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^{13}C AND ^{1}H NUCLEAR MAGNETIC SHIELDINGS AND ELECTRICAL EFFECTS OF ORTHO SUBSTITUENTS IN MONOSUBSTITUTED PYRIDINES

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The complexity of problems associated with the application of the Hammett equation to heterocyclic compounds has been recently discussed by Jaffé and Jones (1) and by Charton (2). The former authors point out that extension of the relationship to the 2-position of pyridine is questionable because the Hammett equation does not apply to substituents in ortho-positions. Since magnetic shieldings of ^{13}C and ^{1}H nuclei in the para-positions of monosubstituted benzenes have been found to correlate well with Hammett σ_p constants (3), we undertook the measurement of the shieldings of the corresponding atoms, i.e., those in the 5-positions, in 2-substituted pyridines to investigate the electrical effects of ortho-substituents in monosubstituted pyridines.

Substituent effects on the ^{13}C and ^{1}H chemical shifts are given in table 1. Except for the ^{13}C datum for 2-picoline which was taken from the work of Lauterbur (4), all measurements were made in these laboratories. A negative substituent effect means that upon substitution of the hydrogen in the 2-position of pyridine, a paramagnetic displacement of the NMR signal arising from the carbon or proton in the 5-position occurs. Corresponding data for the monosubstituted benzenes are included in the table for comparison. Data for the latter are all taken from the work of Spiesecke and Schneider (3) except those for ethylbenzene and benzonitrile, which are from the work of Dhami and Stothers (5) and Retcofsky and Friedel (6) respectively. The substituents are listed in order of increasing σ_p constants.

TABLE 1

Substituent Effects (ppm) on Magnetic Shieldings of ^{13}C and ^{1}H *para* to Substituents in 2-Substituted Pyridines and Monosubstituted Benzenes.

Substituent		NH_2	OCH_3	CH_3	CH_2CH_3	H	F	Cl	Br	$COCH_3$	CN
$\Delta\delta_H$	Pyridines	0.62	0.49	0.22	0.20	0.00	0.17	0.06	-0.04	-0.16	-0.36
	Benzenes	0.63	0.37			0.00	0.22	0.12	0.03		
$\Delta\delta_C$	Pyridines	10.5	7.6	2.5	2.6	0.0	2.4	1.2	0.6	-2.5	-3.3
	Benzenes	9.5	8.1	2.8	2.3	0.0	4.4	2.0	1.0	-4.2	-4.3

With the exception of those for the fluoro and acetyl groups, all ^{13}C NMR substituent effects at the 5-position for the 2-substituted pyridines agree within $\pm$ 1 ppm with those of the *para*-carbon effects in the corresponding monosubstituted benzenes. None exceed $\pm$ 2 ppm. A valid comparison between the corresponding proton shieldings is not possible since suitable data for the monosubstituted benzenes at fixed concentration in the same inert solvent are not available. Those data in table 1 for the benzenes refer to measurements on cyclohexane solutions containing 5 mole per cent of the appropriate compounds. Nevertheless, for the data available, the proton shielding effects are quite similar to those found for the monosubstituted benzenes. Thus it can be concluded that the shielding mechanisms for atoms *para* to substituents are similar for benzenes and 2-substituted pyridines. Small differences in substituent effects for the two classes of compounds do not appear to reflect any unique property of the substituents or the ring system involved.

A straight-line relationship (with some scatter of points around the line) exists between the carbon and proton shieldings and suggest that shieldings of both nuclei are responding to the same property, presumably the resonance effects of the substituents. The substituent effects show no discernible correlation with σ_I constants and only very crude correlation with σ_m constants. Thus, it can be concluded that inductive effects of the substituents do not extend to the 5-position. The substituent effects on shieldings are plotted against σ_p constants in figure 1. The scatter of points about a straight line, though certainly not trivial, is

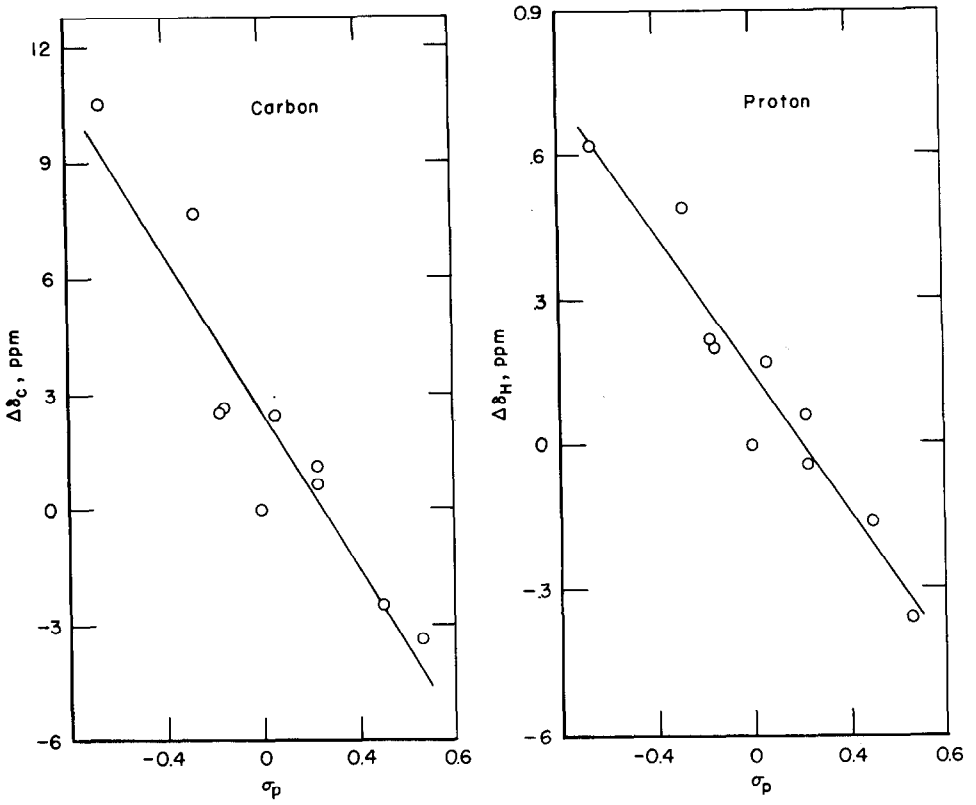

FIG. 1

Substituent Effects on the Magnetic Shieldings of Nuclei para to Substituents in 2-Substituted Pyridines vs Hammett σ_p Constants.

about the same as that found for the monosubstituted benzenes (3) and indicates that σ_p constants, as generally given in the scientific literature, are applicable to 2-substituted pyridines.

EXPERIMENTAL

All ^{13}C NMR measurements were made on neat liquids except those for 2-aminopyridine which was examined as a saturated solution in carbon tetrachloride. Spectra were of the rapid passage, dispersion mode variety. Proton spectra were obtained using 10 per cent solutions by

volume in carbon tetrachloride. Spectrometer operating frequencies were 15.085 MHz and 60 MHz for the ^{13}C and ^{1}H measurements respectively.

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References

1. H. H. Jaffé and H. L. Jones in Advances in Heterocyclic Chemistry, A. R. Katritzky, Ed., Vol. III, pp. 209, Academic Press, New York (1964).
2. M. Charton, J. Am. Chem. Soc. 86, 2033 (1964).
3. H. Spiesecke and W. G. Schneider, J. Chem. Phys. 35, 731 (1961).
4. P. C. Lauterbur, J. Chem. Phys. 43, 360 (1965).
5. K. S. Dhami and J. B. Stothers, Can. J. Chem. 43, 479 (1965).
6. H. L. Retcofsky and R. A. Friedel, J. Phys. Chem. 71, 3592 (1967).