Carbon-13 NMR Study of 1-Methyl-3-phenyl-4-diazo-5-benzoylamido-pyrazole and Other Model Pyrazole Compounds

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A ^{13}C nmr study of a diazo, of two diazonium salts and of some other model pyrazole compounds is reported. It is found that the C-4 diazo carbon is more shielded than the normal sp^2 pyrazole hybridized carbon, while its diazonium salt is more deshielded. The electron density on the C-4 of the diazopyrazole is probably due to the positive charge on the terminal nitrogen. Thus the ^{13}C chemical shift values allowed us to understand the chemical behaviour of a compound of potential antitumor activity.

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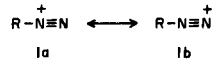
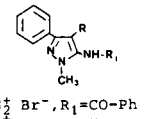
Heterocyclic diazo compounds and their diazonium salts are an interesting class of reacitve substrates and their synthetic potentialities have received recent attention [1-2]. In recent papers [3-4] the synthesis, the chemical and the photochemical behaviour of 1-methyl-3-phenyl-4-diazo-5-benzoylamidopyrazole (**1**) have been reported. The interest of compound **1**, a dacarbazine analog with potential antitumor action [5], prompted us to a ^{13}C study of a series of pyrazole derivatives. These ^{13}C chemical shift values are fundamental to the understanding of the structure and chemical behaviour of compound **1**. The ^{13}C chemical shifts of diazopyrazole **1**, of the diazonium salts **2** and **3**, of their parent compounds **4-8** and **13**, of 1-methyl-3-phenyl-5-(4-methylbenzoyl)amidopyrazole **9** as well as of compounds **10**, **11** and **12** are given in Table 1. It can be seen that the C-4 diazo carbon of **1-3** is characterized by a larger upfield shift compared with the normal range for an sp^2 pyrazole hybridized carbon, *e.g.*, compounds **4-5**, **9**. A more dramatic illustration of these large shielding effects can be made by a comparison with the 4-nitroso **6**, 4-nitro **7**, 4-amino **8** and 4-hydroxypyrazole **10**, in which the C-4 carbon is strongly deshielded. The increased shielding seen for the diazo carbon of compound **1** indicates that on the C-4 atom there should be a considerable electron density. This finding suggests that of the two resonance structures **1a** and **1b**, the most probable is the **1b** with the positive charge on the terminal nitrogen. This explains the

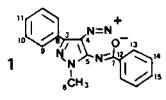


Ia **Ib**

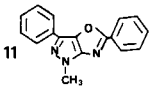
Table 1



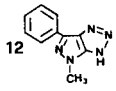
2 R=N_2^+ Br^-, R_1=CO-Ph
3 R=N_2^+ Br^-, R_1=H
4 R=R_1=H
5 R=H, R_1=CO-Ph
6 R=NO, R_1=CO-Ph
7 R=NO_2, R_1=CO-Ph
8 R=NH_2, R_1=CO-Ph
9 R=H, R_1=CO-PhCH$_3$ (p)
10 R=OH, R_1=CO-Ph
13 R=NO, R_1=H



1



11



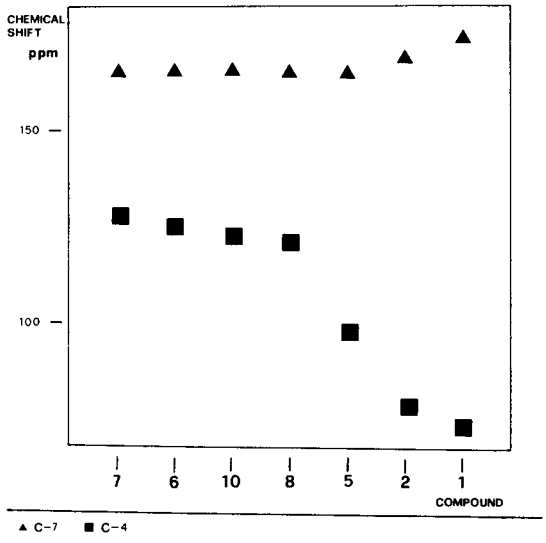
12

Compound	Carbon Number												
	3	4	5	6	7	8	9	10	11	12	13	14	15
1	155.5	73.1	146.5	35.4	173.5	128.0 [a]	128.7 [a]	126.7	130.3	137.1	128.9 [a]	129.3 [a]	131.3
2	149.3	78.6	149.2	38.1	169.1	129.5	127.6	129.1	131.1	133.3	127.1	128.5	132.9
3	154.9	71.1	146.8	36.0		129.3	131.0	126.5	129.0				
4	148.1	85.4	147.9	34.3		128.4	134.4	124.6	126.8				
5	148.3	97.8	137.6	35.9	165.7	127.9	133.4	124.8	127.4	133.5	128.5 [a]	128.6 [a]	132.1
6	153.8	124.6	149.1	36.4	166.1	128.7	131.0	128.3	129.8	132.5	128.7	128.7	132.9
7	145.7	127.8	136.2	36.9	165.9	128.2	130.6	128.2	129.1	132.4	128.7 [a]	128.9 [a]	132.8
8	137.7	122.0	125.1	35.9	166.1	128.0	133.4	125.8	126.4	134.2	128.4 [a]	128.5 [a]	132.0
9 [b]	148.2	97.8	137.7	35.9	165.6	127.9	133.5	124.8	127.4	130.5	128.6	129.1	142.0
10	135.8	123.8	133.6	36.1	166.5	128.0	133.1	125.1	126.5	133.4	128.3 [a]	128.4 [a]	132.1
11	150.9	128.8	137.0	36.2	167.0	126.8 [a]	127.0 [a]	125.3	128.1	130.6	129.1 [a]	129.3 [a]	131.8
12	160.6	140.3	131.3	36.3		128.5	134.5	125.3	126.3				
13	150.6	131.3	148.1	33.6		128.5	136.7	127.9	129.2				

[a] Assignments may be reversed for these resonances. [b] The resonance for CH_3 was 21.0 ppm.

easy reactivity of compound **1** in coupling reactions such as with reactive methylene compounds to yield hydrazones [3] or when heated with sodium hydroxide to give 1-methyl-3-phenylpyrazolo[4,5-*d*][1,2,3]triazole (**12**) [4]. Our conclusions confirm what has been observed by Albright and Freeman [6] who in a ^{15}N nmr study pointed out that the terminal nitrogen of a diazo group is deshielded relative to the central one. Furthermore, comparison of the ^{13}C chemical shift of the C-4 of compound **1** with that of compound **2** reveals that in the latter there is a deshielding effect of 5.5 ppm. That means that in compound **2** the two resonance structures **1a** and **1b** are both probable. On the other hand the effect of the diazo group on the two other carbons of the pyrazole ring, namely on the C-3 and C-5, is a deshielding one. The N_2^+ group has the same deshielding effect even on the C-7. In fact, the ^{13}C chemical shift of this carbon has similar values for all benzoylamido derivatives but compounds **1** and **2**. Comparison between the latter two shows that the C-7 chemical shift of **1** is more downfield than that of **2**. This deshielding effect of **1** is probably due to the oxygen being the anion of the N_2^+. In the case of compound **2** we are dealing with a normal C=O, the anion being a Br^- (see Table 2). In the series of 5-aminopyrazole derivatives, namely in compounds **3** and **4**, the substituents have the same effect on the pyrazole carbons as in the 5-benzoylamido series. Moreover the ^{13}C chemical shift values of two fused pyrazoles **11** and **12** are reported.

Table 2



EXPERIMENTAL

The natural abundance ^{13}C nmr spectra were recorded on a Varian FT-80A spectrometer at 20 MHz in the Fourier transform mode. All samples were recorded in 10 mm o.d. tubes at the probe temperature (32 ± 2°C), with concentrations of approximately 10% w/v in dimethyl-d_6 sulfoxide which provided the deuterium signal for the field frequency lock. Chemical shifts were measured relative to the central peak of the solvent (dimethyl-d_6 sulfoxide = 39.5 ppm) and corrected to internal tetramethylsilane. Typical acquisition parameters included a spectral width of 5000 Hz, 1 second acquisition time and a flip angle of 45°. Chemical shift values were reproducible to better than ± 0.05 ppm. For compounds **1-3**, **7** and **11** chromium(III) acetylacetonate (5 mg/ml *c.a.*) was added to shorten relaxation time.

For new synthesized compounds all melting points were determined on a Buchi capillary melting point apparatus and are uncorrected. The ir spectra were measured for potassium bromide discs with a Perkin-Elmer 283 spectrophotometer. The ^1H nmr spectra were recorded with a Varian EM-360 instrument: chemical shifts are reported in δ (ppm) downfield from internal tetramethylsilane. Silica-gel plates (Merck F_{254}) were used for analytical tlc.

Materials.

The syntheses of the following compounds have been previously reported in the cited papers: **1, 2** and **3** [3]; **10, 11** and **12** [4]; **4** and **13** [7]; **5, 7** and **8** [8].

1-Methyl-3-phenyl-4-nitroso-5-benzoylamidopyrazole (**6**).

To an ice-cooled solution of compounds **5** (0.5 g) in glacial acetic acid (12.5 ml) and hydrochloric acid (1 ml) sodium nitrite (0.35 g) dissolved in little water was added under stirring. Upon standing a precipitate formed, green crystals, mp 151-152° (from ethanol), 58% yield; ir: 3260 (NH), 1680 (C=O) cm^{-1}; ^1H nmr (deuteriochloroform): 10.53 (br s, 1H, NH, it exchanges with deuterium oxide), 8.5-8.2 (m, 2H, benzene protons), 8.2-7.9 (m, 2H, benzene protons), 7.8-7.4 (m, 6H, benzene protons), 4.92 (s, 3H, NCH_3).

Anal. Calcd. for $C_{17}H_{14}N_4O_2$: C, 66.66; H, 4.71; N, 18.29. Found: C, 66.44; H, 4.78; N, 18.55.

1-Methyl-3-phenyl-5-(4-methylbenzoyl)amidopyrazole (**9**).

To a solution of compound **4** (1 g) in pyridine (2.5 ml) 4-methylbenzoyl chloride (1.3 ml) was added. The mixture was heated in a steam bath for 30 minutes. Upon addition of water a precipitate formed, white crystals, mp 156-158° (from ethyl acetate), 80% yield; ir: 3260 (NH), 1650 (C=O) cm^{-1}; ^1H nmr (deuteriochloroform): 8.2 (br s, 1H, NH, it exchanges with deuterium oxide), 7.9-7.6 (m, 4H, benzene protons), 7.5-7.1 (m, 5H, benzene protons), 6.47 (s, 1H, C_4 pyrazole proton), 3.70 (s, 3H, NCH_3), 2.35 (s, 3H, CH_3).

Anal. Calcd. for $C_{18}H_{17}N_3O$: C, 74.21; H, 5.88; N, 14.42. Found: C, 74.03; H, 6.00; N, 14.30.

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