Tetrahedron. Vol. 26, pp. 1665 to 1673. Pergamon Press 1970. Printed in Great Britain

N-OXIDES AND RELATED COMPOUNDS—XXXIX[1]

SOME REACTIONS OF 1-AMINOPYRIDINIUM SALTS

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(*Received in the UK* 30 *October* 1969; *Accepted for publication* 12 *November* 1969)

Abstract—1-Aminopyridinium cation in aqueous solution at high pH is in equilibrium with pyridine 1-imide (of pK 13·5) which slowly decomposes. N-Aminopyridinium cations and their acylated and sulphonylated derivatives readily undergo deuterium exchange at the 2- and 6-positions on base catalysis but are not susceptible to acid-catalysed deuteration. Nitration occurs at the amino group with the concomitant hydrolysis of an acyl or sulphonyl group.

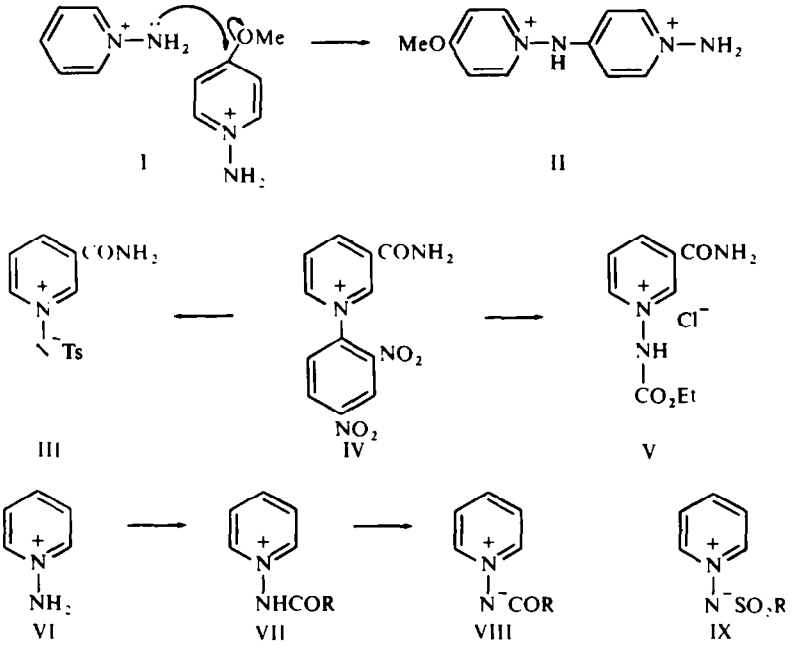
HETEROAROMATIC N-IMIDES[4] have been relatively neglected as potential synthetic intermediates, especially compared with the large amount of work available on the isoelectronic heterocyclic N-oxides.[5] N-Imide derivatives have been prepared by reaction of the parent heterocycle with acyl[6-8] and sulphonyl nitrenes,[6,8-11] chloramine[12] and, conveniently, hydroxylamine-O-sulphonic acid,[13-18] by rearrangement,[19,20] and by reaction of pyrylium salts,[21] and pyrans[22] with hydrazines. Reactions of these compounds previously investigated include 1,3-dipolar additions,[23,24] reaction with aldehydes,[25] and photolysis to diazepines.[26] Recently Okamoto *et al.* have explored the reactions of 1-acylaminopyridinium cations with cyanide ion to give 2- and 4-cyanopyridines via intermediate dihydro derivatives:[17,27] 1-aminopyridinium salts and cyanide ion react similarly, but the intermediate cyanopyridine reacts further to give a triazolopyridine.[28,29] Similar reactions occur in the quinoline series.[16] With diazonium ions and nitrous acid, 1-aminopyridinium salts yield pyridine together with, respectively, the aryl azide or nitrous oxide.[30]

We now report the initial results of a general study of the physical and chemical properties of heteroaromatic N-imides, particularly designed to test their susceptibility to electrophilic and nucleophilic substitution. 1-Aminopyridinium salts were most conveniently prepared using the hydroxylamine-O-sulphonic acid method which was applied successfully to make the 1-amino-3-methoxy- and 1-amino-4-carboxy-pyridinium compounds (but failed with 3-carboxy- and 3-ethoxycarbonyl-pyridine). The cations were isolated as iodides from which other salts were conveniently prepared by anion exchange.

The reaction of hydroxylamine-O-sulphonic acid with 4-methoxypyridine gave an anomalous product which was assigned structure II on the basis of the NMR spectra and analysis (Experimental). It is presumably formed by a mechanism of type I→II. The bis-iodide was highly hygroscopic and was therefore characterized as the bis-nitrate.

The Zincke salt IV[31] from nicotinamide and 2,4-dinitrochlorobenzene reacted with ethoxycarbonylhydrazine and toluene-*p*-sulphonhydrazide to yield products V and III

respectively, but attempted application of this method to the preparation of N-amino derivatives of 3-ethoxycarbonyl- and 3- and 4-cyano-pyridine failed due to difficulty in obtaining the corresponding Zincke salts.[32, 33]



Acylation and sulphonylation of 1-*aminopyridinium salts*

Acylation of 1-aminopyridinium salts, as described by Okamoto *et al.*,[15, 17] gave 1-acetamido- and 1-benzamido-pyridinium and -3-methoxypyridinium derivatives, cf. VI→VIII. The benzamido cations were readily converted by base into pyridine 1-benzoylimides (as VIII).

Arylsulphonylation converted 1-aminopyridinium salts into pyridine 1-aryl-sulphonylimides (as IX, R=Ph or $Cl_3C_6H_3$), cf. Ref. 10. However, the corresponding methanesulphonyl derivative could only be isolated as the picrate and then only from 1-aminopyridinium chloride; attempted preparation from the iodide salt gave pyridinium picrate.[34]

Acid-base behaviour of 1-*aminopyridinium cations*

In strong acids, the cations probably add another proton to give dications of type XII, as do other hydrazine derivatives. However, no estimate of the pK_a value for proton addition to 1-aminopyridinium cation could be made as there was insufficient change in the UV spectrum, and the NMR spectrum was too broad in strong sulphuric acid to allow its use.[35] 1-Acetamidopyridinium salts also form dications in strong acid on NMR evidence.

The pK_a for proton loss for the 1-aminopyridinium ion (XI→X, R = H) was given as 11·2 by Japanese workers,[28] from potentiometric titration. Although pyridine 1-imide has been trapped *in situ*[23] it is insufficiently stable to be isolated. We have shown that

the free imide exists in aqueous solution of high pH: the NMR spectrum of 1-aminopyridinium perchlorate is significantly changed from the cationic species, and then strongly resembles the NMR of the isoelectronic species pyridine 1-oxide (Fig. 1). Acidification regenerates the spectrum of the 1-aminopyridinium cation. The pK_a value was determined as 13·4 by using the NMR method[35] (Experimental) on the 3,5-proton singlet of 2,4,6-trideutero-1-aminopyridinium cation (see later) and correcting the value for D_2O.[36]

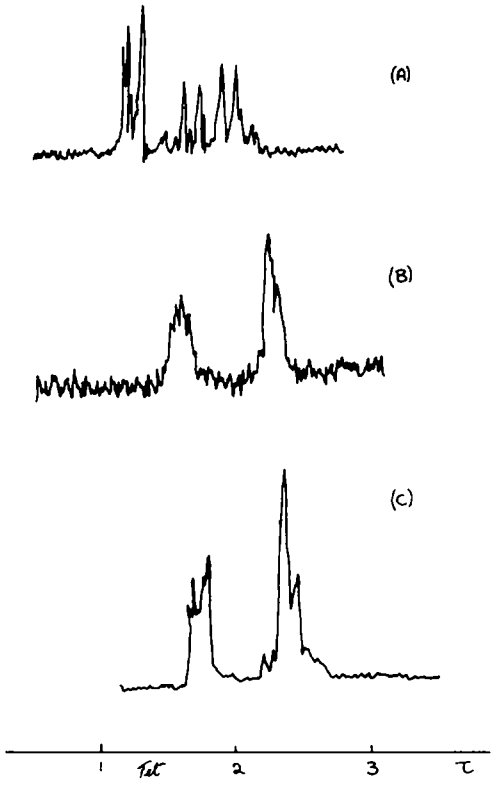


FIG. 1 NMR spectra at 60 MHz of (A) 1-aminopyridinium iodide in D_2O; (B) 1-aminopyridinium perchlorate in 1·12 N-KOH; (C) pyridine 1-oxide in D_2O

The reaction of 1-aminopyridinium cation with aqueous alkali was also investigated by UV spectroscopy: the absorption maximum at 245 nm in the cationic species was replaced by a peak at 322 nm which slowly decayed (Fig. 2); provided the measurements were made within 1 hr, a good isobestic point was found. If a reversible equilibrium of type (1) is assumed, where the equilibrium constant = K and the

$$PyNH_2^+ + nOH^- \rightleftharpoons \text{Product} \quad (1)$$

extinction coefficient of the product = ε, then the optical density α, hydroxide ion concentration $[OH^-]$, and original concentration of substrate [c] are related by Eq. (2).

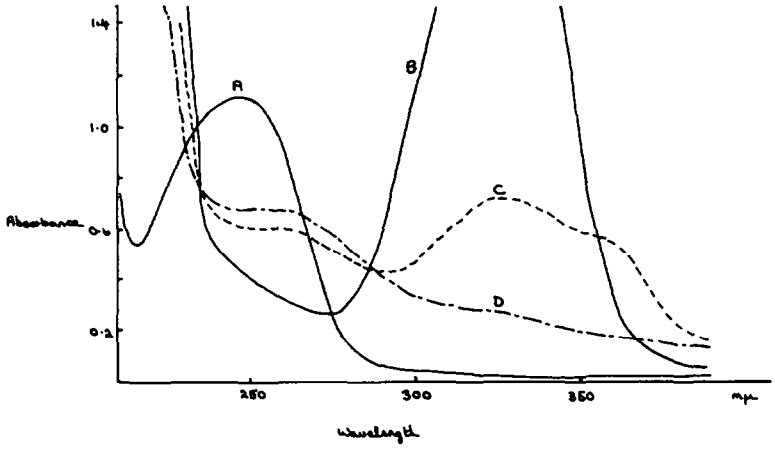


FIG. 2 UV spectra of 1-aminopyridinium perchlorate (A) in water; (B) in 4·5N KOH after 10 min; (C) after 48 hr; (d) after 42 days

Experimental points were fitted to this equation by a computer programme and gave $\varepsilon = 10{,}000$, $n = 1{\cdot}02$, and

$$\log \{\alpha/([c]\,\varepsilon - \alpha)\} = \log K + n \log [OH^-] \qquad (2)$$

$K = 2{\cdot}57$. This corresponds to $pK_a = 13{\cdot}6$ which is in good agreement with the value from the NMR determination. The difficulty of measuring pK values in this range by potentiometric titration is known.[37] We found that a purple compound could be extracted from alkaline solutions of the imide (cf. Ref. 9, 23), but its structure was not elucidated.[34]

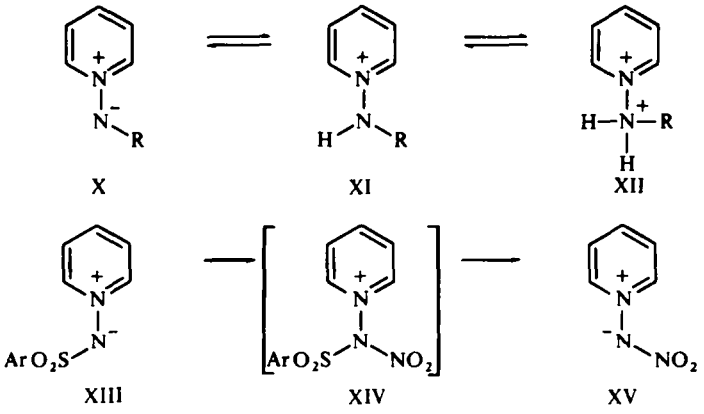
N-Acylation of pyridine 1-imide reduces the pK_a values for proton loss to 3·6 for the 1-acetylimide;[28] we find 3·2 for the 1-benzoylimide. Pyridine 1-nitroimide has pK_a $-4{\cdot}6 \pm 0{\cdot}1$; the change in the UV spectrum of the corresponding 1-benzenesulphonylimide was insufficient to allow an accurate estimate of its pK_a value.

Hydrogen exchange

All attempts at acid-catalysed ring-hydrogen exchange failed. When 1-aminopyridinium sulphate was heated in 99% D_2SO_4 a slow decrease in the intensity of the aromatic protons occurred at 300° but the concomitant changes in the spectrum indicated that decomposition preceded exchange. No reaction occurred below 300°. In lower strengths of acid (30 and 60% w/w) neither deuteration nor decomposition was observed, the spectrum being unchanged even after 18 days at 180°. When 1-acetamidopyridinium sulphate was heated in 99% D_2SO_4 at 100°, the Me group exchanged while the aromatic pattern was unaffected: this reaction corresponds to the acid-catalysed deuterium exchange of Me groups in ketones. No further change occurred below 180°, when decomposition set in.

By contrast, base-catalysed hydrogen exchange was rapid. 1-Aminopyridinium cations in 0·2 N NaOD had exchanged at the 2,4,6-positions by the time the NMR spectrum could be measured. Under similar conditions, pyridine 1-benzenesulphonylimide and 1-(2,4,6-trichlorobenzenesulphonylimide) had undergone exchange almost completely at the 2- and 6-positions after 15 min at 35°, but the 4-H

atom still remained unexchanged after 48 hr. For pyridine 1-benzoylimide the 2- and 6-positions were exchanged very rapidly, but the 4-position had also reacted within 5 hr at 35°. 3-Methoxypyridine 1-benzoylimide and 1-benzenesuplhonylimide showed similar behaviour: no detectable exchange in acid conditions but rapid base-catalysed exchange of the 2- and 6-H atoms.



X XI XII

XIII XIV XV

Nitration

Attemped nitration of pyridine 1-benzenesulphonylimide in sulphuric acid resulted in no reaction at low temperatures, or profound decomposition.[38] However, in acetic acid–acetic anhydride, reaction took place (XIII→XIV) at the amino group; the intermediate XIV lost the sulphonyl group to yield pyridine 1-nitroimide XV. The same product was formed from pyridine 1-(2,4,6-trichlorobenzenesulphonylimide) and 1-benzoylimide and also from 1-aminopyridinium nitrate.[1]

The corresponding 3-methoxy 1-nitroimide was obtained by the nitration of either 1-amino-3-methoxypyridinium nitrate or 3-methoxypyridine 1-benzenesulphonylimide.

EXPERIMENTAL

1-Aminopyridinium salts

The iodide[13] had m.p. 160–161° (lit.,[13] 161–162°). The chloride, m.p. 156–158°, was prepared in a similar way, except that the methanolic soln was treated with conc HCl, evaporated and the residue crystallized from MeOH/ether and then ethanol (lit.,[9] 160°).

The *perchlorate* precipitated on adding sodium perchlorate to an aqueous soln of the iodide; it formed needles, m.p. 203–204°, from EtOH. (Found: C, 30·2; H, 4·0; N, 14·3. $C_5H_7ClN_2O_4$ requires: C, 30·8; H, 3·6; N, 14·4%).

1-Aminopyridinium iodide (4·44 g, 0·02 mole) in water (40 ml) was added to silver sulphate (3·12 g, 0·02 mole) in boiling water (700 ml), and the whole kept at 0° for 12 hr. The precipitated AgI was filtered off; the filtrate and washings were evaporated to give the *sulphate*, (2.45 g, 86%) which formed needles, m.p. 199–200° from EtOH. (Found: C, 41·5; H, 5·3; N, 19·5. $C_{10}H_{14}N_2O_4S$ requires: C, 41·9; H, 4·9; N, 19·6%).

The iodide (8·88 g, 0·04 mole) in water (60 ml) was added to $AgNO_3$ (6·78 g, 0·04 mole) in water (40 ml) at 60°. The mixture was left for 12 hr at 0°, then filtered, and the filtrate and washings were evaporated to give the *nitrate* (5·5 g, 87%) which crystallized from EtOH as hygroscopic needles, m.p. 77–78°. (Found: C, 37·9; H, 4·7; N, 27·2. $C_5H_7N_3O_3$ requires: C, 38·2; H, 4·5; N, 26·8%).

1-Acetamidopyridinium salts

The chloride[15] had m.p. 213-214° (dec) [lit.,[15] 216° (dec)]. The iodide, prepared similarly,[15] (59%) had m.p. 187–189° (lit.,[15] 189°). The picrate had m.p. 168° (lit.,[15] 168°). The *sulphate* was obtained as a gum by addition of the iodide (5 g, 0·019 mole) in water (70 ml) to silver sulphate (2·95 g, 0·019 mole) in water (1000 ml) at 100°. The mixture was left overnight at 0°, then filtered, and the filtrate was evaporated to give a yellow syrup (3·7 g, 100%) which was characterized by the NMR spectrum.

1-(N-Benzamido)pyridinium iodide and pyridine 1-benzoylimide. 1-Aminopyridinium iodide (2·22 g, 0·01 mole), in water (20 ml) and acetone (10 ml), was treated with solid K_2CO_3 (2·8 g, 0·02 mole). Benzoyl chloride (1·3 g, 0·01 mole) in acetone 10 ml was added dropwise over 15 min. The mixture was stirred for 1 hr, then conc HI was added to pH 2. Recrystallization of the precipitated *iodide* from EtOH gave yellow needles, m.p. 228–230° (dec) (2·4 g, 73·6%). (Found: C, 44·7; H, 2·85; N, 8·5. $C_{12}H_{11}IN_2O$ requires: C, 44·2; H, 3·4; N, 8·6%).

2N NaOH (10 ml) was added to the iodide (0·3 g) in water (5 ml). The resulting mixture was evaporated to give the *1-benzoylimide* (0·165 g, 90·7%) which crystallized from benzene as needles, m.p. 179–180°. (Found: C, 72·5; H, 5·4; N, 14·1. $C_{12}H_{10}N_2O$ requires: C, 72·7; H, 5·5; N, 14·1%). This compound was also prepared directly from 1-aminopyridinium iodide.[34]

Pyridine 1-benzenesulphonylimide. 1-Aminopyridinium iodide (15.54 g, 0·07 mole) in water (70 ml) and acetone (110 ml) was treated with solid K_2CO_3 (9·8 g, 0·07 mole). Benzenesulphonyl chloride (12·36 g, 0·07 mole) in acetone (35 ml) was added, followed by water and acetone, until a homogenous soln was obtained. The soln was shaken, kept overnight, and evaporated. Water (20 ml) was added and the sulphonylimide (10·2 g, 62·6%) filtered off and recrystallized from EtOH, m.p. 153·5–154·5° (lit.,[10] 152°).

Pyridine 1-(2,4,6-trichlorobenzenesulphonimide) (23%) was prepared similarly. It formed prisms, m.p. 202–203° (from abs EtOH). (Found: C, 39·3; H, 1·8; N, 8·2. $C_{11}H_7Cl_3N_2O_2S$ requires: C, 39·2; H, 2·1; N, 8·3%). From the ethanolic mother liquors, treatment with water and two sublimations under reduced press (150°/0·2 mm) gave 2,4,6-trichlorobenzenesulphonamide (10%) m.p. 179–180° (lit.,[40] m.p. 179°). (Found: C, 27·0; H, 1·4; N, 5·2. Calc. for $C_6H_4Cl_3NO_2S$: C, 27·6; H, 1·55; N, 5·4%).

1-Methylsulphonamidopyridinium picrate. 1-Aminopyridinium chloride (0·25 g) (dried over P_2O_5 *in vacuo*) and methanesulphonyl chloride (2·5 ml) were heated at 95° for 17 hr. Excess sulphonyl chloride was removed under reduced press, and the residue (0·31 g) was triturated with ether, dissolved in water, and treated with a slight excess of aqueous lithium picrate. The *picrate* (0·21 g, 28%) crystallized from EtOH as plates, m.p. 157–158°. (Found: C, 36·3; H, 2·8; N, 17·45. $C_{12}H_{11}N_5O_9S$ requires: C, 35·9; H, 2.75; N, 17·45%). NMR spectrum (10% in perdeuterodimethyl sulphoxide) showed (in addition to the picrate singlet at τ 1·34) multiplets centered at τ 0·86 (2H), 1·24 (1H) and 1·71 (2H); the Me peak was at τ 6·68.

1-Amino-3-methoxypyridinium derivatives. The *iodide* (54%) prepared by the procedure of Ref. 13, formed prisms, m.p. 114-115°, from EtOH. (Found: C, 28·2; H, 3·7; N, 10·6. $C_6H_9IN_2O$ requires: C, 28·6; H, 3·6; N, 11·1%). The *nitrate* (92%) formed plates, m.p. 109–110° (from EtOH). (Found: C, 38·3; H, 4·9; N, 23·0. $C_6H_9N_3O_4$ requires: C, 38·5; H, 4·8; N, 22·5%).

The iodide was benzoylated as above to give the *1-benzamido-3-methoxypyridinium iodide* (70%), which formed buff needles, m.p. 153·5-155° (dec), from EtOH. (Found: C, 43·95; H, 3·4; N, 7·7. $C_{13}H_{13}IN_2O_2$ requires: C, 43·8; H, 3·7; N, 7·9%).

Treatment of the preceding compound with base gave *3-methoxypyridine 1-benzoylimide* (0·49 g, 93·4%) which formed prisms, m.p. 135-136° from EtOH. (Found: C, 68·7; H, 5·7; N, 12·0. $C_{13}H_{12}N_2O_2$ requires: C, 68·4; H, 5·3; N, 12·3%).

1-Amino-3-methoxypyridinium iodide (2·52 g, 0·01 mole) and benzenesulphonyl chloride (1·76 g, 0·01 mole) in the presence of K_2CO_3 (1·4 g, 0·01 mole), as above, gave *4-methoxypyridine 1-benzenesulphonylimide* which formed prisms, m.p. 144–145°, from EtOH (1·55 g, 58·7%). (Found: C, 54·9; H, 4·3; N, 10·6. $C_{12}H_{12}N_2SO_3$ requires: C, 54·5; H, 4·5; N, 10·6%).

Reaction of hydroxylamine-O-sulphonic acid with 4-methoxypyridine. Potassium hydroxylimine-O-sulphonate (from 27·1 g of the acid) in water (100 ml) was added dropwise over 1 hr to 4-methoxypyridine (26·1 g) in water (50 ml) at 80–85°. After 4 hr more at this temp K_2CO_3 (16·5 g) was added and the mixture was evaporated to dryness on a water bath at 30–40°. MeOH (300 ml) was then added K_2SO_4 was filtered off, and conc HII added to the filtrate. The soln was again evaporated. The residue crystallized from abs EtOH–MeOH [3 : 2] to give the *iodide* salt, (30·5 g) m.p. 143·5–145° (dec).

The iodide (1·26 g) in water (15 ml) was added to $AgNO_3$ (0·84 g) in water (100 ml). After 12 hr in the

dark, precipitated AgI was filtered off and washed with water. The filtrate and washings were evaporated to give 1-(1′-*aminopyridinium-4′-yl)amino-4-methoxypyridinium dinitrate* which crystallized from EtOH as prisms, m.p. 198–200° (dec) (0·78 g). (Found: C, 38·8; H, 3·7; N, 24·0. $C_{11}H_{14}N_6O_7$ requires: C, 38·6; H, 4·1; N, 24·6%); NMR spectrum (15% in D_2O): τ 1·12 (d, 2H, J = 12 Hz), 1·46 (d, 2H, J = 12 Hz), 2·25 (d, 2H, J = 12 Hz), 2·84 (d, 2H, J = 12 Hz), 5·74 (s, 3H).

Anhydro 1-amino-4-carboxypyridinium hydroxide. Isonicotinic acid (0·77 g) in water (10 ml) and 5N KOH (1·25 ml) was stirred and potassium hydroxylamine-O-sulphonate (from 2·82 g of the acid) in water (20 ml) added at 80° in 3 portions at intervals of 1 hr. after a further ½ hr at 80–85°, the mixture was cooled, kept overnight, neutralized with K_2CO_3 (1·73 g) in water (10 ml), evaporated (to ca. 12 ml volume) and diluted with MeOH (50 m). The precipitated inorganic salts were filtered off and washed with MeOH. The filtrate and washings were evaporated and the residual solid triturated with cold dimethylformamide to give the *betaine* (0·78 g, 91%) which crystallized from water as fawn needles (0·4 g), m.p. 311–314° (dec). (Found: C, 52·5; H, 4·4; N, 19·9. $C_6H_6N_2O_2$ requires: C, 52·15; H, 4·4; N, 20·3%); NMR spectrum (10% in D_2O): A_2B_2 pattern at τ 1·04, 1·61 ($J + J'$ = 7·1 Hz).

3-Aminocarbonylpyridine derivatives. 3-Aminocarbonyl-1-(2,4-dinitrophenyl)pyridinium chloride was prepared from 2,4-dinitrochlorobenzene (50 g) and nicotinamide (10 g) as described by Lettré,[31] except that the product was crystallized from isopropanol to give the *isopropanolate* (9·85 g, 32%), m.p. 130–132° (lit.,[31] m.p. 115° for the methanolate). NMR spectrum (20% in D_2O): heteroaromatic proton signals at τ 0·2 (H_2); 0·53 (H_4, H_6, $H_{3'}$); 0·89 ($H_{5'}$); 1·28 (H_5); 1·56 ($H_{6'}$) and isopropanol signals at τ 5·87 (septet, 1H) and τ 8·76 (doublet, 6H). The *picrate* formed microprisms, m.p. 200–201° (from AcOH). (Found: C, 42·2; H, 1·7; N, 19·3. $C_{18}H_{12}N_7O_{12}$ requires: C, 41·8; H, 2·1; N, 19·0%).

3-Aminocarbonyl-1-(2,4-dinitrophenyl)pyridinium chloride isopropanolate (1·2g) and ethoxycarbonylhydrazine (0·39 g) in MeOH (10 ml) were refluxed for 2 hr, then kept overnight. Separated 2,4-dinitroaniline (0·45 g) was filtered off and the filtrate was evaporated. The residue was extracted with hot water (2 × 30 ml) and the extracts cooled and filtered. The filtrate was evaporated and the solid triturated with 2-ethoxyethanol–ethyl acetate to yield *3-aminocarbonyl-1-ethoxycarbonyl aminopyridinium chloride* (0·54 g, 76%) which crystallized from EtOH as prisms, m.p. 176–177° (dec) (depends on rate of heating). (Found: C, 44·1; H, 5·2; N, 16·9. $C_9H_{12}ClN_3O_3$ requires: C, 43·8; H, 4·9; N, 17·05%).

Use of toluene-*p*-sulphonylhydrazide instead of ethoxycarbonylhydrazine gave *3-aminocarbonyl-1-toluene-p-sulphonyliminopyridine* (8%), as plates, m.p. 232–233° (from MeOH). (Found: C, 53·2; H, 4·1; N, 14·3; S, 10·8. $C_{13}H_{13}N_3O_3S$ requires: C, 53·6; H, 4·5; N, 14·4; S, 11·0%).

Hydrogen exchange

(a) *Acid catalysis.* The N-amino sulphate and deuteriosulphuric acid (ca. 0·5 M in substrate) were weighed into NMR tubes with a small amount of tetramethylammonium sulphate (TMAS) as internal reference. The NMR spectrum was then recorded before and after heating the tube in a constant temp bath for a known period of time. The areas of the proton resonances under observation were integrated against the standard resonance of the added TMAS, as previously described.[36]

(b) *With base catalysis.* The samples (approximately 0·5 M in substrate) were made up in NMR tubes from weighed amounts of the appropriate pyridine 1-benzenesulphonylimide or 1-benzoylimide in D_2O with sodium 3-trimethylsilylpropane sulphonate (TMSP) as internal reference.

The NMR spectrum was then recorded, and sodium deuteroxide added to obtain 0·3–0·4 N soln. The spectrum was immediately recorded again at intervals, the temp being held at 35°.

Nitration of N-aminopyridinium derivatives. A cooled mixture of HNO_3 (3·2 g) and Ac_2O (30 ml) was added to pyridine 1-benzenesulphonylimide (1·17 g) in Ac_2O (25 ml) and AcOH (10 ml) at −5°. The mixture was kept at −5° for 1 hr, then the solvents were evaporated at 30°/10 mm. The solid residue crystallized from EtOH to give *pyridine 1-nitroimide* (0·63 g, 90%) as needles, m.p. 149·5–150°. (Found: C, 43·5; H, 5·1; N, 29·7. $C_5H_5N_3O_2$ requires: C, 43·2; H, 3·6; N, 30·2%).

Treatment of pyridine 1-(2,4,6-trichlorobenzenesulphonylimide) (0·84 g) as above gave the same nitroimide (0·21 g, 67%), m.p. and mixed m.p. 149–150°.

Nitration of pyridine 1-benzoylimide (0·99 g) essentially as described above gave after evaporation a solid residue. Extraction of this residue with light petroleum (b.p. 60–80°) gave benzoic acid (0·52 g, 87%), m.p. and mixed m.p. 119·5–120·5° (lit.,[40] m.p. 122°). Recrystallization of the solid remaining after this extraction from EtOH gave the nitroimide (0·35 g, 85%), m.p. and mixed m.p. 148–149°.

Nitric acid (6·3 g) in Ac_2O (30 ml) was added over 1 hr to 1-aminopyridinium nitrate (3·14 g) in Ac_2O

(20 ml) and AcOH (10 ml) at 0°. After 2 hr more at 0°, the mixture was evaporated at 40°/10 mm and the residue crystallized from EtOH to give the nitroimide (2·28 g, 82%), m.p. and mixed m.p. 149·5–150°.

3-*Methoxypyridine* 1-*nitroimide*, which crystallized as plates m.p. 141–142°, from EtOH (Found: C, 43·3; H, 4·0; N, 24·6. $C_6H_7N_3O_3$ requires: C, 42·8; H, 4·1; N, 24·8%) was prepared as above from 1-amino-3-methoxypyridinium nitrate (81%) and from 3-methoxypyridine 1-benzenesulphonimide (79%).

Spectroscopy and pK_a determinations. NMR spectra were obtained at 60 MHz on a Perkin Elmer R 10 and at 100 MHz on a Varian HA 100 spectrometer: $Me_3SiCH_2CH_2CH_2SO_3Na$, $SiMe_4$ (each $\tau = 10{\cdot}0$) or $(Me_4N)_2SO_4$ ($\tau = 6{\cdot}81$), were used as internal references. For the NMR determination of pK_a values, N-aminopyridinium perchlorate, with sodium trimethylsilylpropanesulphonate as reference, was weighed (under N_2) into 1 ml portions of NaOD of known strength. The NMR spectrum was recorded within 20 min (little decomposition was observed within 1 hr) and the 3,5-proton chemical shift measured (Table 1). The shift for fully deprotonated imine was taken as 2·99 τ, the value in 0·5N-t-BuOK–t-BuOH (H^- ca. 19·6[41]). The shift value corresponding to the pK_a was taken as midway between points 2 pH units below and above the steepest portion of the curve.

TABLE 1. VARIATION OF 3,5-CHEMICAL SHIFT IN N-AMINOPYRIDINIUM PERCHLORATE WITH pH

$N(OD^-)$ added	pH/H^- (Calc.)	$\tau_{3,5}$ (ppm)
4·8	15·5	2·65
2·4	14·5	2·48
1·21	14·1	2·38
0·75	13·82	2·27
0·605	13·77	2·25
0·24	13·38	2·07
None	7·0	1·97

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