ipso- and *tele*-Substitution in reactions of 3-chloro-1-ethyl-2-R-pyrazinium salts with C-nucleophiles*

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The reactions of 2,3-dichloro- and 3-chloro-1-ethyl-2-morpholinopyrazinium tetrafluoroborates with compounds containing the active methylene group were studied. The reactions with malonodinitrile and cyanoacetic ester afford products of *ipso*-substitution at position 2, while 1,3-dicarbonyl compounds produce products of *tele*-substitution of the Cl atom at the C(3) atom due to the attack of a nucleophile to position 6 of the pyrazine cycle.

Key words: *N*-ethylchloropyrazinium salts, C-nucleophiles, nucleophilic substitution, NMR spectra.

Great attention has recently[1—5] been given to problems of nucleophilic substitution in the aromatic ring containing nucleophugic groups (Cl, Br, SO_2Me, NO_2, and others) along with unsubstituted C atoms in activated positions. The attack to the unsubstituted C atom occurs rapidly, as a rule, but aromatization of the formed σ^H-adducts is hindered. The latter usually requires an external oxidant to remove the H atom from the geminal node or auxiliary groups capable of eliminating in the form of an anion from the different position of the σ^H-adducts (variants of *kine*- and *tele*-substitution). Several examples of competing processes of *ipso*- and *tele*-substitution in the series of chloropyrimidines,[3] chloropyrazines,[4] chloronaphthiridines,[5] and other halogen-containing azines[2] were published. In this work, quaternary 1-ethylpyrazinium salts containing nucleophugic groups in positions 2 and 3 became the objects of the study for the first time.

We have previously[6] reported that 2,3-dichloro-1-ethylpyrazinium cation (**1**) prepared by the alkylation of 2,3-dichloropyrazine by triethyloxonium tetrafluoroborate readily reacts with different amines to substitute one or two chlorine atoms by the amine residue. In particular, the reaction of salts **1** with morpholine affords salt **2** in which the chlorine atom at the C(2) atom is replaced by the morpholine residue. Salt **2** has positions activated for the nucleophilic attack, *viz.*, C(2) and C(6), and a fairly mobile chlorine atom at the C(3) atom. Since the morpholine residue is rather bulky and can prevent the nucleophilic attack to this position, it could be assumed that the C(3) and C(6) positions would be the main reaction centers in cation **2** at a reduced activity of the C(2) position. This creates favorable prerequisites for *tele*-substitution compared to the 2,3-dichloropyrazinium cation. The position of the nucleophilic attack in 1-alkylpyrazinium salts is shown[7—11] to depend on the nature of the nucleophile and substituents in the heterocycle, and the reactions can include heterocycle opening and transformations.

The purpose of this work is to study the reactions of 2,3-dichloro-1-ethylpyrazinium (**1**) and 3-chloro-1-ethyl-2-morpholinopyrazinium (**2**) tetrafluoroborates with C-nucleophiles.

It is established that carbanions generated from malononitrile, cyanoacetic ester, and β-dicarbonyl compounds in the presence of bases (alkoxides, secondary and tertiary amines) attack the C(2) and C(6) positions of the heterocycle (Scheme 1) to yield products of *ipso*- (**3a**,**b**) and *tele*-substitution (**7a**—**e**), and sometimes we succeeded to detect intermediate σ-adducts (**6b**,**c**). In addition, when morpholine is used as a base, *ipso*- and *tele*-substitutions

Table 1. Ratio of products (%) in the reaction mixtures of salt **2** with C-nucleophiles ZCH_2Y and morpholine (1 : 1 : 2) in CD_3CN after 0.5 h (^{1}H NMR data)

Z	Y	Reaction products (%)				
		3	**4**	**5**	**6**	**7**
CN	CN	73	22	4	—	<1
CN	COOEt	32	24	6	2	35
COOEt	COOEt	—	—	31	9	59
COOEt	COMe	—	—	77	—	22
COMe	COMe	—	—	88	—	12

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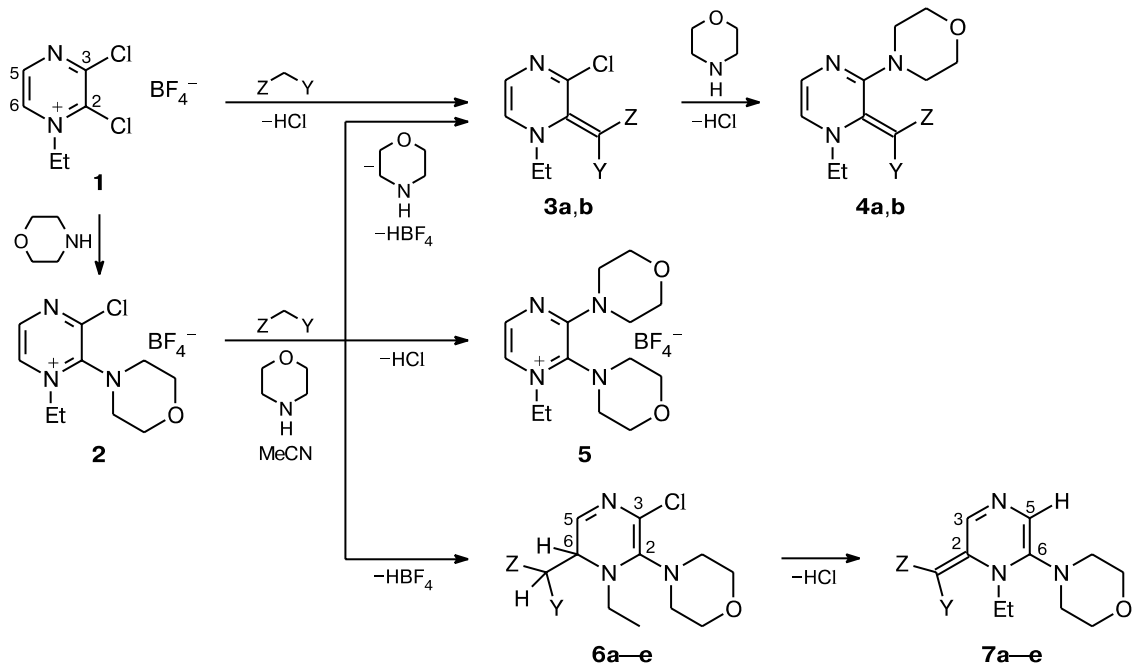
Scheme 1



Y = Z = CN (**3a**, **4a**), Y = COOEt, Z = CN (**3b**, **4b**)
Y = Z = CN (**6a**, **7a**), COOEt (**6c**, **7c**), COMe (**6e**, **7e**); Z = COOEt, Y = CN (**6b**, **7b**), COMe (**6d**, **7d**)

by the C-nucleophile are accompanied by the expected competitive reaction with amine resulting in the products of replacement of the chlorine atom at the C(3) atom (**4a**,**b** and **5**) (Scheme 1, Table 1).

According to the ^{1}H NMR data, the ratio of the reaction products depends substantially on the character of the Z and Y groups in the C-nucleophile ZCH_2Y.

The obtained results show that the C(2) position in the cation of **2** remains, most likely, most reactive. Indeed, salt **2** reacts with dinitriles $NCCH_2CN$ and $NCCH_2COOEt$ in the presence of bases to form, first, 2-ylidene derivatives **3a**,**b**. The latter react subsequently with secondary amine at the C(3) atom to form products **4a**,**b**. This sequence follows from the structure of compounds **3** and **4** and is confirmed by their synthesis from salt **1** (see Scheme 1).

In the ^{1}H NMR spectra of compounds **3** and **4**, the H(5) and H(6) protons of the pyrazine ring appear as two characteristic doublets with a vicinal constant of ~4 Hz. They are difficult to assign unambiguously, except for the spectrum of compound **3a** in $CDCl_3$ in which the signal from H(6) is broadened due to the additional interaction with protons of the NCH_2 group (Table 2). The arrangement of substituents in the structure of **4b** was unambiguously established by X-ray diffraction analysis (Fig. 1).

Unlike the reactions with nitriles, salt **2** reacts with carbanions of 1,3-dicarbonyl compounds at room temperatures in MeCN to form predominantly considerable amounts of products of *tele*-substitution of the chlorine atom at the C(3) atom in **7c**—**e** (see Table 1). Compound **7d** formed in the reaction with acetoacetic ester was isolated in the crystalline state, and its structure was confirmed by the data of mass spectrometry, elemental analysis, IR spectroscopy, and ^{1}H and ^{13}C NMR spectroscopy including the 2D HMQC and HMBC methods. In the ^{1}H NMR spectrum of compound **7d**, signals from the H(3) and H(5) protons of the pyrazine ring appear as singlets, whose assignment and determination of the con-

Table 2. Characteristics of the ^{1}H NMR spectra (δ, *J*/Hz) of compounds **3** and **4**

Compound, solvent	H(5)*		H(6)*		NCH_2	
	δ	$J_{5,6}$	δ	$J_{5,6}$	δ	$J_{H,H}$
3a, DMSO-d	8.12	4.1	7.87	4.1	4.40	7.1$_6$
3a, CD_3CN	7.67	4.2	7.63	4.2	4.42	7.2
3a, $CDCl_3$	7.56	4.1	7.25 br	4.1	4.42	7.0
3b, $CDCl_3$	7.86	4.0	7.60	4.0	—**	
3b, CD_3CN	8.00	4.0	7.83	4.0	—**	
4a, CD_3CN	7.42	4.3	7.13	4.3	4.33	7.1
4b, $CDCl_3$	7.90	4.0	7.26	4.0	—**	
4b, CD_3CN	7.96	4.0	7.54	4.0	4.23	7.2

* An alternative assignment of signals of the H(5) and H(6) atoms is possible.
** Superposition of signals from OEt and NEt.

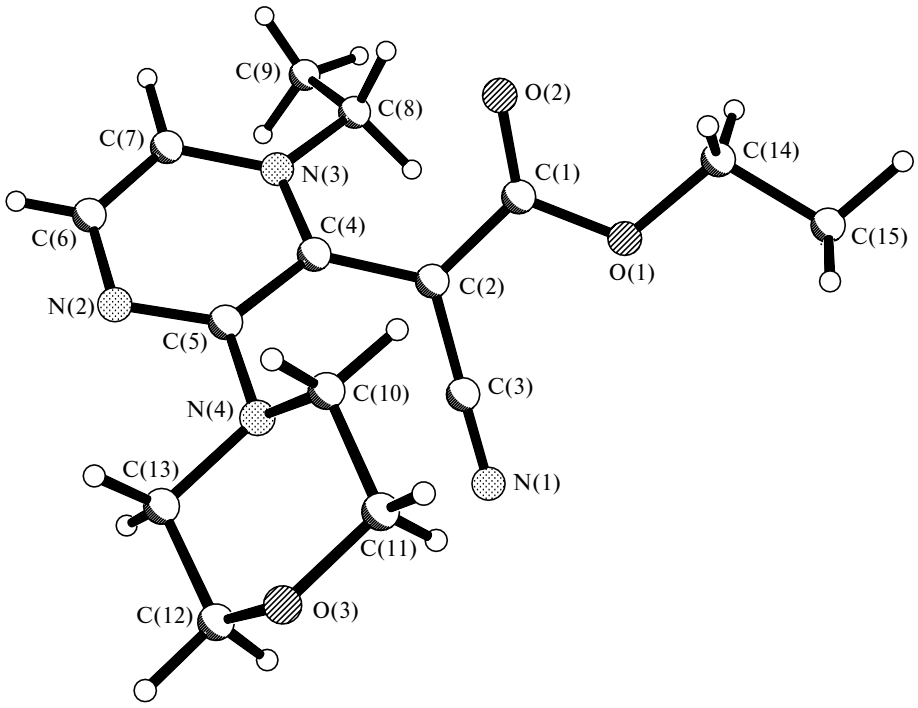


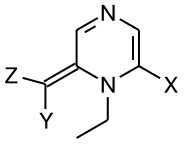
Fig. 1. Molecular structure of compound **4b**.

figuration of the compound were based on the 2D NOESY experiment. The cross peaks of $COOC\underline{H}_2$—$\underline{H}$(3) and $COC\underline{H}_3$—$NC\underline{H}_2Me$ allow one to establish the orientation of substituents at the double bond and conclude that the synthesized compound was the *E* isomer (Z = COOEt, Y = COMe, Scheme 1).

We could not preparatively isolate products **7b**,**c**,**e** because of the complicated composition of the reaction mixtures and/or their low content. The reaction of salt **2** with 5,5-dimethylcyclohexane-1,3-dione in the presence of morpholine (2 equiv.) occurred much more rapidly, and *tele*-substitution product **7f** was preparatively obtained in 46% yield, whereas by-product **5** was not detected at all.

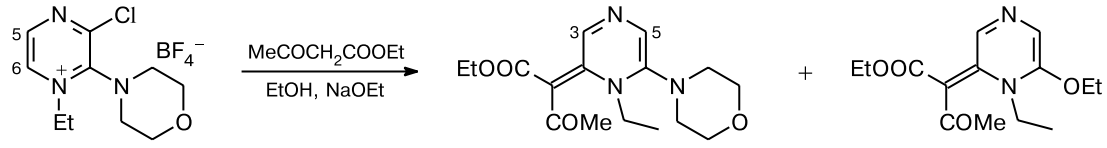
To prevent the formation of compound **5** in the reactions of salt **2** with 1,3-dicarbonyl compounds, we replaced morpholine by Et_3N. In this case, the ^1H NMR spectra of the reaction mixture were difficult to examine because of the increased amount of the reaction products, so that we could estimate only the ratio of compounds **7** and **6** in the mixture. It was 0.0 : 1.0 for the **7c**/**6c** pair, 2.2 : 7.8 for the **6d**/**7d** pair, and 0.9 : 9.1 for **7e**/**6e**. It is worth mentioning that the fraction of adducts **6c**—**e** increased compared to that in the reaction in the presence of morpholine (see Tables 1 and 3). This allows the reliable detection in mixtures to be performed by ^1H NMR in CD_3CN from the characteristic signal of the proton at the sp^3-hybridized C(6) atom as a doublet of doublets at 4.5—4.7 ppm with the spin-spin coupling constant $^3J_{H,H} \approx$ 10.5 Hz with the YCHZ fragment and $J_{5,6}$ = 3.7 Hz (see Table 3), which is typical of the σ^H-adducts of C-nucleophiles with 1,4-diazinium salts.[12,13]

When MeCN is replaced by EtOH, the yields of products of the attack to the C(6) position increase. For example, in the reaction of salt **2** with acetoacetic ester in EtOH in the presence of EtONa, the yield of compound **7d** increases slightly (to 27%), and ethoxy derivative **8** forms in parallel in 12% yield (Table 4, Scheme 2).



Compounds **7** and **8** can be considered as products of nucleophilic substitution of hydrogen, formed by the

Scheme 2



2 **7d** **8**

Table 3. Characteristics of the ^{1}H NMR spectra of σ-adducts **6** (in CD_3CN)

Compound	H(5)		H(6)		CHXY	
	δ	$J_{2,3}$/Hz	δ	$J_{i,j}$/Hz	δ	J/Hz
6c	6.69	3.7	4.52	3.7; 11.0	3.47	11.0
6e	6.65	3.7	4.65	3.7; 10.5	—	—
6d	6.60	3.7	4.68	3.7; 10.2	4.00	10.2

Table 4. Chemical shifts of the H(3) and H(5) protons in the ^{1}H NMR spectra of the products of *tele*-substitution of the chlorine atom

Compound	Y	Z	Solvent	δ	
				H(3)	H(5)
7b	CN	COOEt	CD_3CN	8.61	7.92
7c	COOEt	COOEt	CD_3CN	8.60	7.93
7d	COMe	COOEt	CD_3CN	8.61	7.92
			$CDCl_3$	8.74	7.79
7e	COMe	COMe	CD_3CN	8.92	8.43
7f	$COCH_2C(Me)_2CH_2CO$		$CDCl_3$	9.00	8.03
8	COMe	COOEt	$CDCl_3$	8.69	8.07

autoaromatization of adducts **6** due to the elimination of the proton and chloride anion from the remote (*tele*) position.[1]

Thus, the reactions of chloropyrazinium salts **1** and **2** with C-nucleophiles exhibit the dependence of the ratio of *ipso*- and *tele*-substitution products on the structure of substituents Z and Y at the carbanionic center. C-Nucleophiles bearing fairly small CN groups preferentially attack the C(2) position, whereas 1,3-dicarbonyl compounds attack the unsubstituted C(6) position.

Experimental

Mass spectra were obtained on a Varian MAT-311A spectrometer with an accelerating voltage of 3 kV and an energy of ionizing electrons of 70 eV, and the direct injection of a sample into the source. 2D NMR experiments were performed and ^{1}H and ^{13}C NMR spectra were recorded on a Bruker DRX 400 spectrometer with a working frequency of 400 MHz. IR spectra were recorded on a Specord spectrometer.

X-ray diffraction analysis of compound **4b** was carried out on a Bruker AXS SMART 1000 diffractometer. Crystals **4b** ($C_{15}H_{20}N_4O_3$) existed in the orthorhombic system, 0.8×0.3×0.05 mm, space group *Pbca*, unit cell parameters: a = 9.235(6) Å, b = 17.043(11) Å, c = 38.88(2) Å, α = β = γ = 90°. Hydrogen atoms were localized from difference syntheses and refined isotropically. The structure was solved by the direct method using the SHELXS97 program and refined by the SHELXL97 program using the least-squares method in the anisotropic (isotropic for H atoms) approximation to R = 0.057 [$wR(F^2)$ = 0.081] for 6058 reflections with $F^2 \geq 2\sigma$. The main bond lengths and bond angles are presented in Table 5.

Table 5. Bond lengths (d) and bond angles (ω) in compound **4b**

Bond	d/Å	Angle	ω/deg
O(1)—C(1)	1.350(3)	C(1)—O(1)—C(14)	115.4(2)
O(1)—C(14)	1.461(4)	C(12)—O(3)—C(11)	110.0(2)
O(2)—C(1)	1.240(3)	C(5)—N(2)—C(6)	117.5(3)
O(3)—C(12)	1.433(4)	C(4)—N(3)—C(7)	120.8(3)
O(3)—C(11)	1.436(4)	C(4)—N(3)—C(8)	119.7(2)
N(1)—C(3)	1.150(3)	C(7)—N(3)—C(8)	119.1(3)
N(2)—C(5)	1.321(3)	C(5)—N(4)—C(13)	116.1(2)
N(2)—C(6)	1.347(4)	C(5)—N(4)—C(10)	115.7(2)
N(3)—C(4)	1.374(3)	C(13)—N(4)—C(10)	109.5(2)
N(3)—C(7)	1.370(3)	O(2)—C(1)—O(1)	122.4(3)
N(3)—C(8)	1.502(4)	O(2)—C(1)—C(2)	124.7(3)
N(4)—C(5)	1.399(3)	O(1)—C(1)—C(2)	112.9(3)
N(4)—C(13)	1.479(4)	C(3)—C(2)—C(4)	117.7(3)
N(4)—C(10)	1.487(4)	C(3)—C(2)—C(1)	119.6(3)
C(1)—C(2)	1.458(4)	C(4)—C(2)—C(1)	122.4(3)
C(2)—C(3)	1.421(4)	N(1)—C(3)—C(2)	176.6(3)
C(2)—C(4)	1.434(4)	N(3)—C(4)—C(2)	121.2(3)
C(4)—C(5)	1.455(4)	N(3)—C(4)—C(5)	115.4(3)
C(6)—C(7)	1.358(4)	C(2)—C(4)—C(5)	123.4(3)
C(8)—C(9)	1.512(5)	N(2)—C(5)—N(4)	118.1(3)
C(10)—C(11)	1.521(4)	N(2)—C(5)—C(4)	123.2(3)
C(12)—C(13)	1.508(4)	N(4)—C(5)—C(4)	118.6(3)
C(14)—C(15)	1.500(5)	N(2)—C(6)—C(7)	123.3(3)
		C(6)—C(7)—N(3)	119.4(3)
		N(3)—C(8)—C(9)	113.8(3)
		N(4)—C(10)—C(11)	109.6(3)
		O(3)—C(11)—C(10)	111.4(3)
		O(3)—C(12)—C(13)	111.8(3)
		N(4)—C(13)—C(12)	108.9(3)
		O(1)—C(14)—C(15)	107.3(3)

Standard procedure for studying mixtures of products of the reactions of salt 2 with C-nucleophiles by ^{1}H NMR. A solution of salt **2** (15.78 mg, $5 \cdot 10^{-5}$ mol) in CD_3CN (0.25 mL) was added by a solution of C-nucleophile ($5 \cdot 10^{-5}$ mol) in CD_3CN (0.25 mL) in the presence of amine ($1 \cdot 10^{-4}$ mol). After 0.5 h, the resulting solution was filtered off, and the ^{1}H NMR spectrum of the obtained reaction mixture was recorded. Signals of the unreacted salt **2** and hydrolysis products were ignored when analyzing the ratio of the reaction products.

Ethyl (3-chloro-1-ethyl-1,2-dihydropyrazin-2-ylidene)cyanoacetate (3b). A solution of 2,3-dichloro-1-ethylpyrazinium tetrafluoroborate (**1**)[6] (106 mg, 0.4 mmol) in MeCN (2 mL) was added with stirring by a solution of $NCCH_2COOEt$ (42.6 μL, 0.4 mmol) in MeCN (1 mL) in the presence of Et_3N (112 μL, 0.8 mmol). The solvent was distilled off, and the residue was separated on alumina eluting with an ethyl acetate—hexane (1 : 1) mixture. Red crystals of ester **3b** were obtained, m.p. 136—138 °C (from hexane). The yield was 86 mg (86%). Found (%): C, 52.07; H, 4.46; N, 16.45. $C_{11}H_{12}ClN_3O_2$. Calculated (%): C, 52.08; H, 4.77; N, 16.56. ^{1}H NMR ($CDCl_3$), δ: 7.86 and 7.60 (both d, 1 H each, H(5), H(6), J = 4.1 Hz); 4.25 (q, 2 H, J = 7.1 Hz) and 4.18 (q, 2 H, J = 7.2 Hz) (OCH_2 and NCH_2); 1.56 (t, 3 H, Me, J = 7.2 Hz); 1.34 (t, 3 H, Me, J = 7.1 Hz).

2-(3-Chloro-1-ethyl-1,2-dihydropyrazin-2-ylidene)malonodinitrile (3a) was obtained similarly in 46% yield as an orange product with m.p. 121—122 °C. Found (%): C, 52.33; H, 3.28; N, 27.33. $C_9H_7ClN_4$. Calculated (%): C, 52.31; H, 3.41; N, 27.11. ^{1}H NMR ($CDCl_3$), δ: 7.56 (d, 1 H, H(5), J = 4.2 Hz); 7.25 (d, 1 H, H(6), J = 4.2 Hz); 4.42 (q, 2 H, NCH_2, J = 7.2 Hz); 1.63 (t, 3 H, $NCH_2C\underline{H}_3$, J = 7.0 Hz); DMSO-d_6: 8.13, 7.87 (both d, 1 H each, H(5) and H(6), J = 4.1 Hz); 4.40 (q, 2 H, NCH_2, J = 7.1 Hz); 1.63 (t, 3 H, $NCH_2C\underline{H}_3$, J = 7.1 Hz).

Ethyl (1-ethyl-3-morpholino-1,2-dihydropyrazin-2-ylidene)cyanoacetate (4b). A solution of 3-chloro-2-morpholinopyrazinium tetrafluoroborate (**2**) (126 mg, 0.4 mmol) in MeCN (3 mL) was added by a suspension of Bu^{t}OK (45 mg, 0.4 mmol) in MeCN (4 mL) in the presence of $NCCH_2COOEt$ (48 μL 0.4 mmol). The mixture was stirred on a magnetic stirrer for 20 min, the solvent was distilled off, and the residue was chromatographed on silica gel with ethyl acetate as eluent. Compounds **3b** (15 mg, 14%) and **4b** (44 mg, 40%) were obtained as red crystals, m.p. 120—121 °C (from hexane). Found (%): C, 59.31; H, 6.71; N, 18.22. $C_{15}H_{20}N_4O_3$. Calculated (%): C, 59.20; H, 6.62; N, 18.41. ^{1}H NMR ($CDCl_3$), δ: 7.90 and 7.26 (both d, 1 H each, H(5) and H(6), J = 4.0 Hz); 4.2 (m, 4 H, NCH_2 and OCH_2); 3.93 (m, 4 H, $C\underline{H}_2OC\underline{H}_2$); 3.48 (m, 4 H, $C\underline{H}_2NC\underline{H}_2$); 1.53 (t, 3 H, J = 7.2 Hz) and 1.32 (t, 3 H, J = 7.0 Hz) ($NCH_2C\underline{H}_3$ and $OCH_2C\underline{H}_3$). ^{13}C NMR ($CDCl_3$), δ: 166.93 (C(2)); 142.83 (C(3)); 160.09 ($\underline{C}OOEt$); 135.51 (C(5)); 122.24 (C(6)); 120.34 ($\underline{C}N$); 66.23 ($\underline{C}H_2O\underline{C}H_2$); 60.07 ($OCH_2$); 59.08 ($NC\underline{C}COOEt$); 53.51 ($NCH_2$); 49.06 ($\underline{C}H_2N\underline{C}H_2$); 14.76 and 14.44 ($NCH_2\underline{C}H_3$ and $OCH_2\underline{C}H_3$). IR ($CHCl_3$), ν/cm^{-1}: 2175 (CN), 1640 (CO).

2-(1-Ethyl-3-morpholino-1,2-dihydropyrazin-2-ylidene)malonodinitrile (4a) was synthesized similarly and obtained in the form of yellow crystals with m.p. 138 °C. The yield was 26%. Found (%): C, 60.32; H, 5.64; N, 27.24. $C_{13}H_{15}N_5O$. Calculated (%): C, 60.69; H, 5.88; N, 27.22. ^{1}H NMR (CD_3CN), δ: 7.42, 7.12 (both d, 1 H each, H(5) and H(6), J = 4.2 Hz); 4.33 (q, 2 H, NCH_2, J = 7.2 Hz); 3.85 (m, 4 H, $C\underline{H}_2OC\underline{H}_2$); 3.21 (m, 4 H, $C\underline{H}_2NC\underline{H}_2$); 1.48 (t, 3 H, CH_3, J = 7.2 Hz).

Ethyl 2-(1-ethyl-6-morpholino-4-(1,2-dihydropyrazin-2-ylidene)-3-oxobutanate (7d). A solution of salt **2** (946 mg, 3 mmol) in MeCN (10 mL) in the presence of acetoacetic ester (381 μL, 3 mmol) was added dropwise with stirring by piperidine (495 μL, 6 mmol). The formed precipitate of piperidine hydrochloride was filtered off, and MeCN was distilled off. The residue was chromatographed on silica gel, eluting yellow products with a MeCN—PhH (1 : 1) mixture. An orange product remained on silica gel was isolated eluting with a CH_2Cl_2—MeOH (9 : 1) mixture and recrystallized from *n*-heptane. The dark red precipitate was obtained (78 mg, 8%), m.p. 130—132 °C. ^{1}H NMR ($CDCl_3$), δ: 8.74 (s, 1 H, H(3)); 7.74 (s, 1 H, H(5)); 4.38 (q, 2 H, NCH_2, J = 7.0 Hz); 4.21 (q, 2 H, OCH_2, J = 7.1 Hz); 3.88 (m, 4 H, CH_2OCH_2); 3.19 (m, 4 H, CH_2NCH_2); 2.47 (s, 3 H, COMe); 1.29 (t, 3 H, $NCH_2C\underline{H}_3$, J = 7.0 Hz); 1.28 (t, 3 H, $OCH_2C\underline{H}_3$, J = 7.1 Hz). ^{13}C NMR ($CDCl_3$), δ: 190.28 (q, $Me\underline{C}O$, ^2J = 5.9 Hz); 167.78 (t, $\underline{C}OOCH_2$, ^3J = 3.1 Hz); 154.52 (dtd, C(3)$\underline{H}$, NCH_2, $\underline{C}$(2), ^2J = 12.6 Hz, ^3J = 3.6 Hz); 150.25 (dd, C(5)$\underline{H}$, $\underline{C}$(3), ^1J = 199.6 Hz, ^3J = 10 Hz); 149.19 (dm, C(5)H, $\underline{C}$(6), ^2J = 7.7 Hz); 127.59 (ddd, C(3)H, C(5), ^1J = 188.9 Hz, ^3J = 12.7 Hz); 98.61 (s, MeCO)$\underline{C}$, COOEt); 66.16 (tm, $H_2\underline{C}OC\underline{C}H_2$, ^1J = 144.3 Hz); 59.11 (tq, $OCH_2C\underline{H}_3$, $O\underline{C}H_2Me$, ^1J = 146.5 Hz, ^2J = 4.4 Hz); 52.78 (tq, $N\underline{C}H_2Me$, ^1J = 145.8 Hz, ^2J = 4.2 Hz); 51.32 (tm, $\underline{C}H_2N\underline{C}H_2$, ^1J = 137.9 Hz); 29.83 (q, $CO\underline{C}H_3$, ^1J = 127.8 Hz); 14.99 (qt, $NCH_2\underline{C}H_3$, ^1J = 128.9 Hz, ^2J = 3.6 Hz); 14.58 (qt, $OCH_2\underline{C}H_3$, ^1J = 126.6, ^2J = 2.5). Found (%): C, 59.76; H, 7.56; N, 13.00. $C_{16}H_{23}N_3O_4$. Calculated (%): C, 59.80; H, 7.21; N, 13.01.

Reaction of salt 2 with acetoacetic ester. A solution of salt **2** [6] (158 mg, 0.5 mmol) in ethanol (3 mL) was added dropwise with stirring by a solution of acetoacetic ester (190 μL, 1.5 mmol) in ethanol (2 mL) in the presence of sodium (23 mg, 1 mmol). Ethanol was distilled off on a rotary evaporator, and the residue was separated on silica gel eluting first with acetone and then with a MeOH—CH_2Cl_2 (1 : 10) mixture. Compound **7d** (44 mg, 27%) and ethyl 2-(1-ethyl-6-ethoxy-1,2-dihydropyrazin-2-ylidene)-3-oxobutanate (**8**) (17 mg, 12%) were obtained as a red precipitate, m.p. 135 °C (from heptane). Found (%): C, 59.76; H, 6.78; N, 10.23. $C_{14}H_{20}N_2O_4$. Calculated (%): C, 59.98; H, 7.19; N, 9.99. ^{1}H NMR ($CDCl_3$), δ: 8.69 (s, 1 H, H(3)); 8.07 (s, 1 H, H(5)); 4.5 (m, 4 H, $NC\underline{H}_2$, $OC\underline{H}_2$) and 4.12 (q, 2 H, $COOC\underline{H}_2$, J = 7.0 Hz); 2.50 (s, 3 H, COMe); 1.62 (t, 3 H, Me, J = 7.0 Hz); 1.33 (t, 3 H, Me, J = 7.2 Hz); 1.20 (t, 3 H, Me, J = 7.2 Hz).

5,5-Dimethyl-2-(1-ethyl-6-morpholino-1,2-dihydropyrazin-2-ylidene)cyclohexane-1,3-dione (7f). A solution of salt **2** (252 mg, $8\cdot10^{-4}$ mol) in MeCN(5 mL) was added dropwise with stirring by a solution of 5,5-dimethylcyclohexane-1,3-dione (112 mg, $8\cdot10^{-4}$ mol) in MeCN (3 mL) in the presence of morpholine (80 μL, $8\cdot10^{-4}$ mol). The resulting mixture was stirred for 10 min, added by another portion of morpholine (80 μL, $8\cdot10^{-4}$ mol), and stirred for 5 min. The formed precipitate of morpholine hydrochloride was filtered off, and the filtrate was evaporated. The residue was chromatographed on silica gel eluting first with an ethyl acetate—acetone (2 : 1) mixture and then with a $CHCl_3$—MeOH (10 : 1) mixture. Compound **7f** was obtained as an orange powder in 46% yield (122 mg), m.p. 150 °C (from heptane). Found (%): N, 12.50. $C_{18}H_{25}N_3O_3$. Calculated (%): N, 12.68. MS: m/z = 331 $[M]^+$. ^{1}H NMR ($CDCl_3$), δ: 9.00 (s, 1 H, H(3)); 8.03 (s, 1 H, H(5)); 4.49 (q, 2 H, NCH_2, J = 7.0 Hz); 3.90 (m, 4 H, $C\underline{H}_2OC\underline{H}_2$) and 3.27 (m, 4 H, $C\underline{H}_2NC\underline{H}_2$); 2.38 (s, 4 H, $COCH_2$); 1.28 (t, 3 H, Me, J = 7.0 Hz); 1.10 (s, 6 H, $C(C\underline{H}_3)_2$). ^{13}C NMR ($CDCl_3$), δ: 191.78 (t, $CH_2\underline{C}O$, J = 6.2 Hz); 151.51 (dt, C(3)$\underline{H}$, $NC\underline{H}_2$, C(2), ^2J = 12.8 Hz, ^3J = 3.6 Hz); 150.04 (dd, C(5)H, C(3), ^1J = 197.0 Hz, ^3J = 10.3 Hz); 149.85 (dm, C(5)H, C(6), ^2J = 10.4 Hz); 131.53 (dd, C(3)H, C(5), ^1J = 188.9 Hz, ^2J = 12.7 Hz); 108.42 (s, $=\underline{C}(CO)_2$); 66.14 (tm, CH_2OCH_2); 52.61 (tq, NCH_2, ^1J = 145.9 Hz, ^2J = 4.0 Hz); 51.67 (tm, $_2NCH_2$, ^1J = 138.28 Hz); 51.20 (tsept, 2 Me, $\underline{C}H_2CO$, ^1J = 127.1 Hz, J = 4.3 Hz); 31.11 (sept, $\underline{C}(Me)_2$, ^2J = 3.8 Hz); 28.63 (q, $C(\underline{C}H_3)_2$, ^1J = 123.5 Hz); 15.36 (qt, $NCH_2\underline{C}H_3$, ^1J = 129.19 Hz, ^2J = 3.66 Hz).

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