N-Oxides and Related Compounds. Part XLII.[1] Amine *N*-Nitroimides derived from Trimethylamine, 1-Methylpiperidine, 1,4-Diazabicyclo[2.2.2]-octane (Triethylenediamine), Pyridines, Quinoline, and Isoquinoline

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The title amines have been converted into the corresponding *N*-nitroimides by nitration of their *N*-amino-derivatives in acetic or trifluoroacetic acid–anhydride mixtures or by treatment with nitronium tetrafluoroborate.

THE first examples of amine *N*-nitroimides were described in a preliminary communication from this laboratory.[2] There has since been considerable interest in these compounds.[3-5] We now give full details for the preparation of two compounds described in ref. 2, and for further *N*-nitroimides.

All the *N*-nitroimides were prepared by nitration of the corresponding quaternary *N*-amino-salts [equation (i)]. Quaternary *N*-amino-salts from tertiary amines were most conveniently prepared by reaction with

$$R_3N^+-NH_2 \xrightarrow{NO_2^+} R_3N^+-N^--NO_2 \qquad (i)$$

hydroxylamine-*O*-sulphonic acid, although a recent publication [6] emphasises the advantages of *O*-mesitylsulphonylhydroxylamine.

N-Nitroimides derived from Aliphatic and Heteroalicyclic Amines.—1,1,1-Trimethylhydrazinium iodide was converted by $AgNO_3$ into the corresponding nitrate. On treatment with nitric acid in acetic anhydride–acetic acid the nitrate yielded trimethylamine *N*-nitroimide as a colourless crystalline compound, very soluble in water, sparingly so in lower alcohols, and insoluble in non-polar solvents. The nitroimide showed considerable thermal stability, and resistance to the action of strong acids.

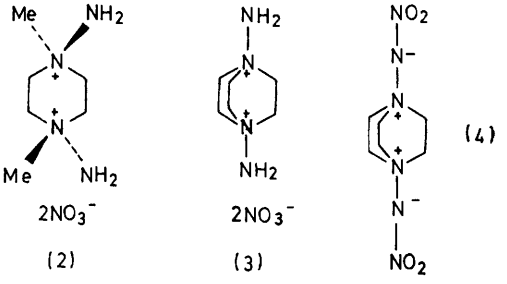
In the same manner, 1-amino-1-methylpiperidinium nitrate gave the corresponding nitroimide, which had similar properties to trimethylamine *N*-nitroimide.

We attempted to prepare aliphatic bis-*N*-nitroimides from *NNN'N'*-tetramethylethylenediamine, *NN'*-dimethylpiperazine and 1,4-diazabicyclo[2.2.2]octane (triethylenediamine). The bis-*N*-amino-salts (1)—(3) were readily obtained from the corresponding diamines by treatment with hydroxylamine-*O*-sulphonic acid, assignment of the *trans*-configuration of (2) being based on the equivalence of the methyl groups, as shown by the n.m.r. spectrum. Compounds (1) and (2) gave complex product mixtures when treated with nitric acid in acetic anhydride, trifluoroacetic anhydride in trifluoroacetic acid, or NO_2BF_4 in acetonitrile. Compound (3), however, gave the bis-*N*-nitroimide (4) in 87% yield when treated with trifluoroacetic anhydride in trifluoroacetic acid. We found this nitration method to be generally useful (see next section); the nitrating agent is presumably trifluoroacetyl nitrate, formed by the reaction of trifluoroacetic anhydride with nitrate anion. The bis-*N*-nitroimide (4) is very inert, insoluble in most solvents, and slowly chars without melting at temperatures over 220°.

$H_2N\cdot\overset{+}{N}Me_2\cdot CH_2\cdot CH_2\cdot\overset{+}{N}Me_2\cdot NH_2$

$2NO_3^-$

(1)



(2) (3) (4)

N-Nitroimides derived from Pyridines and Quinolines.—Details of the preparations of pyridine 1-nitroimide and its 3-methoxy-derivative have already been given.[5] We used hydroxylamine-*O*-sulphonic acid to aminate further heteroaromatic tertiary amines, the products being isolated as iodide salts. The corresponding nitrate salts (Table 1) were prepared by reaction of the iodide salts with silver nitrate.

Nitration with nitric acid and acetic anhydride as previously reported [5] gave good results for 2- and 3-methylpyridine and 2,6-dimethylpyridine, poor yields for 2,4-dimethylpyridine, 3-bromopyridine, and quinoline, and failed for the other compounds (see Table 2). These gave complex product mixtures: in the case of 1-aminoquinolinium nitrate and 1-amino-4-methylpyridinium nitrate the major components were the deamination products, quinolinium nitrate and 4-methylpyridinium nitrate. The use of trifluoroacetic anhydride in tri-

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fluoroacetic acid was more successful in certain cases, notably in the preparation of 4,4′-bipyridyl 1,1′-bis-*N*-nitroimide, which was similar in physical properties to the bis-*N*-nitroimide prepared from triethylenediamine. However, in the case of 1-amino-4-methylpyridinium nitrate again only the deamination product was isolated. Reaction of pyridine 1-phenylsulphonylimide and 1-benzoylimide with nitric acid and acetic anhydride has given pyridine nitroimide, but attempted syntheses of quinoline 1- and isoquinoline 2-nitroimides from the corresponding phenylsulphonyl- or benzoyl-imides were all unsuccessful. Nitronium tetrafluoroborate nitrated 2-aminoisoquinolinium nitrate but not the corresponding 1-aminoquinolinium compound.

Infrared Spectra.—All the nitroimides described here had two very strong NO_2 stretching vibrations as the main feature of their i.r. spectra ($\nu_{max.}$ 1260—1300 and 1380—1415 cm^{-1}).

EXPERIMENTAL

N-Amino-iodide Salts.—1,1,1-Trimethylhydrazinium iodide was prepared from trimethylamine and hydroxylamine-*O*-sulphonic acid by the method of Gösl and Meuwsen.[7] 1-Amino-1-methylpiperidinium iodide (70%), m.p. 198—200° (decomp.) (lit.,[8] 203—205°) was prepared following the same procedure. For the diamines the following procedure was used: a solution of aqueous 3N-KOH was added slowly, with cooling, to hydroxylamine-*O*-sulphonic acid [9] (12·5 g) in water (35 ml) until the resultant solution was alkaline (pH 8). This solution was then added to *NNN′N′*-tetramethylethylenediamine (5·8 g) in water (20 ml) and the whole was stirred at room temperature for 2·5 h, with periodic checks to ensure that the solution was alkaline, and then at 60° for 15 min. Potassium iodide (17·6 g) in water (50 ml) was added, followed by EtOH (400 ml). The precipitated K_2SO_4 was filtered off and the filtrate evaporated to give *NN′-diamino-NNN′N′-tetramethylethylenediammonium di-iodide* (12·0 g, 60%), plates from EtOH–H_2O, m.p. 159—160° (decomp.) (Found: C, 17·8; H, 5·1; N, 13·6. $C_6H_{20}I_2N_4$ requires C, 17·9; H,

TABLE 1

N-Aminoammonium and *N*-aminopyridinium nitrates

Parent amine	M.p. (°C)	Crystal form	Solvent for recrystallisation	Yield (%) [a]	Found (%) C	H	N	Formula	Calc. (%) C	H	N
Me_3N	228—230 *	Needles	EtOH	78	26·3	8·0	30·6	$C_3H_{11}N_3O_3$	26·3	8·1	30·7
1-Methylpiperidine	216—219 *	Plates	EtOH–Et_2O	80	40·6	8·7	23·5	$C_6H_{15}N_3O_3$	40·7	8·5	23·7
$Me_2N{\cdot}CH_2{\cdot}CH_2{\cdot}NMe_2$ [b]	164—165	Needles	EtOH–H_2O	85	26·4	7·3	30·6	$C_6H_{20}N_4O_6$	26·5	7·4	30·9
NN′-Dimethylpiperazine [b]	255—256 *	Plates	EtOH–H_2O	82	26·4	6·5	31·3	$C_6H_{18}N_4O_6$	26·7	6·7	31·1
1,4-Diazabicyclo[2.2.2]-octane [b]	244—246 *	Needles	EtOH–H_2O	87	27·1	6·1	31·4	$C_6H_{16}N_4O_6$	26·9	6·0	31·3
2-Methylpyridine	79	Needles	EtOH	87	41·0	4·9	23·1	$C_6H_9N_3O_3$	42·1	5·3	24·5
3-Methylpyridine	79	Needles	EtOH	81	38·3	4·9	23·1	$C_6H_9N_3O_3$	39·0	5·4	22·8 [c]
2,6-Dimethylpyridine	130	Needles	EtOH	80	45·1	6·2	21·6	$C_7H_{11}N_3O_3$	45·4	6·0	22·7
3-Bromopyridine	149—150	Needles	EtOH	93	25·4	2·8	17·8	$C_5H_6BrN_3O_3$	25·5	2·6	17·8
Quinoline	110	Prisms	EtOH	78	52·0	9·6	20·3	$C_9H_9N_3O_3$	52·0	9·3	20·5
Isoquinoline	123	Plates	EtOH	80	52·0	9·6	20·3	$C_9H_9N_3O_3$	52·0	9·3	20·5
4,4′-Bipyridyl [b]	235	Needles	H_2O	87	38·3	4·1	27·2	$C_{10}H_{12}N_6O_6$	38·5	3·8	26·9

[a] Based on iodide salt. [b] Bis *N*-amino-salt. [c] Compound was hygroscopic; figures include $0{\cdot}75H_2O$.

* Decomp.

TABLE 2

N-Nitroimides [a]

Parent amine	M.p. (°C)	Crystal form	Solvent for recrystallisation	Nitration method	Yield (%)	Found (%) C	H	N	Formula	Calc. (%) C	H	N
Me_3N	212—213 *	Needles	EtOH	*b*	72	30·1	7·5	35·5	$C_3H_9N_3O_2$	30·3	7·6	35·3
1-Methylpiperidine	181—182	Plates	EtOH	*b*	74	45·4	8·0	26·4	$C_6H_{13}N_3O_2$	45·3	8·2	26·4
1,4-Diazabicyclo[2.2.2]-octane [e]	*f*	Plates	Me_2SO–H_2O	*c*	87	31·4	5·5	35·9	$C_6H_{12}N_6O_4$	31·0	5·2	36·2
2-Methylpyridine	155	Plates	EtOH	*b*	81	47·3	4·6	27·5	$C_6H_7N_3O_2$	47·0	4·6	27·5
3-Methylpyridine	123	Plates	EtOH	*b*	80	44·8	5·1	26·4	$C_6H_7N_3O_2$	44·4	4·9	25·9 [g]
2,4-Dimethylpyridine [h]	170	Needles	EtOH	*b*	15	49·7	5·5	24·9	$C_7H_9N_3O_2$	50·3	5·4	25·1
2,6-Dimethylpyridine	195	Needles	EtOH	*b*	90	50·1	5·4	25·8	$C_7H_9N_3O_2$	50·3	5·4	25·1
3-Bromopyridine	173·5—174·5	Plates	EtOH	*b* (*c*)	21 (37)	27·8	2·1	19·5	$C_5H_4BrN_3O_2$	27·5	1·9	19·3
Quinoline	156—157	Needles	Me_2CO	*b*	2	56·3	3·9	22·6	$C_9H_7N_3O_2$	57·1	3·7	22·2
Isoquinoline	160	Needles	EtOH	*c* (*d*)	66 (55)	56·4	3·9	22·5	$C_9H_7N_3O_2$	57·1	3·7	22·2
4,4′-Bipyridyl [e]	*f*	Amorphous solid	*i*	*c*	87	41·8	3·2	28·8	$C_{10}H_8N_6O_4$	42·2	3·2	29·4 [g]

[a] Nitroimides could not be obtained from 1,3,5-trimethylpyridine or 4-methylpyridine by methods *b*, *c*, and *d*. [b] HNO_3–Ac_2O. [c] $(CF_3{\cdot}CO)_2O$–$CF_3{\cdot}CO_2H$. [d] NO_2BF_4. [e] Bis-*N*-nitroimide. [f] No m.p.; charring above 220°. [g] $0{\cdot}5H_2O$ of crystallisation. [h] Crude hygroscopic nitrate used in this preparation. The nitrate was very hygroscopic; it could not be crystallised, and good analyses could not be obtained. [i] Insufficiently soluble for crystallisation.

* Decomp.

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5·0; N, 13·9%). The following were similarly prepared: trans-NN′-*diamino*-NN′-*dimethylpiperazinium di-iodide* (63%), plates from EtOH–H_2O, m.p. 160—163° (decomp.) (Found: C, 17·8; H, 4·7; N, 14·5. $C_6H_{18}I_2N_4$ requires C, 18·0; H, 4·5; N, 14·0%); τ (60 MHz; D_2O) 6·3 (6H, s), and 5·5—6·3 (8H, m); and NN′-*diamino*-1,4-*diazoniabicyclo*[2.2.2]*octane di-iodide* (82%), plates from EtOH–H_2O, m.p. 137—138° (decomp.) (Found: C, 18·3; H, 4·2; N, 14·1. $C_6H_{16}I_2N_4$ requires C, 18·1; H, 4·1; N, 14·1%).

N-Amino-iodides of trimethylamine [m.p. 236—238° (decomp.) (lit.,[7] 238°)], 2-methylpyridine [m.p. 154° (lit.,[7] 154°)], 2,4-dimethylpyridine [m.p. 112—113° (lit.,[7] 112—113°)], 2,6-dimethylpyridine [m.p. 193° (lit.,[7] 193°)], 2,4,6-trimethylpyridine [m.p. 201° (lit.,[7] 201—203°)], and quinoline [m.p. 180° (lit.,[7] 188°)], were prepared as described by Gösl and Meuwsen.[7] The *N*-amino-iodide of 1-methylpiperidine [m.p. 198—200° (decomp.) (lit.,[8] 203—205°)] was prepared as described in ref .8. 1,1′-Diamino-4,4′-bipyridylium di-iodide [m.p. 210° (lit.,[10] 210°)] was made by the method of Downes.[10] Use of isoquinoline under the conditions reported [7] for quinoline gave 1-*amino-isoquinolinium iodide* (27%), m.p. 174°, plates from EtOH (Found: C, 39·5; H, 3·5; N, 10·2. $C_9H_9IN_2$ requires C, 39·8; H, 3·3; N, 10·3%). Use of 3- and 4-methylpyridine under the conditions used for 2-methylpyridine gave 1-amino-3-methylpyridinium iodide (67%), m.p. of picrate 145° (lit.,[11] 149°), and 1-amino-4-methylpyridinium iodide (29%), m.p. of picrate 162—164° (lit.,[11] 165°).

Hydroxylamine-*O*-sulphonic acid (23·4 g) in H_2O (50 ml) was neutralised with 3N-KOH at 0° and added during 1 h to a suspension of 3-bromopyridine (90·2 g) in water (200 ml) with vigorous stirring. After cooling, K_2CO_3 (13·2 g) was added. The solution was evaporated, EtOH (300 ml) was added, and the K_2SO_4 was filtered off. The filtrate was acidified with HI and kept at −20° for 3 h, giving 1-amino-3-bromopyridinium iodide (5·4 g, 9·5%), needles from EtOH, m.p. 172—173·5° (decomp.) [lit.,[12] 175° (decomp.)].

N-*Amino-nitrate Salts*.—The iodide salt (0·03 mol) in H_2O (100 ml) at 60° was added to $AgNO_3$ (0·03 mol) in H_2O (100 ml), also at 60°. After cooling and filtration the solution was evaporated and the product recrystallised to give the nitrate salt (Table 1).

Nitrations (Table 2).—(a) Ac_2O–HNO_3. HNO_3 (6·3 g) in Ac_2O (50 ml) was added dropwise over 1 h at 0° to the nitrate salt (0·02 mol) in Ac_2O (40 ml) and AcOH (15 ml). After 2 h more at 0° the solvents were evaporated off (temperature below 45°) and the residue was recrystallised to give the nitroimide.

(b) *Trifluoroacetic acid–trifluoroacetic anhydride*. Trifluoroacetic anhydride (1 ml) in trifluoroacetic acid (7 ml) was added dropwise during 20 min at 0° to the nitrate salt (0·001 mol) in trifluoroacetic acid (5 ml). The solution was stirred overnight at 20°, then evaporated and the residue was recrystallised to give the nitroimide.

(c) NO_2BF_4. The nitrate salt (0·001 mol) in dry MeCN (15 ml) was added to NO_2BF_4 [13] (0·001 mol) in dry MeCN (5 ml). After 2 min the solvent was evaporated off (temperature below 30°) and the residual oil triturated with EtOH. The resulting solid was recrystallised to give the nitroimide.

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