Synthesis, alkylation, and molecular and crystal structure of *N*-methylmorpholinium 6-amino-3,5-dicyano-1,4-dihydropyridine-4-spirocyclohexane-2-thiolate

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The reaction of cyano(cyclohexylidene)thioacetamide with cyanothioacetamide or malononitrile and *N*-methylmorpholine yields *N*-methylmorpholinium 6-amino-3,5-dicyano-1,4-dihydropyridine-4-spirocyclohexane-2-thiolate. Its structure was established based on the results of alkylation and X-ray structural analysis.

Key words: cyano(cyclohexylidene)thioacetamide, cyanothioacetamide, malononitrile; X-ray structural analysis.

Recently, the chemistry of functionally substituted hydrogenated pyridines has drawn the attention of researchers because of the biological activity of these compounds. Among them, compounds that exhibit cardiovascular,[1,2] hypertensive,[3–5] and other kinds of activities have been found. Spiro derivatives of hydrogenated pyridines have a special place in this series. This field of the chemistry of heterocycles remains poorly studied, primarily because of the lack of convenient methods for preparing these compounds. However, they represent a promising class of heterocycles from the standpoint of a search for new biologically active compounds.[6]

As part of continuing studies devoted to the synthesis and investigation of the properties of hydrogenated 3-cyanopyridine-2(1*H*)-chalcogenones,[7] we studied the reaction of cyano(cyclohexylidene)thioacetamide (**1**) with cyanothioacetamide (**2**) in the presence of an excess of *N*-methylmorpholine. *N*-Methylmorpholinium 6-amino-3,5-dicyano-1,4-dihydropyridine-4-spirocyclohexane-2-thiolate (**6**) was obtained in a yield of 71% (method *A*). Compound **6** was also obtained in a yield of 78% by the reaction of compound **1** with malononitrile (**3**) in the presence of *N*-methylmorpholine (method *B*). Both reactions proceed apparently as the Michael addition to yield adducts (**4**) and (**5**), respectively. As a result of subsequent intramolecular cyclocondensation (with elimination of hydrogen sulfide, method *A*) under the action of a base (*N*-methylmorpholine), adducts **4** and **5** transform into salt **6**. The structure of **6** has been established by X-ray structural analysis (Fig. 1; Tables 1 and 2). When treated with 10% HCl, *N*-methylmorpholinium salt **6** gave 6-amino-3,5-dicyano-1,4-dihydropyridine-4-spirocyclohexane-2-thiol (**7**) in a yield of 92%. The melting point and spectral characteristics of **7** differ from those of thione, which has been obtained previously[8] by the reaction of cyclohexylidenemalononitrile with **2** or by the reaction of cyano(cyclohexylidene)thioacetamide with **3** and to which the structure of **6** was ascribed. X-ray structural study of salt **6** cast some doubt on the data reported previously.[8]

According to the data of the ^{1}H NMR spectra, compound **7** occurs in a DMSO solution as a mixture of prototropic tautomers (**7A**) and (**7B**) in a ratio of 1 : 1. Thus, the signal at δ 4.60 (s, C(3)—H) confirms the structure of thione (**7B**), whereas the signal at δ 4.06 (br.s, SH) confirms the structure of its tautomer (**7A**). It is interesting that the prototropic tautomerism is also typical of the derivatives of thione **7**, namely, of 2-alkylthiopyridines (**9**) and thienopyridines (**11**) (Scheme 1). In this case, amino and imino forms, **9A**, **11A**, and **9B**, **11B**, are observed in the ^{1}H NMR and IR spectra. Thus, the IR spectra of pyridines **9** showed absorption bands of stretching vibrations of the conjugated cyano group in the region of 2180—2200 cm^{-1} and absorption bands of stretching vibrations of the non-

†Deceased.

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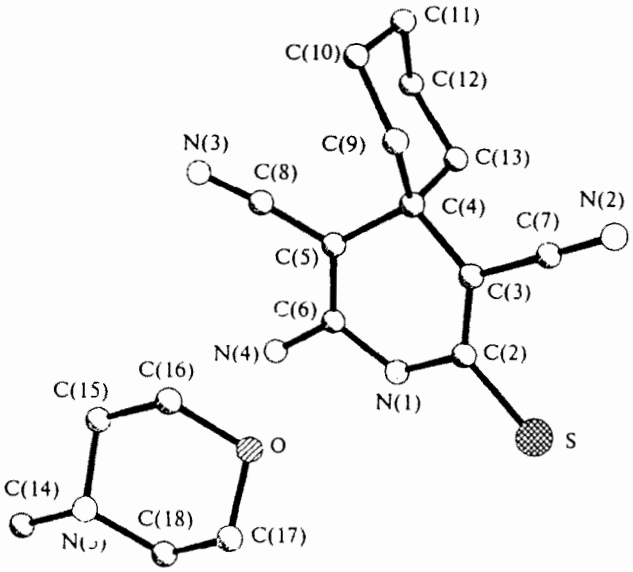


Fig. 1. Overall view of molecule **6**.

Table 1. Bond lengths (d) and bond angles (ω) in the structure of **6**

Bond	d/Å	Bond	d/Å
C(2)—C(3)	1.363(3)	C(8)—N(3)	1.154(4)
C(2)—C(7)	1.737(2)	C(5)—C(6)	1.371(3)
C(3)—C(4)	1.535(3)	C(6)—N(4)	1.348(3)
C(3)—C(7)	1.419(3)	C(6)—N(1)	1.378(3)
C(7)—N(2)	1.149(3)	N(1)—C(2)	1.385(2)
C(4)—C(5)	1.529(3)	C(14)—N(5)	1.510(8)
C(4)—C(9)	1.554(3)	N(5)—C(15)	1.428(8)
C(9)—C(10)	1.536(3)	C(15)—C(16)	1.52(1)
C(10)—C(11)	1.502(5)	C(16)—O	1.48(1)
C(11)—C(12)	1.515(5)	O—C(17)	1.397(9)
C(12)—C(13)	1.531(4)	C(17)—C(18)	1.454(8)
C(13)—C(4)	1.550(4)	C(18)—N(5)	1.456(6)
C(5)—C(8)	1.407(3)		

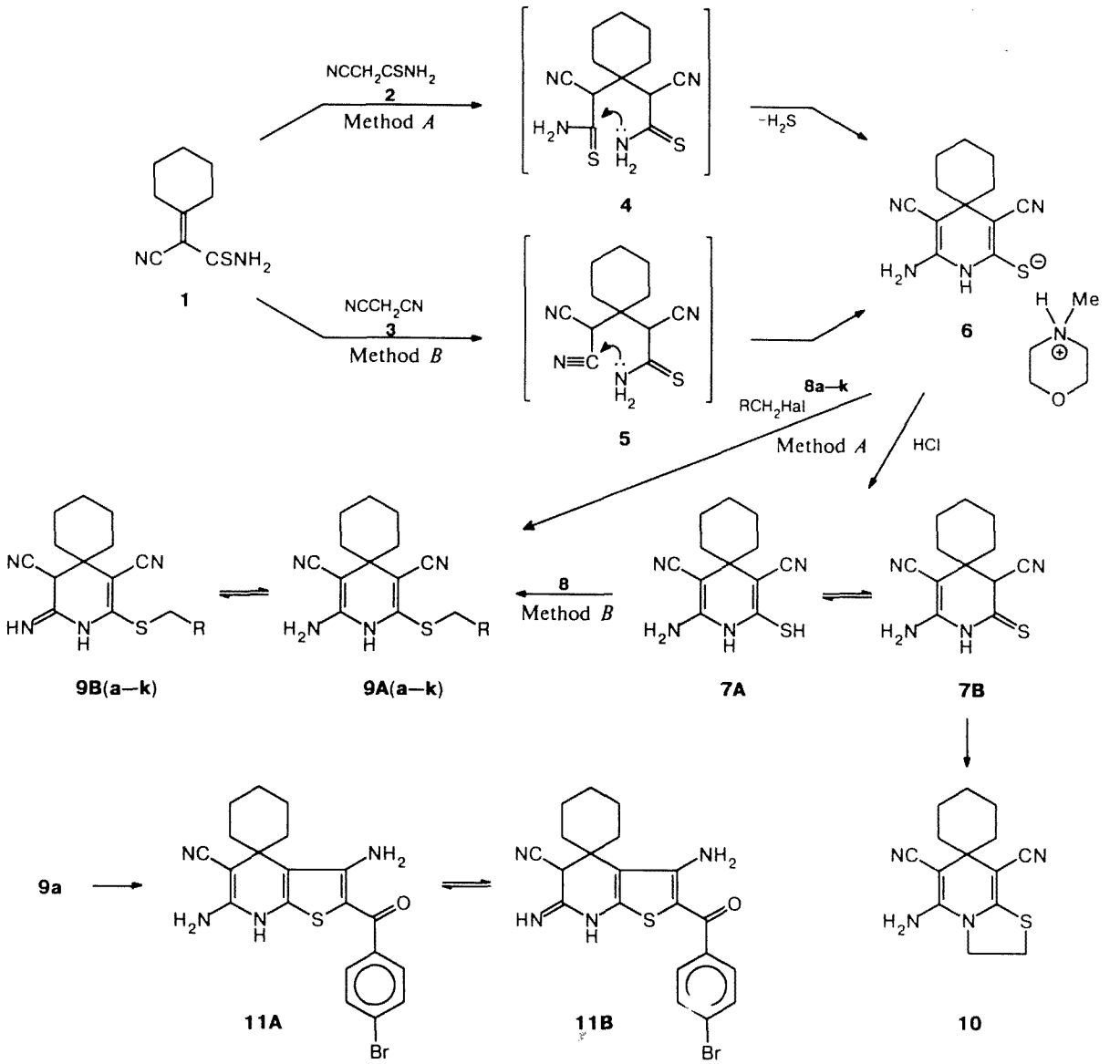
Angle	ω/deg	Angle	ω/deg
C(16)—O—C(17)	108.4(7)	C(4)—C(5)—C(6)	122.2(2)
C(2)—N(1)—C(6)	121.8(2)	C(4)—C(5)—C(8)	121.7(2)
C(14)—N(5)—C(15)	108.2(5)	C(6)—C(5)—C(8)	116.0(2)
C(14)—N(5)—C(18)	112.9(4)	N(1)—C(6)—N(4)	115.0(2)
C(15)—N(5)—C(18)	112.3(5)	N(1)—C(6)—C(5)	120.5(2)
S—C(2)—N(1)	116.0(1)	N(4)—C(6)—C(5)	124.5(2)
S—C(2)—C(3)	125.6(1)	N(2)—C(7)—C(3)	178.8(3)
N(1)—C(2)—C(3)	118.4(2)	N(3)—C(8)—C(5)	176.1(3)
C(2)—C(3)—C(4)	124.8(2)	C(4)—C(9)—C(10)	115.2(2)
C(2)—C(3)—C(7)	116.8(2)	C(9)—C(10)—C(11)	112.9(2)
C(4)—C(3)—C(7)	117.9(2)	C(10)—C(11)—C(12)	111.5(3)
C(3)—C(4)—C(5)	106.7(2)	C(11)—C(12)—C(13)	111.0(3)
C(3)—C(4)—C(9)	109.2(2)	C(4)—C(13)—C(12)	113.0(2)
C(5)—C(4)—C(9)	112.4(2)	N(5)—C(15)—C(16)	107.2(6)
C(3)—C(4)—C(13)	108.8(2)	O—C(16)—C(15)	115.0(7)
C(5)—C(4)—C(13)	110.7(2)	O—C(17)—C(18)	111.7(5)
C(9)—C(4)—C(13)	109.0(2)	N(5)—C(18)—C(17)	112.0(4)

conjugated cyano group in the region of 2250 cm^{-1}. The ^1H NMR spectra of compounds **9** showed signals for the protons of the amino group as a singlet at δ 5.80, the signals of the N—H proton of the dihydropyridine nucleus of the amino and imino forms as singlets at δ 8.00 and 8.50, respectively, and the signal of the proton of the =NH group as a singlet at δ 9.38—9.46 (Tables 3 and 4).

Table 2. Atomic coordinates ($\times 10^4$; for H, $\times 10^3$) in the structure of **6**

Atom	x	y	z
S	2082(1)	3052(1)	1978(1)
O	835(6)	1975(4)	4646(3)
N(1)	3772(3)	2079(1)	3210(1)
N(2)	139(4)	1913(1)	−110(2)
N(3)	3449(6)	−248(1)	4024(2)
N(4)	4952(3)	1405(1)	4579(1)
N(5)	1225(5)	1744(2)	6714(3)
C(2)	2620(3)	2200(1)	2276(1)
C(3)	2036(3)	1654(1)	1666(1)
C(4)	2653(3)	910(1)	1912(1)
C(5)	3351(3)	869(1)	3044(2)
C(6)	4023(3)	1430(1)	3614(1)
C(7)	978(3)	1802(1)	688(2)
C(8)	3421(5)	245(1)	3559(2)
C(9)	941(4)	427(1)	1511(2)
C(10)	1441(5)	−335(1)	1474(2)
C(11)	3064(6)	−461(2)	984(2)
C(12)	4780(5)	−30(2)	1449(3)
C(13)	4278(4)	732(1)	1391(2)
C(14)	2363(8)	1615(4)	7761(6)
C(15)	1444(10)	1167(3)	6115(7)
C(16)	346(12)	1320(7)	5061(10)
C(17)	605(7)	2501(4)	5294(5)
C(18)	1730(6)	2384(2)	6298(4)
H(1)	397(4)	240(1)	359(2)
H(4a)	530(4)	106(1)	484(2)
H(4b)	519(4)	174(1)	486(2)
H(5)	−4(4)	177(1)	678(2)
H(9a)	32(4)	59(1)	81(2)
H(9b)	−2(4)	53(1)	194(2)
H(10a)	28(4)	−59(1)	114(2)
H(10b)	178(4)	−52(1)	219(2)
H(11a)	335(4)	−96(2)	100(2)
H(11b)	257(4)	−34(1)	32(2)
H(12a)	582(4)	−9(1)	110(2)
H(12b)	529(4)	−16(1)	219(2)
H(13a)	541(4)	101(1)	170(2)
H(13b)	386(4)	87(1)	72(2)
H(14a)	199(4)	110(2)	791(2)
H(14b)	382(4)	167(1)	772(2)
H(14c)	231(5)	206(2)	783(2)
H(15a)	93(4)	71(2)	641(2)
H(15b)	290(4)	110(1)	607(2)
H(16a)	57(5)	112(2)	476(3)
H(16b)	−61(5)	135(2)	502(3)
H(17a)	−70(4)	254(1)	538(2)
H(17b)	106(4)	293(2)	501(2)
H(18a)	307(4)	233(1)	628(2)
H(18b)	145(4)	277(1)	696(2)

Scheme 1



8, 9: Hal = Br, R = 4-BrC_6H_4CO (**a**), Et (**d**), 4-ClC_6H_4CO (**e**), 2-MeC_6H_4 (**h**), 4-MeC_6H_4CO (**i**);
Hal = Cl, R = Ph (**b**), 4-BrC_6H_4NHCO (**f**), PhNHCO (**g**);
Hal = I, R = Me (**c**), H (**k**).

Alkylation of thione **7** with 1,2-dibromoethane yielded 5-amino-6,8-dicyano-spiro-2,3-dihydrothiazolo-[3,2-*a*]pyridine-7,1′-cyclohexane (**10**), whereas treatment of substituted 2-(4-bromobenzoylmethylthio)dihydropyridine (**9a**) with a 10% aqueous KOH solution yielded thienopyridine (**11**). The structures of compounds **10** and **11** are consistent with the data of spectral and physicochemical studies (see Tables 3 and 4).

The dihydropyridine heterocycle (see Fig. 1 and Table 1) has a boat conformation; the N(1) and C(4) atoms deviate from the plane through the other atoms of the "bottom" (planar to within ±0.022 Å) by 0.116 and 0.296 Å, respectively, which corresponds to the fold of the ring along the C(2)...C(6), C(3)...C(5), and N(1)...C(4) lines by 10.0°, 18.9°, and 18.8°, respectively. Previously,[9] we have established an analogous conformation of the 1,4-dihydropyridine ring in the molecule of morpholinium 5-acetyl-3-cyano-6-methyl-4-(2-nitrophenyl)-1,4-dihydropyridine-2-thiolate (**12**).

As can be seen from Fig. 1, the cyclohexane spiro substituent has a chair conformation. The C(4) and C(11) atoms deviate from the plane through the C(9),

Table 3. Yields, melting points, and the data of IR spectroscopy for spirodihydropyridines **9a—k**

Compound	Yield (%) (method *A*/*B*)	M.p./°C (solvent for crystallization)	ν/cm^{-1}		
			NH, NH_2	CN	CO
9a	69/65	198—200 (EtOH)	3195, 3305, 3364	2185	1710
9b	92/84	158—160 (EtOH)	3390, 3474	2172, 2190	
9c	80/75	141—143 (EtOH)	3175—3390	2178	
9d	77/85	147—149 (EtOH)	3183, 3190, 3308, 3390	2190, 2248	
9e	81/69	179—181 (AcOH)	3180, 3302, 3384	2188, 2250	1684
9f	74/70	199—201 (EtOH)	3182, 3304, 3390, 3496	2189, 2245	1690
9h	63/61	158—160 (Bu^nOH)	3150, 3328, 3445	2188, 2196	
9g	71/84	203—205 (EtOH)	3155, 3422	2170, 2253	1682
9i	63/60	189—191 (EtOH)	3335—3450	2190, 2215	1674
9k	90/88	143—145 (EtOH)	3304—3400	2180, 2242	

Table 4. Data of ^{1}H NMR spectroscopy and elemental analysis of spirodihydropyridines **9a—k**

Compound	δ						Found / Calculated (%)				Molecular formula
	$(SH_2)_5$ (m)	NH_2, =NH (s)	N—H (s)	C(3)H (s)	SCH_2	R	C	H	N	S	
9a	1.31—1.77	5.82, 9.49	8.17, 8.51	4.19	4.66 (s)	7.85 (m)	54.20 54.18	4.41 4.32	12.58 12.64	7.34 7.23	$C_{20}H_{19}BrN_4OS$
9b	1.15—1.85	5.78, 9.46	8.17, 8.71		4.23 (s)	7.29 (m)	67.78 67.83	5.93 5.99	16.71 16.65	9.47 9.53	$C_{19}H_{20}N_4S$
9c	1.20—1.76	5.82, 9.38	8.07, 8.58	4.19	2.99 (q)	1.19 (t)	61.33 61.28	6.57 6.61	20.47 20.42	11.65 11.69	$C_{14}H_{18}N_4S$
9d	1.15—1.80	5.80, 9.38	8.06, 8.55	4.17	2.93 (t)	0.92 (m)	62.52 62.47	7.03 6.99	19.38 19.43	11.18 11.12	$C_{15}H_{20}N_4S$
9e	1.3[illegible]1.76	5.80, 9.47	8.15, 8.48	[illegible]7	4.66 (s)	7.60 and 7.99 (d)	60.19 60.22	4.84 4.80	13.89 14.05	8.08 8.04	$C_{20}H_{19}ClN_4OS$
9f	1.33—1.76	5.84, 9.65	8.22, 8.61	4.22	3.91 (s)	7.51 (d), 10.16 and 10.40 (s)	52.37 52.41	4.45 4.40	15.35 15.28	6.87 7.00	$C_{20}H_{20}BrN_5OS$
9h	1.00—1.85	5.84, 9.50	8.15, 8.76		4.22 (s)	2.28 (s), 7.12 (m)	68.50 68.54	6.29 6.33	16.03 15.98	9.18 9.15	$C_{20}H_{22}N_4S$
9g	1.34—1.78	5.89, 9.74	8.25, 8.66	4.25	3.93 (s)	7.05—7.57 (m), 10.05 and 10.31 (s)	63.42 63.30	5.64 5.58	18.31 18.45	8.39 8.45	$C_{20}H_{21}N_5OS$
9i	1.32—1.76	5.81, 9.46	8.14, 8.54	4.20	4.67 (s)	2.39 (s), 7.35 and 7.87 (d)	66.68 66.64	5.79 5.86	14.85 14.80	8.42 8.47	$C_{21}H_{22}N_4OS$
9k	1.31—1.80	5.06, 9.28	8.11, 8.62	4.17	2.37 and 2.46 (s)		59.93 59.97	6.21 6.19	21.46 21.52	12.37 12.32	$C_{13}H_{16}N_4S$

C(10), C(12), and C(13) atoms (to within ±0.032 Å) by 0.625 and −0.646 Å, respectively. This ring has an analogous conformation in the molecules of 4-amino-5-cyano-6-phenyl-2-cyclohexanespiro-1,3-dithia-4-cyclohexene[10] and 2,5-dicyclohexanespiro-1,3-dithiacyclohexane.[11] It should be noted that the forced shortened

nonbonded intramolecular contacts (C(7)...C(9), 2.918(3) Å; C(7)...C(13), 3.153(4) Å; C(8)...C(9), 2.999(3) Å; C(8)...C(10), 3.116(3) Å; C(8)...C(12), 3.321(4) Å; and C(8)...C(13), 3.327(4) Å (the double van der Waals radius of the C atom is 3.40 Å[12])) affect the conformation of the cyclohexane substituent (the dihedral angle between the planar fragments of the rings in the anion is 105.5°).

As in **12**, the negative charge in the anion of salt **6** is formally located on the sulfur atom as evidenced by the C(2)—S bond length (1.737(2) Å; 1.725(3) Å in **12**), which is substantially larger than that of the conjugated multiple C=S bond (1.660(4) Å and 1.666(5) Å) in substituted pyridine-2(1*H*)-thiones,[13,14] but is smaller than the C—S bond length (1.753(4) Å) in 2-allylthio-3-cyano-5-ethoxycarbonyl-6-methyl-4-phenyl-1,4-dihydropyridine.[15,16]

As noted for the anion of salt **12**, conjugation in the planar S—C(2)=C(3)—C(7)≡N(2) and N(4)—C(6)=C(5)—C(8)≡N(3) fragments in the anion of salt **6** also results in a substantial redistribution of bond lengths (shortening of single bonds and lengthening of double bonds) compared to the standard values.[17]

The heterocycle of the *N*-methylmorpholinium cation adopts a chair conformation. The O and N(5) atoms deviate from the plane through the C(15), C(16), C(17), and C(18) atoms (planar to within ±0.014 Å) by 0.637 and −0.622 Å, respectively.

In the crystal of **6**, cations and anions of the salt are linked in layers parallel to the *bc* plane *via* intermolecular hydrogen bonds: N(1)—H(1)...N(2) (0.5 + *x*, 0.5 − *y*, 0.5 + *z*) [N(1)...N(2) 3.029(3), N(1)—H(1) 0.81(3), H(1)...N(2) 2.24(2) Å, the N(1)—H(1)...N(2) angle is 164(2)°], N(4)—H(4a)...N(3) (1 − *x*, 1 − *y*, 1 − *z*) [N(4)...N(3) 3.023(3), N(4)—H(4a) 0.77(3), H(4a)...N(3) 2.28(2) Å, the N(4)—H(4a)...N(3) angle is 164(2)°], and N(5)—H(5)...S (−0.5 + *x*, 0.5 − *y*, 0.5 + *z*) [N(5)...S 3.124(3), N(5)—H(5) 0.94(3), H(5)...S 2.19(2) Å, the N(5)—H(5)...S angle is 173(2)°] (Fig. 2). The second hydrogen atom of the $N(4)H_2$ group is involved in a weak intermolecular contact H(4b)...N(2) (0.5 + *x*, 0.5 − *y*, 0.5 − *z*) with the distance of 2.63(3) Å, which is comparable to the sum of the van der Waals radii (2.75 Å).[12]

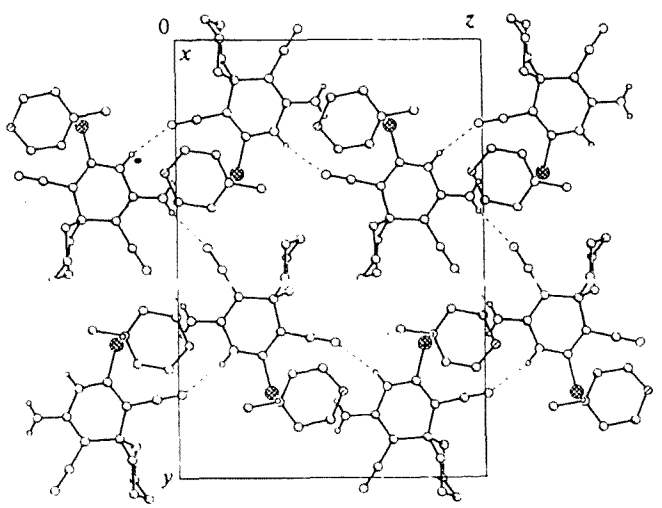


Fig. 2. Projection of the crystal structure of **6** onto the *ab* plane. Intermolecular N—H...N hydrogen bonds are indicated by dashed lines.

Experimental

The IR spectra were recorded on an IKS-29 spectrophotometer as Nujol mulls. The ^{1}H NMR spectra were measured on a Bruker WP-100 SY instrument (100 MHz) in DMSO-d_6 relative to TMS. The purity of the compounds was checked by TLC on Silufol UV-254 plates in a 3 : 5 acetone—hexane system.

***N*-Methylmorpholinium 6-amino-3,5-dicyano-1,4-dihydropyridine-4-spiro(cyclohexane)-2-thiolate (6). Method *A*.** *N*-Methylmorpholine (2 mL, 20 mmol) was added with stirring to a mixture of **1** (10 mmol) and **2** (10 mmol) in absolute ethanol (15 mL) at 20 °C. After 48 h, the colorless crystals that formed were filtered off and washed with absolute ethanol and hexane. The yield was 2.5 g (71%), m.p. 133—135 °C. Found (%): C, 58.81; H, 7.21; N, 20.20; S, 9.19. $C_{17}H_{25}N_5OS$. Calculated (%): C, 58.76; H, 7.25; N, 20.16; S, 9.23. IR, ν/cm^{-1}: 3310, 3405 (NH, NH_2), 1600 ($\delta(NH_2)$), 2190 (C≡N). ^{1}H NMR, δ: 8.05 (s, 1 H, NH); 5.43 (s, 2 H, NH_2); 3.74 (m, 4 H, CH_2NCH_2); 3.02 (m, 4 H, CH_2OCH_2); 2.68 (s, 3 H, CH_3); 1.54 (m, 10 H, $(CH_2)_5$).

Method *B*. *N*-Methylmorpholine (2 mL, 20 mmol) was added with stirring to a suspension of **1** (10 mmol) and **3** (10 mmol) in absolute ethanol (15 mL) at 20 °C. After 24 h, the precipitate that formed was separated and washed with ethanol and hexane. Compound **6** was obtained in a yield of 2.7 g (78%). The melting point and the ^{1}H NMR spectrum of this compound were identical to those of the compound obtained by method *A*.

Crystals of compound **6** are monoclinic, at 20 °C: a = 7.230(2) Å, b = 19.537(3) Å, c = 13.788(4) Å, β = 103.20(2)°, V = 1896(2) Å^3, d_{calc} = 1.224 g cm^{-3}, Z = 4, $C_{17}H_{25}N_5OS$, M = 347.41, space group $P2_1/n$. The unit cell parameters and intensities of 4265 independent reflections were measured on a four-circle automated Siemens P3/PC diffractometer (λ(Mo-Kα) radiation, graphite monochromator, θ/2θ scanning technique to θ_{max} = 28°). The structure was solved by the direct method. All nonhydrogen atoms were revealed and refined anisotropically by the full-matrix least-squares method using 3847 reflections with $I > 3\sigma(I)$. All hydrogen atoms were located from difference Fourier syntheses and refined isotropically. The final values of the R factors were as follows: R = 0.057 and R_w = 0.057. All calculations were carried out using the SHELXTL PLUS program[18] (the PC version). Atomic coordinates are given in Table 2 (thermal parameters of the atoms may be obtained from the authors).

6-Amino-3,5-dicyano-1,4-dihydropyridine-4-spirocyclohexane-2-(1*H*)-thiol (7). A 10% HCl solution was added dropwise with stirring to a suspension of **6** (10 mmol) in ethanol (15 mL) until pH became 5. Then the reaction mixture was filtered and kept at 20 °C for 24 h. The yellow powder that formed was separated and washed with ethanol and hexane.

The yield was 2.3 g (92%), m.p. 194—196 °C (from ethanol) (*cf.* Ref. 8: m.p 168—169 °C). Found (%): C, 58.60; H, 5.60; N, 22.81; S, 12.99. $C_{12}H_{14}N_4S$. Calculated (%): C, 58.51; H, 5.73; N, 22.74; S, 13.02. IR, ν/cm^{-1}: 3210, 3334, 3448 (NH, NH_2); 1646 ($\delta(NH_2)$); 2195 and 2256 (C≡N). ^1H NMR, δ: 12.13 (s, 1 H, NH); 6.27 (s, 2 H, NH_2); 4.60 (m, 0.5 H, C(3)); 4.06 (m, 0.5 H, SH); 1.20—1.75 (m, 10 H, $(CH_2)_5$).

6-Amino-3,5-dicyano-2-R-methylthio-1,4-dihydropyridine-4-spirocyclohexanes (9a—k). Method *A*. Halide **8** (10 mmol) was added with stirring to a suspension of salt **6** (10 mmol) in DMF (10 mL). Then the mixture was stirred for 4 h and diluted with water (10 mL). The precipitate was separated and washed with water, ethanol, and hexane. Compounds **9** were obtained (see Tables 3 and 4).

Method *B*. A 10% aqueous KOH solution (5.6 mL, 10 mmol) was added with stirring to a solution of thione **7** (10 mmol) in DMF. After 5 min, halide **8** was added. The reaction mixture was stirred for 4 h and diluted with water (10 mL). The precipitate was washed sequentially with water, ethanol, and hexane (see Tables 3 and 4).

5-Amino-6,8-dicyano-spiro-(2,3-dihydrothiazolo[3,2-*a*]pyridine-7,1′-cyclohexane) (10). A 10% aqueous KOH solution (5.6 mL, 10 mmol) was added with stirring to a solution of thione **7** (10 mmol) in DMF (8 mL), and then 1,2-dibromoethane (0.86 mL, 10 mmol) was added. After 30 min, more aqueous 10% KOH solution (5.6 mL, 10 mmol) was added to the reaction mixture. The reaction mixture was stirred for 8 h and then diluted with water (15 mL). The precipitate was separated and washed sequentially with water, ethanol, and hexane. The yield was 1.85 g (68%), m.p. 156—158 °C (from Bu^nOH). Found (%): C, 61.60; H, 6.11; N, 20.64; S, 11.65. $C_{14}H_{16}N_4S$. Calculated (%): C, 61.74; H, 5.92; N, 20.57; S, 11.77. IR, ν/cm^{-1}: 3345, 3420 (NH_2); 1635 ($\delta(NH_2)$); 2175 (CN). ^1H NMR, δ: 6.24 (s, 2 H, NH_2); 4.09 (t, 2 H, SCH_2); 3.38 (t, 2 H, NCH_2); 1.40—1.64 (m, 10 H, $(CH_2)_5$).

3,6-Diamino-2-(4-bromobenzoyl)-5-cyano(spirothieno[2,3-*b*]-4,7-dihydropyridine-4-spirocyclohexane) (11). A 10% aqueous KOH solution (5.6 mL, 10 mmol) was added with stirring to a solution of compound **9a** (10 mmol) in DMF (10 mL). After 4 h, the reaction mixture was diluted with water (10 mL). The precipitate was filtered off and washed with water, ethanol, and hexane. The yield was 2.4 g (54%), m.p. 165—167 °C (from AcOH). Found (%): C, 54.21; H, 4.38; N, 12.63; S, 7.28. $C_{20}H_{19}BrN_4OS$. Calculated (%): C, 54.18; H, 4.32; N, 12.64; S, 7.23. IR, ν/cm^{-1}: 3330, 3365, 3428 (NH, NH_2); 1675 (C=O); 2195 and 2254 (C≡N). ^1H NMR, δ: 8.30 (s, 1 H, NH); 7.81 (s, 0.5 H, N—H); 7.75 (s, 3 H, NH_2); 7.45 (d, 2 H, Ar); 7.61 (d, 2 H, Ar); 4.44 (s, 0.5 H, C(5)H); 1.49 (m, 10 H, $(CH_2)_5$).

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