4. T. A. Kuz'menko, V. V. Kuz'menko, A. F. Pozharskii, V. N. Doron'kin, N. L. Chikina, and S. S. Pozharskaya, Khim. Geterotsikl. Soedin., (1989), in print.
5. N. V. Subba Rao and C. V. Ratham, J. Indian Chem. Soc., 38, 631 (1961).
6. A. V. Zeiger and M. M. Joullie, J. Org. Chem., 42, 542 (1977).
7. D. Jerchel, H. Fischer, and M. Kracht, Annalen, 575, 162 (1952).
8. T. Okamoto and M. Hirobe, J. Synth. Org. Chem., 26, 746 (1968).
9. E. F. Pratt and T. P. McGovern, J. Org. Chem., 29, 1540 (1964).
10. A. E. Abdel-Rahman, A. M. Mahmoud, G. M. El-Nagger, and H. A. El-Sherief, Pharmazie, 38, 589 (1983).
11. V. A. Anisimova, A. M. Simonov, and A. F. Pozharskii, Khim. Geterotsikl. Soedin., No. 6, 797 (1973).

ETHYL ESTERS OF 1,4-DIHYDROPYRIDINE-3,5-DICARBOTHIONIC ACIDS

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Methods for the synthesis of the esters of 1,4-dihydropyridine-3,5-dicarbothionic acids by the thionation of the carbonyl analogs with Lawesson's reagent are developed. The influence of the substituents at the nitrogen atom on the course of the thionation reaction is considered. The physicochemical characteristics of this series of substances are analyzed; their reactivity in the reactions of N-alkylation, oxidation, and anion formation is studied.

The 1,4-dihydropyridines (1,4-DHPs), which are hydrogenated nitrogen-containing heterocycles with unusual chemical properties [1, 2] and varied biological activity [3], have recently been widely investigated.

Continuing the investigations into the synthesis of sulfur-containing 1,4-DHPs [4], we set ourselves the objective of developing methods for the isolation of unknown ethyl esters of 1,4-DHP-dicarbothionic acids unsubstituted in the 2 and 6 positions. We previously developed methods for the synthesis of esters of 2,6-dimethyl-1,4-DHP-dicarbothionic acids, studied their physicochemical properties and reactivity [5], and determined the induction and resonance constants of the ethoxythiocarbonyl substituent in the aromatic compounds [6].

Taking into account the possible superimposing of the steric factor of the 2,6-methyl groups on the electronic effects of the ethoxythiocarbonyl substituent in the 1,4-DHP ring, it was expedient to study the physicochemical properties and reactivity of the thione esters of 1,4-DHP-dicarboxylic acids unsubstituted at the 2 and 6 positions.

The 4-aryl-3,5-diethoxythiocarbonyl-1,4-DHPs (IIa-h) are not successfully obtained by cyclocondensation [7], since the corresponding thione esters of propiolic acid are hitherto unknown. Attempts at the thionation of ethyl propiolate with Lawesson's reagent [the dimer of the sulfide of p-methoxyphenylthionophosphine (XI)] were unsuccessful due to the polymerization of the esters of propiolic acid. There is a known method for the thionation of the carbonyl and alkoxycarbonyl groups in aliphatic and aromatic compounds, as well as the keto group in the indene fragment of 5-oxo-4,5-dihydroindenopyridines [8, 9]. We found that the 4-aryl-3,5-diethoxycarbonyl-1,4-DHPs (Ia-h) react readily with Lawesson's reagent, and form the new thione esters (IIa-h).

The thionation was carried out by the prolonged boiling of (Ia-h) with double the molar amount of Lawesson's reagent in dry toluene or xylene in an atmosphere of argon. The

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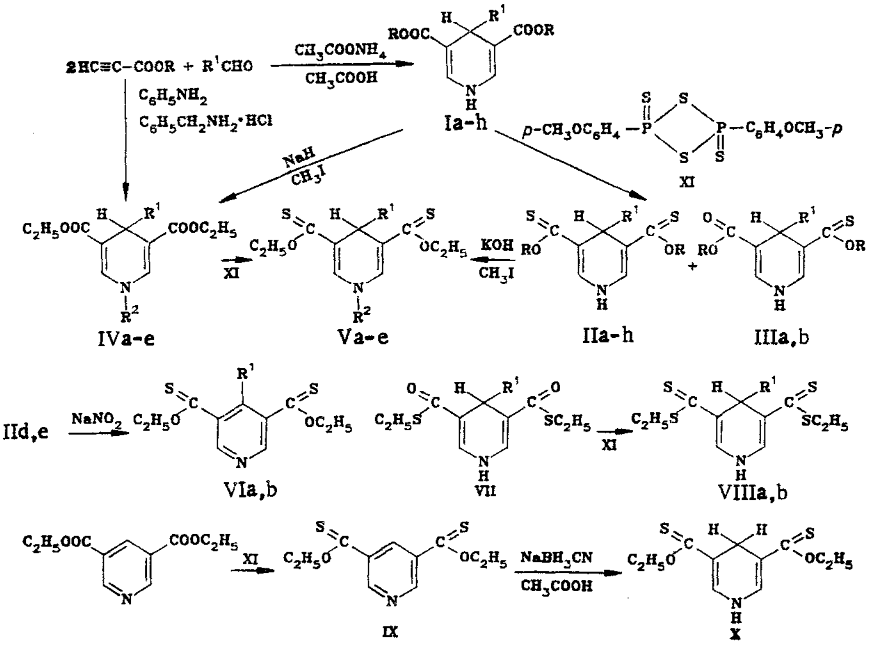
reaction time depends mainly on the nature of the substituent at the nitrogen atom, and at the 3 and 5 positions of the 1,4-DHP ring. Together with the dithione esters (IIa-h), the monothione-DHPs (TLC) are formed as by-products in all cases; in particular cases (IIIa,b), they are isolated in the crystalline form using TLC. The presence of the electron-donor substituents at the para position of the phenyl residue in the 4 position of the compounds (Ia-h) favors the thionation reaction [the reaction time, the yield of (IIa-h)]. A significant role is probably played by both the electronic and the steric factors of the substituent at the 4 position. The methyl esters of the 1,4-DHP-dicarboxylic acids (Ia) react with more difficulty than the ethyl esters (Ib,c).

The esters of 2,6-dimethyl- as well as 2,6-diphenyl-1,4-DHP-dicarboxylic acids do not enter into this reaction. The reason for this is probably concealed in the steric influence of the 2,6-substituents. Such unusual stability of the ester group of 2,6-dimethyl-1,4-DHPs was also noted in the literature for other reactions [10]. In contrast to 2,6-dimethyl-1,4-DHPs, the 2,6-unsubstituted compounds (Ia-h) are readily hydrolyzed to mono- and dicarboxylic acids [11].



I, II a $R=CH_3$, b-h $R=C_2H_5$; a, b $R^1=C_6H_5$, c $R^1=C_6H_4OCH_3$-4, d $R^1=C_6H_4NO_2$-4, e $R^1=C_6H_4Br$-4, f $R^1=C_6H_4NO_2$-3, g $R^1=C_6H_4OCHF_2$-2, h $R^1=C_6H_2(OCH_3)_3$-3,4,5; III a $R=CH_3$, $R^1=C_6H_5$; b $R=C_2H_5$, $R^1=C_6H_2(OCH_3)_3$-3,4,5; IV, V a, c, d, $R^1=C_6H_5$, b $R^1=C_6H_4OCHF_2$-2, e $R^1=C_6H_4NO_2$-3; a, b $R^2=CH_3$; c $R^2=C_6H_5$; d, e $R^2=C_6H_5CH_2$; VI a $R^1=C_6H_4Br$-4, b $R^1=C_6H_4NO_2$-4; VII, VIII a $R^1=C_6H_5$, b $R^1=C_6H_4Br$-4

The presence of substituents at the nitrogen atom in the 2,6-unsubstituted derivatives (IVa-e) increases the reactivity of the alkoxycarbonyl groups at the 3 and 5 position; the N-substituted compounds (Va-e) are already isolated in good yields after the brief heating with Lawesson's reagent. The thiol esters of 1,4-DHP-dicarboxylic acids (VIIa,b) are thionated more easily than the esters (Ia-h).

The results obtained conform to the data of [12] on the possible mechanism of thionation of the alkoxycarbonyl group in aromatic systems. It was noted that the increase in the electron density on the oxygen atom of the carbonyl group and the removal of the steric hindrance to the approach of the thionating reagent permit the electrophilic attack of the carbonyl oxygen by the P atom of Lawesson's reagent [12].

In contrast to the 4-aryl derivatives of 1,4-DHP (Ia-h), the 3,5-dialkoxycarbonyl-1,4-DHPs unsubstituted in the 4 position do not enter into the thionation reaction due to their low stability and ready oxidizability. The 3,5-diethoxythiocarbonyl-1,4-DHP (X) was obtained by the reduction of the pyridine (IX) with sodium borohydride in acetic acid. Together with the 1,4-DHP (X), the method of TLC led to the isolation of the 1,2-isomer – 3,5-diethoxythiocarbonyl-1,2-dihydropyridine – from the reaction mixture; the structure of the latter was proved by the methods of NMR and UV spectroscopy. By utilizing sodium cyanoborohydride in acetic acid as the reducing agent, the 1,4-isomer (X) was obtained exclusively in almost quantitative yield.

TABLE 1. Characteristics of the 1,4-Dihydropyridines (I-VI) and (VIII-X)

Compound	mp, °C	Found, %				Empirical formula	Calculated, %				Time of thionation, h	Yield, %, method A (method B)
		C	H	N	S		C	H	N	S		
Ie	122	53,8	4,6	3,4	—	$C_{17}H_{18}BrNO_4$	53,7	4,8	3,7	—	—	73
If	117	59,3	5,0	7,9	—	$C_{17}H_{18}N_2O_6$	58,9	5,2	8,1	—	—	63
Ig	157	58,6	5,4	3,6	—	$C_{18}H_{19}F_2NO_5$	58,9	5,2	3,8	—	—	47
Ih	181	60,9	6,3	3,3	—	$C_{20}H_{25}NO_7$	61,4	6,4	3,6	—	—	66
IIa	169 . . . 172	59,2	4,7	4,5	20,5	$C_{15}H_{15}NO_2S_2$	59,0	5,0	4,6	21,0	30	41
IIb	135	60,8	5,5	4,2	19,7	$C_{17}H_{19}NO_2S_2$	61,2	5,7	4,2	19,2	20	66
IIc	139	59,0	5,9	3,7	17,2	$C_{18}H_{21}NO_3S_2$	59,5	5,8	3,9	17,6	10	75
IId	149	53,6	4,9	7,2	16,1	$C_{17}H_{18}N_2O_4S_2$	54,0	4,8	7,4	16,9	30	49
IIe	137	49,4	4,4	3,6	15,2	$C_{17}H_{18}BrNO_2S_2$	49,5	4,4	3,4	15,6	10	59
IIf	208 . . . 210	53,6	4,9	7,1	16,5	$C_{17}H_{18}N_2O_4S_2$	54,0	4,8	7,4	16,9	20	56
IIg	115	54,2	4,6	3,4	16,0	$C_{18}H_{19}F_2NO_3S_2$	54,1	5,9	3,5	16,1	25	65
IIh	226	57,4	5,9	3,0	14,8	$C_{20}H_{25}NO_5S_2$	56,7	4,8	3,3	15,1	7	68
IIIa	199 . . . 202	61,8	5,0	4,4	11,1	$C_{15}H_{15}NO_3S$	62,3	5,2	4,8	11,1	30	34
IIIb	175	58,5	6,0	3,2	8,0	$C_{20}H_{25}NO_6S$	59,0	6,2	3,4	7,9	20	28
Ivd	152 . . . 153	73,5	6,5	3,4	—	$C_{24}H_{25}NO_4$	73,6	6,4	3,6	—	—	47
Ive	109	66,1	5,5	6,5	—	$C_{24}H_{24}N_2O_6$	66,1	5,5	6,4	—	—	23
Va	152	62,2	6,0	3,8	18,4	$C_{18}H_{21}NO_2S_2$	62,2	6,1	4,0	18,5	5	71 (70)
Vb	152 . . . 154	54,9	5,0	3,1	15,5	$C_{19}H_{21}F_2NO_3S_2$	55,2	5,1	3,4	15,5	6	75 (88)
Vc	181	67,4	5,4	3,5	15,5	$C_{23}H_{23}NO_2S_2$	67,5	5,7	3,4	15,7	4	76
Vd	140 . . . 143	67,7	5,8	3,3	15,2	$C_{24}H_{25}NO_2S_2$	68,1	6,0	3,3	15,1	9	64
Ve	118 . . . 120	61,2	5,1	5,8	13,3	$C_{24}H_{24}N_2O_4S_2$	61,5	5,2	6,0	13,7	14	46
VIa	97 . . . 99	50,4	3,7	3,2	15,4	$C_{17}H_{16}BrNO_2S_2$	49,8	3,9	3,4	15,6	—	90
VIb	131	54,6	4,2	7,2	16,5	$C_{17}H_{16}N_2O_4S_2$	54,3	4,3	7,4	17,0	—	85
VIIIa	Oil	55,4	5,1	3,9	34,7	$C_{17}H_{19}NS_4$	55,9	5,2	3,8	35,1	1	81
VIIIb	145 . . . 147	46,5	4,2	2,9	28,5	$C_{17}H_{18}BrNS_4$	45,9	4,1	3,2	28,9	1	78
IX	145 . . . 150 (10 mm)	51,7	5,0	5,2	25,0	$C_{11}H_{13}NO_2S_2$	51,7	5,1	5,5	25,1	20	91
X	149 . . . 153	51,3	5,6	5,1	24,5	$C_{11}H_{15}NO_2S_2$	51,3	5,9	5,4	24,9	—	93

Regardless of the data of [13, 14] on the inertness of the esters of 2-, 2,6-, and 3-pyridinecarboxylic acids in the reaction with Lawesson's reagent, we managed to obtain a high yield of 3,5-diethoxythiocarbonylpyridine (IX). The reaction was carried out by the prolonged boiling of 3,5-diethoxycarbonylpyridine with Lawesson's reagent in xylene in an inert atmosphere in the presence of pyridine.

The compounds (IIa-h) are readily methylated (in contrast to 2,6-dimethyl-3,5-diethoxythiocarbonyl-1,4-DHP) at the nitrogen atom on heating them with methyl iodide in 1,2-dimethoxyethane in the presence of alkali, whereas the oxygen-containing esters (Ia-h), which are weaker NH-acids, are only methylated by utilizing sodium hydride as the basic agent [15].

The thione esters (IId,e) are oxidized by nitrogen oxides with the formation of the pyridine derivatives (VIa,b).

The data of UV, PMR, and IR spectroscopy confirm the structure of the substances (I-X) (Table 2).

The UV region of the spectrum of the compounds (IIa-h) shows three absorption bands characteristic of the monocyclic 1,4-DHPs (Table 2); there is thereby a bathochromic shift of the central and long-wave maxima (~100 nm) by comparison with (Ia-h). When the hydrogen atoms at the 2 and 6 positions in the compounds (IIa-h) are substituted by methyl groups, a hypsochromic shift of approximately 30 nm is observed for the long-wave absorption maximum; this is three times higher than that observed by the same substitution in the corresponding 1,4-DHPs (Ia-h). This evidently indicates the predominant influence of the steric factors of the 2,6-methyl groups on the absorption of the 3,5-diethoxythiocarbonyl groups in the observable region. In the compounds (Va-e), the long-wave band of UV absorption is shifted bathochromically (~25 nm) in relation to the 1-unsubstituted 1,4-DHP (Ib). This conforms with the features of the influence of 1-alkyl substituents in the 2,6-unsubstituted derivatives [15, 16]. The long-wave absorption band of the anionic form of the compounds (IIa-h) and (VIII) has the bathochromic shift of approximately 130 and 180 nm correspondingly.

Two characteristic absorption maxima at 1650 and 1600 cm^{-1} are observed in the region of the absorption of the double bonds in the IR spectra of the compounds (IIa-h); these maxima have approximately the same intensity, and can be assigned to the vibrations of the $C{=}C<$ bond of the iminovinyl fragment. In the transition from the alkoxycarbonyl derivatives (Ia-h) to the thione analogs (IIa-h), the characteristic absorption maximum of the carbonyl group at 1700 cm^{-1} disappears.

In the PMR spectra of the compounds (IIa-h), the shift of approximately 0.60 ppm for the signal of the proton at $C_{(4)}$ to the high field region by comparison with the 4-aryl-2,6-dimethyl-3,5-diethoxythiocarbonyl-1,4-DHPs is observed [5]. It should be noted that the presence of the 2,6-methyl groups in the 4-unsubstituted compounds (X) does not cause the shift of the signal of this proton. There is some low-field shift (~0.70 ppm) of the N—H protons in the compounds (IIa-h) by comparison with the 4-aryl-2,6-dimethyl-3,5-diethoxythiocarbonyl-1,4-DHPs. The shift of the signals of the protons of the methylene and methyl groups of the ethoxythiocarbonyl substituent in (IIa-h) to the low field region is observed by comparison with the esters (Ia-h) (Table 2). Such a pattern was also established for the ester substituents in the series of the corresponding 2,6-dimethyl-1,4-DHPs [5].

The compounds (IIa-h) are stronger NH acids than the derivatives (Ia-h). In the 0.1 M solution of KOH in 90% alcohol, they are completely dissociated, whereas the oxygen-containing analogs (Ia-h) are dissociated by approximately 45...50% [this was established from the change of the long-wave maximum of the neutral and anionic forms of the compounds (IIa-h) and (X) in the electronic spectra]. The presence of the 2,6-methyl groups in the 4-aryl-3,5-diethoxycarbonyl-1,4-DHPs causes a decrease of the NH-acidity, and they exist completely in the neutral form in the 0.1 M solution of KOH in alcohol.

The quantitative data on the acidity of the substances studied and the evaluation of the electronic properties of the β-substituents in the given 1,4-DHP system will be presented in the following communication.

TABLE 2. Spectral Characteristics of the Synthesized Compounds (I)-(VI) and (VIII)-(X).

Compound*1	PMR spectrum in deuterochloroform, δ, ppm						IR spectrum, ν, cm⁻¹	UV spectrum, λ_{max}, nm (log ε)	long-wave λ_{max} of the anion, mm, 0.1 M KOH
	N-R², t	2,6-CH, d	3,5-CXOCH₂CH₃*2 CH₃, t 6H	CH₂, q, 4H	4-CH, s	4-Ar			
Ie	6,49	7,25	1,18	4,07	4,84	6,98 ... 7,40 m	1600, 1640, 1680, 1710, 3320	208 sh. (4,31); 216 (4,34); 242 sh. (4,13); 365 (3,94)	450
If	6,67	7,33	1,18	4,07	5,02	7,62 ... 8,11 m,	1610, 1690, 1710, 3400	208 (4,38); 230 (4,33); 272 sh. (3,96); 368 (3,90)	450
Ig	6,40	7,29	1,18	4,00	5,20	7,00 ... 7,28 m 7,30 s	1610, 1680, 1700, 3360	208 (4,42); 238 sh. (4,12); 373 (4,02)	450
Ih	7,11	7,29	1,22	4,09	4,84	6,53 s 3,80 s	1620, 1680, 1700, 3310	206 (4,33); 234 (4,25); 365 (4,00)	450
IIa	6,49	7,64	4,02, c	—	5,62	7,24 s	1580, 1640, 3420	206 (4,27); 250 (3,96); 303 (4,01); 463 (4,07)	582
IIb	6,47	7,73	1,33	4,47	5,53	7,24 s	1590, 1660, 3260	208 (4,42); 250 (4,13); 285 (4,07); 305 sh. (4,02); 468 (4,09)	580
IIc	6,60	7,69	1,36	4,47	5,49	6,73 ... 7,20 m 3,73 s	1590, 1610, 1650, 3310	206 (4,36); 228 (4,23); 247 sh. (4,06); 305 (4,02); 468 (4,11)	580
IId	6,64	7,76	1,36	4,47	5,73	7,51 d 8,09 d	1610, 1660, 3340	205 (4,39); 280 (4,28); 300 sh. (4,24); 465 (3,95)	585
IIe	6,56	7,69	1,33	4,47	5,56	7,04 ... 7,24 m	1590, 1660, 3310	206 (4,37); 222 sh. (4,26); 300 (4,06); 463 (4,09)	580
IIf	6,58	7,71	1,36	4,44	5,71	7,20 ... 7,56 m	1600, 1660, 3320	205 (4,37); 267 (4,21); 300 sh. (4,11); 463 (3,96)	585
IIg	6,62	7,73	1,31	4,47	5,71	6,98 ... 7,44 m	1600, 1650, 3300	205 (4,42); 270 (4,20); 300 (4,02); 468 (4,02)	585
IIh	6,76	7,73	1,38	4,51	5,56	6,56 s 3,80 s	1600, 1640, 3240	208 (4,56); 300 (3,90); 460 (3,96)	580
IIIa	6,44	7,31 7,78	3,64, s 4,02, s	—	6,24	7,20 s	1600, 1660, 1680, 3340	206 (4,15); 240 (3,92); 272 (4,04); 400 (4,06)	508
IIIb	6,89	7,29 7,78	1,24 1,36	4,13 4,49	5,18	5,56 s 3,80 s	1600, 1660, 1700, 3240	206 (4,51); 273 (4,02); 402 (4,05)	510
IVd	7,31 ... 7,46*3	7,08*4	1,08	3,97	4,66	7,31 ... 7,46 m	1665, 1675, 1695	210 (4,34); 232 (4,26); 374 (3,93)	—
IVe	7,26 ... 7,66*3 4,87*4	7,95*4	1,10	4,00	4,87	7,26 ... 7,66 m	1685, 1705	210 (4,23); 236 (4,31); 373 (3,83)	—
Va	3,38*4	7,60*4	1,33	4,47	5,51	7,20 m	1550, 1645	205 (4,30); 255 (4,00); 294 sh. (3,70); 319 (3,90); 489 (4,06)	—
Vb	3,78*4	7,58*4	1,33	4,44	5,62	6,93 ... 7,42 m	1560, 1660	204 (4,27); 255 (3,94); 323 (3,90); 500 (4,12)	—
Vc	7,27*3	7,98*4	1,36	4,47	5,58	7,27 m	1560, 1650	208 (4,46); 257 (4,23); 337 (4,24); 465 (4,03)	—
Vd	7,11 ... 7,38*3 4,69*4	7,67*4	1,31	4,44	5,53	7,11 ... 7,38 m	1560, 1660	208 (4,52); 254 (4,08); 332 (4,06); 478 (4,05)	—
Ve	7,33 ... 8,07*3 4,73*4	7,67*4	1,33	4,44	5,67	7,33 ... 8,07 m	1560, 1650	208 (4,60); 269 (4,26); 313 (4,13); 480 (3,90)	—
VIa	—	8,87*4	0,93	4,24	—	7,08 ... 7,30 m	—	—	—
VIb	—	8,93*4	0,89	4,24	—	7,38 d; 8,18 m	—	—	—
VIIIa	10,14	7,90	1,20	3,20	6,35	7,21 s	1560, 1635	207 (4,30); 259 (3,72); 304 (3,69); 333 (3,90); 475 (4,00)	630
VIIIb	10,11	7,90	1,20	3,18	6,27	7,09 ... 7,33 m	1565, 1630	207 (4,48); 221 (4,47); 273 sh. (3,98); 304 (4,08); 343 (4,10); 480 (4,22)	630
IX	—	9,40*4	1,56	4,78	8,90	—	—	—	—
X	6,09	7,42	1,38	4,56	3,51	—	1590, 1650, 3280	243 (3,94); 288 (4,33); 484 (4,26)	609

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*1The PMR spectrum of the compounds (IVd,e) and (VIIIa,b) was taken in DMSO- D_6.

*2X = O, S.

*3The signal of the protons at N–C_6H_5 is superimposed by the signals of the aromatic protons at $C_{(4)}$; multiplet.

*4Singlet.

EXPERIMENTAL

The IR spectra were taken on the UR-20 spectrometer using Nujol. The UV spectra were taken on a Specord UV-vis spectrophotometer in ethanol. The PMR spectra were taken on the R-12 (60 MHz) and WH-90 (90 MHz) instruments; the internal standard was TMS. The individuality of the synthesized substances was checked by TLC on plates of Silufol UV-254 with the solvent systems comprising the 9:7:1 mixture of chloroform-hexane-acetone (A) and the 9:1 mixture of hexane-n-propyl alcohol (B). The preparative TLC was performed on a loose layer of silica gel (L 40/100 μm); the eluent was the system (A).

The esters of the 4-aryl-1,4-dihydropyridine-3,5-dicarboxylic acids (Ia-d) were obtained by the condensation of the esters of propiolic acid with aromatic aldehydes in the presence of ammonium acetate [7, 15, 17]. The physicochemical characteristics of the newly synthesized ethyl esters of the 4-aryl-1,4-dihydropyridines (Ie-h) are given in Table 2).

The N-methyl- and N-phenyl-4-aryl-3,5-diethoxycarbonyl-1,4-DHPs (Va-c) were obtained according to the method of [11, 15]. The ethyl esters of the 4-aryl-N-benzyl-1,4-DHP-dicarboxylic acids were synthesized by the modified method of [7] utilizing benzylamine hydrochloride as the amine component in the presence of pyridine.

General Method for the Synthesis of 4-Aryl-3,5-diethoxythiocarbonyl- (IIa-h), 4-Aryl-3-ethoxycarbonyl-5-ethoxythiocarbonyl- (IIIa,b), and 1-Substituted 4-Aryl-3,5-diethoxythiocarbonyl-1,4-dihydropyridines (Va-e). Method A. The compounds (Ia-h) (5 mmole) or (IVa-e) (5 mmole) and 4.5 g (11 mmole) of Lawesson's reagent are boiled in 50 ml of abs. xylene in an atmosphere of argon (the time of boiling is monitored by TLC). The reaction mass is mixed with 20 g of silica gel (L 40/100 μm) in 100 ml of hexane and chromatographed on a column 70 × 350 mm. The elution is performed sequentially with 0.4 liters of hexane and 1.5 liters of the solvent A. The bright orange (IIa-h), (Va-e), and the yellow (IIIa, b) are obtained from the fractions of the eluate with the system A after evaporation. The compounds obtained are purified, or the mixture of (IIa,g) and (IIIa,b) is separated on a preparative plate 220 × 260 mm with the 2...3 mm thickness of the layer of loose silica gel L 40/100 using the system A. The bands of the bright orange (IIa,g) and yellow (IIIa, b) are collected from the plate; the elution is performed with ethanol. The solvent is evaporated, and the residue is recrystallized from ethanol.

1-Benzyl-4-aryl-3,5-diethoxycarbonyl-1,4-dihydropyridines (IVd,e). The corresponding aromatic aldehyde (10 mmole) is heated with 20 mmole of ethyl propiolate and 10 mmole of benzylamine hydrochloride in the presence of 1 ml of pyridine in 10 ml of acetic acid for 30 min. The solution is poured into 250 ml of water; the precipitated residue is recrystallized from ethanol.

1-Methyl-4-aryl-3,5-diethoxythiocarbonyl-1,4-dihydropyridines (Va,b). Method B. The compounds (IIb,g) (3 mmole) are dissolved in 20 ml of 1,2-dimethoxyethane; 0.84 g (15 mmole) of finely ground KOH is added, and the mixture is heated for 5 min on a water bath. To the dark blue solution are added 1.12 ml (18 mmole) of methyl iodide. The mixture is heated for 5 min on a water bath and concentrated to dryness. To the residue are added ~100 ml of water, and the oily crystals are filtered off after cooling the mixture for 10 h at 5°C. The recrystallization is performed from ethanol.

4-Aryl-3,5-diethoxythiocarbonylpyridines (VIa,b). The compounds (IId,e) (3 mmole) are dissolved in 5 ml of glacial acetic acid prior to the addition of 2.07 g (30 mmole) of sodium nitrite. At the completion of the release of the nitrogen oxides (~10 min), the mixture is diluted with 50 ml of water and neutralized with sodium bicarbonate to the pH 7. The mixture is cooled to −5°C, and the yellow crystals are filtered off and recrystallized from 50% ethanol.

4-Aryl-3,5-di(ethylthio)thiocarbonyl-1,4-dihydropyridines (VIIIa,b). These compounds are obtained from the 4-aryl-3,5-di(ethylthio)carbonyl-1,4-DHPs (VIIa,b) as described for the synthesis of (IIa-h).

3,5-Diethoxythiocarbonylpyridine (IX). The mixture of 9.4 g (40 mmole) of 3,5-diethoxycarbonylpyridine and 32 g (80 mmole) of Lawesson's reagent is boiled for 20 h in 150 ml of abs. xylene in an atmosphere of argon in the presence of 0.1 ml of dry pyridine. The xylene is distilled off in vacuo; the residue is mixed with 50 g of silica gel in 100 ml of hexane and applied to the column. The eluent is the system A. The bright yellow band is collected and the fractionation is performed in vacuo after the removal of the solvents. The yield of 7.5 g (91%) of the yellow oil is obtained; it has the bp 147...150°C (10 mm of Hg).

3,5-Diethoxythiocarbonyl-1,4-dihydropyridine (X). The dithionopyridine (IX) (1 g; 4 mmole) is dissolved in 10 ml of glacial acetic acid; the mixture is cooled to 0°C prior to the addition of 1 g (16 mmole) of finely ground sodium cyanoborohydride. The mixture is filtered after 10 min, and the residue is washed with 5 ml of methanol and dried. The yield of 0.7 g of the dark red dithio-1,4-DHP (X) is obtained. The addition of 30 ml of water to the filtrate leads to the isolation of a further 0.26 g of (X). After the crystallization from methanol, the yield of 0.94 g (93%) of (X) is obtained.

LITERATURE CITED

1. J. Kuthan and A. Kurfürst, Ind. Eng. Chem. Prod. Rec. Dev., 21, 191 (1982).
2. D. M. Stout and A. I. Meyers, Chem. Rev., 82, 223 (1982).
3. A. s., 300465 (USSR). S. A. Giller, G. Ya. Dubur, Ya. R. Uldrikis, G. Ya. Tirzit, A. R. Val'dman, I. N. Zakharchenko, Ya. Ya. Spruzh, V. E. Ronis, and A. A. Makarova, B. I., No. 13, 95 (1971).
4. B. A. Vigante, Ya. Ya. Ozols, G. Ya. Dubur, Yu. I. Beilis, E. M. Belash, and V.V. Prezhdo, Khim. Geterotsikl. Soedin., No. 2, 219 (1982).
5. B. A. Vigante, Ya. Ya. Ozols, G. Ya. Dubur, E. M. Belash, and Yu. I. Beilis, Khim. Geterotsikl. Soedin., No. 2, 210 (1984).
6. B. A. Vigante, Ya. Ya. Ozols, M. I. Terekhova, É. S. Petrov, G. Ya. Dubur, É. É. Liepin'sh, and G. I. Rozentale, Khim. Geterotsikl. Soedin., No. 4, 491 (1986).
7. T. Chennat and U. Eisner, J. Chem. Soc., Perkin 1, No. 10, 926 (1975).
8. B. S. Pedersen, S. Scheibye, K. Clausen, and S.-O. Lawesson, Bull. Soc. Chim. Belges, 87, 293 (1978).
9. V. K. Lusis, D. Kh. Mutsenietse, and G. Ya. Dubur, Khim. Geterotsikl. Soedin., No. 5, 709 (1986).
10. B. Loev and M. M. Goodman, J. Heterocycl. Chem., No. 12, 363 (1975).
11. B. S. Chekavichus, A. É. Sausin', and G. Ya. Dubur, Khim. Geterotsikl. Soedin., No. 8, 1072 (1982).
12. B. A. Jones and J. S. Bradshaw, Chem. Rev., 84, 17 (1984).
13. S. L. Baxter and J. S. Bradshaw, J. Org. Chem., 46, 831 (1981).
14. J. S. Bradshaw, B. A. Jones, and J. S. Gebhard, J. Org. Chem., 48, 1127 (1983).
15. V. K. Lusis and G. Ya. Dubur, Khim. Geterotsikl. Soedin., No. 8, 1067 (1982).
16. P. J. Brignell, U. Eisner, and P. G. Farrell, J. Chem. Soc. (B), No. 11, 1083 (1966).
17. P. M. Carbateas and G. L. Williams, J. Heterocycl. Chem., 11, 819 (1974).