DIPYRROLO[1,2-*a*:2',1'-*c*]PYRAZINES. 8*. ELECTROPHILIC SUBSTITUTION IN DIPYRROLO[1,2-*a*:2',1'-*c*]PYRAZINES AND 5,6-DIHYDRODIPYRROLO[1,2-*a*:2',1'-*c*]PYRAZINES. ACYLATION OF DIPYRROLO[1,2-*a*:2',1'-*c*]PYRAZINES

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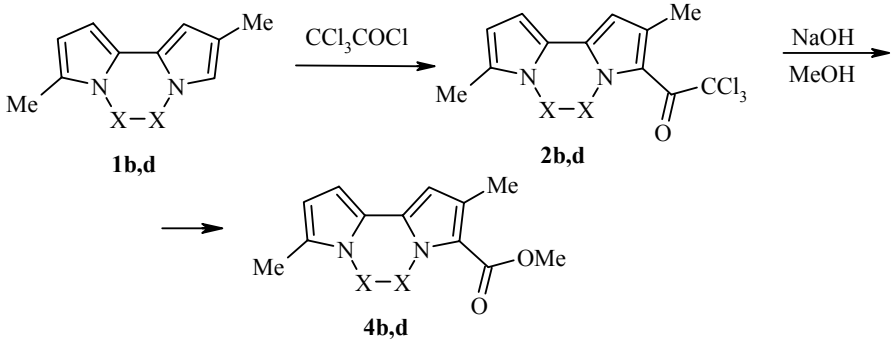
Esters, nitriles, and amides of dipyrrolo[1,2-a:2',1'-c]pyrazines have been synthesized by the acylation of dipyrrolo[1,2-a:2',1'-c]pyrazines and 5,6-dihydrodipyrrolo[1,2-a:2',1'-c]pyrazines with trichloroacetic acid chloride, p-tosyl isocyanate, and isocyanatophosphoric acid dichloride (Kirsanov isocyanate).

Keywords: dipyrrolo[1,2-*a*:2',1'-*c*]pyrazines, 5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazines, acylation.

Dipyrrolo[1,2-*a*:2',1'-*c*]pyrazines readily react by electrophilic substitution, such as acylation, nitration, aminomethylation, and formylation [2]. In continuing these investigations, the reactivity of dipyrrolopyrazines **1a,b** and their 5,6-dihydro analogs **1c,d** has been studied under conditions of trichloroacetylation with trichloroacetyl chloride.

The free α-position of the pyrrole ring is the initial point of attack by the trichloroacetyl cation. Products of monosubstitution **2b,d** were obtained in high yield in the reaction of 2,8-dimethyldipyrrolo[1,2-*a*:2',1'-*c*]-pyrazine (**1b**) and its dihydro analog **1d** with an equimolar quantity of trichloroacetyl chloride.



1b,d **2b,d** **4b,d**

1, **2**, **4 b** X–X = –CH=CH–; **d** X–X = $–CH_2–CH_2–$

* For Part 7 see [1].

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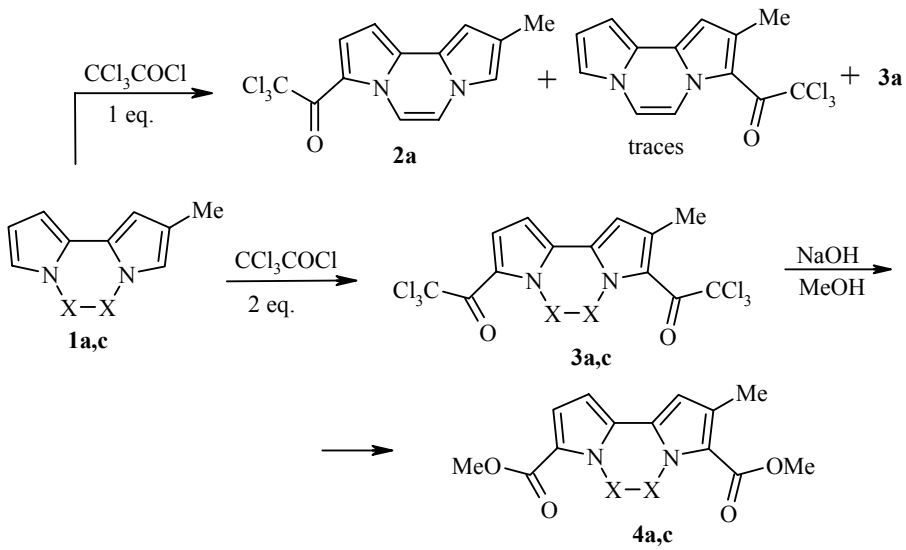
In the case of 2-methyldipyrrolopyrazines **1a,c**, having two free α-positions in the pyrrole rings, acylation products may be formed at both one and two pyrrole rings in the molecule. The result of the reaction depends on the substrate : reactant ratio.

According to quantum-chemical calculations, the π-orbital densities in the HOMO of positions 3 and 8 are practically identical in dipyrrolopyrazine **1a**, but the cations formed on electrophilic attack at position 3 are thermodynamically more stable. However the formation of 8-substituted derivatives is less sterically hindered. On trichloroacetylation of pyrrolopyrazine **1a** with an equimolar ratio of reactants 2-methyl-8-trichloroacetyldipyrrolo[1,2-*a*:2',1'-*c*]pyrazine (**2a**) was isolated in addition to the disubstitution product **3a** in a ratio of 1 : 2. 2-Methyl-3-trichloroacetyldipyrrolo[1,2-*a*:2',1'-*c*]pyrazine was formed in only trace amounts (based on ^{1}H NMR spectral analysis of the reaction mixture), which may be explained by the dominance of the steric factor. On trichloroacetylation of dipyrrolopyrazines **1a,c** with a twofold excess of reactant the disubstitution products were isolated, 2-methyl-3,8-trichloroacetyldipyrrolo[1,2-*a*:2',1'-*c*]pyrazine (**3a**) and 2-methyl-3,8-ditrichloroacetyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazine (**3c**) respectively.



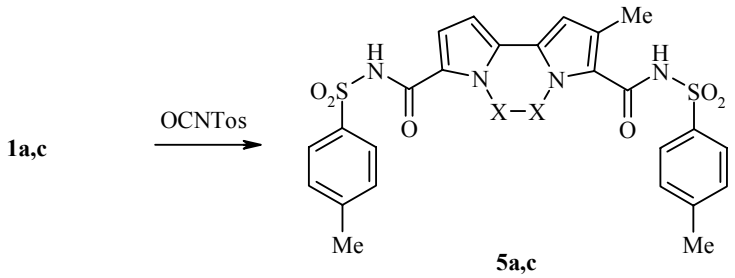
1, 3, 4 a X–X = –CH=CH–; **c** X–X = $–CH_2–CH_2–$

In the majority of cases trihaloacetylpyrroles undergo the haloform reaction under the action of hydroxide ion with the formation of pyrrolecarboxylic acids and trihalomethane. Trifluoroacetylpyrrole does not react with alcohols, however its trichloro analog was converted under base catalysis conditions into ester in more than 80% yield [3]. On treating trichloroacetyldipyrrolopyrazines with an alcoholic alkaline solution they readily undergo a haloform reaction and are converted into the corresponding dipyrrolopyrazine ester derivatives **4a-d**.

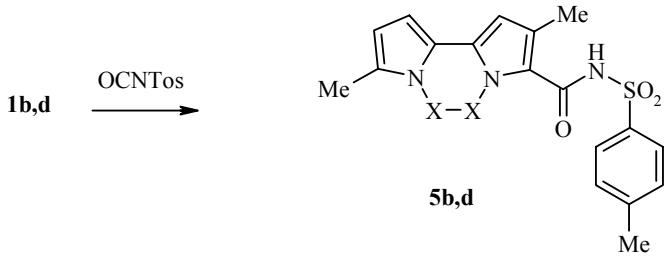
Arenesulfonyl isocyanates are used for C-acylation of electron-rich nitrogen heterocycles. However the literature data on such reactions are extremely contradictory. According to [4] pyrrole reacts with *p*-tosyl isocyanate at position 3, the β-position of the pyrrole ring. In later studies [5,6] it was demonstrated on the basis of ^{1}H NMR spectral data that pyrrole and N-methylpyrrole react with *o*-chlorobenzenesulfonyl isocyanate at the α-position.

As a reagent we chose *p*-tosyl isocyanate as one of the most reactive isocyanates in electrophilic substitution reactions [6]. Dipyrrolopyrazines undergo acylation, giving substitution products at the α-position of the pyrrole rings. The disubstitution products **5a,c** were obtained from 2-methyldipyrrolo[1,2-*a*:2',1'-*c*]-pyrazine (**1a**) and the 5,6-dihydro analog **1c** at a reactant ratio of 1 : 2 in yields of the order of 90%. At an equimolar reactant ratio a complex mixture was obtained of mono- and disubstituted products and the initial

dipyrrolopyrazine. In the reaction of compound **1b** and 2,8-dimethyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazine (**1d**) with *p*-tosyl isocyanate at an equimolar reactant ratio monosubstitution products were obtained, *viz*. N^1-[(2,8-dimethyldipyrrolo[1,2-*a*:2',1'-*c*]pyrazin-3-yl)carbonyl]-4-toluenesulfonamide (**5b**) and N^1-[(2,8-dimethyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazin-3-yl)carbonyl]-4-toluenesulfonamide (**5d**). On using an excess of *p*-tosyl isocyanate a mixture of disubstituted products was obtained, the separation of which was unsuccessful.



5a,c

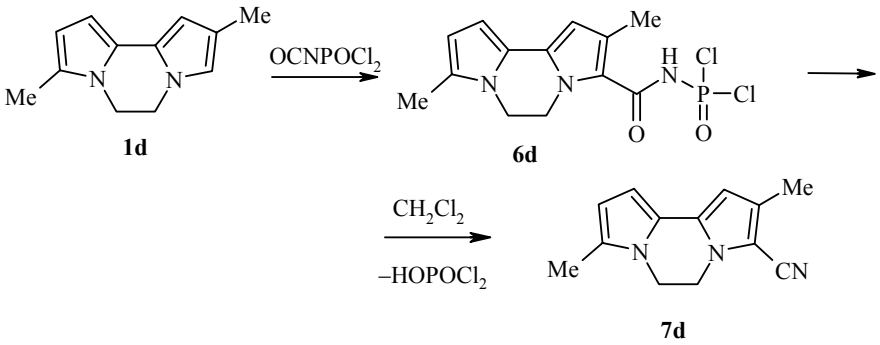


5b,d

5 a, b X–X = –CH=CH–; **c, d** X–X = $–CH_2–CH_2–$

Another reactive C-acylating reagent is the dichloride of isocyanatophosphoric acid (Kirsanov isocyanate) which interacts, for example, with N-methylpyrrole, indole, and 2-methylfuran forming dichlorides of N-hetarylamidophosphoric acids [7].

N-(2,8-Dimethyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazine-3-carboxy)aminophosphoric acid dichloride (**6d**) was obtained by the interaction of compound **1d** with Kirsanov isocyanate. The signal of the phosphorus atom was recorded at 7.503 ppm in the ^{31}P NMR spectrum of this compound in $CDCl_3$.



1d **6d** **7d**

The dichloride obtained is an extremely unstable compound and is converted in methylene chloride solution at room temperature into 2,8-dimethyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazine-3-carbonitrile (**7d**). The intermediate dichlorides **6a-c** in the reaction of dipyrrolopyrazines **1a-c** with Kirsanov isocyanate were not isolated.

TABLE 1. Physicochemical Characteristics of the Compounds Synthesized

Compound	Empirical formula	Found, % / Calculated, %			mp, °C	Mass spectrum, *m/z* (I_{rel},%)	Yield, %
		C	H	N			
1	2	3	4	5	6	7	8
2a	$C_{13}H_9Cl_3N_2O$					M^+ 314 (21), 280 (12), 253 (12), 251 (19), 217 (7), 198 (26), 197 (100), 170 (15), 169 (77), 168 (14)	11
2b	$C_{14}H_{11}Cl_3N_2O$		M^+ 327.993710 / 327.993693		142 (dec.)	M^+ 328 (24), 294 (5), 265 (12), 212 (15), 211 (100), 183 (41), 115 (2), 106 (6), 92 (4), 91 (7)	69
2d	$C_{14}H_{13}Cl_3N_2O$	50.91 / 50.70	3.62 / 3.95	8.25 / 8.45	172	M^+ 330 (8), 296 (9), 267 (14), 233 (12), 214 (15), 213 (77), 186 (12), 185 (60), 183 (13)	88
3a	$C_{15}H_8Cl_6N_2O_2$		M^+ 457.872440 / 457.871694		159-160	M^+ 458 (3), 397 (6), 345 (17), 343 (45), 341 (46), 309 (19), 307 (31), 250 (15), 196 (36), 168 (10), 115 (12), 112 (44)	72
3c	$C_{15}H_{10}Cl_6N_2O_2$		M^+ 459.888670 / 459.887344		196	M^+ 460 (2), 399 (8), 345 (40), 343 (41), 311 (15), 309 (24), 252 (10), 198 (18), 170 (9), 142 (19), 115 (20), 113 (46)	64
4a	$C_{15}H_{14}N_2O_4$	62.31 / 62.93	5.06 / 4.93	9.65 / 9.78	188	M^+ 286 (100), 225 (41), 228 (45), 227 (41), 168 (18), 142 (10), 140 (11), 112 (29), 63 (15)	47
4b	$C_{14}H_{14}N_2O_2$	69.79 / 69.41	6.42 / 5.82	6.32 / 5.78	150	M^+ 242 (100), 241 (43), 211 (15), 184 (44), 183 (52), 182 (13), 181 (11), 121 (11), 91 (21), 57 (11)	59
4c	$C_{15}H_{16}N_2O_4$	62.59 / 62.49	5.57 / 5.59	9.65 / 9.72	186	M^+ 288 (100), 258 (9), 257 (23), 230 (20), 229 (19), 214 (3), 197 (2), 169 (7), 144 (8), 142 (4), 116 (3), 115 (6), 89 (4), 59 (4)	52
4d	$C_{15}H_{16}N_2O_4$	68.83 / 68.83	6.51 / 6.60	11.30 / 11.47	154	M^+ 244 (100), 243 (25), 228 (4), 213 (14), 186 (28), 185 (34), 169 (6), 122 (8), 92 (9), 71 (10), 57 (17), 43 (28)	68

TABLE 1 (continued)

1	2	3	4	5	6	7	8
5a	$C_{27}H_{24}N_4O_6S_2$	57.37 / 57.43	4.09 / 4.28	9.66 / 9.92	246-247	[M^+–197] 367 (4), 197 (28), 170 (55), 169 (44), 155 (53), 92 (12), 91 (100), 89 (10), 65 (27), 63 (13), 40 (20)	91
5b	$C_{20}H_{19}N_3O_3S$	62.44 / 62.97	4.97 / 5.02	10.75 / 11.02	198-200	M^+ 381 (26), 211 (21), 197 (26), 184 (77), 183 (100), 155 (48), 92 (13), 91 (96), 65 (20), 63 (10), 39 (11)	79
5c	$C_{27}H_{26}N_4O_6S_2$	57.31 / 57.23	4.70 / 4.62	9.73 / 9.89	202	[M^+–197] 369 (3), 197 (16), 172 (38), 171 (27), 155 (38), 92 (11), 91 (100), 65 (24), 63 (10), 39 (11)	82
5d	$C_{20}H_{19}N_3O_3S$		M^+ 383.130364 / 383.132200		192-194	M^+ 383 (7), 197 (18), 187 (13), 186 (100), 185 (75), 144 (32), 93 (12), 92 (16), 91 (44), 65 (9)	98
6 d	$C_{13}H_{14}Cl_2N_3O_2P$				123 (dec.)		87
7a	$C_{12}H_9N_3$	73.97 / 73.83	4.81 / 4.65	21.51 / 21.52	132	M^+ 195 (100), 194 (61), 193 (11), 169 (7), 140 (7), 115 (4), 97 (15), 63 (12)	42
7b	$C_{13}H_{11}N_3$	74.59 / 74.62	5.34 / 5.30	19.94 / 20.08	161	M^+ 209 (86), 208 (100), 207 (10), 193 (6), 127 (3), 103 (13), 77 (5), 63 (5)	67
7c	$C_{12}H_{11}N_3$	73.26 / 73.07	5.92 / 5.62	21.54 / 21.30	126	M^+ 197 (100), 196 (29), 194 (4), 181 (7), 169 (6), 142 (5), 115 (4), 98 (10), 97 (4)	34 (14)
7d	$C_{13}H_{11}N_3$	73.71 / 73.91	5.99 / 6.20	19.64 / 19.89	162-163	M^+ 211 (100), 210 (70), 195 (5), 186 (5), 185 (5), 105 (7), 104 (11)	63
8c	$C_{13}H_{10}N_4$						6

* High resolution mass spectra are given for compounds **2b**, **3a,c**, and **5d**.

TABLE 2. ^{1}H NMR Spectra of Compounds **2-8**

Compound	Chemical shifts, δ, ppm (coupling constants, *J*, Hz)							
	Protons and substituents of the pyrrole rings					Protons of the pyrazine nucleus		Other protons
	H (1)	R (2)	H(R) (8)	H (9)	H(R) (10)	H (5)	H (6)	
1	2	3	4	5	6	7	8	9
2a	6.68 (1H, br. s)	2.31 (3H, br. s)		7.88 (1H, d, $J_{9,10}$ = 4.8)	6.61 (1H, d, $J_{10,9}$ = 4.8)	7.34 (1H, d, $J_{5,6}$ = 6.3)	8.74 (1H, d, $J_{6,5}$ = 6.1)	7.07 (1H, br. s, H-3)
2b	6.47 (1H, br. s.)	2.73 (3H, br. s)	2.45 (3H, br. s)	6.43 (1H, dd, $J_{9,10}$ = 3.8; $J_{H,CH3}$ = 0.8)	6.94 (1H, d, $J_{10,9}$ = 3.8)	8.59 (1H, d, $J_{5,6}$ = 6.3)	7.13 (1H, d, $J_{6,5}$ = 6.4)	
2d	6.20 (1H, d, $J_{H,CH3}$ = 0.7)	2.56 (3H, br. s)	2.29 (3H, br. s)	5.98 (1H, dd, $J_{9,10}$ = 3.7; $J_{H,CH3}$ = 0.7)	6.41 (1H, d, $J_{10,9}$ = 3.7)	4.63 (2H, m)	4.09 (2H, m)	
3a	6.79 (1H, s)	2.78 (3H, br. s)		7.95 (1H, d, $J_{9,10}$ = 4.8)	6.87 (1H, dd, $J_{10,9}$ = 4.8 $J_{10,6}$ = 0.5)	8.75 (1H, d, $J_{5,6}$ = 6.4)	8.90 (1H, d, $J_{6,5}$ = 6.4)	
3c	6.46 (1H, d, $J_{H,CH3}$ = 0.8)	2.57 (3H, br. s)		7.58 (1H, d, $J_{9,10}$ = 4.8)	6.55 (1H, d, $J_{10,9}$ = 4.8)	4.63 (2H, m)	4.86 (2H, m)	
4a	6.55 (1H, br. s)	2.50 (3H, br. s)	—*	7.33 1H, d, ($J_{9,10}$ = 4.5)	6.63 (1H, dd, $J_{10,9}$ = 4.2; $J_{10,6}$ = 0.6)	8.58 (1H, d, $J_{5,6}$ = 6.6)	8.68 (1H, d, $J_{6,5}$ = 6.6)	3.90 (3H, s, OCH_3 -8); 3.93 (3H, s, OCH_3-3)*[2]

TABLE 2 (continued)

1	2	3	4	5	6	7	8	9
4b	6.39 (1H, br.)	2.49 (3H, br. s)	2.45 (3H, br. s)	6.35 (1H, dd, $J_{5,10}$ = 3.5; $J_{H,CH3}$ = 0.6)	6.59 (1H, dd, $J_{10,9}$ = 3.7; $J_{10,6}$ = 0.4)	8.60 (1H, d, $J_{5,6}$ = 6.3)	7.19 (1H, d, $J_{6,5}$ = 6.2; $J_{6,10}$ = 0.4)	3.91 (3H, s, OCH_3-3)
4c	6.26 (1H, br. s)	2.34 (3H, br. s)	—*	6.97 (1H, d, $J_{5,10}$ = 4.1)	6.35 (1H, d, $J_{10,9}$ = 4.1)	4.73 (4 H, s)		3.83 (3H, s, OCH_3-8); 3.86 (3H, s, OCH_3-3)*[2]
4d	6.09 (1H, br. s)	2.33 (3H, br. s)	2.26 (3H, d, $J_{CH3,H}$ = 0.7)	5.93 (1H, dd, $J_{9,10}$ = 3.6; $J_{H,CH3}$ = 0.6)	6.29 (1H, d, $J_{10,9}$ = 3.5)	4.72 (2H, m)	4.04 (2H, m)	3.83 (3H, s, OCH_3-3)
5a	6.88 (1H, br. s)	—*	—*	7.81 (1H, d, $J_{5,10}$ = 4.7)	6.96 (1H, d, $J_{10,9}$ = 4.5)	8.49 (1H, d, $J_{5,6}$ = 6.2)	8.09 (1H, d, $J_{6,5}$ = 6.0)	2.35, 2.38, 2.46 (9H, 3s, CH_3-2, $2CH_3$–Tos)*[2]; 7.52 (4H, m, *m*-Tos); 7.95-8.00 (4H, m, *o*-Tos)
5b	6.36 (1H, br. s)	—*	2.42 (3H, s)	6.37 (1H, d, $J_{5,10}$ = 3.7)	6.60 (1H, d, $J_{10,9}$ = 3.9)	8.51 (1H, d, $J_{5,6}$ = 6.3)	7.03 (1H, d, $J_{6,5}$ = 6.2)	2.44, 2.58 (6H, 2s, CH_3-2, CH_3–Tos)*[2]; 7.36 (2H, d, *J* = 8.2, *m*-Tos); 8.06 (2H, d, *J* = 8.2, *o*-Tos)
5c	(1H, br. s)	—*	—*	6.91 (1H, d, $J_{5,10}$ = 4.4)	6.31 (1H, d, $J_{5,10}$ = 4.5)	4.50 (2H, m)	4.56 (2H, m)	2.41, 2.43, 2.44 (9H, 3s, CH_3-2, $2CH_3$-Tos)*[2]; 7.34 (4H, m, *m*-Tos); 7.98-8.01 (4H, m, *o*-Tos)
5d	6.07 (1H, br.)	—*	2.24 (3H, s)	5.93 (1H, d, $J_{5,10}$ = 3.6)	6.31 (1H, d, $J_{10,9}$ = 3.5)	4.63 (2H, m)	3.96 (2H, m)	2.43, 2.44 (6H, 2s, CH_3-2, CH_3-Tos)*[2]; 7.35 (2H, d, *J* = 8.2, *m*-Tos); 8.02 (2H, d, *J* = 8.2, *o*-Tos)

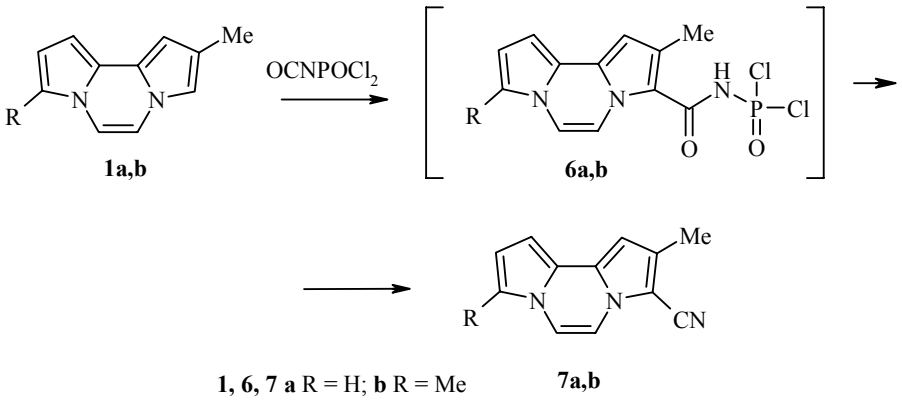
TABLE 2 (continued)

1	2	3	4	5	6	7	8	9
6d	6.06 (1H, s)	2.27 (3H, s)	2.23 (3H, s)	5.94 (1H, d, $J_{9,10}$ = 3.2)	6.29 1H, d, $J_{10,9}$ = 3.5	4.22 (2H, m)	4.11 (2H, m)	4.40 (1H, br. s, NH)
7a	6.32 (1H, br. s)	2.35 (3H, d, $J_{CH3,H}$ = 0.7)	7.08 (1H, dd, $J_{8,9}$ = 2.5; $J_{8,10}$ = 1.6)	6.59-6.60 (2H, m)		7.20 (1H, d, $J_{5,6}$ = 6.1)	7.17 (1H, d, $J_{6,5}$ = 6.1)	
7b	6.33 (1H, br. s)	2.44 (3H, d, $J_{CH3,H}$ = 0.8)	2.38 (3H, br. s)	6.35 (1H, dd, $J_{9,10}$=3.9; $J_{H,CH3}$ = 0.8)	6.56 (1H, d, $J_{10,9}$ = 3.9)	7.14 (1H, d, $J_{5,6}$ = 6.0)	7.27 (1H, d, $J_{6,5}$ = 6.0)	
7c*[3]	6.11 (1H, d, $J_{H,CH3}$ = 0.5)	2.24 (3H, br. s)	6.68 (1H, dd, $J_{8,9}$ = 2.3; $J_{8,10}$ = 1.2)	6.21 (1H, dd, $J_{9,10}$ = 3.9; $J_{9,8}$ = 2.3)	6.37 (1H, dd, $J_{10,9}$ = 3.9; $J_{10,8}$ = 1.3)	4.25 (4H, s)		
7d	6.06 (1H, s)	2.27 (3H, br. s)	2.23 (3H, br. s)	5.94 (1H, dd, $J_{9,10}$ = 3.6; $J_{H,CH3}$ = 0.7)	6.29 (1H, d, $J_{10,9}$ = 3.6)	4.22 (2H, m)	4.10 (2H, m)	
8c	6.27 (1H, d, $J_{H,CH3}$ = 0.4)	2.26 (3H, br. s)		6.85 (1H, d, $J_{9,10}$ = 4.1)	6.37 (1H, d, $J_{10,9}$ = 4.1)	4.25-4.38 (4H, m)		

* Chemical shifts are given in the "Other protons" column.

*[2] The reverse assignment of protons is possible.

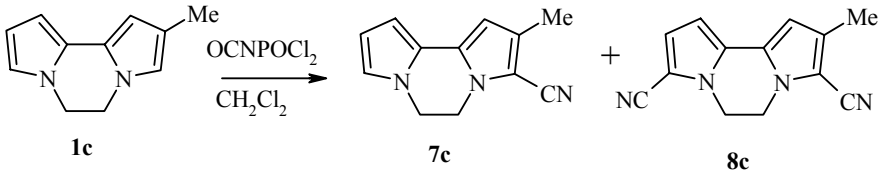
*[3] ^{13}C NMR spectra, δ, ppm: 11.77 (CH_3); 42.91, 43.81 (CH_2-5,6); 104.18, 105.15, 109.44, 120.81 (CH-1,8,9,10); 100.61, 114.17, 123.19, 130.28, 132.95 (C-2,3,11,12); 114.17 (CN).



1, 6, 7 a R = H; **b** R = Me

Products of monosubstitution at position 3, nitriles **7a,b**, were isolated from the reaction of Kirsanov isocyanate with dipyrrolopyrazines **1a,b**. In addition, according to data of TLC and chromato-mass spectrometry, in the reaction of 2-methyldipyrrolo[1,2-*a*:2',1'-*c*]pyrazine (**1a**), having two free α-positions on the pyrrole rings, with Kirsanov isocyanate the dinitrile was formed in trace amounts.

However the reaction did not proceed so unequivocally for 2-methyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]-pyrazine (**1c**). At an equimolar ratio of substrate to reactant the dominant reaction product was 2-methyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]pyrazine-3-carbonitrile (**7c**) in 34% yield. At a twofold excess of reactant two reaction products were isolated. In addition to compound **7c** 2-methyl-5,6-dihydrodipyrrolo[1,2-*a*:2',1'-*c*]-pyrazine-3,8-dicarbonitrile (**8c**) was obtained in a ratio of 2:1. The overall yield of product was 20%.



EXPERIMENTAL

The ^{1}H NMR spectra were recorded on a Varian VXR-400 spectrometer (operating frequency 400 MHz) in $CDCl_3$ solution at 28°C. Internal standard was TMS. The ^{31}P NMR spectra (operating frequency 160 MHz) were recorded relative to H_3PO_4 as external standard. The mass spectra of compounds were recorded on a Kratos MS-90 instrument at an ionizing energy of 70 eV. High resolution mass spectra were obtained using perfluorokerosene (PFK) as standard, by peak-matching at a resolution ≈ 8000 (at the 10% level) on a VG ZabSpec instrument (VG Analytical, Manchester, UK). A check on the progress of reactions was effected by TLC on Silufol-254 plates.

Yields, constants, and spectral characteristics of the compounds investigated are given in Tables 1 and 2.

Trichloroacetylation of Dipyrrolopyrazines (General Method). Trichloroacetyl chloride (1 mmol / 2 mmol) was added with stirring to a solution of dipyrrolopyrazine (1 mmol) in dry methylene chloride (5 ml). The reaction mixture was heated for 1 h, poured into water, the organic layer was separated, and the solvent evaporated. The residue was chromatographed on a column of neutral Al_2O_3, eluting with ethyl acetate.

Ester Derivatives of Dipyrrolopyrazines (General Method). The trichloroacetyldipyrrolopyrazine (1 mmol) was treated with 5N NaOH (in 50% MeOH: 10 ml) and kept at room temperature for 1 h. The solid was filtered off, washed with water, and dried. The product was chromatographed on a column of SiO_2, 100/160, eluting with ethyl acetate.

Acylation of Dipyrrolopyrazines with *p*-Toluenesulfonyl Isocyanate (General Method). *p*-Toluenesulfonyl isocyanate (1 mmol / 2 mmol) was added with stirring to a solution of dipyrrolopyrazine (1 mmol) in dry benzene (5 ml). The mixture was stirred for 1 h, the solid filtered off, and washed with heptane.

Acylation of Dipyrrolopyrazines with Kirsanov Isocyanate, Nitrile Preparation (General Method). The dichloride of isocyanatophosphoric acid [8] (Kirsanov isocyanate) (1 mmol / 2 mmol) was added with stirring and cooling to the dipyrrolopyrazine (1 mmol) in dry hexane (5 ml). The mixture was stirred for 1 h, the solid filtered off, and washed with heptane. The solid was then dissolved in dry methylene chloride, left for 1 h at room temperature, the solvent evaporated, and the dry residue extracted with hot heptane.

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