

## Nitroenamines. Part 6.† Carbon-13 Nuclear Magnetic Resonance Spectral Studies on 1-Amino-2-nitro- and 1,1-Diamino-2-nitro-ethylenes

By Srinivasachari Rajappa and Kuppaswamy Nagarajan,\* CIBA-GEIGY Research Centre, Goregaon East, P.O. 9002, Bombay 400063, India

<sup>13</sup>C N.m.r. spectra of 1-amino-2-nitroethylenes (1a—c), 1,1-diamino-2-nitroethylenes (2a—c), and 2-acyl-1-aminoethylenes (3a and b) have been analysed. The chemical shifts of C-2 and 2-H are shown to correlate well with each other and with the chemical reactivity of the enamines. Nonequivalence was observed for the methyl groups in 1-dimethylamino-2-nitroethylene (1a) both in <sup>13</sup>C and <sup>1</sup>H n.m.r. spectra and is explained on the basis of restricted rotation around the N—C-1 bond due to extensive delocalization. A similar phenomenon occurs in the pyrrolidinoenamine (1b) and to a less pronounced extent in the morpholinoenamine (1c). Nonequivalence of N—CH<sub>3</sub> groups is not observed in 1,1-bis(dimethylamino)-2-nitroethylene (2a), as well as in the enamino acyl compounds (3a and b), reflecting decreased double bond character around N—C-1.

WE reported previously on the <sup>1</sup>H n.m.r. spectra of enamines of 4-phenylthiazol-2-ylacetone<sup>1</sup> and cycloalkanones.<sup>2</sup> The latter study attempted a correlation of the chemical shift of the 'enamine' proton with the reactivity of the enamine; this received independent confirmation in the elegant studies of Kuehne and Garbacik.<sup>3</sup> More recently, we have investigated the synthetic potentials<sup>4-6</sup> of a series of 1-monoamino- (1) and 1,1-diamino-2-nitroethylenes (2) and studied their enamine properties in relation to those of the enamino-acyl compounds (3), trying to relate them to the chemical shifts of the 'enamine' proton 2-H. These were found to parallel the electron densities at C-2 obtained by extended Hückel (EH) calculations.<sup>4</sup> In keeping with our experimental observations of decreasing enamine activity in the order (3) > (2) > (1), the electron density at C-2 decreased and the chemical shifts of the attached proton increased.<sup>4</sup> We have now examined the <sup>13</sup>C n.m.r. spectra of these molecules, and we present in the Table salient chemical shifts and coupling constants.

A general inspection of the chemical shifts of C-2 and 2-H reveals a gratifying correspondence except for (2c),

† Part 5, S. Rajappa and B. G. Advani, *Indian J. Chem.*, 1977, **15B**, 890.

‡ In contrast, this effect is reported to be -7.9 p.p.m. in alkenes.<sup>8</sup> However, the authors of ref. 8 feel that this is due to electronic rather than steric factors. In this event it is not necessary to apply a correction.

<sup>1</sup> T. R. Govindachari, S. Rajappa, and K. Nagarajan, *Helv. Chim. Acta*, 1968, **51**, 2102.

<sup>2</sup> K. Nagarajan and S. Rajappa, *Tetrahedron Letters*, 1969, 2293.

which shows a somewhat smaller  $\delta$  for 2-H than expected. The data fit the linear regression equation (1) with cor-

$$\delta(\text{C-2}) = 11.23\delta(2\text{-H}) + 34.02 \quad (1)$$

relation coefficient  $r$  0.947. We then attempted correction of the chemical shifts for certain factors. It can be assumed that inductive and mesomeric factors are both important for the electron density at C-2 and hence for enamine activity. The chemical shift of 2-H presumably reflects these factors already and is affected by steric effects only negligibly, if at all. On the other hand steric factors play a more important role in <sup>13</sup>C chemical shifts. A correction is desirable, but is not easy for our cases, since strict precedents are not available in the literature. The effect of CH<sub>3</sub> group at C-1 in (3a and b) is considered to be +1.8 p.p.m. from data published<sup>7</sup> for the enamines (4a and b). This effect would be at least partially steric in origin.† Other correction terms are -1.8 p.p.m. for the  $\gamma$ -CH<sub>2</sub> (2b and c) and CH<sub>3</sub> groups (3a) and -1.5 p.p.m. for the  $\gamma$ -(O)CH<sub>2</sub> group in (3a) on the basis of the findings for alkenes.<sup>8</sup> The extrapolation is admittedly approximate since the

<sup>3</sup> M. E. Kuehne and T. Garbacik, *J. Org. Chem.*, 1970, **35**, 1555.

<sup>4</sup> S. Rajappa, R. Sreenivasan, B. G. Advani, R. H. Summer-ville, and R. Hoffmann, *Indian J. Chem.*, 1977, **15B**, 297.

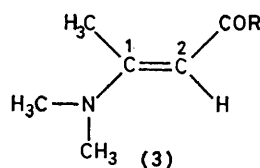
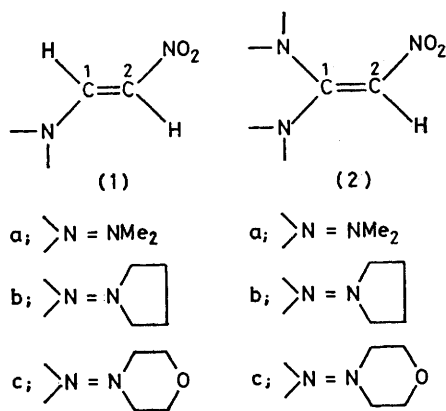
<sup>5</sup> S. Rajappa, B. G. Advani, and R. Sreenivasan, *Tetrahedron*, 1977, **33**, 1057.

<sup>6</sup> S. Rajappa, *Heterocycles*, 1977, **7**, 507.

<sup>7</sup> Md. G. Ahmed and P. W. Hickmott, *J.C.S. Perkin II*, 1977, 838.

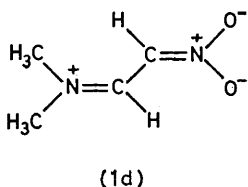
<sup>8</sup> D. E. Derman, M. Jautelat, and J. D. Roberts, *J. Org. Chem.*, 1971, **36**, 2757.

molecules are not strictly comparable. The effect of the nitrogen *cis* to the NO<sub>2</sub> group in (2a—c) is considered to be solely electronic as also is that of NO<sub>2</sub> [(1a—c),

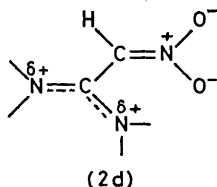


a; R = OEt

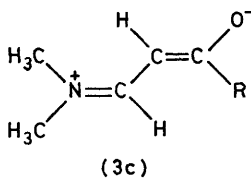
b; R = Me



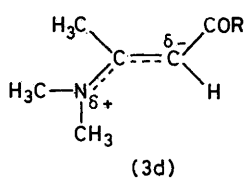
(1d)



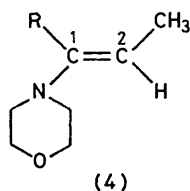
(2d)



(3c)



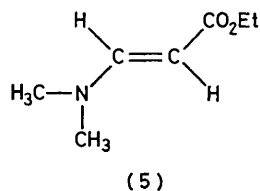
(3d)



(4)

a; R = H [ $\delta$ (C-2) 95.8]

b; R = CH<sub>3</sub> [ $\delta$ (C-2) 97.6]



(5)

(2a—c)], CO<sub>2</sub> (3a), and COCH<sub>3</sub> (3b) groups. *cis*-Effects present in (2a—c) and (3a and b) are not taken into consideration.  $\delta$  Effects (considered to be generally steric) due to (O)CH<sub>2</sub> in (2c) and (NCH<sub>2</sub>) CH<sub>2</sub> in (2b) are unlikely because of unfavourable geometry and the one

due to (OCH<sub>2</sub>)CH<sub>3</sub> in (3a) negligible.<sup>9</sup> Column 3 of the Table lists the corrected <sup>13</sup>C shifts of C-2. These are now found to correlate better with  $\delta$ (2-H) according to the linear regression equation (2) with  $r$  0.990.

$$\delta(\text{C-2}) = 12.26\delta(2\text{-H}) + 28.87 \quad (2)$$

In the series (1a—c), carbon and proton chemical shifts at C-2 decrease in the order (1c) > (1a) > (1b). If we make the reasonable assumption that the  $\gamma$ -effects of the >N groups are about the same in the three cases, the observed differences must be due to the greater ease with which nitrogen atom in a pyrrolidine ring can delocalize its lone pair into the nitroethylene system (double bond *exo* to a five-membered ring<sup>2</sup>). Obviously morpholine is less efficient in this respect<sup>2</sup> and a dimethylamino group is in between.

In the series (2a—c), carbon and proton shifts at C-2 indicate greater enamine activity compared with (1) in keeping with our qualitative experimental findings and Hoffmann's EH calculations.<sup>4</sup> This can be ascribed to the feeding of another electron pair into the conjugated system, but rationalization within the series is not straightforward. Presumably differential distortions caused by interactions of dimethylamino, pyrrolidino, and morpholino groups among themselves and with a *cis*-placed nitro-group are responsible but cannot be properly assessed.

The smaller chemical shifts of C-2 and its proton in the enamino ester (3a) compared to the enamino ketone (3b) must be due to increased delocalization in (3b).

The one-bond coupling of C-2 with 2-H falls into three groups, one comprising (1a—c) with  $J$  186.8—188.3 Hz, the second consisting of (2a—c) with  $J$  185.3—186 Hz, and the third consisting of (3a and b) with  $J$  151.5—152 Hz. There is an apparent qualitative correlation of this coupling with enamine activity, the enamine with lower  $J$  value being more reactive. But this correlation cannot be taken too seriously considering that  $^1J(\text{CH})$  is much affected by the electronegativity of the substituents, *e.g.* in the series CH<sub>3</sub>X<sup>10</sup> and PhCH=CHX.<sup>11</sup>

The chemical shifts of C-1, which are less relevant to our discussion, fall within a narrower range of 146.4—162 p.p.m. The spread is reasonably well rationalized by the  $\alpha$ -effects of the nitrogen atom and CH<sub>3</sub>, the  $\beta$ -effects of NCH<sub>3</sub> and NCH<sub>2</sub>, the  $\gamma$ -effect of COCH<sub>3</sub>, and the  $\delta$ -effect of OCH<sub>2</sub>. The effect of delocalization is not assessed.

We now comment upon another interesting feature of this study. An inspection of the NCH<sub>3</sub> and NCH<sub>2</sub> data in the Table shows (1a) to possess two nonequivalent CH<sub>3</sub> groups,  $\delta_{\text{C}}$  45.0 and 37.5 p.p.m.,  $\delta_{\text{H}}$  3.22 and 2.90. The signals were of equal intensity. The picture was similar in the <sup>1</sup>H n.m.r. spectrum of (1a) in [<sup>2</sup>H<sub>6</sub>]DMSO. Signals were not duplicated for other carbons or protons. These data rule out the presence of a geometrical isomer (around C=C) and compel us to postulate that the phenomenon is due to a barrier to free

<sup>9</sup> F. W. Wehrli and T. Wirthlin, 'Interpretation of Carbon-13 N.M.R. Spectra,' Heyden, London, 1976, p. 38.

<sup>10</sup> J. B. Stothers, 'Carbon-13 N.M.R. Spectroscopy,' Academic Press, New York, 1972.

<sup>11</sup> K. Nagarajan, unpublished observations.

rotation around the N-C-1 bond in (1a) because of extended delocalization as in (1d). The nonequivalence of CH<sub>3</sub> groups in (1a) has been observed in the <sup>1</sup>H spectrum by Büchi<sup>12</sup> in CDCl<sub>3</sub> solution at room temperature and in CDBr<sub>3</sub> solution by Mannshreck.<sup>13</sup> In the latter study, coalescence of methyl signals occurred at 52 °C, leading to  $\Delta G_C^\ddagger$  16.5 kcal mol<sup>-1</sup>.

The observed multiplicity of signals for the carbon and protons of NCH<sub>2</sub> in (1b) can be explained similarly. In the case of the morpholino compound (1c), decreased conjugation (evident in the shift of C-2) lowers the barrier to rotation around N-C-1 to a point where only broadened signals are seen for the carbon and proton nuclei of NCH<sub>2</sub>. In this connection it is interesting to note that a recent publication mentions decreased C=C double bond character and an (implied) increase in the barrier to N-C rotation in a series of 1,1-diamino-2-acyl ('push-pull')ethylenes, but this barrier is small and nonequivalence is obtained only at low temperatures.<sup>14</sup>

The nonequivalence of NCH<sub>3</sub> and NCH<sub>2</sub> is not seen

The validity of these rationalizations can, however, be cross-checked by the chemical shifts of the carbon atom of the NCH<sub>3</sub> group in (1a), (2a), and (3a and b). After correcting<sup>9</sup> for a  $\delta$ -effect in (2a) (+1 p.p.m. per each NCH<sub>3</sub> group) and a  $\gamma$ -effect in (3a and b) (-2.0 p.p.m. for 1-CH<sub>3</sub>) and assuming that there is no steric influence on the NCH<sub>3</sub> group by a *trans*-oriented substituent at C-2, the carbon shifts of the NCH<sub>3</sub> group in (1a), (2a), and (3a and b) can be computed as 41.25 (average of the two carbon shifts), 37.3, 40.7, and 40.2 p.p.m. respectively.

The study reveals a dichotomy. Although enamine reactivity decreases in the order (3a) > (2a) > (1a), the double-bond character around N-C-1 is a maximum in (1a) as shown by nonequivalence of the NCH<sub>3</sub> groups. Our explanation in effect is that the nitro group is most effective as an electron sink, causing extensive delocalization in (1a), whereas in the enamino ester (3a), there is lesser involvement of the nitrogen lone pair, but a greater electron density at C-2.

<sup>13</sup>C and <sup>1</sup>H n.m.r. data for enamines

Compound	C-2				C-1			$J_{H(1),H(2)}$ / Hz	NCH <sub>3</sub> or NCH <sub>2</sub>	
	$\delta_C$	Corrected $\delta_C$	$\delta_H$	$J_{CH}/\text{Hz}$	$\delta_C$	$\delta_H$	$J_{CH}/\text{Hz}$		$\delta_C$	$\delta_H$
(1c)	112.8	112.8	6.85	186.8	149.4	8.17	169.1	10.8	49.2	ca. 3.36
(1a)	111.4	111.4	6.64	188.3	151.0	8.14	172.0	10.5	45.0, 37.5	3.22, 2.90
(1b)	111.1	111.1	6.58	186.8	146.4	8.28	169.1	10.5	52.3, 47.0	3.65, 3.23
(2c)	102.6	106.2	6.23	185.3	161.4				49.7	3.33
(2b)	101.6	105.2	6.42	185.3	155.1				49.4	3.50
(2a)	100.9	104.5	6.30	186	162.0				39.3	2.97
(3b)	93.7	91.9	5.03	151.5	160.3				38.2	2.97
(3a)	84.0	83.7	4.53	152	160.6				38.7	2.92

at the probe temperature (30 °C) in the series (2a-c). This can be accounted for by invoking the amidine resonance structure (2d), which will result in decreased double bond character around N-C-1 in (2d) compared with (1d). The barrier consequently becomes smaller than the thermal energy at ambient temperature.

Mannshreck<sup>13</sup> has reported on the proton spectrum of the de-C-methyl derivative (5) of (3a) in CDCl<sub>3</sub> and noted nonequivalence at -40°, coalescence taking place at 0°.  $\Delta G_C^\ddagger$  for this process was calculated to be 13.9 kcal mol<sup>-1</sup>. The absence of nonequivalence of NCH<sub>3</sub> groups in (5) above 0°<sup>13</sup> and in (3a and b) at probe temperature may be due to a decrease in delocalization (which was evident in our EH calculations<sup>4</sup>) and the consequent decrease in the contribution of (3c) to the resonance hybrid. However, it must be conceded that there is sufficient contribution from (3d) to explain the observed shifts of C-2 and the reactivity of (3a and b). These speculations must await confirmation by experimental determination of energy barriers by variable temperature studies.

<sup>12</sup> G. Büchi and C-P. Mak, *J. Org. Chem.*, 1977, **42**, 1784.

<sup>13</sup> A. Mannshreck and U. Koelle, *Tetrahedron Letters*, 1967, 863.

<sup>14</sup> J. Sandström, U. Sjöstrand, and I. Wennerbeck, *J. Amer. Chem. Soc.*, 1977, **99**, 4526.

<sup>13</sup>C N.m.r. spectra of other types of enamines have been recorded recently.<sup>7,15</sup> Our present study supplements these reports, while extending our earlier work.<sup>4</sup>

#### EXPERIMENTAL

Compounds (1a-c), (2a-c), and (3a and b) were available from our earlier study.<sup>4</sup> Their n.m.r. spectra were measured on a Bruker WH 90 Fourier transform n.m.r. spectrometer, using 10-20% w/v solutions in CDCl<sub>3</sub> at a probe temperature of 30 ± 1°. <sup>1</sup>H Resonances were measured at 90 MHz, <sup>13</sup>C resonances at 22.63 MHz, using the broad band decoupling technique. Chemical shifts are quoted in p.p.m. downfield from tetramethylsilane internal reference and <sup>13</sup>C values are correct to ±0.06 p.p.m. Gated decoupling allowed the measurement of C-H couplings (accuracy ±1.47 Hz) while in the case of (1a) specific proton decoupling confirmed the identification of the signal due to C-2. <sup>1</sup>H and <sup>13</sup>C measurements on solutions of (2c) in CDCl<sub>3</sub> at different concentrations showed no change in proton shifts and less than ±0.2 p.p.m. alteration in  $\delta(C-2)$ .

We thank Dr. R. S. Grewal, Director, CIBA-GEIGY Research Centre, for his support and Dr. S. Selvavinayakam and Mr. R. K. Agashe for the n.m.r. spectra.

[7/1895 Received, 31st October, 1977]

<sup>15</sup> D. Tourwe, G. Van Binst, S. A. G. De Graaf, and U. K. Pandit, *Org. Magnetic Resonance*, 1975, **7**, 433.