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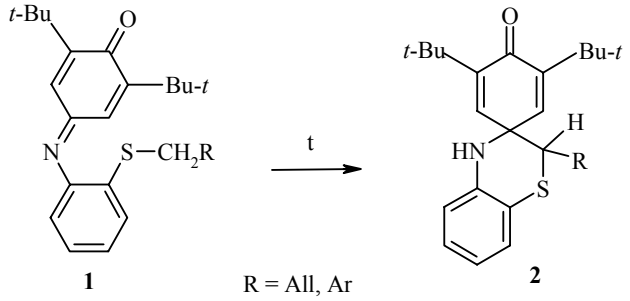
SYNTHESIS OF 3,4-DIHYDRO-2H-IMIDAZO-[2,1-*b*][1,3,4]THIADIAZINES

A. A. Kolodina, N. I. Ganonenko, and A. V. Lesin

Thiomethylene-active derivatives of N-imidazolylimines undergo intramolecular cyclization to give 3,4-dihydro-2H-imidazo[2,1-b][1,3,4]thiadiazines. This reaction is a new convenient method for the fusion of a dihydrothiadiazine ring to an imidazole fragment through formation of a C–C bond.

Keywords: N-alkylisatin, aminothioimidazole, imidazothiadiazine, thiobenzyl ether, thiophenacyl ether.

In previous work [1], we reported a new thermally-induced intramolecular cyclization of derivatives of N-arylimines **1**, which contain S-methylene-active substituents in the *ortho* position, yielding spirobenzothiazines **2**.



1 R = All, Ar **2**

In the present communication, we report a study of this reaction using 1-amino-2-mercapto-4-R-imidazoles **3** as the heterocyclic analogs of *o*-aminothiophenols.

The condensation of 1-amino-2-mercaptoimidazole (**3a**) with benzylisatin and *p*-bromobenzylaldehyde gave the corresponding aldimines **4** and **5**.

The alkylation of the thiol group in **4** by *p*-bromophenacyl halide immediately yielded spiroimidazo[2,1-*b*][1,3,4]thiadiazine **6**.

The cyclic structure of **6** was indicated by the one-proton peaks at 6.05 and 7.75 ppm assigned to the CH and NH groups, respectively, and the lack of a two-proton signal for the methylthio group in the ^{1}H NMR spectrum (Table 1). Furthermore, an AB quartet was observed for the prochiral methylene group of the benzylisatin fragment at 4.8 ppm, which also indicates the formation of a chiral spiran **6**.

Rostov State University, Chemical Faculty, Rostov-on-the-Don 344090, Russia; e-mail: lexandra@inbox.ru. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1415-1423, September, 2007. Original article submitted December 29, 2006.

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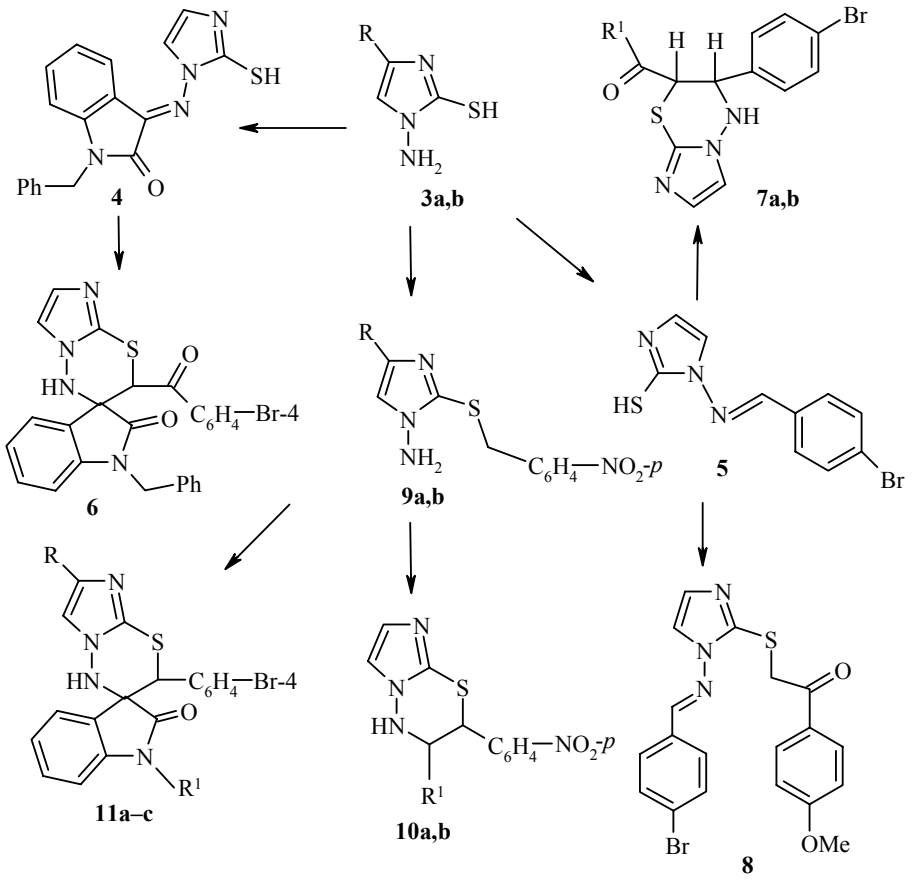

3, **9**, **a** R = H; **b** R = Ph; **7a** R^1 = Ph; **b** R^1 = 4-BrC_6H_4; **10 a** R^1 = 3-$O_2NC_6H_4$; **b** R^1 = 4-BrC_6H_4;
11 a R = R^1 = H, **b** R = H, **c** R = Ph, **b**, **c** R^1 = CH_2Ph

The alkylation of aldimine **5** by phenacyl halides gave imidazothiadiazines **7a**,**b**.

The ^{1}H NMR spectra of the obtained compounds **7** show doubling of all the signals in 68.5:31.5 ratio (for **7a**) and 82.8:17.2 ratio (for **7b**), which may be attributed to formation of a mixture of diastereomers in both cases.

When *p*-methoxyphenacyl bromide was used, the reaction stops upon formation of imidazolyl phenacyl sulfide **8**, which is attributed to the decrease in acidity of the methylene protons due to the electron-donor methoxy group in the phenyl ring.

Under base catalysis conditions, sulfides **9a**,**b** react with N-R-isatins and benzaldehydes to give imidazo[2,1-*b*][1,3,4]thiadiazines **10a,b**, and **11a-c.**

The structure of the compounds **10** was supported by the evolution of the signals of the methylene and amino groups of starting sulfide **9a** to spin-coupled one-proton signals of the vicinal protons of two CH groups and an NH group of the thiadiazine ring in the ^{1}H NMR spectra. The clear resolution of the signals for H-2 and H-3 and their coupling constants (J = 10 Hz) indicate that thiadiazines **10** are not stochastic mixtures of the four possible configurations due to the existence of two stereogenic carbon sites C(2) and C(3) but rather probably a racemates with *trans* arrangement of H-2 and H-3.

The ^{1}H NMR spectra of **11a-c** show two one-proton signals at 7.6 and 5.2-5.5 ppm due to NH and CH groups. The spectra of **11b**,**c**, similar to the spectra of **6**, show an AB quartet for the protons of the prochiral NCH_2Ph methylene group at 4.9 ppm, indicating spirocyclization of the thiadiazine and isatin fragments.

TABLE 1. Physicochemical and Spectral Characteristics of Compounds **4-11**

Compound	Empirical formula	Found, % / Calculated, %			mp, °C	^{1}H NMR, ppm (*J*, Hz)*	Yield, %
		C	H	N			
1	2	3	4	5	6	7	8
4	$C_{18}H_{14}N_4OS$	64.87 / 64.65	4.53 / 4.22	16.56 / 16.75	148	4.81 (2H, s, NCH$_2$Ph); 6.72-6.8 (2H, m, H$_{isat}$); 6.88 (1H, s, H-4); 6.99 (1H, s, H-5); 7.04-7.13 (2H, m, H$_{isat}$); 7.32-7.4 (5H, m, C$_6$H$_5$); 7.92 (1H, s, SH)	46
5	$C_{10}H_8BrN_3S$	42.76 / 42.57	3.04 / 2.86	14.78 / 14.89	237	7.09 (1H, s, H-4); 7.67-7.85 (5H, m, H-5, H$_{Ar}$); 9.01 (1H, s, N=CH); 12.41 (1H, s, SH)	65
6	$C_{31}H_{23}N_5O_3S$	59.18 / 58.76	3.94 / 3.60	11.05 / 10.54	209	4.81 (2H, m, CH$_2$Ph); 6.07 (1H, s, H-2'); 6.64 (1H, d, *J* = 6.8, H$_{isat}$); 6.85-7.06 (4H, m, Ph, H$_{isat}$); 7.15-7.38 (6H, m, Ph, H-6,7, H$_{isat}$); 7.51 (1H, s, NH); 7.65 (2H, d, *J* = 8.4, H$_{Ar}$); 7.75 (2H, d, *J* = 8.7, H$_{Ar}$)	51
7a	$C_{18}H_{14}BrN_3OS$	54.40 / 54.01	3.71 / 3.53	10.75 / 10.50	190	5.01–5.05 (1H, m, H-3); 5.74 (1H, d, *J* = 2.6, H-2); 6.91 (1H, d, *J* = 1.3, H-7); 7.03 (1H, d, *J* = 11.4, NH); 7.24 (1H, d, *J* = 1.3, H-6); 7.48 (2H, d, *J* = 8.8, H$_{Ar}$); 7.53-7.56 (5H, m, C$_6$H$_5$); 7.96 (2H, d, *J* = 8.8, H$_{Ar}$)	57
7b	$C_{18}H_{13}Br_2N_3OS$	45.39 / 45.12	2.96 / 2.73	8.91 / 8.77	192	5.03 (1H, dd, *J* = 2.3, *J* = 10.3, H-3); 5.83 (1H, d, *J* = 2.8, H-2); 6.91 (1H, d, *J* = 1.2, H-7); 7.23 (2H, d, *J* = 8.5, H$_{Ar}$); 7.27 (1H, d, *J* = 1.2, H-6); 7.29 (2H, d, *J* = 10.2, NH); 7.45 (2H, d, *J* = 8.5, H$_{Ar}$); 7.72 (2H, d, *J* = 8.7, H$_{Ar}$); 7.81 (2H, d, *J* = 8.7, H$_{Ar}$)	60
8	$C_{19}H_{16}BrN_3O_2S$	53.06 / 53.03	3.92 / 3.75	9.59 / 9.76	167	3.88 (3H, s, OCH$_3$); 4.8 (2H, s, CH$_2$); 6.95 (2H, d, *J* = 8.9, H$_{Ar}$); 7.12 (1H, d, *J* = 1.6, H-4); 7.47 (1H, d, *J* = 1.6, H-5); 7.6 (2H, d, *J* = 8.6, H$_{Ar}$); 7.71 (2H, d, *J* = 8.6, H$_{Ar}$); 8.13 (2H, d, *J* = 8.9, H$_{Ar}$); 8.22 (1H, s, N=CH)	68.5
9a	$C_{10}H_{10}N_4O_2S$	48.12 / 47.99	4.21 / 4.03	22.56 / 22.39	155	4.41 (2H, s, CH2); 5.9 (2H, s, NH2); 6.81 (1H, d, *J* = 1.3, H-4); 7.12 (1H, d, *J* = 1.3, H-5); 7.61 (2H, d, *J* = 8.7, HAr); 8.12 (2H, d, *J* = 8.7, HAr)	88

TABLE 1. (continued)

1	2	3	4	5	6	7	8
							67
9b	$C_{16}H_{14}N_4O_2S$	59.34 58.88	4.78 4.32	16.88 17.17	167	4.34 (2H, s, CH_2); 4.46 (2H, s, NH_2); 7.27 (1H, s, H-5); 7.33–7.4 (3H, m, Ph); 7.44 (2H, d, J = 8.4, H_{Ar}); 7.71-7.74 (2H, m, Ph); 8.12 (2H, d, J = 8.4, H_{Ar})	
10a	$C_{17}H_{13}N_5O_4S$	53.45 53.26	3.61 3.42	18.52 18.27	207	5.08 (1H, dd, J = 9.5, J = 9.7, H-3); 5.28 (1H, d, J = 9.5, H-2); 6.91 (1H, s, H-7); 7.31 (1H, s, H-6); 7.46 (1H, d, J = 9.8, NH); 7.55 (1H, dd, J = 7.9, J = 8.1, H_{Ar}); 7.71 (2H, d, J = 8.6, H_{Ar}); 7.75 (1H, d, J = 7.5, H_{Ar}); 8.08 (3H, d, J = 8.6, H_{Ar}); 8.31 (1H, s, H_{Ar})	13
10b	$C_{17}H_{13}BrN_4O_2S$	49.11 48.93	3.33 3.14	13.69 13.43	110	4.85 (1H, dd, J = 10.0, J = 10.0, H-3); 5.16 (1H, d, J = 9.67, H-2); 6.87 (1H, d, J = 0.7, H-7); 7.22-7.29 (4H, m, H-6, NH, H_{Ar}); 7.43 (2H, d, J = 8.49, H_{Ar}); 7.65 (2H, d, J = 8.8, H_{Ar}); 8.08 (2H, d, J = 8.8, H_{Ar})	66
11a	$C_{18}H_{13}N_5O_3S$	57.15 56.98	4.02 3.45	18.79 18.46	248	5.49 (1H, s, H-2); 6.5 (1H, d, J = 7.4, H_{isat}); 6.7 (1H, d, J = 7.5, H_{isat}); 6.95 (2H, m, H-7, H_{isat}); 7.15-7.3 (4H, m, H_{Ar}, H-6, H_{isat}); 7.61 (1H, s, 4-NH); 8.05 (2H, d, J = 8.8, H_{Ar}); 10.65 (1H, s, CONH)	55
11b	$C_{25}H_{19}N_5O_3S$	64.11 63.95	3.93 4.08	14.61 14.92	190	5.02 (2H, m, CH_2Ph); 5.51 (1H, s, H-2); 6.62 (1H, d, J = 7.7, H_{isat}); 6.82 (3H, m, H_{isat}, Ph); 6.91-7.13 (5H, m, Ph, H-7, H_{isat}); 7.22 (2H, d, J = 8.8, H_{Ar}); 7.31 (2H, m, H-6, H_{isat}); 7.61 (1H, s, NH); 8.05 (2H, d, J = 8.8, H_{Ar})	52
11c	$C_{31}H_{23}N_5O_3S$	69.18 68.24	3.94 4.25	12.55 12.84	198	4.71 (1H, d, J = 15.8, CH_2Ph); 5.22 (1H, d, J = 15.8, CH_2Ph); 5.32 (1H, s, H-2); 6.71 (3H, m, Ph, H_{isat}); 6.87 (1H, d, J = 7.4, H_{isat}); 7.03-7.15 (4H, m, Ph, H_{isat}); 7.22 (2H, d, J = 8.7, H_{Ar}); 7.32 (2H, m, H-6, H_{isat}); 7.45 (3H, m, Ph); 7.61 (1H, s, NH); 7.75 (2H, m, C_6H_5); 8.05 (2H, d, J = 8.7, H_{Ar})	53

* Solvents: $CDCl_3$ (compounds **4**, **8**, **9b**, **10b**, **11c**); DMSO-d_6 (compounds **5**, **6**, **7b**, **9a**, **10a**, **11a**,**b**) and $(CD_3)_2CO$ (compound **7a**).

The structure of **11a** was confirmed by X-ray diffraction structural analysis (Fig. 1). The major bond lengths, bond angles, and torsion angles are given in Tables 2 and 3.

The S(1)–C(9)–N(5)–N(4) part of the thiadiazine ring condensed with the imidazole ring is compressed and the C(9)–S(1) bond lies virtually in the plane of the imidazole ring (the sulfur atom extrudes from this plane by 0.075Å, while N(4) extrudes by 0.17 Å). Atoms C(2) and C(3) extrude significantly from the virtually coplanar arrangement of the other atoms of the thiadiazine and imidazole rings. The distance from C(2) and C(3) to the plane of the imidazole ring is 1.160 and 0.658 Å, respectively.

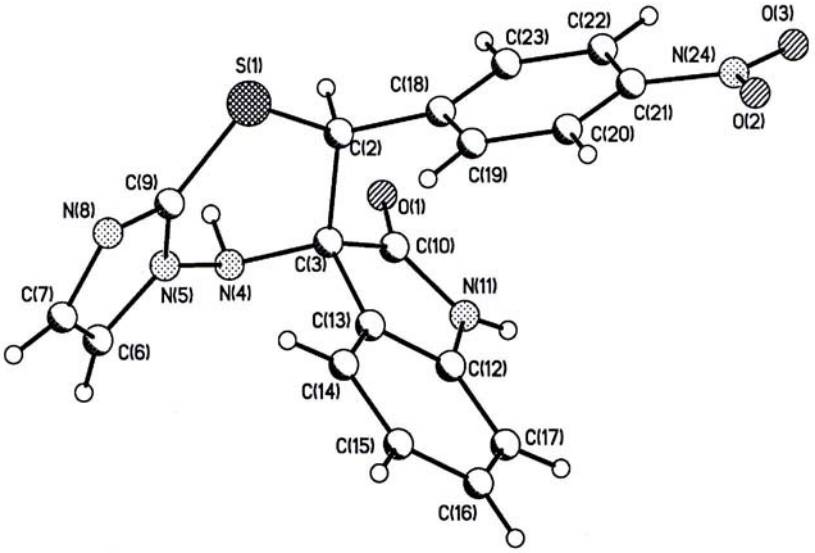

Fig. 1. Structure of compound **11a**.

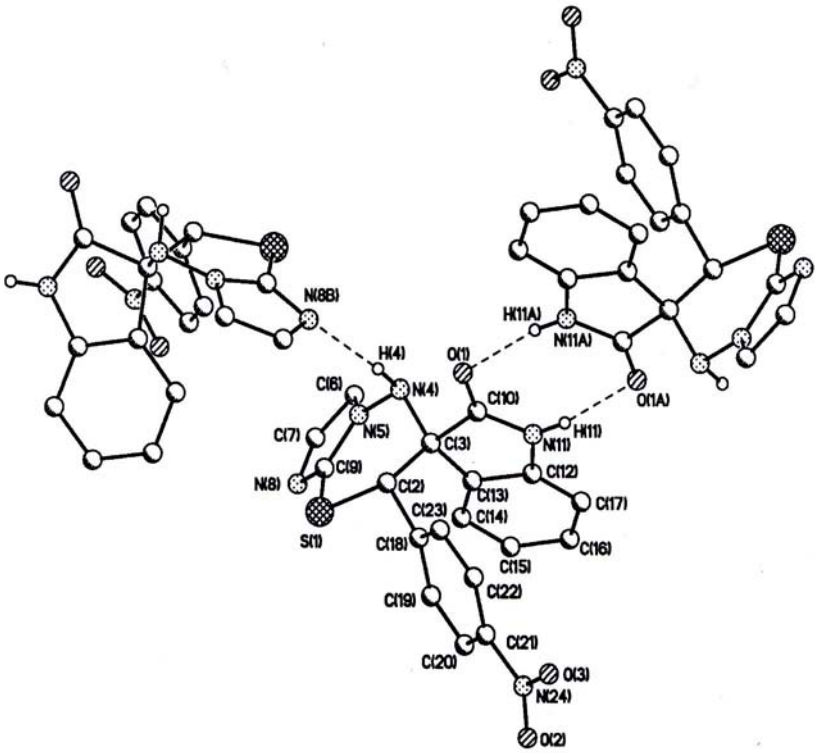

Fig. 2. Fragment of the hydrogen-bonded chain in the crystal of compound **11a**.

The atom N(4) has pyramidal bond geometry (the N(5)–N(4)–C(3), NH(5)–N(4)–H(4), and C(3)–N(4)–H(4) valence angles are 109.15, 106.7, and 107.1°, respectively). Hydrogen atoms H-4 and H-2 of the thiadiazine ring are located *cis* relative to each other and *trans* to the C(3)–C(13) bond of the isatin fragment (the H(4)–N(4)–C(3)–C(13) and H(2)–C(2)–C(3)–C(13) torsion angles are -178.78 and -164.20°, respectively). We should note the *cis* orientation of the isatin and *p*-nitrophenyl substituents relative to the thiadiazine ring (the (C13)–C(3)–C(2)–C(18) torsion angle is 46.94°). The dihedral angle formed by the planes of the isatin and *p*-nitrophenyl fragments is 51.29°.

Asymmetric atoms C(2) and C(3) shown in Fig. 1 have *S*-configuration according to the Cahn-Ingold-Prelog rules. The monoclinic crystal lattice of **11a** with $P2_1/n$ group symmetry forms two chiral antipodes (*s,s* and *r,r*) in 50:50 ratio.

The *S*- and *R*-enantiomers are combined in the crystal structure shown in Fig. 2 by means of two hydrogen bonds between the isatin fragments (the NH···O bond length is 2.01 Å). The similar enantiomers are connected by an NH···N hydrogen bond between the thiadiazine and imidazole fragments (the NH···N bond length is 2.10 Å).

TABLE 2. Bond Lengths (*l*) and Valence Angles (ω) in molecule **11a** from X-Ray Diffraction Data

Bond	*l*, Å	Angle	ω, deg
S(1)–C(9)	1.7321(18)	C(9)–S(1)–C(2)	101.37(7)
S(1)–C(2)	1.8413(15)	C(18)–C(2)–C(3)	112.52(12)
C(2)–C(18)	1.514(2)	C(18)–C(2)–S(1)	110.16(10)
C(2)–C(3)	1.561(2)	C(3)–C(2)–S(1)	112.84(10)
C(2)–H(2)	0.98(2)	S(1)–C(2)–H(2)	107.1(11)
C(3)–N(4)	1.4666(19)	N(4)–C(3)–C(13)	112.73(12)
C(3)–C(13)	1.515(2)	N(4)–C(3)–C(10)	105.80(11)
C(3)–C(10)	1.5533(19)	C(13)–C(3)–C(10)	102.15(11)
N(4)–N(5)	1.4142(17)	N(4)–C(3)–C(2)	112.95(11)
N(4)–H(4)	0.88(2)	C(13)–C(3)–C(2)	116.11(12)
N(5)–C(9)	1.3622(19)	C(10)–C(3)–C(2)	105.63(12)
N(5)–C(6)	1.374(2)	C(9)–N(5)–C(6)	107.85(13)
C(6)–C(7)	1.363(2)	C(9)–N(5)–N(4)	125.96(13)
C(7)–N(8)	1.381(2)	C(6)–N(5)–N(4)	125.29(13)
N(8)–C(9)	1.322(2)	N(8)–C(9)–N(5)	111.08(14)
C(10)–N(11)	1.3453(18)	N(8)–C(9)–S(1)	124.76(12)
		N(5)–C(9)–S(1)	124.11(12)

TABLE 3. Torsion Angles (τ) in molecule **11a** from X-Ray Diffraction Data

Angle	τ, deg	Angle	τ, deg
C(9)-S(1)-C(2)-C(18)	-138.58(11)	C(7)-N(8)-C(9)-S(1)	-177.71(12)
C(9)-S(1)-C(2)-C(3)	-11.90(12)	N(4)-N(5)-C(9)-S(1)	6.7(2)
C(18)-C(2)-C(3)-N(4)	179.39(12)	C(2)-S(1)-C(9)-N(5)	-17.26(14)
S(1)-C(2)-C(3)-N(4)	53.98(14)	N(4)-C(3)-C(10)-O(1)	58.07(19)
S(1)-C(2)-C(3)-C(13)	-78.47(14)	C(2)-C(3)-C(10)-O(1)	-61.93(18)
C(18)-C(2)-C(3)-C(10)	-65.42(15)	C(2)-C(3)-C(10)-N(11)	117.12(13)
S(1)-C(2)-C(3)-C(10)	169.17(9)	S(1)-C(2)-C(18)-C(23)	-137.24(13)
C(3)-N(4)-N(5)-C(9)	36.65(18)	C(3)-C(2)-C(18)-C(19)	-80.14(17)
N(4)-N(5)-C(6)-C(7)	171.70(14)	S(1)-C(2)-C(18)-C(19)	46.71(17)

Thus, the condensation of 1-amino-2-benzylthioimidazoles with carbonyl compounds does not stop upon formation of the imine due to further intramolecular cyclization leading to 3,4-dihydro-2H-imidazo-[2,1-*b*][1,3,4]thiadiazines. A similar intramolecular cyclization occurs in the alkylation of the mercapto group in imidazolylimines by phenacyl halides. This reaction is a convenient method for the fusion of a dihydrothiadiazine ring and preparation of previously unreported 3,4-dihydro-2H-imidazo-[2,1-*b*][1,3,4]thiadiazines. A special feature of this reaction is the formation of a C–C bond in the final heterocyclization step. The conditions for this reaction are a basic medium and enhanced acidity of the methylene protons of the thioethers group.

EXPERIMENTAL

The ^{1}H NMR spectra were taken on a Varian Unity-300 spectrometer at 300 MHz and on a Bruker DPX-250 spectrometer at 250 MHz at 25°C with TMS as the internal standard.

X-ray Diffraction Structural Analysis of 11a. The study of **11a** was carried out at 183(2) K on a Syntex P21 automatic four-circle diffractometer using MoKα radiation, graphite monochromator, and θ/2θ-scanning, $2\theta < 60°$. The unit cell parameters of the monoclinic crystal at -90°C grown from acetonitrile: $a = 13.154(3)$, $b = 8.8690(18)$, $c = 16.163(3)$ Å, $\beta = 111.90(3)°$, $V = 1749.4(7)$ Å^3, space group $P2_1/n$, $Z = 4$ ($Z' = 1$), $M = 379.39$, $d_{calc} = 1.441$ g/cm^3, $\mu = 2.16$ cm^{-1}, $F(000) = 748$. A total of 5289 reflections were measured ($R_{int} = 0.0225$) and 5101 independent reflections were used in the subsequent calculations and refinements.

The structure of **11a** was solved by the direct method and refined by the method of least squares in the anisotropic full-matrix approximation. The hydrogen atoms were localized from the electron density Fourier difference map and their positions were refined isotropically. The final $R = 0.0455$ using 4258 reflections with $I \geq 2\sigma(I)$, $wR2 = 0.1032$, $GOOF = 1.072$. All the calculations were carried out using the SHELXTL PLUS 5 program package [2].

The complete crystallographic data have been deposited at the Cambridge Crystallographic Data Center, CCDC No. 633535.

Samples of starting hydrochloride salt of 1-amino-2-mercaptoimidazole **3a** and 1-amino-2-mercapto-6-phenylimidazole **3b** were obtained according to reported procedures [3, 4].

1-Benzyl-3-(2-mercapto-1-imidazolylimino)-2,3-dihydro-2-indolone (4). Triethylamine (2 ml) was added to a mixture of 0.3 g (2 mmol) hydrochloride salt of aminomercaptoimidazole **3a** and N-benzylisatin (0.47 g, 2 mmol) in glacial acetic acid (3 ml). The mixture was heated at reflux for 2 h. After cooling, water (20 ml) was added to the reaction mixture. The precipitate formed was filtered off, washed with water, and dried. The crude product was recrystallized from benzene.

1-[(4-Bromophenyl)methylideneamino]-1H-imidazole-2-thiol (5). Triethylamine **(**0.6 ml) was added to a mixture of hydrochloride salt of aminomercaptoimidazole **3a** (0.5 g, 3.3 mmol) and *p*-bromobenzaldehyde (0.611 g, 3.3 mmol) in glacial acetic acid (10 ml) and the mixture was heated at reflux for 3.5 h. The precipitate formed was filtered off and recrystallized from ethanol.

1'-Benzyl-2-(4-bromobenzoyl)spiro[imidazo[2,1-*b*][1,3,4]thiadiazine-3,3'-indol]-2'(1H)-one (6). Imidazolylisatinimine **4 (**0.33 g, 1 mmol) was added to a solution of NaOH (0.04 g, 1 mmol) in ethanol (3 ml). After dissolution, *p*-bromophenacyl bromide (0.28 g, 1 mmol) was added and the solution was heated at reflux for 5 min. After cooling, water (20 ml) was added and the precipitate was filtered off. The crude product was recrystallized from acetonitrile.

2-Benzoyl-3-(4-bromophenyl)-3,4-dihydro-2H-imidazo[2,1-*b*][1,3,4]thiadiazine (7a). Methylidene-amino-1H-imidazole-2-thiol **5 (**0.28 g, 1 mmol) was added to a solution of NaOH (0.04 g, 1 mmol) in ethanol (3 ml). After the complete dissolution of **5**, phenacyl bromide (0.2 g, 1 mmol) was added. The mixture was stirred for 5 min and, then, water (20 ml) was added. The precipitate formed was filtered off and recrystallized from acetonitrile.

2-[(4-Bromobenzoyl)-3-(4-bromophenyl)-3,4-dihydro-2H-imidazo[2,1-*b*][1,3,4]thiadiazine (7b) was prepared analogously to **7a** from equimolar amounts of **5** and *p*-bromophenacyl bromide.

1-[(4-Bromophenyl)methylideneamino]-2-(4-methoxyphenyl)thio-1H-imidazole (8) was obtained analogously to **7a** from equimolar amounts of **5** and *p*-methoxyphenacyl bromide.

1-Amino-2-(4-nitrobenzylthio)imidazole (9a). Hydrochloride salt of **3a** (0.23 g, 1.5 mmol) was added to a solution of NaOH (0.12 g, 3 mmol) in methanol (5 ml). After complete dissolution of the salt, *p*-nitrobenzyl bromide (0.32 g, 1.5 mmol) was added and the mixture was heated for 2-3 min. The precipitate formed upon cooling was filtered off, washed with water, and recrystallized from methanol.

1-Amino-2-(4-nitrobenzylthio)-4-phenylimidazole (9b) was obtained analogously to **9a** using equimolar amounts of NaOH, 1-amino-2-mercapto-4-phenylimidazole **(3b)**, and *p*-nitrobenzyl bromide.

3-(3-Nitrophenyl)-2-(4-nitrophenyl)-3,4-dihydro-2H-imidazo[2,1-*b*][1,3,4]thiadiazine (10a). A catalytic amount NaOH (0.5 mmol) was added to a solution of S-benzyl ether **9a** (0.5 g, 2 mmol) and 3-nitrobenzaldehyde (0.3 g, 2 mmol) in ethanol (10 ml). The mixture was heated at reflux for 1 h. After cooling, water (30 ml) was added to the reaction mixture, which was then neutralized by adding dilute hydrochloric acid. The precipitate formed was filtered off and recrystallized from acetonitrile.

3-(4-Bromophenyl)-2-(4-nitrophenyl)-3,4-dihydro-2H-imidazo[2,1-*b*][1,3,4]thiadiazine (10b) was obtained analogously to **10a** from equimolar amounts of **9a** and *p*-bromobenzaldehyde.

2-(4-Nitrophenyl)spiro[imidazo[2,1-*b*][1,3,4]thiadiazine-3,3'-indol]-2'(1H)-one (11a). NaOH (0.05 g, 1.2 mmol) was added to a solution of **9a** (0.3 g, 1.2 mmol) and isatin (0.18 g, 1.2 mmol) in methanol (5 ml) and heated at reflux for 1.5 h. After cooling, water (20 ml) was added to the reaction mixture, which was then neutralized by adding dilute acetic acid. The precipitate formed was filtered off and recrystallized from acetonitrile.

1'-Benzyl-2-(4-nitrophenyl)spiro[imidazo[2,1-*b*][1,3,4]thiadiazine-3,3'-indol]-2'(1H)-one (11b) was obtained analogously to **11a** from equimolar amounts of **9a** and N-benzylisatin.

1'-Benzyl-2-(4-nitrophenyl)-7-phenylspiro[imidazo[2,1-*b*][1,3,4]thiadiazine-3,3'-indol]-2'(1H)-one (11b) was obtained analogously to **11a** from equimolar amounts of **9b** and N-benzylisatin.

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REFERENCES

1. L. P. Olekhnovich, E. P. Ivakhnenko, S. N. Lyubchenko, V. I. Simakov, G. S. Borodkin, A. V. Lesin, I. N. Shcherbakov, and S. V. Kurbatov, *Ros. Khim. Zh.*, **48**, No. 1, 103 (2004).
2. G. M. Sheldrick, *SHELXTL v. 5.10, Structure Determination Software Suite*, Bruker AXS, Madison, Wisconsin, USA (1998).
3. W. Thorwart, U. Gebert, R. Schleyerbach, R. Bartlett, Ger. Pat. Appl. 3702757 (1988); *Ref. Zh. Khim.*, 10O140 (1989).
4. T. Pyl, F. Waschk, and H. Beyer, *Liebigs Ann. Chem.*, **663**, 113 (1963).