Tetrahedron Letters No. 43, pp 3697 - 3700, 1975. Pergamon Press. Printed in Great Britain.

REPLY TO THE COMMENT ON "NOVEL SUBSTITUENT EFFECTS IN ^1H AND ^{13}C NMR SPECTRA OF 4- AND 4'-SUBSTITUTED N-BENZYLIDENEANILINES."

PROBLEMS OF ^1H CHEMICAL SHIFT MEASUREMENT

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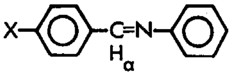
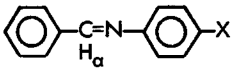
(Received in Japan 28 August 1975; received in UK for publication 15 September 1975)

In recent years, organic chemists have appeared to treat ^1H NMR data not cautiously. Before presenting ^1H NMR data,[1] we must overcome the two tedious problems: (1) how to measure a peak position accurately, and (2) how to analyse a signal pattern. In fact, a description such as "δ 4.38 ($C\underline{H}OH$, t, J = 3) in $CDCl_3$" is not so much informative for the reader unless the accuracies are noted. Accuracies and precisions of ^1H NMR data are dependent upon the kind of the instrument used, the measurement procedure and the method of the signal analysis.

Quite recently, Sandhu, Mago and Wakefield[2] have made the following comment on our recent paper[3] in which we discussed the Hammett relationships of chemical shifts of the imidoyl proton H_α in 4'- (series I) and 4-substituted N-benzylideneanilines (series II): they suggest that our chemical shift measurements may not be accurate to $\delta \pm 0.01$; (2) even if the data might be sufficiently accurate, they do not believe the Hammett correlation obtained with only five data of such small $\Delta\delta_H$ values as in series II; (3) $CDCl_3$ may not be a solvent suitable for the present purpose; and (4) their NMR measurements on series II and 4-substituted 4'-methoxy-N-benzylideneanilines in CCl_4 did not reveal any Hammett correlations for δ_{H_α} values.

Therefore, we have re-examined the signal positions of this H_α singlet in series I and II in C_6H_{12} and CCl_4 as well as $CDCl_3$; the results are shown in the TABLE. The δ_{H_α} data newly obtained in $CDCl_3$ agree well with those previously reported.[3] However, our δ_{H_α} values in CCl_4 considerably differ from their

TABLE. Chemical Shift Data on H_α and Hammett ρ Values[a]

Substituent												
	Series I						Series II					
X	C_6H_{12}[b]		CCl_4[c]		$CDCl_3$[c]		C_6H_{12}[b]		CCl_4[c]		$CDCl_3$[c]	
	60	100	60	100	60	100 MHz	60	100	60	100	60	100 MHz
NO_2	8.44	8.43_0	8.51	8.49_5	8.56 (8.56)[e]	8.55_5	8.31	8.30_0	8.37 (8.45)[d]	8.35_5	8.43 (8.43)[e]	8.42_0
Cl	8.31	8.30_0	8.35	8.34_0	8.42 (8.42)[e]	8.41_5	8.32	8.31_5	8.36 (8.43)[d]	8.35_0	8.43 (8.43)[e]	8.42_5
H	8.33	8.32_0	8.37	8.36_5	8.46 (8.47)[e]	8.45_5	8.33	8.32_0	8.37 (8.43)[d]	8.36_5	8.46 (8.47)[e]	8.45_5
Me	8.30	8.29_0	8.33	8.31_5	8.41 (8.41)[e]	8.41_0	8.34	8.33_0	8.37	8.36_0	8.47 (8.45)[e]	8.46_0
OMe	8.26	8.25_0	8.29	8.27_5	8.38 (8.38)[e]	8.37_5	8.36	8.35_0	8.39	8.37_5	8.49 (8.48)[e]	8.47_5
NMe_2	8.21	8.20_0	8.21	8.20_0	8.31 (8.29)[e]	8.31_0	--	--	--	--	--	--
ρ	-0.139	-0.138_6	-0.180	-0.176_9	-0.149	-0.145_6	+0.041	$+0.040_6$	+0.013	$+0.016_0$	+0.054	$+0.051_5$
r[f]	0.960	0.960	0.971	0.970	0.954	0.990	0.896	0.910	0.445	0.631	0.866	0.908

[a] Chemical shifts are expressed by δ. In accordance with the procedure of other studies of Hammett relationships so far reported,[3] we use a negative sign for a downfield shift. [b] Measured at a concentration of about 0.025 mmol/cm^3, because the compounds were too insoluble to obtain values at infinite dilutions. [c] Values extrapolated to infinite dilutions. Several data were plotted for concentrations from 0.25 to 0.015 mmol/cm^3. [d] Taken from ref 2. [e] Taken from ref 3. [f] Correlation coefficients.

values.[2] Furthermore, similar Hammett ρ_{H_α} values having a positive sign were obtained for series II in the three solvents. We don't think that CCl_4 is a good solvent for a Hammett analysis; it is not an inert solvent[4] as well as $CDCl_3$.[5] Further, we think that the analysis employing the five data obtained with the typical substituents are sufficiently significant.[6]

We feel that the Sandhu, Mago and Wakefield data on δ_{H_α} might be inaccurate, although we cannot easily criticize them because they do not state any experimental procedures as well as accuracies or precisions, and even the instrument used.[2] Even though their data might be enough accurate, the 4-substituted 4'-methoxy series belongs to a π-conjugation system different from series II, and therefore, it is not necessary to have a positive ρ_{H_α}. Conversely speaking, the very small variations in the δ_{H_α} values for this series as well as those observed by other workers[7] can further support our discussion reported in the following paper.[8]

^1H NMR spectral measurement procedures were as follows. The spectra at 60 MHz were measured with a Varian A-60A spectrometer at ordinary probe temperature (38°). Calibrations of the spectrometer were performed by the side-band technique using a Hewlett-Packard 200CD audio-oscillator and an HP-521C electronic counter. For avoiding a change in the instrumental condition of stability during an about 500 Hz sweep from the H_α to TMS signal (sweep rate, 1 Hz/sec), the H_α signal position was measured from an about 490 Hz downfield side-band of the TMS signal modulated by the audio-oscillator: the side-band frequency was measured by the electronic counter with an accuracy to ± 0.1 Hz. The accuracies and precisions of δ are about ± 0.01. The NMR spectra at 100 MHz were taken with a Varian HA-100 spectrometer at ordinary probe temperature (30°) in the frequency-swept and internal-TMS-locked mode (sweep rate, 0.5 Hz/sec). The H_α signal position was, several times, measured by the direct reading of the signal peak from the internal-TMS lock using a Hewlett-Packard 5212A electronic counter with a precision to ± 0.2 Hz. We think the accuracies of δ are about $\pm 0.00_5$. Discrepancies between the δ values observed at 60 and 100 MHz are generally seen for most spectrometers.[9]

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(5) Fortunately, the compounds of series I and II were, though slightly, soluble in C_6H_{12} in the present case. This is not always the case, however. We believe that even in CCl_4 and $CDCl_3$, chemical shifts are useful for a Hammett analysis, conventionally.

(6) It has been suggested that more than ten substituents should be included in an investigation of transmission of substitution effects;[10] however, the use of typical substituents such as the present ones, though less than ten,[11] appears enough to examine the tendency for ρ, unless the ρ values are discussed in detail and if the data are sufficiently accurate and precise.

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