

SHORT
COMMUNICATIONS

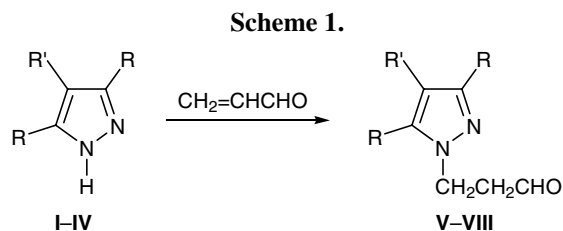
Structure of the Products of Acrolein Reactions with Pyrazoles

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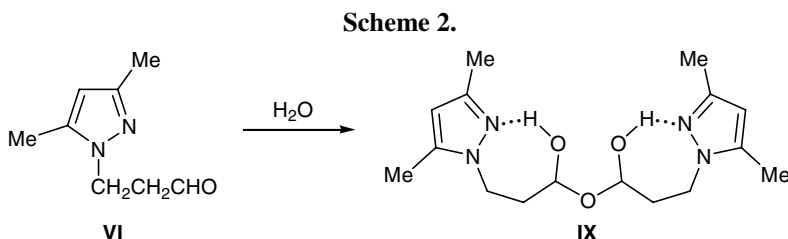
Pyrazoles **I–IV** reacted with acrolein to give 3-(1H-pyrazol-1-yl)propionaldehydes **V–VIII** in fairly high yields (Scheme 1).



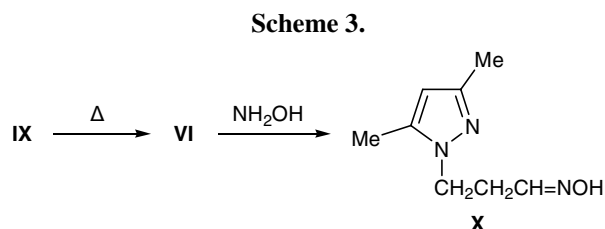
I, V, R = R' = H; **II, VI**, R = Me, R' = H; **III, VII**, R = Me,
R' = Cl; **IV, VIII**, R = Me, R' = Br.

The structure of compounds **V–VIII** was confirmed by the analytical and ¹H NMR data. Surprisingly, liquid compound **VI** on storage was transformed into crystalline product **IX** (Scheme 2) whose ¹H NMR spectrum lacked aldehyde proton signal (δ 9.74 ppm in the spectrum of **VI**), but a new signal appeared at δ 4.80 ppm. Absorption bands at 2720 and 1715 cm⁻¹, which are typical of aldehyde group, disappeared from the IR spectrum, and new absorption bands assignable to water molecules were observed at 3100–3500 and 1640 cm⁻¹ (δHOH). The structure of compound **IX** was unambiguously determined by X-ray analysis: it is

a product of condensation of two molecules of pyrazolylaldehyde **VI** with one water molecule. Molecule **IX** may be regarded as consisting of two 3-(3,5-dimethyl-1H-pyrazol-1-yl)propionaldehyde moieties linked through the O¹ atom (Fig. 1); the hydroxy groups of each part (O³–H³ and O¹⁴–H¹⁴) are involved in intramolecular hydrogen bonds with the pyridine-like nitrogen atom in the pyrazole ring of the other part (N¹⁸ and N⁷, respectively). The molecule is symmetric through a second-order symmetry axis which is not a crystallographic symmetry element (Fig. 1). Presumably, the intramolecular hydrogen bonds make the molecule conformationally more rigid. Molecules **IX** in crystal are packed together with water molecules (O²⁴) at a ratio of 2:1. The hydrogen atoms in H₂O form two intermolecular hydrogen bonds with the O¹⁴ atoms of two molecules **IX** (Fig. 2). Only one oxygen atom (O¹⁴) in each molecule **IX** participates in hydrogen bonding with water molecule. Thus the O¹⁴ atom in **IX** is involved in intramolecular hydrogen bond O¹⁴...H¹⁴...N⁷ and intermolecular hydrogen bond O²⁴...H²⁴...O¹⁴, while the other oxygen atom (O³) participates only in intramolecular hydrogen bonding O³...H³...N¹⁸. The bond lengths and bond angles in structure **IX** are consistent with the corresponding standard values.



Compound **IX** decomposed on heating to give initial pyrazolylaldehyde **VI**; treatment of the latter with hydroxylamine afforded the corresponding oxime **X** (Scheme 3).



It should be emphasized that the other pyrazolylaldehydes, both unsubstituted **V** and 4-halo-3,5-dimethylpyrazolyl derivatives **VII** and **VIII**, did not change on storage. Therefore, we concluded that the main factor responsible for the transformation of pyrazolylpropionaldehyde **VI** into compound **IX** is the possibility for hydrogen bonding with more nucleophilic pyridine-like nitrogen atoms in the pyrazole ring of **VI** (Fig. 1), as compared to **V**, **VII**, and **VIII**.

Initial pyrazoles **I–IV** were synthesized according to the procedures described in [1–3], and their physical constants coincided with published data.

3-(1H-Pyrazol-1-yl)propionaldehyde (V). A solution of 0.07 mol of acrolein in 20 ml of dioxane was added to a solution of 0.05 mol of pyrazole **I** in 20 ml of dioxane at such a rate that the temperature did not exceed 40°C, and the mixture was then stirred for 24 h at 40°C. The solvent was distilled off, and the residue was distilled under reduced pressure. Yield 80%, bp 85°C (1 mm), $n_D^{20} = 1.4996$, $d_4^{20} = 1.1230$. IR spectrum, ν , cm^{-1} : 1510 (ring), 1715 (C=O). ^1H NMR spectrum, δ , ppm: 2.99 t.d (2H, COCH₂, $J = 6.4$, 1.2 Hz), 4.42 t (2H, NCH₂, $J = 6.4$ Hz), 6.13 d.d (1H, 4-H, $J = 2.3$, 1.9 Hz), 7.32 d (1H, 3-H, $J = 1.9$ Hz), 7.53 d (1H, 5-H, $J = 2.3$ Hz), 9.74 t (1H, CHO, $J = 1.2$ Hz). Found, %: C 58.12; H 6.38; N 22.65. C₆H₈N₂O. Calculated, %: C 58.06; H 6.45; N 22.58.

3-(3,5-Dimethyl-1H-pyrazol-1-yl)propionaldehyde (VI) was synthesized in a similar way from 3,5-dimethyl-1H-pyrazole (**II**). Yield 85%, bp 95°C (1 mm), $n_D^{20} = 1.4988$. IR spectrum, ν , cm^{-1} : 1530 (ring), 1715 (C=O). ^1H NMR spectrum, δ , ppm: 2.10 s and 2.26 s (3H each, CH₃), 2.96 t.d (2H, COCH₂, $J = 6.4$, 1.1 Hz), 4.17 t (2H, NCH₂, $J = 6.4$ Hz), 5.65 s (1H, 4-H), 9.74 t (1H, CHO, $J = 1.1$ Hz). Found, %: C 63.28; H 7.78; N 18.28. C₈H₁₂N₂O. Calculated, %: C 63.16; H 7.89; N 18.42.

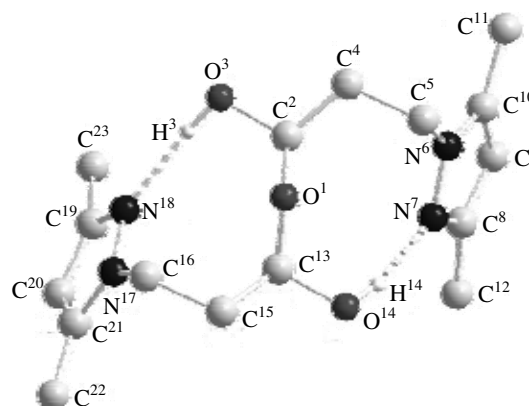


Fig. 1. Structure of the molecule of 1,1'-oxybis[3-(3,5-dimethyl-1H-pyrazol-1-yl)propan-1-ol] (**IX**) according to the X-ray diffraction data. Hydrogen atoms are not shown. Intramolecular hydrogen bonds are shown with dashed lines.

3-(4-Chloro-3,5-dimethyl-1H-pyrazol-1-yl)propionaldehyde (VII) was synthesized in a similar way from 4-chloro-3,5-dimethyl-1H-pyrazole (**III**). Yield 75%, bp 110°C (1 mm), crystallized on storage, mp 98–99°C. IR spectrum, ν , cm^{-1} : 1525 (ring), 1571 (C=O). ^1H NMR spectrum, δ , ppm: 2.10 s and 2.25 s (3H each, CH₃), 2.95 t.d (2H, COCH₂, $J = 6.4$, 1.2 Hz), 4.1 t (2H, NCH₂, $J = 6.4$ Hz), 9.70 t (1H, CHO, $J = 1.1$ Hz). Found, %: C 51.40; H 5.95; Cl 19.34; N 14.98. C₈H₁₁ClN₂O. Calculated, %: C 51.49; H 5.90; Cl 19.01; N 15.02.

3-(4-Bromo-3,5-dimethyl-1H-pyrazol-1-yl)propionaldehyde (VIII) was synthesized in a similar way from 4-bromo-3,5-dimethyl-1H-pyrazole (**IV**). Yield 80%, bp 120°C (1 mm), crystallized on storage, mp 124–126°C. IR spectrum, ν , cm^{-1} : 1530 (ring), 1571 (C=O). ^1H NMR spectrum, δ , ppm: 2.10 s and 2.25 s (3H each, CH₃), 2.95 t.d (2H, COCH₂, $J = 6.4$, 1.2 Hz), 4.1 t (2H, NCH₂, $J = 6.4$ Hz), 9.71 t (1H, CHO, $J = 1.1$ Hz). Found, %: C 41.50; H 4.70; Br 34.58; N 12.31. C₈H₁₁BrN₂O. Calculated, %: C 41.56; H 4.76; Br 34.63; N 12.20.

1,1'-Oxybis[3-(3,5-dimethyl-1H-pyrazol-1-yl)propan-1-ol] (IX). Pyrazolylpropionaldehyde **VI** crystallized on storage to give compound **IX**, mp 85–95°C. IR spectrum, ν , cm^{-1} : 1530 (ring); 3100–3500 (OH), 1640 (δOH). ^1H NMR spectrum, δ , ppm: 1.91 t.d (4H, CH₂, $J = 6.7$, 5.6 Hz), 2.10 s and 2.24 s (6H each, CH₃), 3.95–4.10 m (4H, NCH₂), 4.80 t (2H, CH, $J = 5.6$ Hz), 5.67 s (2H, 4-H), 6.19 br (2H, HOH). Found, %: C 60.55; H 7.95; N 16.80. C₁₆H₂₄N₄O₃. Calculated, %: C 60.00; H 7.50; N 17.50.

3-(3,5-Dimethyl-1H-pyrazol-1-yl)propionaldehyde oxime (X). A mixture of 0.075 mol of hydroxyl-

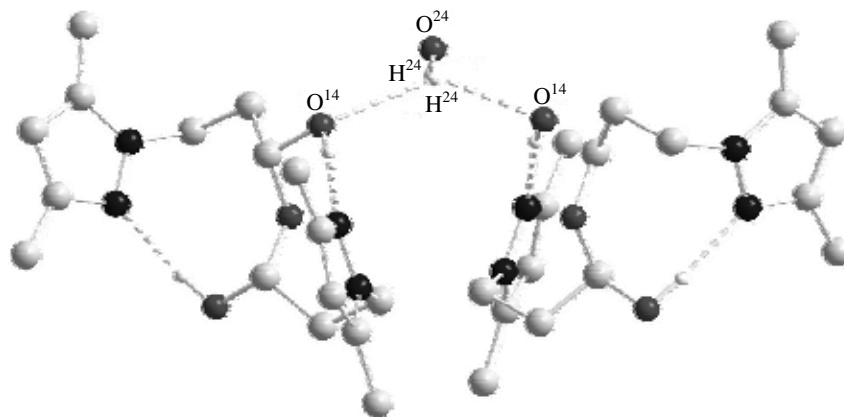


Fig. 2. Formation of dimeric structures by molecules of 1,1'-oxybis[3-(3,5-dimethyl-1H-pyrazol-1-yl)propan-1-ol] (**IX**) and water in crystal.

amine and 0.05 mol of compound **IX** in 30 ml of ethanol was heated for 5 h under reflux. The solvent was removed under reduced pressure, and the crystals were filtered off and dried. Yield 90%, mp 85°C. IR spectrum, ν , cm^{-1} : 1530 (ring), 1640 (CH), 3100–3300 (OH). ^1H NMR spectrum, δ , ppm: *syn* isomer: 2.10 s and 2.25 s (3H each, CH_3), 2.70 t.d (2H, CH_2 , $J = 7.2$, 5.4 Hz), 4.06 t (2H, NCH_2 , $J = 7.2$ Hz), 5.65 s (1H, 4-H), 7.25 t (1H, NCH , $J = 5.4$ Hz), 10.77 s (1H, OH); *anti* isomer: 2.10 s (3H, CH_3), 2.95 t.d (1H, CH_2 , $J = 7.2$, 5.4 Hz), 4.05 t (2H, NCH_2 , $J = 7.2$ Hz), 5.65 s (1H, 4-H), 6.59 t (1H, NCH , $J = 5.4$ Hz), 10.32 s (1H, OH).

The ^1H NMR spectra were recorded on a Varian Mercury-300 spectrometer (300 MHz). The IR spectra were obtained on a Specord 75IR spectrometer from thin films. The products were analyzed by GLC on an LKhM-8MD chromatograph [1.5-m \times 3-mm column packed with 10% of Carbowax-20M on Inerton AW-HMDS (0.20–0.25 mm); carrier gas helium, flow rate 50 ml/min].

X-Ray diffraction study. Crystals of compound **IX** suitable for X-ray analysis were obtained by slow crys-

tallization from dioxane. Reflection intensities were measured from a 0.25 \times 0.3 \times 0.35-mm crystal on an Enraf–Nonius CAD-4 automatic diffractometer; 4354 independent reflections were measured. Monoclinic crystal system, space group $C2/c$; $a = 27.851(6)$, $b = 7.927(2)$, $c = 17.024(3)$ Å; $\beta = 106.18(3)^\circ$. The structure was solved by the direct method using SHELXTL program. The coordinates of hydrogen atoms were determined from the Fourier difference syntheses of electron density. In the final step, the coordinates of all atoms (including hydrogen atoms) and anisotropic thermal parameters of non-hydrogen atoms were refined by the full-matrix least-squares procedure. The complete set of crystallographic data for compound **IX** is available from the authors.

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