j; X = Br) were also prepared by direct bromination of the amides (IIa and b) and acids (IId and e). On reduction the ethers (IIIg and j; X = Br) yielded the pyridones (IIIf; X = Br) [11] and (IIIi; X = Br),[11] respectively.



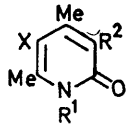
(I)

a; R = H
b; R = Zn/2
c; R = Ac
d; R = Bz
e; R = Me
f; R = CH_2Ph
g; R = $CH_2{\cdot}CH{:}CH_2$



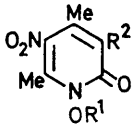
(II)

	R^1	R^2		R^1	R^2
a;	OH	$CO{\cdot}NH_2$	g;	OH	H
b;	OMe	$CO{\cdot}NH_2$	h;	H	H
c;	H	$CO{\cdot}NH_2$	i;	OH	CO_2Me
d;	OH	CO_2H	j;	H	CN
e;	OMe	CO_2H	k;	OMe	H
f;	H	CO_2H			



(III)

	R^1	R^2		R^1	R^2
a;	OH	CN	j;	OMe	CO_2H
b;	OBz	CN	k;	OH	X
c;	H	CN	l;	OBz	X
d;	OMe	CN	m;	H	X
e;	OH	$CO{\cdot}NH_2$	n;	OAc	CN
f;	H	$CO{\cdot}NH_2$	o;	OAc	X
g;	OMe	$CO{\cdot}NH_2$	p;	OMe	X
h;	OH	CO_2H			
i;	H	CO_2H			



(IV)

	R^1	R^2
a;	Ac	CN
b;	H	CN
c;	H	$CO{\cdot}NH_2$
d;	H	CO_2H

Treatment of the acid (IId) with 2 mol. of bromine gave a dibromide, m.p. 199°; the 5-bromo-derivative (IIIh; X = Br) could be isolated after addition of 1 mol. The same dibromide was obtained by bromination (2 mol.) of compound (IIg); it was identified as 3,5-dibromo-1-hydroxy-4,6-dimethyl-2(1*H*)-pyridone (IIIk; X = Br) by reduction of its benzoate (IIIl; X = Br) to 3,5-dibromo-4,6-dimethyl-2(1*H*)-pyridone (IIIm; X = Br), m.p. 265° (decomp.). The m.p. of the product has been reported by Moir [12] to be 253° and by Mariella [10] to be 236—237°. Accordingly, its preparation was re-investigated; five different procedures (see Experimental section) led to 3,5-dibromo-4,6-dimethyl-2(1*H*)-pyridone of the same m.p. as that obtained from reduction of the benzoate (see Table 3). The reaction of bromine (2 mol.) with 3-carboxy-2-pyridones seems to be a general procedure for preparing 3,5-dibromo-2-pyridones in one step and in good yields. For instance 1,2-dihydro-4,6-dimethyl-5-nitro-2-oxopyridine-3-carboxylic acid on bromination or nitration gave the 3-bromo-derivative (85%)[13] or the 3-nitro-derivative (83%).[13]

1-Hydroxy-4,6-dimethyl-2(1*H*)-pyridone (IIg) underwent chlorination and iodination to give the 3,5-halogeno-derivatives (IIIk; X = Cl or I). The iodo-substituent could be replaced by bromine in compounds (IIIa; X = I) and (IIIk; X = I) to give compounds (IIIa and k; X = Br). Compound (Ia) was nitrated in the presence of acetic anhydride to yield the 1-acetoxy-5-nitro-derivative (IVa) (60%), which was hydrolysed to the hydroxy compound (IVb). This was converted into the amide (IVc), which on treatment with nitrous acid gave the acid (IVd).

EXPERIMENTAL

N.m.r. spectra were determined with a Varian A60 spectrophotometer. I.r. spectra (Nujol) were run on a Perkin-Elmer 521 spectrophotometer. Elemental analyses were performed by Alfred Bernhardt Laboratories, West Germany. Light petroleum used had b.p. 50—70°. All products having an N–OH group gave colours varying from

[9] U.S.P. 2,523,612/1950 (*Chem. Abs.*, 1951, **45**, 2030d).
[10] R. P. Mariella and E. P. Belcher, *J. Amer. Chem. Soc.*, 1952, **74**, 1916.
[11] U.S.P. 2,516,673/1950 (*Chem. Abs.*, 1950, **45**, 670h).
[12] J. Moir, *J. Chem. Soc.*, 1902, **81**, 100.
[13] R. P. Mariella, J. J. Callahan, and A. O. Jibril, *J. Org. Chem.*, 1955, **20**, 1721.

violet to intense blood-red with iron(III) chloride in methanol.

1,2-*Dihydro*-1-*hydroxy*-4,6-*dimethyl*-2-*oxopyridine*-3-*carbonitrile* (Ia).—Potassium hydroxide (28 g., 0·5 mole) in ethanol (200 ml.) was added slowly with shaking and cooling to a solution of hydroxylamine hydrochloride (17·35 g., 0·25 mole) in ethanol (200 ml.); potassium chloride was rapidly filtered off. Ethyl cyanoacetate (28·2 g., 0·25 mole) was added at once to the filtrate with shaking during 5 min., followed by acetylacetone (25 g., 0·25 mole). The mixture was treated with piperidine (5 ml.), refluxed for 30 min., and left overnight; the solvent was then distilled off under reduced pressure. The residual solution (150 ml.) was diluted with water and acidified with glacial acetic acid to give the pyridone (Ia) (9 g.), δ[$(CD_3)_2SO$] 2·44 (3H, s, Me), 2·50 (3H, s, Me), and 4·46 (1H, s, =CH). The *zinc salt* (Ib) was prepared by refluxing a solution of compound (Ia) (1 g.) in glacial acetic acid (200 ml.) with zinc dust (1 g.) for 30 min. The boiling solution was filtered and left to cool; compound (Ib) (1 g.) crystallised out. Compound (Ic) was prepared from compound (Ia) and acetyl chloride in pyridine and compound (Id) from compound (Ia) by a Schotten–Baumann reaction. Compounds (Ie—g) were made from compound (Ia) and methyl iodide, benzyl chloride, and allyl bromide, respectively, by refluxing in acetone in the presence of anhydrous potassium carbonate for 3 hr. (see Table 2).

Reduction Procedure.—A solution of the material to be reduced (0·5—0·7 g.) in glacial acetic acid (12—15 ml.) was refluxed with zinc dust (1 g.) for 20—30 min. The boiling mixture was filtered, acetic acid was distilled off under reduced pressure, and the residue was treated with water or methanol to give the 2-pyridone derivative (see Table 3).

Conversion of Nitriles into Amides (*Table* 4).—A solution of the nitrile in a small volume of concentrated sulphuric acid was heated on a boiling water bath for 3 hr. The mixture was poured into ice–water, then chilled for 1 hr., and the amide was separated.

Hydrolysis of Amides to Carboxylic Acids (*Table* 5).—To a solution of the amide in a small volume of concentrated sulphuric acid a suitable amount of powdered sodium nitrite was added with swirling. Fumes of oxides of nitrogen were evolved. The mixture was then heated on a water-bath for 5 min., left at room temperature for 1 hr., and poured into ice–water; the acid was then filtered off.

1-*Hydroxy*-4,6-*dimethyl*-2(1H)-*pyridone* (IIg).—(i) A mixture of the nitrile (Ia) (8 g.) and 70% sulphuric acid (10 ml.) refluxed for 2 hr., cooled, poured into ice–water, neutralised with ammonia and then acidified with acetic acid. The mixture was chilled overnight; the pyridone deposited (IIg) (4·7 g.) crystallised from benzene in prisms or sublimed under reduced pressure, to give *needles*, m.p. 135° (Found: C, 60·65; H, 6·7; N, 10·0. $C_7H_9NO_2$ requires C, 60·4; H, 6·5; N, 10·1%), $\nu_{max.}$ 2300—3200 (bonded OH) and 1667vs cm.$^{-1}$ (CO).

(ii) A mixture of the acid (IId) (1·5 g.) was refluxed with 90% sulphuric acid for 1 hr.; the pyridone was purified as in procedure (i).

Methyl 1,2-*Dihydro*-1-*hydroxy*-4,6-*dimethyl*-2-*oxopyridine*-3-*carboxylate* (IIi).—A solution of the acid (IId) (1·5 g.) in absolute methanol (20 ml.) was refluxed with concentrated sulphuric acid (1 ml.) for 3 hr. Most of the solvent was distilled off and the residual solution was cooled and diluted to give the *methyl ester* (1·1 g.), which formed needles, m.p. 115° (from benzene–light petroleum) (Found: C, 54·9; H, 5·6; N, 6·9. $C_9H_{11}NO_4$ requires C, 54·8; H, 5·6; N, 7·1%). The ester was hydrolysed back to the starting acid during crystallisation from dilute methanol.

Halogenation Procedure.—The required amount of chlorine gas, bromine, or iodine chloride was passed through or added to a solution of the hydroxamic acid in the minimum amount of glacial acetic acid; the mixture became warm. It was left overnight at room temperature (in the case of the chloro-derivatives) or for 1—2 hr. (in the case of the bromo- and iodo-derivatives). Acetic acid and halogen acid were distilled off under reduced pressure if the halogen compound did not crystallise (see Table 6).

3,5-*Dibromo*-1-*hydroxy*-4,6-*dimethyl*-2(1H)-*pyridone* (IIIk; X = Br).—(i) Bromination of compound (IIg) (see Table 6). (ii) A mixture of compound (IIIh; X = Br) (1·2 g.) and bromine (0·9 g.) in acetic acid was boiled for 5 min.,

TABLE 2

Compound (Ia) and its derivatives

	M.p.	Solvent [a]	Found (%) C	H	N	Formula	Required (%) C	H	N	ν(C≡N)	ν(C=O)
(Ia) [b,c]	235°	DE	58·4	4·8	17·0	$C_8H_8N_2O_2$	58·5	4·9	17·1	2237m	1650s
(Ib) [c]	*d*		49·0	3·7	14·2	$C_{16}H_{14}N_4O_4Zn$	49·05	3·6	14·3	2237s	1675vs
(Ic) [c]	163	B–L	58·1	4·9	13·7	$C_{10}H_{10}N_2O_3$	58·25	4·9	13·6		
(Id) [e]	182	B–L	67·2	4·6	10·6	$C_{15}H_{12}N_2O_3$	67·2	4·5	10·45		
(Ie) [f]	165	M	60·75	5·7	15·7	$C_9H_{10}N_2O_2$	60·65	5·65	15·75	2217s	1667vs
(If) [e]	186	DM	70·8	5·5	10·9	$C_{15}H_{14}N_2O_2$	70·85	5·55	11·0	2237s	1664vs
(Ig) [e]	132	DA	64·6	5·8	14·0	$C_{11}H_{12}N_2O_2$	64·7	5·9	13·75	2260s	1648vs

[a] D = dilute, E = ethanol, B = benzene, L = light petroleum, M = methanol, A = acetone. [b] Showed bonded OH band at 2300—3100 cm.$^{-1}$ (KBr). [c] Needles. [d] >300°; analysed crude. [e] Prisms. [f] Plates.

TABLE 3

Reduction products

Hydroxamate	2-Pyridone [a]	Solvents [b]	M.p.
(Ie—g)	(IIj) [6]	DAc	285 [c]
(IIb)	(IIc) [7,8]	M	222
(IIe)	(IIf) [8]	DM	257 [c]
(IIk) [d]	(IIh) [7]	W	178
(IIIb; X = Cl)	(IIIc; X = Cl) [9]	Ac	279
(IIIb; X = Br)	(IIIc; X = Br) [10]	DPy	260
(IIIn; X = Br)	(IIIc; X = Br)		
(IIId; X = Br)	(IIIc; X = Br)		
(IIIb; X = I)	(IIj) [6]	DAc	285 [c]
(IIIg; X = Br)	(IIIf; X = Br) [11]	DAc	268 [c]
(IIIj; X = Br)	(IIIi; X = Br) [11,12]	M	265 [c]
(IIIl; X = Br)	(IIIm; X = Br)	M	265 [c]
(IIIo; X = Br)	(IIIm; X = Br)		
(IIIp; X = Br)	(IIIm; X = Br)		

[a] Needles. [b] D = dilute, Ac = acetic acid, M = methanol, W = water, Py = pyridine. [c] Decomp. [d] Used crude.

during which most of the acetic acid distilled off. On dilution, the dibromide (1 g.) separated, and gave prisms (from methanol), m.p. and mixed m.p. 199°. (iii) From compound (IId) (0·8 g.) and bromine (1·4 g.) as for experiment (ii). (iv) A solution of compound (IIIk; X = I) (0·4 g.) was refluxed with bromine (0·3 ml.) in acetic acid (8 ml.) for 5 min. The mixture was diluted to give the same dibromo-derivative, m.p. and mixed m.p. 199°.

3,5-*Dibromo*-4,6-*dimethyl*-2(1H)-*pyridone* (IIIm; X = Br).—(i) From compound (III; X = Br) by reduction; see Table 3; (ii) From 4,6-dimethyl-2(1*H*)-pyridone (IIh) (1·2 g.) and bromine (3·2 g.) in acetic acid; (iii) From 5-bromo-4,6-dimethyl-2(1*H*)-pyridone (0·5 g.) and bromine (0·4 g.) in acetic acid; (iv) 1,2-Dihydro-4,6-dimethyl-2-oxopyridine-3-carboxylic acid (IIf) (1·7 g.) in acetic acid (15 ml.) was refluxed with bromine (3·5 g.) for 5 min. On dilution, the dibromo-derivative (1·6 g.) was recovered; (v) From 5-bromo-1,2-dihydro-4,6-dimethyl-2-oxopyridine-3-carboxylic acid (IIIi; X = Br) (1·2 g.) and bromine (1 g.) as for experiment (iv); (vi) From 5-iodo-1,2-dihydro-4,6-dimethyl-2-oxopyridine-3-carboxylic acid (IIIi; X = I) and bromine as in experiment (iv). In all the experiments, the product had the same m.p. and mixed m.p. and was crystallised from a large volume of methanol or pyridine–methanol.

3-*Bromo*-4,6-*dimethyl*-5-*nitro*-2(1H)-*pyridone*.—A solution of 1,2-dihydro-4,6-dimethyl-5-nitro-2-oxopyridine-3-carboxylic acid (1·5 g.) in acetic acid (20 ml.) was refluxed with bromine (1·5 g.) in the presence of water (2 ml.) for 10 min. Most of the acetic acid was distilled off and the yellowish residual solution was diluted to give the 3-bromo-derivative

TABLE 4

1,2-Dihydro-2-oxopyridine-3-carboxamides

	M.p.	Solvent [a]	Found (%) C	H	N	Formula	Required (%) C	H	N
(IIa) [b]	212°†	DE	52·35	5·6	15·5	$C_8H_{10}N_2O_3$	52·7	5·5	15·4
(IIb) [c]	207 †	M	55·25	6·2	14·05	$C_9H_{12}N_2O_3$	55·1	6·2	14·3
(IIIe; X = Cl) [c]	218	M	44·5	4·2	13·05	$C_8H_9ClN_2O_3$	44·35	4·2	12·95
(IIIe; X = Br) [c]	226 †	M	34·4	3·4	10·3	$C_8H_9BrN_2O_3$	34·2	3·25	10·0
(IIIg; X = Br) [b]	190	B–M	39·3	4·2	9·95	$C_9H_{11}BrN_2O_3$	39·3	4·05	10·2
(IIIe; X = I) [c]	210	B–M	31·3	3·0	9·05	$C_8H_9IN_2O_3$	31·2	2·95	9·1
(IVc) [d]	237 †	B–M	42·5	4·1	18·7	$C_8H_9N_3O_5$	42·3	4·0	18·5

† Decomp.

[a] See Tables 2 and 3. [b] Prisms. [c] Needles. [d] Yellow needles.

TABLE 5

1,2-Dihydro-2-oxopyridine-3-carboxylic acids

	M.p.	Solvent [a]	Found (%) C	H	N	Hal.	Formula	Required (%) C	H	N	Hal.
(IId) [b]	161°	DM	47·85	5·5	7·0		$C_8H_9NO_4,H_2O$	48·0	5·5	7·0	
(IIe) [c]	186	M	54·8	5·4	7·2		$C_9H_{11}NO_4$	54·8	5·6	7·1	
(IIIh; X = Cl) [d]	222 †	M	44·3	3·8	6·3	16·15	$C_8H_8ClNO_4$	44·15	3·7	6·45	16·3
(IIIh; X = Br) [d]	211†	M	36·7	3·2	5·5	30·4	$C_8H_8BrNO_4$	36·65	3·1	5·35	30·5
(IIIj; X = Br) [b]	164	B	39·35	3·7	4·9		$C_9H_{10}BrNO_4$	39·15	3·65	5·05	
(IIIh; X = I) [e]	221 †	M	31·25	2·7	4·5	40·85	$C_8H_8INO_4$	31·1	2·6	4·5	41·05
(IVd) [d]	174	B–M	42·3	3·6	12·3		$C_8H_8N_2O_6$	42·1	3·55	12·3	

† Decomp.

[a] See Tables 2 and 3. [b] Needles. [c] Flakes. [d] Prisms. [e] Yellow prisms.

TABLE 6

Halogeno-2-pyridones

	M.p.	Solvent [a]	Found (%) C	H	N	Hal.	Formula	Required (%) C	H	N	Hal.
(IIIa; X = Cl) [b]	236°	B–M	48·5	3·6	14·05	17·8	$C_8H_7ClN_2O_2$	48·4	3·55	14·1	17·85
(IIIa; X = Br) [c]	237 *	B	39·6	3·0	11·7	32·85	$C_8H_7BrN_2O_2$	39·5	2·9	11·5	32·9
(IIIa; X = I) [d]	237 †	Ac	33·2	2·5	9·6	43·8	$C_8H_7IN_2O_2$	33·1	2·45	9·65	43·75
(IIIb; X = Cl) [b]	173	B–M	59·65	3·8	9·3		$C_{15}H_{11}ClN_2O_2$	59·5	3·7	9·25	
(IIIb; X = Br) [b]	178	B–L	51·9	3·3	7·8		$C_{15}H_{11}BrN_2O_3$	51·9	3·2	8·05	
(IIIn; X = Br) [b]	170	B–L	42·3	3·1	9·6		$C_{10}H_9BrN_2O_3$	42·1	3·2	9·8	
(IIId; X = Br) [d]	160	M	42·2	3·4	10·9		$C_9H_9BrN_2O_2$	42·1	3·5	10·9	
(IIIb; X = I) [d]	174	B	45·9	2·9	6·85		$C_{15}H_{11}IN_2O_3$	45·7	2·8	7·1	
(IIIk; X = Cl) [b]	212	M	40·5	3·6	6·6	33·8	$C_7H_7Cl_2NO_2$	40·4	3·4	6·7	34·05
(IIIk; X = Br) [b]	199	M	28·45	2·15	4·85	54·15	$C_7H_7Br_2NO_2$	28·3	2·35	4·7	53·85
(IIIk; X = I) [b]	188	M	27·3	1·8	3·55	64·7	$C_7H_7I_2NO_2$	27·1	1·8	3·6	64·9
(IIIl; X = Br) [b]	134	M	42·0	2·9	3·65		$C_{14}H_{11}Br_2NO_3$	41·9	2·75	3·5	

* Decomp. † Darkens at 220° and decomposes at 237°.

[a] See previous Tables. [b] Prisms. [c] Flakes. [d] Needles.

(1·5 g.), yellow prisms (pyridine–methanol), m.p. and mixed m.p. 274° (decomp.).

4,6-*Dimethyl*-3,5-*dinitro*-2(1H)-*pyridone*.—A suspension of 1,2-dihydro-4,6-dimethyl-2-oxopyridine-3-carboxylic acid (2·4 g.) in acetic anhydride (10 ml.) was treated dropwise with a nitrating mixture (4 ml.) (2 ml. conc. HNO_3 and 2 ml. Ac_2O). An exothermic reaction occurred which subsided when the mixture was cooled with stirring. The mixture was left at room temperature for 15 min., then poured into ice–water; the 3,5-dinitro-derivative (2 g.) was filtered off after 2 hr. It formed needles, m.p. and mixed m.p. 240° (decomp.) (from dilute acetic acid). The experiment was repeated with 1,2-dihydro-4,6-dimethyl-2-oxopyridine-3-carboxylic acid to give the same dinitro-compound.

1-*Acetoxy*-1,2-*dihydro*-4,6-*dimethyl*-5-*nitro*-2-*oxopyridine*-3-*carbonitrile* (IVa).—A nitrating mixture (6 ml.) (3 ml. conc. HNO_3 and 3 ml. Ac_2O) was added dropwise with swirling to a suspension of compound (Ia) (7·5 g.) at such a rate that the temperature did not rise above 50°. The mixture was then poured into ice–water and left at 0° for 2 hr. with occasional shaking. The acetate (6·9 g.) m.p. 128—130° (decomp.), was filtered off and crystallised from benzene–light petroleum in *prisms*, m.p. 132° (decomp.) (Found: C, 47·6; H, 3·5; N, 16·7. $C_{10}H_9N_3O_5$ requires C, 47·8; H, 3·6; N, 16·75%).

1,2-*Dihydro*-1-*hydroxy*-4,6-*dimethyl*-5-*nitro*-2-*oxopyridine*-3-*carbonitrile* (IVb).—A solution of compound (IVa) (1 g.) in 80% methanol (15 ml.) was refluxed with concentrated hydrochloric acid (4 drops) for 30 min. The 1-hydroxy-derivative (0·8 g.), m.p. 219—220°, was filtered off from the cooled mixture and crystallised from benzene in yellow *prisms*, m.p. 221° (decomp.) (Found: C, 45·65; H, 3·5; N, 20·0. $C_8H_7N_3O_4$ requires C, 49·95; H, 3·4; N, 20·1%), $\nu_{max.}$ (KBr) 2600—3300 (bonded OH), 2230s (CN), 1650vs (CO), 1535vs, and 1375s (NO_2) $cm.^{-1}$.

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