## A new method for the synthesis of N-methylmorpholinium 4-aryl-5-cyano-2-oxo-1,2,3,4-tetrahydropyridine-6-thiolates and their properties

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*N*-Methylmorpholinium 4-aryl-S-cyano-2-oxo-1,2,3,4-tetrahydropyridine-6-thiolates were obtained by the condensation of aromatic aldehydes, cyanothioacetamide, and Meldrum's acid in the presence of *N*-methylmorpholine. They were then used in the syntheses of substituted 6-alkylthio-3,4-dihydropyridin-2(1*H*)-ones and 4,5-dihydrothieno[2,3-*b*]pyridin-6(7H)-ones.

Key words: aromatic aldehydes, cyanothioacetamide, Meldrum's acid, condensation, cyclization, alkylation.

We have shown previously that the Michael's adducts that are formed in the reaction of arylidenecyanothioacetamides with Meldrum's acid can undergo cyclization on heating in ethanol to give ammonium 4-aryl-5-cyano-2-oxo-1,2,3,4-tetrahydropyridine-6-thiolates.<sup>1</sup> In a continuation of studies into the synthesis and properties of substituted pyridinechalcogenones and their hydrogenated analogs, we elaborated a new method for the preparation of the salts mentioned above. The method involves the condensation of aromatic aldehydes (1), cyanothioacetamide (2b), and Meldrum's acid (3) in the presence of N-methylmorpholine in boiling ethanol (Scheme 1, method A).

The formation of thiolates 4 proceeds through the step of the corresponding Michael's adducts 5. The latter can be isolated as N-methylmorpholinium salts if the reaction is carried out at 25 °C. The increase in the temperature of the reaction mixture results in the cyclization of compounds 5 (see Scheme 1, method B) into thiolates 4 with elimination of carbon dioxide and acetone or cyclohexanone, which agrees with the common features of reactions involving Meldrum's acid.<sup>2</sup>

When adduct 5e was boiled in ethanol, it decomposed into substituted acrylonitrile 6. Under the same conditions, adducts 5c,d gave the respective selenoamides 7, which added cyanoselenoacetamide 2c to give selenolates 8a,b. The structure of the latter was confirmed by an independent synthesis, namely, by treatment of aldehyde 1a or 1b with cyanoselenoacetamide (2c), malononitrile, and N-methylmorpholine in boiling ethanol.<sup>3</sup> Boiling in ethanol of aromatic aldehydes 1, cyanothioacetamide (2b), Meldrum's acid (3), and N-methylmorpholine followed by acidification of the reaction mixture affords tetrahydropyridones 9 (see Scheme 1, method A), whose solutions in DMSO exist as an equimolar equilibrium mixture of tautomers 9A (thiol) and 9B (thione) (<sup>1</sup>H NMR spectroscopy data, see Experimental). Compounds 9 are also formed upon treatment of salts 4 with dilute aqueous HCl (method B).

Thiolates 4 react with halides 10 to give sulfides 11 (see Scheme 1, method A), which can also be obtained by the alkylation of pyridones 9 (method B). Subsequent alkylation of sulfide 11a with methyl iodide gives tetrahydropyridone 12.

Substituted 4,5-dihydrothieno[2,3-b]pyridin-6(7*H*)ones (13) were synthesized by reactions of thiones 9 with compounds 10, which contain reactive H atoms, in the presence of excess of a base.

The structures of compounds 4-6, 8, 9, and 11-13 were confirmed by physicochemical and spectroscopic studies (see Experimental and Tables 1, 2).

## Experimental

IR spectra were obtained on an IKS-29 spectrophotometer in Vaseline oil. <sup>1</sup>H NMR spectra were recorded on a Bruker WP-100 SY instrument (100 MHz) in DMSO-d<sub>6</sub>, using Me<sub>4</sub>Si as the internal standard. The purity of compounds was monitored by TLC on Silufol UV-254 plates in an acetone—hexane system (3 : 5).

*N*-Methylmorpholinium 5-cyano-2-oxo-4-(2-thienyl)-1,2,3,4-tetrahydropyridine-6-thiolate (4a). A suspension of

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B - N-methylmorpholine

Compound	R <sup>1</sup>	R <sup>2</sup>	R <sup>3</sup>	х	Compound	Hal	Z	R <sup>1</sup>
1a. 4a. 8a. 9a	2-thienyl				102, 112	[	Н	2-thienyl
1b, 4b, 8b, 9b	2-furyl			_	106, 115	Cl	$CONH_2$	2-thienyl
1c. 4c. 8c. 9c	4-MeOC <sub>6</sub> H <sub>4</sub>				10c, 11c	Cl	PhNHĈO	2-thienyl
1d. 4d. 8d. 9d	I-naphthyl	_			10d, 11d	Cl	4-BrC <sub>6</sub> H₄NHCO	l-naphthyl
2a	_ ` `			0	10e, 11e	Cl	CONH <sub>2</sub>	1-naphthyl
2b	-			S	10f, 11f	CI	Ph	l-naphthyl
2c				Se	10g, 11g	ſ	Н	l-naphthyl
3a		Me	Me		10h, 11b	C1	COOEt	l-naphthyl
3b		(CH	2)5*	-	10i, 11i	Br	CH=CH,	l-naphthyl
5a	2-thienvl	Me	Me	· S	10j, 11j	ł	Me	l-naphthyl
5b	2-thienvl	(CH	2)5*	S	10k, 13k	Br	4-CIC <sub>6</sub> H₄CO	2-thienyl
5c	2-furvl	(CH	2)5*	Se	101, 131	Br	4-BrC <sub>6</sub> H <sub>4</sub> CO	l-naphthyl
5d	2-thienvl	(CH	2)5*	Se				
5e	4-MeOC <sub>6</sub> H <sub>4</sub>	Me	Me	0				

\*  $R^2 - R^3$ .

aldehyde 1 (10 mmol), cyanoacetamide 2b (10 mmol), Meldrum's acid 3a (10 mmol), and N-methylmorpholine (10 mmol) in ethanol (25 mL) was refluxed for 3 h. The

reaction mixture was cooled, and the precipitate was filtered off and washed with acetone. Yield 2.4 g (71%), m.p. 103–105 °C. Found (%): C, 53.47; H, 5.59; N, 12.19; S, 19.14.

Compo- und	Yield (%)	M.p./°C (A) <sup>a</sup>		<u>Found</u> Calcul	Molecular formula		
			С	Н	N	S	
11a	<u>83</u> <sup>b</sup> 75	181—183 (EtOH)	<u>52.84</u> 52.78	<u>4.19</u> 4.03	<u>11.04</u> 11.19	<u>25.50</u> 25.62	$C_{11}H_{10}N_2OS_2$
11b	<u>84</u> 6 74	156—158 (EtOH)	<u>48.98</u> 49.13	<u>3.80</u> 3.78	<u>14.41</u> 14.32	<u>21.95</u> 21.86	$C_{12}H_{11}N_3O_2S_2$
11c	<u>63</u> 72	193—195 (AcOH)	<u>58.65</u> 58.52	<u>4.15</u> 4.09	<u>11.20</u> 11.37	<u>17.12</u> 17.36	$C_{18}H_{15}N_3O_2S_2$
11d	73	233—235 (Bu <sup>n</sup> OH)	<u>58.42</u> 58.54	<u>3.51</u> 3.68	<u>8.70</u> 8.53	<u>6.62</u> 6.51	C <sub>24</sub> H <sub>18</sub> BrN <sub>3</sub> O <sub>2</sub> S
11e	86	184—186 (Bu <sup>n</sup> OH—DMF, 1 : 1)	<u>63.89</u> 64.08	<u>4.25</u> 4.48	<u>12.58</u> 12.45	<u>9.63</u> 9.50	C <sub>18</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub> S
11f	68	179—181 (EtOH)	<u>74.39</u> 74.57	<u>4.85</u> 4.90	<u>7.49</u> 7.56	<u>8.80</u> 8.65	$C_{23}H_{18}N_2OS$
11g	81	191—193 (EtOH)	<u>69.25</u> 69.36	<u>4.68</u> 4.79	<u>9.64</u> 9.52	<u>11.02</u> 10.89	$C_{17}H_{14}N_2OS$
1 l h	71	168—170 (Bu <sup>n</sup> OH)	<u>65.72</u> 65.56	<u>5.14</u> 4.95	<u>7.53</u> 7.64	<u>8.61</u> 8.75	$C_{20}H_{18}N_2O_3S$
11i	61	166—168 (EtOH)	<u>71.32</u> 71.22	<u>5.15</u> 5.03	<u>8.60</u> 8.74	<u>9.93</u> 10.01	$C_{19}H_{16}N_2OS$
11j	88	171—173 (EtOH)	<u>69.89</u> 70.10	<u>5.10</u> 5.23	<u>9.22</u> 9.08	<u>10.28</u> 10.40	$C_{1\$}H_{16}N_2OS$

Table 1. Yields, melting points, and elemental analysis data for compounds 11a--j

<sup>a</sup> A is solvent for crystallization. <sup>b</sup> Method A/B.

Table :	2.	Spectroscopic	parameters	of	compounds	llaj
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Compo- IR, v/cm <sup>-1</sup>				<sup>1</sup> H N					
und	NH	C≊N	NHCO	NH (s)	R1	H(4) (q)	SCH <sub>2</sub>	CH <sub>2</sub> (3)* (dd)	Z
11a	3200	2216	1680	10.59	7.43 (m), 6.95 (m)	4.28	2.51 (s)	3.07, 2.64	
116	3210, 3400	2197	1680, 1710	11.15	7.45 (m), 6.96 (m)	4.32	3.77 (d)	3.04, 2.63	7.92 and 7.60 (both s, 1 H, $NH_2$ )
11c	3300	2218	1655, 1708	10.83	7.58 (m), 6.95 (m)	4.31	3.99 (s)	3.02, 2.65	10.38 (s, 1 H, NH): 7.10-7.50 (m, 5 H, Ph)
11d	3300	2220	1655, 1710	10.81	7.10 (m), 8.03 (m)	4.93	4.06 (s)	3.11, 2.62	10.55 (s, 1 H, NH); 7.57 (m, 4 H, C <sub>6</sub> H <sub>4</sub> )
11e	3374	2212	1700	11.16	7.36— 7.95 (m)	4.94	3.86 (s)	3.13, 2.63	8.17 (br.s, 2 H, NH <sub>2</sub> )
11f	3300	2210	1684	10.85	6.86 (d), 7.50 8.10 (m)	4.81	4.48 (q)	2.93, 2.47	7.41 (m, 5 H, Ph)
11g	3270	2190	1715	10.62	7.25— 8.20 (m)	4.90	2.60 (s)	3.14, 2.66	_
11b	3300	2194	1640, 1730	10.72	7.33— 8.30 (m)	4.95	4.07 (s)	3.09, 2.62	4.18 (q, 2 H, CH <sub>2</sub> O); 1.22 (t, 3 H, CH <sub>3</sub> )
11i	3200	2230	1680	10.70	7.20— 8.25 (m)	4.93	3.81 (d)	3.09, 2.69	5.90 (m, 1 H, CH=); 5.31 (dd, 2 H, CH <sub>2</sub> =)
11j	3220	2217	1700	10.66	7.25— 8.30 (m)	4.92	3.13 (q)	2.74, 2.65	1.29 (t, 3 H, CH <sub>3</sub> )

\*  ${}^{3}J_{H(3)-H(4)} = 16$  Hz.

 $C_{15}H_{19}N_3O_2S_2$ . Calculated (%): C, 53.39; H, 5.68; N, 12.45; S, 19.00. 1R, v/cm<sup>-1</sup>: 3245 (NH), 2178 (CN), 1690 (CONH). <sup>1</sup>H NMR, & 8.62 (br.s, 1 H, NH); 7.38 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 7.31 (d, 1 H, H(5)<sub>thienyl</sub>); 6.90 (m, 2 H, H(3) and H(4)<sub>thienyl</sub>); 3.89 (m, 1 H, H(4)); 3.16 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.80 and 2.40 (both dd, 1 H each, 2 H(3),  ${}^{3}J_{H(3)-H(4)} = 16$  Hz); 2.78 (s, 3 H, NCH<sub>3</sub>).

*N*-Methylmorpholinium 5-cyano-2-oxo-4-(4-methoxyphenyl)-1,2,3,4-tetrahydropyridine-6-thiolate (4c) was obtained according to method *A* similarly to compound 4a using aldehyde 1c, thioamide 2b, and diketone 3a. Yield 2.6 g (72%), m.p. 182–184 °C. Found (%): C, 60.00; H, 6.29; N, 11.71; S, 8.95. C<sub>18</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>S. Calculated (%): C, 59.81; H, 6.41: N, 11.63; S, 8.87. IR, v/cm<sup>-1</sup>: 3150 (NH), 2172 (CN), 1680 (CONH). <sup>1</sup>H NMR,  $\delta$ : 8.68 (s, 1 H, NH); 7.07 and 6.82 (both d, 2 H each, C<sub>6</sub>H<sub>4</sub>); 3.77 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 3.71 (s, 3 H, OCH<sub>3</sub>); 3.59 (m, 1 H, H(4)); 3.17 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.79 (s. 3 H, NCH<sub>3</sub>); 2.70 and 2.29 (both dd, each 1 H, 2 H(3), <sup>3</sup>J<sub>H(3)-H(4)</sub> = 16 Hz).

When compounds 4a and 4c were synthesized by method *B* reported previously,<sup>1</sup> their yields were 8i and 74%, respectively.

Salts 5a-e were obtained by a known procedure.<sup>4</sup>

*N*-Methylmorpholinium 5-[2-cyanoethyl-1-(2-thienyl)-2thiocarbamoyl]-2.2-dimethyl-6-oxo-1,3-dioxacyclohex-4-en-4olate (5a). Yield 91%, m.p. 139–141 °C. Found (%): C, 52.12; H, 5.80; N, 9.41; S, 14.38.  $C_{19}H_{25}N_3O_5S_2$ . Calculated (%): C, 51.92; H, 5.73; N, 9.56; S, 14.59. IR,  $\sqrt{cm^{-1}}$ : 2235 (CN), 1710 (C=O). <sup>1</sup>H NMR, &: 9.62 (br.s. 2 H, NH<sub>2</sub>); 7.13 (m, 1 H, H(5)<sub>thienyl</sub>); 6.86 (m, 2 H, H(3) and H(4)<sub>thienyl</sub>); 5.28 (d, 1 H, CHCN, <sup>3</sup>J<sub>H(2)-H(1)</sub> = 12 Hz); 4.94 (d, 1 H, CHHet, <sup>3</sup>J<sub>H(1)-H(2)</sub> = 12 Hz); 3.76 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 3.11 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.73 (s, 3 H, NCH<sub>3</sub>); 1.48 (m, 6 H, (CH<sub>3</sub>)<sub>2</sub>).

*N*-Methylmorpholinium 5'-[2-cyano-1-(2-thienyl)-2-thiocarbamoylethyl]-6'-oxo-[cyclohexane-1,2'-spiro-1',3'-dioxacyclohex-4'-en-4'-olate] (5b). Yield 88%, m.p. 131-133 °C. Found (%): C, 54.84; H, 6.18; N, 8.83; S, 13.13. C<sub>22</sub>H<sub>29</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>. Calculated (%): C, 55.09; H, 6.09; N, 8.76; S, 13.37. IR, v/cm<sup>-1</sup>: 3348, 3150 (NH<sub>2</sub>); 2247 (CN), 1665 (C=O). <sup>1</sup>H NMR, δ: 9.60 (br.s, 2 H, NH<sub>2</sub>); 7.10 (m, 1 H, H(5)<sub>thienyl</sub>); 6.85 (m, 2 H, H(4) and H(3)<sub>thienyl</sub>); 5.27 (d, 1 H. CHCN, <sup>3</sup>J<sub>H(2)-H(1)</sub> = 11 Hz); 4.95 (d, 1 H, CHHet, <sup>3</sup>J<sub>H(1)-H(2)</sub> = 11 Hz); 3.75 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 3.06 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.71 (s, 3 H, NCH<sub>3</sub>); 1.86 (m, 4 H, (CH<sub>2</sub>)<sub>2</sub>); 1.45 (m, 6 H, (CH<sub>2</sub>)<sub>3</sub>).

*N*-Methylmorpholinium 5'-[2-cyano-1-(2-furyl)-2-selenocarbamoylethyl]-6'-oxo-[cyclohexane-1,2'-spiro-1',3'-dioxacyclohex-4'-en-4'-olate] (5c). Yield 73%, m.p. 108–110 °C. Found (%): C, 51.50; H, 5.61; N, 8.15; Se, 15.58.  $C_{22}H_{29}N_3O_6Se$ . Calculated (%): C, 51.77; H, 5.73; N, 8.23; Se, 15.47. IR, v/cm<sup>-1</sup>: 3315 (NH<sub>2</sub>), 2248 (CN), 1655 (C=O). <sup>1</sup>H NMR,  $\delta$ : 10.64 and 10.49 (both s, 2 H, NH<sub>2</sub>); 7.30 (m, 1 H, H(5)<sub>furyl</sub>); 6.21 (m, 2 H, H(3) and H(4)<sub>furyl</sub>); 5.50 (m, 1 H, CHCN); 4.75 (m, 1 H, CHHet); 3.75 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 3.06 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.70 (s, 3 H, NCH<sub>3</sub>); 1.82 (m, 4 H, (CH<sub>2</sub>)<sub>2</sub>); 1.45 (m, 6 H, (CH<sub>2</sub>)<sub>3</sub>).

*N*-Methylmorpholinium 5'-[2-cyano-1-(2-thienyl)-2-selenocarbamoylethyl]-6'-oxo-[cyclohexane-1,2'-spiro-1',3'-dioxa-4'cyclohex-4'-en-4-olate] (5d). Yield 76%, m.p. 120-122 °C. Found (%): C, 50.22; H, 5.38; N, 8.14.  $C_{22}H_{29}N_{3}O_5SSe$ . Calculated (%): C, 50.19; H, 5.55; N, 7.98. JR, v/cm<sup>-1</sup>: 3300 (NH<sub>2</sub>), 2250 (CN), 1655 (C=O). <sup>1</sup>H NMR,  $\delta$ : 10.59 and 10.35 (both s, 2 H, NH<sub>2</sub>); 7.15 (m, 1 H. H(5)<sub>thienyl</sub>); 6.90 (m, 2 H, H(3) and H(4)<sub>thienyl</sub>); 5.41 (d, 1 H, CHCN, <sup>3</sup>J<sub>H(2)-H(1)</sub> = 11 Hz); 5.02 (d, 1 H, CHHet, <sup>3</sup>J<sub>H(1)-H(2)</sub> = 11 Hz);  $3.75 \text{ (m, 4 H, CH}_2\text{OCH}_2$ );  $3.06 \text{ (m, 4 H, CH}_2\text{NCH}_2$ ); 2.71 (s, 3 H, NCH<sub>3</sub>); 1.80 (m, 4 H, (CH<sub>2</sub>)<sub>2</sub>); 1.44 (m, 6 H, (CH<sub>2</sub>)<sub>3</sub>).

*N*-Methylmorpholinium 5-[2-carbamoyl-2-cyanoethyl-1-(4methoxyphenyl)]-2,2-dimethyl-6-oxo-1,3-dioxacyclohex-4-en-4-olate (5e). Yield 87%, m.p. 160-162 °C. Found (%): C, 58.88; H, 6.60; N, 9.21.  $C_{22}H_{29}N_3O_7$ . Calculated (%): C, 59.05; H, 6.53; N, 9.39. IR,  $\nu/cm^{-1}$ : 2246 (CN), 1700 (C=O). <sup>1</sup>H NMR,  $\delta$ : 7.76 and 7.00 (both s, 2 H, NH<sub>2</sub>); 7.29 and 6.65 (both d, 4 H, C<sub>6</sub>H<sub>4</sub>); 4.87 (d, 1 H, CHCN, <sup>3</sup>J<sub>H(2)-H(1)</sub> = 11 Hz); 4.34 (d, 1 H, CHAr, <sup>3</sup>J<sub>H(1)-H(2)</sub> = 11 Hz); 3.76 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 3.65 (s, 3 H, OCH<sub>3</sub>); 3.11 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.74 (s, 3 H, NCH<sub>3</sub>); 1.44 (s, 6 H, (CH<sub>3</sub>)<sub>2</sub>).

**4-Methoxybenzylidenecyanoacetamide (6).** A suspension of adduct 5e in ethanol was refluxed for 3 h. After cooling the reaction mixture, the precipitate was filtered off and washed with ethanol and hexane. Yield 75%, m.p. 215–216 °C. Found (%): C, 65.15; H, 4.70; N, 13.93.  $C_{11}H_{10}N_2O_2$ . Calculated (%): C, 65.34; H, 4.98; N, 13.85. IR, v/cm<sup>-1</sup>: 3455 (NH<sub>2</sub>), 2205 (CN). 1664 (CONH<sub>2</sub>). <sup>1</sup>H NMR,  $\delta$ : 8.11 (s, 1 H, CH=); 7.95 and 7.12 (both d, each 2 H,  $C_6H_4$ ); 7.74 (br.s, 2 H, NH<sub>2</sub>); 3.86 (s, 3 H, CH<sub>3</sub>).

*N*-Methylmorpholinium 6-amino-3,5-dicyano-4-(2thienyl)pyridine-2-selenolate (8a) was obtained similarly to compound 6 starting from adduct 5d. Yield 63%, m.p. 247--250 °C. Found (%): C. 47.11; H, 4.08; N, 17.40. C<sub>16</sub>H<sub>17</sub>N<sub>5</sub>OSSe. Calculated (%): C, 47.29; H, 4.22; N. 17.23. IR, v/cm<sup>-1</sup>: 3360 (NH<sub>2</sub>), 2218 (CN), 1660 (8(NH<sub>2</sub>)). <sup>1</sup>H NMR, δ: 8.07 (br.s, 2 H, NH<sub>2</sub>); 7.97 (m, 1 H, H(5)<sub>thienyl</sub>); 7.60 (m, 1 H, H(3)<sub>thienyl</sub>); 7.29 (m, 1 H, H(4)<sub>thienyl</sub>); 3.60 (m, 4 H, CH<sub>2</sub>OCH<sub>2</sub>); 2.45 (m, 4 H, CH<sub>2</sub>NCH<sub>2</sub>); 2.28 (s, 3 H, CH<sub>3</sub>).

*N*-Methylmorpholinium 6-amino-3,5-dicyano-4-(2furyl)pyridine-2-selenolate (8b) was obtained similarly to compound 6 starting from adduct 5c. The yield of salt 8b, whose melting point and <sup>1</sup>H NMR spectrum were identical with those reported previously,<sup>3</sup> was 70%.

5-Cyano-6-mercapto-4-(2-thienyl)-3,4-dihydropyridin-2(1*H*)-one (9a). *A*. A suspension of thiophene-2-carbaldehyde Ia (10 mmol), cyanoacetamide 2b (10 mmol), Meldrum's acid 3a or 3b (10 mmol), and *N*-methylmorpholine (20 mmol) in ethanol (25 mL) was refluxed for 3 h. After cooling, the reaction mixture was acidified with 10% HCl to pH 5 and kept for 12 h. The precipitate that formed was filtered off and washed with ethanol and heptane. Yield 1.5 g (64%), m.p. 178–180 °C (ethanol). Found (%): C, 51.04; H, 3.50; N, 11.72; S, 27.00.  $C_{10}H_8N_2OS_2$ . Calculated (%): C, 50.83; H, 3.41; N, 11.85; S, 27.14. IR, v/cm<sup>-1</sup>: 3365 (NH), 2255, 2190 (CN), 1700 (CONH). <sup>1</sup>H NMR,  $\delta$ : 12.38 and 11.07 (both s, each 1 H, NH); 7.44 (m, 1 H, H(5)<sub>furyl</sub>); 6.98 (m, 2 H, H(3) and H(4)<sub>furyl</sub>); 4.81 (m, 1 H, H(4)); 4.20 (m, 1 H, H(3)); 2.80 (m, 2 H, CH<sub>2</sub>).

5-Cyano-6-mercapto-4-(1-naphthyl)-3,4-dihydropyridin-2(1*H*)-one (9d). *A*. Compound 9d was obtained similarly to compound 1d starting from 1-naphthaldehyde 1d and CHacids 2b and 3a or 3b. Yield 1.5 g (53%), m.p. 159–161 °C (ethanol). Found (%): C, 68.70; H, 4.42; N, 9.84; S, 11.30.  $C_{16}H_{12}N_2OS$ . Calculated (%): C, 68.55; H, 4.31; N, 9.99; S. 11.44. IR, v/cm<sup>-1</sup>: 2190 (CN), 1680 (CONH). <sup>1</sup>H NMR, 8: 12.97 and 9.71 (both s, each 1 H, NH); 7.25–8.30 (m, 7 H, 1-naphthyl); 4.76 (m, 1 H, H(4)); 4.00 (m, 1 H, H(3)); 3.00 (m, 2 H, CH<sub>2</sub>).

**B**. A suspension of salt 4a (10 mmol) in ethanol (20 mL) was acidified with 10% HCl with stirring to pH 5 and then filtered. After 24 h, the resulting precipitate was isolated and

washed with ethanol and hexane to give thione 9a in 74% yield. According to the melting point and chromatography data, the compound 9a was identical with that obtained by method A.

5-Cyano-4-R'-6-Z-methylthio-3,4-dihydropyridin-2(1*H*)ones (11a-j). *A*. Halide 10 (10 mmol) was added to a solution of sait 4 (10 mmol) in DMF (12 mL). The mixture was stirred for 1.5 h, and water (10 mL) was added. The precipitate that formed was filtered off and washed with water, ethanol, and hexane to give compounds 11a-k. Data for these compounds are presented in Tables 1 and 2.

**B.** 10% Aqueous KOH (5.6 mL, 10 mmol) was added with stirring to a solution of thione 9 (10 mmol) in DMF (12 mL), and halide 10 (10 mmol) was after added 1 min. After 2 h, the reaction mixture was diluted with water (10 mL), and the precipitate was filtered off and washed with water, ethanol, and hexane to give compounds 11 identical with those synthesized by method A (according to their melting points and TLC data, see Tables 1 and 2).

5-Cyano-1-methyl-2-methylthio-4-(2-thienyl)-3,4-dihydropyridin-2(1H)-2-one (12). 10% Aqueous KOH (5.6 mL, 10 mmol) was added with stirring to a suspension of pyridone 11a (10 mmol) in ethanol (15 mL). After 5 min, methyl iodide (10 mmol) was added to the solution, and the reaction mixture was stirred for 3 h. The precipitate was filtered off and washed with ethanol and heptane. The yield of compound 12 was 1.6 g (61%), m.p.  $80-82 \ ^{\circ}C$  (ethanol). Found (%): C, 54.70; H, 4.67; N, 10.48; S, 24.11. C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>OS<sub>2</sub>. Calculated (%): C, 54.52; H, 4.58; N, 10.60; S, 24.26. IR. v/cm<sup>-1</sup>: 2210 (CN), 1665 (CO). <sup>1</sup>H NMR,  $\delta$ : 7.45 (m, 1 H, H(5)<sub>dhienyl</sub>): 6.96 (m, 2 H, H(3) and H(4)<sub>thienyl</sub>); 4.28 (t, 1 H, H(4)); 3.29 (s, 3 H, NCH<sub>3</sub>); 2.70-3.20 (m, 2 H, CH<sub>2</sub>); 2.50 (s, 3 H, SCH<sub>3</sub>).

3-Amino-2-(4-chlorobenzoyl)-4-(2-thienyl)-4,5-dihydrothieno[2,3-b]pyridin-6(7H)-one (13k). 10% Aqueous KOH (5.6 mL, 10 mmol) was added with stirring to a solution of thione 9a (10 mmol) in DMF (15 mL), and 4-chlorophenacyl bromide (10 mmol) was added after 1 min. After 30 min, an additional portion of 10% aqueous KOH (5.6 mL) was added to the reaction mixture. The resulting precipitate was filtered off after 3 h and washed with water, ethanol, and hexane to give compound **131** a yield of 2.6 g (67%), m.p. 218–220 °C (AcOH). Found (%): C, 55.40; H, 3.28; N, 7.35; S, 16.51. C<sub>18</sub>H<sub>13</sub>ClN<sub>2</sub>O<sub>2</sub>S<sub>2</sub>. Calculated (%): C, 55.59; H, 3.37; N, 7.20; S, 16.49. IR, v/cm<sup>-1</sup>: 3390, 3240 (NH, NH<sub>2</sub>), 1680 (CO). <sup>1</sup>H NMR,  $\delta$ : 11.03 (s, 1 H, NH); 7.85 (br.s, 2 H, NH<sub>2</sub>); 7.33 (m, 1 H, H(5)<sub>thienyl</sub>); 6.70 and 7.55 (both d, each 2 H, C<sub>6</sub>H<sub>4</sub>); 6.89 (m, 2 H, H(3) and H(4)<sub>thienyl</sub>); 4.69 (d, 2 H, CH<sub>2</sub>); 3.19 (m, 1 H, H(4)).

3-Amino-2-(4-bromobenzoyl)-4-(1-uaphthyl)-4,5-dihydrothieno[2,3-b]pyridin-6(7*H*)-one (131) was obtained similarly to compound 13k starting from thione 9d and 4-bromophenacyl bromide 10l. Yield 66%, m.p. 334-336 °C (DMF). Found (%): C, 60.50; H, 3.70; N, 5.71; S, 6.66.  $C_{24}H_{17}BrN_2O_2S$ . Calculated (%): C, 60.38; H, 3.59; N, 5.87; S, 6.72. IR,  $v/cm^{-1}$ : 3470, 3315, 3210 (NH, NH<sub>2</sub>); 1710 (C=O); 1665 ( $\delta(NH_2)$ ). <sup>1</sup>H NMR,  $\delta$ : 11.06 (s, 1 H, NH); 6.78-8.23 (m, 13 H, 1-naphthyl,  $C_6H_4$ , NH<sub>2</sub>); 5.20 (d, 2 H, CH<sub>2</sub>); 3.35 (m, 1 H, H(4)).

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