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# $^{13}$C NMR Spectra of 4-Hydroxymethylpyrazoles and Their Chemical Behavior at Heating

**A. O. Baltayan[a], V. I. Rstakyan[a], S. K. Antanosyan[a], D. A. Tadevosyan[a], O. S. Attaryan[b], and G. V. Asratyan[b]**

[a] *Institute of Organic Chemistry, the National Academy of Sciences of Republic of Armenia,*
*ul. Zakaria Sarkavaga 167a, Yerevan, 375091 Armenia*
*e-mail: angelabaltayan@mail.ru*

[b] *Institute of Applied Chemistry "ARIAK" of Republic of Armenia, Yerevan, Armenia*

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**Abstract**—It was established that in the $^{13}$C NMR spectra of 4-hydroxymethylpyrazoles the carbon atom of hydroxymethyl group of 1,3,5-trimethyl-4-hydroxymethylpyrazole is deshielded by 6.28–6.78 ppm compared to 1-methyl-4-hydroxymethyl-, 1,3-dimethyl-4-hydroxymethyl- and 1,5-dimethyl-4-hydroxymethylpyrazoles. It is assumed that this difference is related to their dissimilar behavior at heating.

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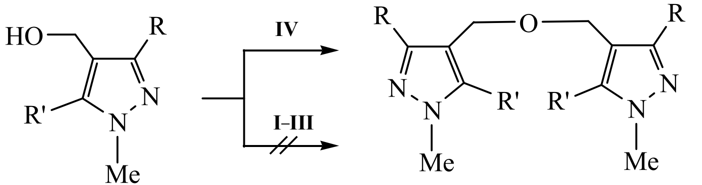
It was found that distillation of 1,3,5-trimethyl-4-hydroxymethylpyrazole **IV** led to the formation of the corresponding symmetrical ether **V** in ~90 % yield [1].

In order to ascertain the general nature of the detected cross-coupling of 4-hydroxymethylpyrazoles **I–III,** in this study we have carried out the synthesis of 1-methyl-4-hydroxymethylpyrazole **I**, 1,3-dimethyl-4-hydroxymethylpyrazole **II**, and 1,5-dimethyl-4-hydroxymethylpyrazole **III**.

The study showed that in contrast to 1,3,5-trimethyl-4-hydroxymethylpyrazole **IV** compounds **I–III** did not enter the cross-coupling reaction at distillation.



**I–IV**

**V**

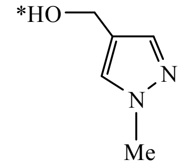
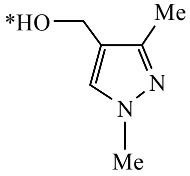
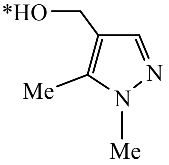
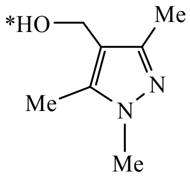
**I**: R = R' = H; **II**: R = CH$_3$, R' = H; **III**: R = H, R' = CH$_3$; **IV–V**: R = R' = CH$_3$.

The comparison of the $^{13}$C NMR spectral data listed in the table shows that in the compound **IV** the total electron density on the ring carbon atoms is reduced compared to compounds **I–III**, and chemical shifts in $^{13}$C NMR spectra in total increase, the difference is 7.28 ppm compared to **I**, 2.38 ppm compared to **II** and 3.54 ppm compared to **III**. This is due to the fact that in going from compound **I** to **IV** the electron density on the nitrogen atoms increases because of the influence of donor methyl groups. This is in agreement with the available literature data on the increase of the relative basicity of *N*-vinylpyrroles at the introduction into the ring of alkyl substituents [2]. A change in $^{13}$C NMR chemical shifts of 160–200 ppm corresponds to the full transition of one π-electron [3, 4].

Interestingly, in compound **IV** the carbon atom of hydroxymethyl group "feels" the increase in the electron density on the nitrogen atom and suffers a shift of its signal downfield by 6.28–6.70 ppm compared to compounds **I–III**.

This unexpected demonstration of the effect of "long-range" action most likely is due to the interaction of π-electronic systems through the nitrogen

Parameters of $^{13}C$ NMR spectra of 4-hydroxymethylpyrazoles **I–IV**

| Compounds **I–IV** | Chemical shifts, δ, ppm | | | | | | |
|---|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | ΣC | ΔΣC | C* | ΔC* |
|  | 132.27 | 121.95 | 127.28 | 385.50 | 7.28 | 54.36 | 6.28 |
|  | 145.51 | 118.63 | 127.26 | 391.40 | 2.38 | 54.29 | 6.35 |
|  | 137.32 | 118.02 | 134.90 | 390.24 | 3.54 | 53.94 | 6.7 |
|  | 145.28 | 112.35 | 136.15 | 393.78 | – | 60.64 | – |

heteroatoms of the molecules of compound **IV**. Deshielding of the carbon nucleus of hydroxymethyl group in compound **IV** is likely to cause its different behavior at the distillation as compared to compounds **I–III**.

## EXPERIMENTAL

IR spectra were taken on a Specord 75-UR instrument (thin layer), the $^1H$ and $^{13}C$ NMR spectra were recorded on a Varian Mercury device (300 MHz) from solutions in DMSO-$d_6$.

The original 4-formylpyrazoles are synthesized by known methods described in [5, 6], 1-methyl-4-formylpyrazole, bp 80–81°C (1 mm Hg), 1,3-Dimethyl-4-formylpyrazole, mp 50°C, 1,5-dimethyl-4-formylpyrazole, mp 60°C.

**1-Methyl-4-hydroxymethylpyrazole (I)**. To a cold solution of 0.1 mol of 1-methyl-4-formylpyrazole, 1.2 g of triethylbenzylammonium chloride in 50 ml of water over 1 h was added by portions 0.1 mol of sodium borohydride maintaining the temperature of the reaction mixture below 10°C. The mixture was stirred at cooling with ice water for 1 h, then at room temperature for 3 h. The solution was acidified with hydrochloric acid, the reaction mixture was neutralized with potassium carbonate, extracted with chloroform, and the extract was dried over magnesium sulfate. After distilling the solvent off, the residue was distilled in a vacuum.

Yield 81 %, bp 92–94°C (1 mm Hg), $n_D^{20}$ 1.5122, $d_4^{20}$ 1.0591. IR spectrum, ν, cm$^{-1}$: 1520 (heterocycle, ring), 3200–3400 (OH). $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm, *J* (Hz): 3.80 s (3H, N–$CH_3$), 3.92 br.t (1H, OH, *J* 3.4), 4.20 br.d (2H, $CH_2$, *J* 3.4), 7.74 s (1H, 3-H), 8.10 s (1H, 5-H). Found, %: C 53.28, H 6.84; N 25.57. $C_8H_5N_2O$. Calculated, %: C 53.57, H 7.14; N 25.00.

**1,3-Dimethyl-4-hydroxymethylpyrazole (II)**. Similarly, from 0.1 mol of 1,3-dimethyl-4-formylpyrazole in 82% yield was prepared compound **II**, bp 107–109°C (1 mm Hg), $n_D^{20}$ 1.5135, $d_4^{20}$ 1.0691. IR spectrum, ν, cm$^{-1}$: 1530 (heterocycle, ring), 3200–3400 (OH). $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm, *J* (Hz): 2.15 s (3H, 3-$CH_3$), 3.31 s (3H, N–$CH_3$), 3.84 br.t (1H, OH, *J* 3.5), 4.25 br.d (2H, $CH_2$, *J* 3.4), 8.15 s (1H, 5-H). Found, %: C 56.72, H 7.24; N 22.57. $C_6H_{10}N_2O$. Calculated, %: C 57.14, H 7.94; N 22.22.

**1,5-Dimethyl-4-hydroxymethylpyrazole (III)**. Prepared like preceding compound from 0.1 mol of 1,5-dimethyl-4-formylpyrazole in 85% yield, bp 115–117°C (1 mm Hg), mp 81–82°C. IR spectrum, ν, cm$^{-1}$: 1530 (heterocycle, ring), 3200–3400 (OH). $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm, *J* (Hz): 2.21 s (3H, 5-$CH_3$), 3.95 s (3H, N–$CH_3$), 3.85 br.t (1H, OH, *J* 3.5), 4.25 br.d (2H, $CH_2$, *J* 3.4), 7.62 s (1H, 3-H). Found, %: C 57.68, H 7.38; N 22.61. $C_6H_{10}N_2O$. Calculated, %: C 57.14, H 7.94; N 22.22.

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