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SYNTHESIS AND REACTIVITY OF THIENO[2,3-*b*]PYRIDINE-2,3-DIAMINES

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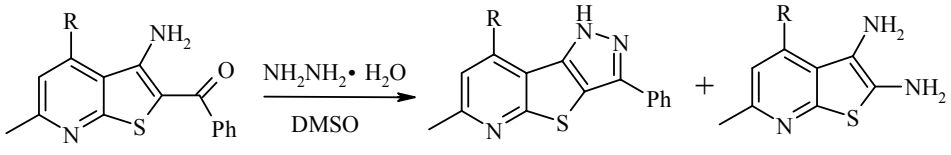
It has been established that the interaction of N^1-(2-hydroxyphenylmethylthieno[2,3-b]pyrid-3-yl)arylamides with hydrazine hydrate leads to thieno[2,3-b]pyridine-2,3-diamines. It was shown that the reaction of the latter with acetylacetone and acetoacetic ester occurs regioselectively at the amino group in position 3 of the thiophene ring.

Keywords: *(Z)*-3-(2-aminothieno[2,3-*b*]pyrid-3-ylamino)-1-R-2-buten-1-one, N^3-[(*E*)-1-arylmethylidene-imino]thieno[2,3-*b*]pyrid-2-ylamine, 2,3-dihydro-1H-imidazo[4′,5′:4,5]thieno[2,3-*b*]pyridine, thieno[2,3-*b*]-pyridine-2,3-diamine, ring-chain tautomerism.

The sole method described in the literature for obtaining 4,6-dimethylthieno[2,3-*b*]pyridine-2,3-diamine (**1a**) is the interaction of 4,6-dimethyl-2-thioxo-1,2-dihydro-3-pyridinecarbonitrile with ethyl 2-chloro-2-fluoroacetate [1]. In spite of the good yield of diamine this method is hardly acceptable in connection with the commercial unavailability of ethyl 2-chloro-2-fluoroacetate. Possibly for this reason the authors of [1], obtaining this compound for the first time, did not investigate its properties practically. At the same time, thieno[2,3-*b*]-pyridine-2,3-diamines are of interest as a subject for investigating the reactivity of the amino groups located in positions α and β of the thiophene ring.

Scheme 1



2a,b **3a,b** **1a,b**

1-3 a R = Me; **b** R = CH_2OMe

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TABLE 1. Characteristics of the Synthesized Compounds

Compound	Empirical formula	Found, % / Calculated, %			mp °C	Yield, %
		C	H	N		
1a	$C_9H_{11}N_3S$	55.87 / 55.93	5.70 / 5.74	21.79 / 21.74	177-178	63
1b	$C_{10}H_{13}N_3OS$	53.88 / 53.79	5.89 / 5.87	18.79 / 18.82	166-167	61
3a	$C_{16}H_{13}N_3S$	68.90 / 68.79	4.71 / 4.69	15.00 / 15.04	>300	42
3b	$C_{17}H_{15}N_3OS$	66.06 / 66.00	4.88 / 4.89	13.61 / 13.58	260-261	52
5a	$C_{16}H_{15}N_3S$	68.40 / 68.30	5.38 / 5.37	14.90 / 14.93	284-285	5.6
5b	$C_{17}H_{17}N_3OS$	65.61 / 65.57	5.48 / 5.50	13.52 / 13.49	155-156	2.4
6b	$C_{17}H_{16}N_2O_2S$	65.45 / 65.36	5.18 / 5.16	9.00 / 8.97	175-176	9
8a	$C_{14}H_{17}N_3OS$	61.16 / 61.06	6.20 / 6.22	15.23 / 15.26	170-171	72
8b	$C_{15}H_{19}N_3O_2S$	59.07 / 58.99	6.27 / 6.27	13.72 / 13.76	156-157	77
8c	$C_{15}H_{19}N_3O_2S$	59.10 / 58.99	6.25 / 6.27	13.74 / 13.76	138-139	64
8d	$C_{16}H_{21}N_3O_3S$	57.35 / 57.29	6.33 / 6.31	12.50 / 12.53	148-149	73
9a, **10a**	$C_{16}H_{15}N_3OS$	64.69 / 64.62	5.05 / 5.08	14.09 / 14.13	239-240	88
9b, **10b**	$C_{17}H_{17}N_3S$	69.03 / 69.12	5.83 / 5.80	14.25 / 14.22	196-197	78
9c, **10c**	$C_{16}H_{14}N_4O_2S$	58.81 / 58.88	4.30 / 4.32	17.22 / 17.17	229-230	75
9d, **10d**	$C_{17}H_{17}N_3OS$	65.66 / 65.57	5.51 / 5.50	13.45 / 13.49	158-159	85
9e, **10e**	$C_{17}H_{17}N_3O_2S$	62.45 / 62.37	5.21 / 5.23	12.85 / 12.83	203-204	68
9f, **10f**	$C_{17}H_{16}N_4O_3S$	57.20 / 57.29	4.52 / 4.53	15.76 / 15.72	203-204	72
9g, **10g**	$C_{18}H_{19}N_3O_2S$	63.41 / 63.32	5.59 / 5.61	12.34 / 12.31	173-174	65
9h, **10h**	$C_{17}H_{15}Br_2N_3O_2S$	42.20 / 42.08	3.11 / 3.12	8.61 / 8.66	211-212	73

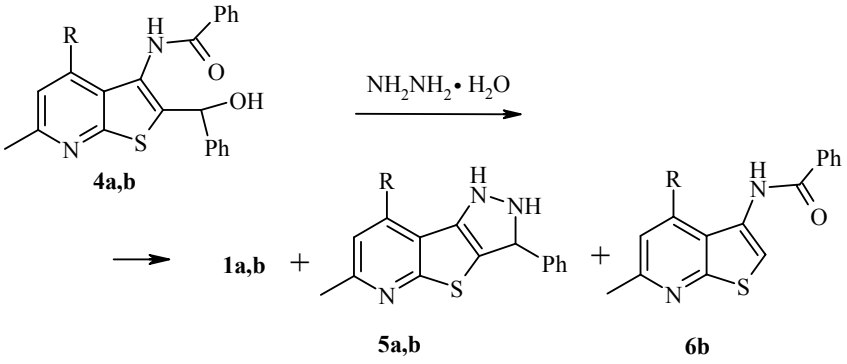
It is known that the interaction of 1-(3-aminothieno[2,3-*b*]pyrid-2-yl)-1-ethanol with hydrazine hydrate leads to the tricyclic system 1H-pyrazolo[3′,4′:4,5]thieno[2,3-*b*]pyridine [2]. On investigating the interaction of compounds **2a,b** [3, 4] with hydrazine hydrate in DMSO we isolated 2,3-diaminothieno[2,3-*b*]pyridines **1a,b** together with 1H-pyrazolo[3',4':4,4]thieno[2,3-*b*]pyridines **3a,b** (Scheme 1, Table 1). The yields of compounds **1a,b** were only 12 and 1% respectively.

The structures of compounds **1a,b**, **3a,b** were confirmed by IR and ^{1}H NMR spectroscopy (Table 2), and of diamines **1a,b** in addition by mass spectroscopy (see Experimental). In the IR spectra of products **1a,b** there were two absorption bands at 3360-3370 and 3190-3195 cm^{-1}. In the ^{1}H NMR spectra of compounds **1a,b** the signals of the amino groups were found at 3.97-3.98 (2-NH_2) and 6.53-6.57 ppm (3-NH_2) respectively (assignment of signals was made on the basis of [5]).

Assuming that compounds **1a,b** may also prove to be products of the reaction of alcohols of the type of **4a,b** [6] with hydrazine hydrate, we investigated this interaction (Scheme 2).

The reaction takes place on boiling for 5 h and the optimal molar ratio of reactants of the initial alcohol **4** with hydrazine hydrate was 1:30 (without solvent).

Scheme 2

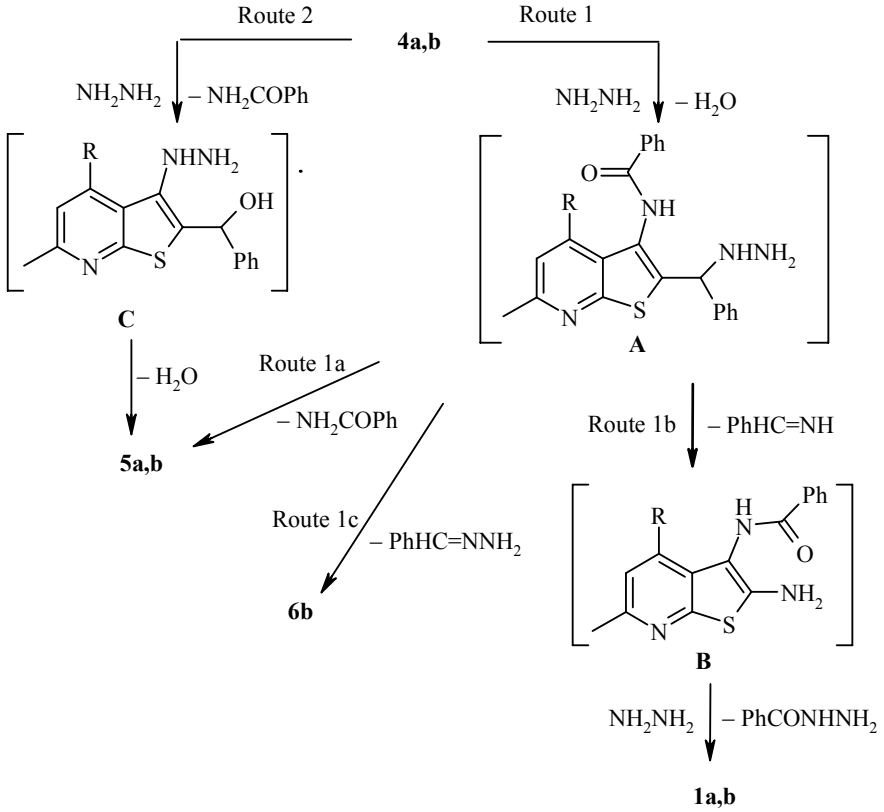


4a, **5a** R = Me; 4-6 **b** R = CH_2OMe

It was established that the main products of this reaction were thieno[2,3-*b*]pyridine-2,3-diamines **1a,b** (yields over 60%), and also 2,3-dihydro-1H-pyrazolo[3',4':4,5]thieno[2,3-*b*]pyridines **5a,b** (in yields ≤5.5%). On using compound **4b** 3-benzoylaminothieno[2,3-*b*]pyridine **6b** was also isolated in small yield (9%). Compounds **3a,b** were not detected among the reaction products. Products **1, 5**, and **6** were separated by fractionation and fractional crystallization.

The presumed reaction routes are illustrated in Scheme 3.

Scheme 3



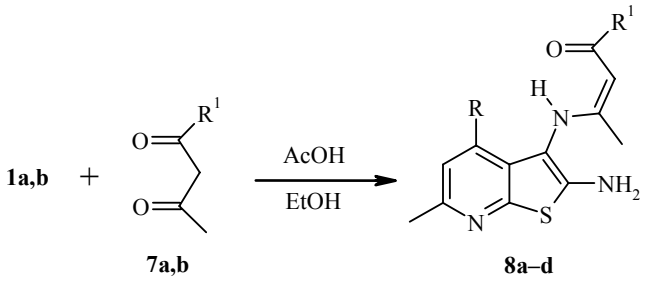
Route 1, the nucleophilic replacement of the OH group by a hydrazine group, leads to intermediate **A**. Then 1a) intramolecular nucleophilic substitution of the benzamide group at atom C(3) leads to compounds **5a,b**; 1b) cleavage of the N–N and C–C bonds accompanying migration of an NH_2 group to the C(2) atom and elimination of phenylmethylamine leads to intermediate **B** (the latter gives diamines **1a,b** under the action of hydrazine); 1c) migration of a hydrogen atom to atom C(2) of the thiophene ring, cleavage of a C–C bond, and elimination of benzhydrazone leads to substance **6b**.

Route 2 is the nucleophilic substitution of the benzamide group by a hydrazine group (structure **C**) with subsequent intramolecular dehydration (compounds **5a,b**).

The reactivity of the amino groups in positions 2 and 3 of the thiophene ring of compounds **1a,b** were investigated in reactions with 1,3-dicarbonyl compounds and aromatic aldehydes.

The chemical nonequivalence of the amino groups in positions 2 and 3 of thieno[2,3-*b*]pyridines was displayed on interaction of thieno[2,3-*b*]pyridine-2,3-diamines **1a,b** with acetylacetone **7a** and with acetoacetic ester **7b**, and led to monocondensation products **8a-d** (Scheme 4).

Scheme 4

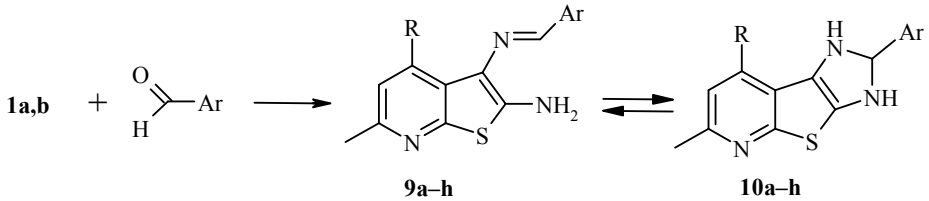


8 a,**c** R = Me, **b**,**d** R = CH_2OMe; **7a**, **8 a**,**b** R^1 = Me; **7b**, **8 c**,**d** R^1 = OEt

The structures of *(Z)*-3-(2-aminothieno[2,3-*b*]pyrid-3-ylamino)-R^1-2-buten-1-ones **8a-d** were proved by IR and ^{1}H NMR spectroscopic methods (Table 2). The signal of the amino group proton in position 3 of the thiophene ring of compounds **8a-d** was registered at low field for **8a,b** at 13.27 and 13.24 ppm and for **8c,d** at 11.36 and 11.34 ppm, which is explained by the formation of a hydrogen bond with the oxygen atom (Scheme 4). The signal of the amino group protons at position 2 of the thiophene ring of compounds **8a-d** is displaced towards low field by approximately 0.20 ppm in comparison with the spectra of the initial diamines **1a,b**.

Thieno[2,3-*b*]pyridine-2,3-diamines **1a,b** interact readily with aromatic aldehydes with the formation of an equilibrium mixture of tautomers **9a-h** and **10a-h** (Scheme 5).

Scheme 5



9, **10 a–d** R = Me, **e–h** R = CH_2OMe; **a**, **e** Ar = 2-HOC_6H_4, **b** Ar = 4-MeC_6H_4;
c, **f** Ar = 4-$O_2NC_6H_4$, **d**, **g** Ar = 4-$MeOC_6H_4$, **h** Ar = 3,5-Br_2-2-HOC_6H_2

TABLE 2. IR and ^{1}H NMR Spectra of the Synthesized Compounds

Compound	IR spectrum, ν, cm^{-1}	^{1}H NMR spectrum (DMSO-d$_6$), δ, ppm (*J*, Hz)
1a	3360 (N–H); 3190 (N–H)	2.34, 2.42 (both 3H, both s, 4-CH_3, 6-CH_3); 3.98 (2H, s, 2-NH_2); 6.53 (2H, br. s, 3-NH_2); 6.77 (1H, s, H_{Py})
1b	3370 (N–H); 3195 (N–H); 1130 (C–O–C)	2.41 (3H, s, 6-CH_3); 3.40 (3H, s, OCH_3); 3.97 (2H, s, 2-NH_2); 4.68 (2H, s, CH_2O); 6.57 (2H, br. s, 3-NH_2); 7.03 (1H, s, H_{Py})
3a	3445 (N–H)	1-H form (34%): 2.57, 2.75 (both 3H, both s, 4-CH_3, 6-CH_3); 7.24 (1H, s, H_{Py}); 7.39-7.45 (1H, m, H-4 arom.); 7.53-7.57 (2H, m, H-3 and H-5 arom.); 7.88 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 14.01 (1H, br. s, NH) 2-H form (66%): 2.56, 2.77 (both 3H, both s, 4-CH_3, 6-CH_3); 7.21 (1H, s, H_{Py}); 7.39-7.45 (1H, m, H-4 arom.); 7.58-7.62 (2H, m, H-3 and H-5 arom.); 7.78 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 14.08 (1H, br. s, NH)
3b	3486 (N–H); 1123 (C–O–C)	1-H form (34%): 2.59 (3H, s, 6-CH_3); 3.43 (3H, s, OCH_3); 4.91 (2H, s, CH_2O); 7.37 (1H, s, H_{Py}); 7.40-7.47 (1H, m, H-4 arom.); 7.53-7.64 (2H, m, H-3 and H-5 arom.); 7.85 (2H, d, *J* = 7.9, H-2 and H-6 arom.); 13.71 (1H, br. s, NH) 2-H form (66%): 2.60 (3H, s, 6-CH_3); 3.46 (3H, s, OCH_3); 4.99 (2H, s, CH_2O); 7.37 (1H, s, H_{Py}); 7.40-7.47 (1H, m, H-4 arom.); 7.53-7.64 (2H, m, H-3 and H-5 arom.); 7.76 (2H, d, *J* = 7.9, H-2 and H-6 arom.); 14.08 (1H, br. s, NH)
5a	3425 (N–H); 3158 (N–H)	2.03, 2.32 (both 3H, both s, 4-CH_3, 6-CH_3); 6.57 (1H, d, *J* = 6.1, CH); 6.60 (1H, s, H_{Py}); 7.26-7.33 (1H, m, H-4 arom.); 7.38-7.45 (2H, m, H-3 and H-5 arom.); 7.84 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 12.81, 13.41 (both 1H, both br. s, NH and NH)
5b	3418 (N–H); 3120 (N–H)	2.41 (3H, s, 6-CH_3); 3.26 (3H, s, OCH_3); 4.11 (2H, s, CH_2O); 6.64 (1H, d, *J* = 5.8, CH); 6.76 (1H, s, H_{Py}); 7.26-7.37 (1H, m, H-4 arom.); 7.39-7.48 (2H, m, H-3 and H-5 arom.); 7.82 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 12.83, 13.57 (both 1H, both br. s, NH and NH)
6b	—	2.61 (3H, s, 6-CH_3); 3.33 (3H, s, OCH_3); 4.43 (2H, s, CH_2O); 7.33 (1H, s, H_{Py}); 7.56-7.61 (2H, m, H-3 and H-5 arom.); 7.62-7.66 (1H, m, *J* = 8.2, H-4 arom.); 7.97 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 8.08 (1H, s, H_{Het}); 10.62 (1H, br. s, NH)
8a	3455 (N–H); 3385 (N–H); 1625 (C=O); 1610 (C=O)	2.05 (3H, s, CH_3); 2.19 (3H, s, CH_3CO); 2.41, 2.50 (both 3H, both s, 4-CH_3, 6-CH_3); 4.17 (2H, s, 2-NH_2); 5.36 (1H, s, CH); 6.92 (1H, s, H_{Py}); 13.27 (1H, br. s, NH)
8b	3371 (N–H); 1615 (C=O); 1115 (C–O–C)	2.06 (3H, s, CH_3); 2.22 (3H, s, CH_3CO); 2.48 (3H, s, 6-CH_3); 3.19 (3H, s, OCH_3); 4.17 (2H, s, 2-NH_2); 4.73 (2H, s, CH_2O); 5.37 (1H, s, CH); 7.13 (1H, s, H_{Py}); 13.24 (1H, br. s, NH)
8c	3205 (N–H); 1650 (C=O); 1620 (C=O); 1280 (CO–O–C)	1.23 (3H, t, *J* = 6.8, CH_3); 2.02 (3H, s, CH_3); 2.43, 2.51 (both 3H, both s, 4-CH_3, 6-CH_3); 4.09 (2H, q, *J* = 6.8, OCH_2); 4.18 (2H, s, 2-NH_2); 4.82 (1H, s, CH); 6.91 (1H, s, H_{Py}); 11.36 (1H, br. s, NH)
8d	1650 (C=O); 1615 (C=O); 1280 (CO–O–C);	1.23 (3H, t, *J* = 6.9, CH_3); 2.22 (3H, s, CH_3); 2.46 (3H, s, 6-CH_3); 3.45 (3H, s, OCH_3); 4.11 (2H, q, *J* = 6.9, OCH_2); 4.17 (2H, s, 2-NH_2); 4.73 (2H, s, CH_2O); 4.82 (1H, s, CH); 7.13 (1H, s, H_{Py});

The overall yields of products **9a-h** and **10a-h** were ~ 70% (Table 1).

The existence of two tautomeric forms and the possibility of transition of one form into the other was proved by ^{1}H NMR spectroscopy (Table 3). The ratios of the tautomeric forms are given in Table 4. It was established that donating substituents in the aromatic fragment were capable of displacing the tautomeric

TABLE 3. ^{1}H NMR Spectra of the Synthesized Compounds **9a-h** and **10a-c,e-h**

Com-pound	Chemical shifts, δ, ppm (*J*, Hz)*
9a	2.44, 2.75 (both 3H, both s, 4-CH_3, 6-CH_3); 4.48 (2H, s, 2-NH_2); 6.94-7.00 (3H, m, H-3 and H-5 arom, H_{Py}); 7.37–7.42 (1H, m, H-4 arom.); 7.72 (1H, d, *J* = 8.0, H-6 arom.); 8.86 (1H, s, CH); 11.08 (1H, s, OH)
	[2.52, 2.68 (both 3H, both s, 4-CH_3, 6-CH_3); 4.34 (2H, s, 2-NH_2); 6.78 (1H, s, H_{Py}); 6.95-6.99 (1H, m, H-5 arom.); 7.04 (1H, d, *J* = 8.1, H-3 arom.); 7.35-7.41 (2H, m, H-4 and H-6 arom.); 8.71 (1H, s, CH); 11.57 (1H, s, OH)]
9b	2.36, 2.43, 2.62 (both 3H, all s, 4-CH_3, 6-CH_3, CH_3–C_6H_5); 4.43 (2H, s, 2-NH_2); 6.92 (1H, s, H_{Py}); 7.30 (2H, d, *J* = 8.0, H-3 and H-5 arom.); 7.78 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 8.50 (1H, s, CH)
9c	2.53, 2.68 (both 3H, both s, 4-CH_3, 6-CH_3); 4.43 (2H, s, 2-NH_2); 6.78 (1H, s, H_{Py}); 8.00 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.30 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 8.54 (1H, s, CH)
	[2.44, 2.62 (both 3H, both s, 4-CH_3, 6-CH_3); 4.48 (2H, s, 2-NH_2); 6.97 (1H, s, H_{Py}); 8.15 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.34 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 8.69 (1H, s, CH)]
9d	2.43, 2.62 (both 3H, both s, 4-CH_3, 6-CH_3); .3.38 (3H, s, OCH_3); 4.47 (2H, s, 2-NH_2); 6.94 (1H, s, H_{Py}); 7.06 (2H, d, *J* = 8.0, H-3 and H-5 arom.); 7.85 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 8.52 (1H, s, CH)
9e	2.48 (3H, s, 6-CH_3); 3.45 (3H, s, OCH_3); 4.45 (2H, s, 2-NH_2); 4.88 (2H, s, OCH_2); 6.93-6.98 (2H, m, H-3 and H-5 arom.); 7.19 (1H, s, H_{Py}); 7.36-7.40 (1H, m, H-4 arom.); 7.72 (1H, d, *J* = 7.9, H-6 arom.); 8.84 (1H, s, CH); 11.03 (1H, s, OH)
	[2.58 (3H, s, 6-CH_3); 3.59 (3H, s, OCH_3); 4.33 (2H, s, 2-NH_2); 4.98 (2H, s, OCH_2); 7.25 (1H, s, H_{Py}); 6.96–7.07 (2H, m, H-3 and H-5 arom.); 7.38-7.43 (2H, m, H-4 and H-6 arom.); 8.73 (1H, s, CH); 11.52 (1H, s, OH)]
9f	2.51 (3H, s, 6-CH_3); 3.46 (3H, s, OCH_3); 4.47 (2H, s, 2-NH_2); 4.89 (2H, s, OCH_2); 7.21 (1H, s, H_{Py}); 8.15 (2H, d, *J* = 8.2, H-2 and H-6 arom.); 8.33 (2H, d, *J* = 8.2, H-3 and H-5 arom.); 8.69 (1H, s, CH)]
9g	2.49 (3H, s, 6-CH_3); 3.47, 3.84 (both 3H, both s, OCH_3, OCH_3); 4.43 (2H, s, 2-NH_2); 4.88 (2H, s, OCH_2); 7.05 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 7.18 (1H, s, H_{Py}); 7.85 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.52 (1H, s, CH)
9h	2.52 (3H, s, 6-CH_3); 3.44 (3H, s, OCH_3); 4.52 (2H, s, 2-NH_2); 4.91 (2H, s, OCH_2); 7.28 (1H, s, H_{Py}); 7.92 (1H, s, H-4 arom.); 7.94 (1H, s, H-6 arom.); 8.84 (1H, s, CH); 12.19 (1H, s, OH)
	[2.59 (3H, s, 6-CH_3); 3.57 (3H, s, OCH_3); 4.32 (2H, s, 2-NH_2); 4.93 (2H, s, OCH_2); 7.24 (1H, s, H_{Py}); 7.48 (1H, s, H-4 arom.); 7.76 (1H, s, H-6 arom.); 8.61 (1H, s, CH); 12.42 (1H, s, OH)]
10a	2.52, 2.63 (both 3H, both s, 4-CH_3, 6-CH_3); 6.86-6.91 (3H, m, CH, H-3 and H-5 arom.); 7.06 (1H, s, H_{Py}); 7.18 (1H, m, H-4 arom.); 7.57 (1H, d, *J* = 8.1, H-6 arom.); 8.41 (1H, br. s, NH); 9.57 (1H, br. s, NH); 10.58 (1H, s, OH)
10b	2.33, 2.51, 2.75 (both 3H, all s, 4-CH_3, 6-CH_3, CH_3–C_6H_5); 6.91 (1H, s, CH); 7.03 (1H, s, H_{Py}); 7.22 (2H, d, *J* = 8.0, H-3 and H-5 arom.); 7.57 (2H, d, *J* = 8.0, H-2 and H-6 arom.); 8.10 (1H, br. s, NH); 9.37 (1H, br. s, NH)
10c	2.51, 2.75 (both 3H, both s, 4-CH_3, 6-CH_3); 7.07 (1H, s, H_{Py}); 7.12 (1H, s, CH); 7.92 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.22 (1H, br. s, NH); 8.25 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 10.07 (1H, br. s, NH)
	[2.63, 2.77 (both 3H, both s, 4-CH_3, 6-CH_3); 6.94 (1H, s, H_{Py}); 7.03 (1H, s, CH); 7.79 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.16 (1H, br. s, NH); 8.24 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 9.98 (1H, br. s, NH)]
10e	2.56 (3H, s, 6-CH_3); 3.42 (3H, s, OCH_3); 4.92 (2H, s, OCH_2); 6.82-6.88 (3H, m, H-3 and H-5 arom., CH); 7.17–7.21 (1H, m, H-4 arom.); 7.26 (1H, s, H_{Py}); 7.58 (1H, d, *J* = 8.0, H-6 arom.); 8.29 (1H, br. s, NH); 9.62 (1H, br. s, NH); 10.48 (1H, s, OH)
	[2.68 (3H, s, 6-CH_3); 3.45 (3H, s, OCH_3); 4.81 (2H, s, OCH_2); 6.75 (1H, s, CH); 6.90-6.94 (1H, m, H-5 arom.); 7.01 (1H, s, H_{Py}); 7.02 (1H, d, *J* = 8.0, H-3 arom.); 7.19 (1H, d, *J* = 8.0, H-6 arom.); 7.24–7.29 (1H, m, H-4 arom.); 7.98 (1H, br. s, NH); 9.67 (1H, br. s, NH); 11.06 (1H, s, OH)]
10f	2.58 (3H, s, 6-CH_3); 3.43 (3H, s, OCH_3); 4.91 (2H, s, OCH_2); 7.13 (1H, s, CH); 7.28 (1H, s, H_{Py}); 7.94 (2H, d, *J* = 8.1, H-2 and H-6 arom.); 8.12 (1H, br. s, NH); 8.24 (2H, d, *J* = 8.1, H-3 and H-5 arom.); 10.10 (1H, br. s, NH)

TABLE 3. (continued)

1	2
10g	2.53 (3H, s, 6-CH_3); 3.54, 3.79 (both 3H, both s, OCH_3, OCH_3); 4.91 (2H, s, OCH_2); 6.93 (1H, s, CH); 6.98 (2H, d, *J* = 8.2, H-3 and H-5 arom.); 7.25 (1H, s, H_{Py}); 7.66 (2H, d, *J* = 8.2, H-2 and H-6 arom.); 7.99 (1H, br. s, NH); 9.76 (1H, br. s, NH)
10h	2.57 (3H, s, 6-CH_3); 3.42 (3H, s, OCH_3); 4.87 (2H, s, OCH_2); 7.02 (1H, s, CH); 7.20 (1H, s, H_{Py}); 7.71 (1H, s, H-4 arom.); 7.73 (1H, s, H-6 arom.); 8.22 (1H, br. s, NH); 9.98 (1H, br. s, NH); 11.93 (1H, s, OH)
	[2.68 (3H, s, 6-CH_3); 3.44 (3H, s, OCH_3); 4.80 (2H, s, OCH_2); 6.78 (1H, s, CH); 7.00 (1H, s, H-4 arom.); 7.24 (1H, s, H_{Py}); 7.59 (1H, s, H-6 arom.); 7.83 (1H, br. s, NH); 9.97 (1H, br. s, NH); 11.87 (1H, s, OH)]

*The ^{1}H NMR spectra were taken in DMSO-d_6, spectra taken in $CDCl_3$ are given in square brackets.

TABLE 4. Ratio of Tautomeric Forms **9a-h** (open) and **10a-h** (closed) in ^{1}H NMR Spectra

Tautomers	Ratio of tautomers	Solvent	Tautomers	Ratio of tautomers	Solvent
9a : **10a**	50: 50	DMSO-d_6	**9e** : **10e**	38 : 62	DMSO-d_6
9a : **10a**	100 : 0	$CDCl_3$	**9e** : **10e**	81 : 19	$CDCl_3$
9b : **10b**	89 : 11	DMSO-d_6	**9f** : **10f**	59 : 41	DMSO-d_6
9c : **10c**	21 : 79	DMSO-d_6	**9g** : **10g**	93 : 7	DMSO-d_6
9c : **10c**	82 : 18	$CDCl_3$	**9h** : **10h**	17 : 83	DMSO-d_6
9d : **10d**	100 : 0	DMSO-d_6	**9h** : **10h**	40 : 60	$CDCl_3$

equilibrium towards the azomethine form **9**, and electron-withdrawing substituents, on the other hand, towards the imidazole form **10**. At the same time replacement of DMSO-d_6 by $CDCl_3$ aided an increase in the mass part of the open form **9**.

EXPERIMENTAL

The ^{1}H NMR spectra were recorded on a Bruker DRX-500 (500 MHz) instrument in DMSO-d_6 and $CDCl_3$, internal standard was TMS. The IR spectra were measured on a Specord IR-75 instrument with NaCl prisms, in KBr or as a suspension in nujol. The mass spectra were taken on a Finnigan MAT INCO S50 instrument with direct insertion of samples into the ion source (energy of ionizing electrons 70 eV, temperature of ionizing chamber 50-180°C).

8-Methoxymethyl-6-methyl-3-phenylpyrazolo[3',4':4,5]thieno[2,3-*b*]pyridine (3b) and 4-Methoxymethyl-6-methylthieno[2,3-*b*]pyridine-2,3-diamine (1b). Compound **2b** (3.12 g, 10 mmol) was dissolved in DMSO (20 ml), hydrazine hydrate (24.5 ml, 500 mmol) was added, and the mixture boiled for 36 h. The reaction mixture was cooled, the precipitated crystals were filtered off, washed with ethanol (10 ml), and dried. Using fractional crystallization from ethanol the mixture obtained was separated into substances **1b** and **3b**. Yield of compound **3b** was 1.57 g (51%) and of compound **1b** 0.02 g (1%).

Compounds 1a and 3a were obtained analogously.

4-Methoxymethyl-6-methylthieno[2,3-*b*]pyridine-2,3-diamine (1b), 8-Methoxymethyl-6-methyl-3-phenyl-2,3-dihydro-1H-pyrazolo[3′,4′:4,5]thieno[2,3-*b*]pyridine (5b), and 3-Benzoylamino-4-methoxymethyl-6-methylthieno[2,3-*b*]pyridine (6b). Hydrazine hydrate (14.5 ml, 300 mmol) was added to 3-benzoylamino-2-hydroxy(phenyl)methyl-4-methoxymethyl-6-methylthieno[2,3-*b*]pyridine (**4b)** (4.19 g, 10 mmol) and the mixture was boiled with vigorous stirring for 5 h. The reaction mixture was cooled, the solid filtered off (filtrate 1), washed with EtOH (100 ml) (filtrate 2), and air-dried to give compound **1b.** Filtrate 1 was poured into water (150 ml), the precipitated crystals were filtered off, to give compound **5b**. Filtrate 2 was cooled additionally, the resulting crystals were filtered off, and recrystallized from ethanol until isolation of a single substance (check by TLC, eluent acetone–hexane, 1:1). Compound **6b** was obtained.

Compounds 1a, 5a were obtained analogously.

4,6-Dimethylthieno[2,3-*b*]pyridine-2,3-diamine (1a). Mass spectrum, *m/z* (I_{rel}, %): 193 $[M]^+$ (13), 178 $[M–CH_3]^+$ (6), 176 $[M–NH_3]^+$ (6), 163 $[M–N_2H_2]^+$ (70).

4-Methoxymethyl-6-methylthieno[2,3-*b*]pyridine-2,3-diamine (1b). Mass spectrum, *m/z* (I_{rel}, %): 223 $[M]^+$ (38), 208 $[M\text{-}CH_3]^+$ (68), 191 $[M–CH_3–NH_3]^+$ (53), 178 (12) $[M–CH_3–N_2H_2]^+$, 163 $[M–CH_3–NH_3–CO]^+$ (100).

***(Z)*-4-(2-Amino-4-methoxymethyl-6-methylthieno[2,3-*b*]pyrid-3-ylamino)-3-penten-2-one (8b).** Acetylacetone (0.52 ml, 5 mmol) and glacial acetic acid (1.72 ml, 30 mmol) were added sequentially to a solution of diamine **1b** (1.12 g, 5 mmol) in EtOH (15 ml). The reaction mixture was brought to boiling, then slowly cooled. The solid which precipitated was filtered off, washed with EtOH (10 ml), and air-dried. The product was recrystallized from EtOH.

Compound 8a was obtained analogously**.**

Ethyl *(Z)*-3-(2-Amino-4-methoxymethyl-6-methylthieno[2,3-*b*]pyrid-3-ylamino)crotonoate (8d). Acetoacetic ester (0.63 ml, 5 mmol) and glacial acetic acid (1.72 ml, 30 mmol) were added sequentially to a solution of diamine **1b** (1.12 g, 5 mmol) in EtOH (15 ml). The reaction mixture was boiled for 5 min, the EtOH (one third) evaporated, and the mixture cooled in an ice bath. The precipitated solid was filtered off, washed with EtOH (10 ml), and air-dried.

Compound 8c was obtained analogously.

4-Methoxymethyl-3-[*(E)*-1-(4-methoxyphenyl)methylideneimino]-6-methylthieno[2,3-b]pyrid-2-ylamine (9g) and 4-Methoxymethyl-2-(4-methoxyphenyl)-6-methyl-2,3-dihydro-1H-imidazo[4',5':4,5]-thieno[2,3-*b*]pyridine (10g). 4-Methoxybenzaldehyde (0.6 ml, 5 mmol) was added to a solution of diamine **1b** (1.12 g, 5 mmol) in toluene (15 ml). The mixture was boiled for 5 min, cooled in an ice bath, the precipitated crystals were filtered off, washed with EtOH (10 ml), air-dried, and recrystallized from EtOH.

Compounds 9a-f,h and 10a-f,h were obtained analogously.

REFERENCES

1. A. W. Erian and F. A. Abu-Shanab, *Bull. Chem. Soc. Jpn.*, **71**, 2387 (1998).
2. Fawzy A. Attaby, M. A. A. Elneairy, and M. S. Elsayed, *Phosphorus, Sulfur, Silicon Relat. Elem.*, **149**, 49 (1999).
3. M. Negm Abdalla, Abd El-Aal Fatma, Abd El-Maksoud, Hafez Ebtisam, H. Elnagdi Mohamed, and M. N. Mostafa Yasser, *Phosphorus, Sulfur, Silicon Relat. Elem.*, **106**, 1 (1995).
4. V. K. Vasilin, E. A. Kaigorodova, S. I. Firgang, and G. D. Krapivin, *Khim. Geterotsikl. Soedin.*, 462 (2004). [*Chem. Heterocycl. Comp.*, **40**, 377 (2004)].
5. E. A. Kaigorodova, V. K. Vasilin, L. D. Konyushkin, E. B. Usova, and G. D. Krapivin, *Molecules*, **5**, 1085 (2000).
6. M. M. Lipunov, E. S. Kostenko, E. A. Kaigorodova, S. I. Firgang, and G. D. Krapivin, *Izv. Vyssh. Uchebn. Zaved., Khim. Khim. Tekhnol.*, **48**, No. 12, 81 (2005).