Notes

[Chem. Pharm. Bull. 17(7)1515—1517(1969)]

UDC 543.422.25 : 547.82.03

Studies on the Proton Magnetic Resonance Spectra in Aromatic Systems. XII.[1] Heterocyclic Series. (4). 4-Substituted Pyridines

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(Received May 27, 1968)

Introduction

In the preceding papers[3,4] of this series, the correlations among the corrected ring ^1H chemical shifts of nitrogen heteroaromatics and π-electron charge —ρ value—distributions have been discussed by the agencies of substituent constant σ_{π}.[5]

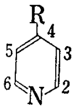
Formerly, several ^1H magnetic resonance spectral parameters of 4-substituted pyridines have been described in the literatures,[6–8] but they are not always satisfactory because of their inadequate experimental conditions. In this work, spectral parameters and ρ-values of 4-substituted pyridines have been estimated.

Experimental

The experimental details are given in an earlier publication.[9] All materials were prepared by the authentic procedures. Spectra were analysed as AA′xX′ system,[6] and the observed ^1H shifts were corrected from nitrogen magnetic anisotropy, nitrogen electric field and ring current effects. The correction terms are as follows (*cf.* Table I).

Table I.[a] Correction Terms of Pyridine Ring[b]

	δ_{RC} ppm	δ_{MA} ppm	δ_E ppm	$\sum$ ppm
C_2,C_6	0.06	−0.35	−0.41	−0.70
C_3,C_5	0.06	0	−0.18	−0.12

[a] The ^1H position numbers are as follows: 

[b] P.J. Black, R.D. Brown and M.L. Heffernan, *Aus. J. Chem.* **20**, 1305 (1967)
δ_{RC}=ring current contribution δ_{MA}=magnetic anisotropy contribution δ_E=electric field contribution

Results and Discussion

The observed —δ— and the corrected —$\delta_{corr.}$[10]—ring ^1H chemical shifts and coupling constants—J—are summarised in Table II and III, respectively.

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[1] Part XI: Y. Sasaki and M. Suzuki, *Chem. Pharm. Bull.* (Tokyo), **17**, 1104 (1969).

[2] *Location*: *Toneyama 6-5, Toyonaka, Osaka.*

[3] Y. Sasaki, M. Suzuki, I. Shiraishi, M. Hatanaka and K. Nishimoto, *Yakugaku Zasshi*, **89**, 21 (1969).

[4] Y. Sasaki, K. Iwasaki, M. Suzuki and K. Nishimoto, *Yakugaku Zasshi*, **89**, 25 (1969).

[5] Y. Yukawa and Y. Tsuno, *J. Chem. Soc. Japan* (Pure Chemistry Section) **86**, 873 (1965).

[6] W. Brügel, *Z. Elektrochem.*, **66**, 159 (1962).

[7] B.D. Nageswara Rao and P. Venkateswarlu, *Proc. Ind. Acad. Sic.*, **54**, 305 (1961).

[8] A.R. Katritzky and J.M. Lagowski, *J. Chem. Soc.*, **1961**, 43.

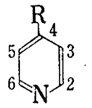
[9] Y. Sasaki, M. Suzuki, T. Hibino and K. Karai, *Chem. Pharm. Bull.* (Tokyo), **15**, 599 (1967).

[10] $\delta_{corr.}$ ppm$=\delta_{obs.}-(\delta_{RC}+\delta_{MA}+\delta_E)-\delta_{ref.}$ ppm $\delta_{ref.}$ ppm$=7.27$ ppm—C_6H_6ring ^1H chemical shift relative to Me_4Si in dilute C_6H_{12} solution.

TABLE II.[a] Observed δ (ppm) and $\delta_{corr.}$ (ppm) of 4-Substituted Pyridines

R	C_3–H δ (ppm)	C_3–H $\delta_{corr.}$ (ppm)	C_2–H δ (ppm)	C_2–H $\delta_{corr.}$ (ppm)
NO_2	7.84	−0.45	8.77	−0.8
CN	7.25	+0.14	8.12	−0.15
CO_2Me	7.66	−0.27	8.62	−0.65
COMe	7.54	−0.15	8.66	−0.69
Me	6.90	+0.49	8.38	−0.41
OMe	6.56	+0.83	8.26	−0.29
H[b]	7.06	+0.33	8.50	−0.53

a) The ^{1}H position numbers are as follows:

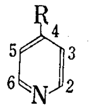


b) A.H. Gawer and B.B. Dailey, *J. Chem. Phys.*, **42**, 2658 (1965)

TABLE III.[a] Coupling Constants (cps) of 4-Substituted Pyridines

R	J_{23}	J_{35}	J_{25}
NO_2	5.2	1.8	1.2
CN	5.1	1.5	0.9
CO_2Me	4.9	1.3	0.8
COMe	4.9	1.6	1.1
Me	5.0	1.7	1.0
OMe	5.0	1.8	1.0
H[b]	4.9	1.4	1.0

a) The ^{1}H position numbers are as follows:



b) S. Castellano, C. Sun and R. Kostelnik, *J. Chem. Phys.*, **46**, 327 (1967)

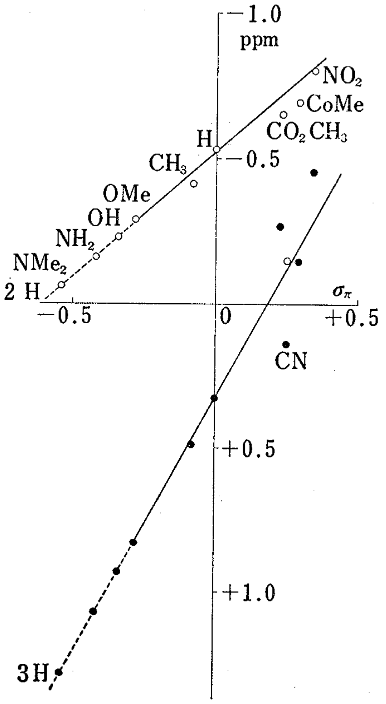


Fig. 1. Corrected and Assumed Shifts (ppm) and σ_π

The correlations of $\delta_{corr.}$ with substituent constants are as below (*cf.* Fig. 1).

As is illustrated in Fig. 1, $\delta_{corr.}$ of both C_2- and C_3-H shifts with electron releasing substituent groups are all linear against the substituent constant σ_π, but they are not always linear in the electron attracting substituent group side. Then, the assumed shifts have been estimated by extrapolating the linear relations obtained in the electron releasing substituent (R=OMe, Me, H) with respect to σ_π. These treatments stated above have already been accept in several aromatics and heteroaromatics.[3,4,11] In this way, the corrected and assumed ring ^{1}H chemical shifts of 4-substituted pyridines have been estimated, and from which ρ_{NMR}[12] are calculated (*cf.* Table IV).

These ρ_{NMR} showed qualitative but not quantitative agreement with $\rho_{calcd.}$[12] from molecular orbital treatment, and for which theoretical approach is now in progress.

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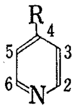
[11] Y. Sasaki and M. Suzuki, *Chem. Pharm. Bull.* (Tokyo), **15**, 1429 (1967).

[12] $\rho_{NMR}=\rho$ value from the corrected and assumed ^{1}H chemical shift ppm/10.7 ppm+1. $\rho_{calcd.}=\rho$ value from molecular orbital method.

TABLE IV.[a] Corrected and Assumed ^{1}H Shifts (ppm), ρ_{NMR} and $\rho_{calcd.}$ of 4-Substituted Pyridines

R		C_3–H			C_2–H	
	δ ppm	ρ_{NMR}	ρ calcd.	δ ppm	ρ_{NMR}	$\rho_{calcd.}$
NO_2	−0.26	0.976		−0.75	0.930	
CN	−0.10	0.991	1.0041[b]	−0.68	0.936	0.8796[b]
CO_2Me	−0.07	0.994		−0.65	0.939	
COMe	−0.18	0.983		−0.70	0.935	
Me	+0.48	1.045		−0.43	0.959	
OMe	+0.83	1.078		−0.29	0.973	
OH	+0.93	1.086		−0.23	0.976	
NH_2	+1.07	1.100		−0.16	0.985	
NMe_2	+1.28	1.200		−0.06	0.995	
H	+0.33	1.031	1.020[c] 1.010[d] 1.0137[b]	−0.50	0.953	0.955[c] 0.951[d] 0.8997[b]

a) The ^{1}H position numbers are as follows:



b) H.E. Popkie and J.B. Moffat, *Canad. J. Chem.*, **43**, 624 (1965)
c) L. Pujol and A. Julg, *Tetrahedron*, 21, 717 (1965)
d) R. McWeeny and T.E. Peacock, *Proc. Phys.Soc.* (London), *Sec. A*, **70**, 41 (1957)

Chem. Pharm. Bull.
17(7)1517—1521(1969)

UDC 543.51 : 547.03.08

Mass Spectra of Acyclic Nitrones

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(Received November 5, 1968)

The photochemistry and thermal rearrangement of amine N-oxides were studied and results are reported in the literature.[2] Cyclic amine N-oxide rearranged to a tri-substituted hydroxylamine analog, that is a 1,2-oxaza ring compound,[3] and aromatic amine N-oxide to an oxazepine or an amide derivative via an unstable oxaziran intermediate.[4] There have been several papers on the mass spectra of amine N-oxide in the past few years, and an ion peak corresponding to loss of oxygen (M-16) is clearly seen with many other strong ion peaks which can be expected from the products produced by photochemical and thermal reactions.[5] Grigg and Odell described the mass spectra of alicyclic nitrones,[5a] reporting that the abundance of M-16 ions is drastically affected by an alkyl substituent at the 2-position and the base peak corresponds to an alkyl fragment.

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1) Location: *Toneyama, Toyonaka, Osaka.*
2) A.H. Wragg, T.S. Stevens and D.M. Ostle, *J. Chem. Soc.*, **1958**, 4057.
3) L.D. Quin and F.A. Shelburne, *J. Org. Chem.*, **30**, 3135 (1965).
4) C. Kaneko, S. Yamada, I. Yokoe and M. Ishikawa, *Tetrahedron Letters*, **20**, 1873 (1967).
5) *a*) R. Grigg and B.G. Odell, *J. Chem. Soc.* (B), **1966**, 218; *b*) A. Kubo, S. Sakai, S. Yamada, I. Yokoe and C. Kaneko, *Chem. Pharm. Bull.* (Tokyo), **16**, 1533 (1968); *c*) T.A. Bryce and J.R. Maxwell, *Chem. Commun.*, **1965**, 206.