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Vanillin Esters of Aliphatic Acids in the Synthesis of 4,7-Phenanthroline Derivatives

N.G. Kozlov, K.N. Gusak, A.B. Tereshko, and E.A. Dikusar

Institute of Physical Organic Chemistry, National Academy of Sciences of Belarus, Minsk, 220072 Belarus
e-mail: loc@ifoch.bas-net.by

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Abstract—Condensation of vanillin esters of aliphatic acids with 6-aminoquinoline and cyclic c-diketones (1,3-cyclohexanedione and dimedone) afforded new 2-methoxy-4-(11-oxo-7,8,9,10,11,12-hexahydrobenzo[b][4,7]-phenanthrolin-12-yl)phenyl esters of carboxylic acids.

Vanillin, 4-hydroxy-3-methoxybenzaldehyde, is a well-known naturally occurring substance used in manufacturing confectionery, perfumery, and cosmetics. Inasmuch as vanillin molecule contains a highly reactive carbonyl group, this compound is of interest as an efficient reagent for organic synthesis. We are developing new synthetic approaches to building up fused nitrogen-containing heterocycles of aza- and diazaphenanthroline series (benzo[*a*]phenanthridines, benzo[*f*]quinolones, and 4,7-phenanthrolines [1–4]) that bring a wide range of aromatic aldehydes into condensation with 2-naphthyl-, 6-aminoquinoline, and CH-acids. As a source of methoxyphenyl substituent and of methine fragment for the structure of azaheterocycles vanillin plays an exclusive role in the synthesis of biologically active compounds: analogs of bactericides, cardioprotectors, enzyme inhibitors, analgetics, and alkaloids [5–8}.

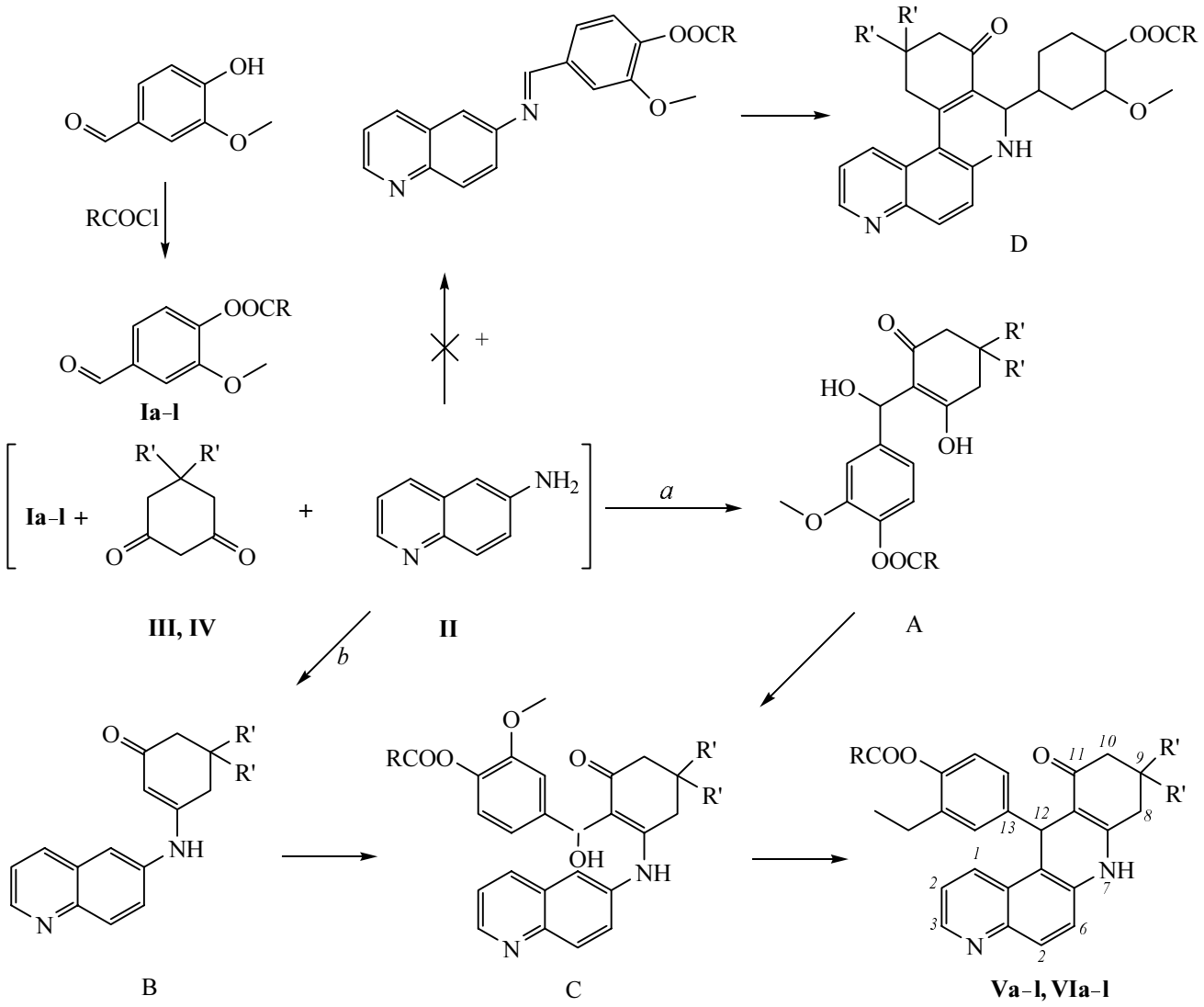
The arising heterocycles possess low reactivity due to their complicated structure and sparing solubility in organic solvents. Therefore their further modification is difficult. It is presumable that an introduction into the heterocycle molecule of an alkylphenoxycarbonyl group with the chain in the alkyl from C_1 to C_{12} would change the relation between hydrophilic and lipophilic characteristics of the compound and would extend its biological opportunities. We carried out the esterification of the hydroxy group in the vanillin with acyl chlorides of aliphatic acids aiming at involving vanillin esters in reaction with aromatic amines and CH-acids in order to prepare previously unknown alkylcarbonyl derivatives of aza- and diazaphenanthrene.

Here we report on results of the study of vanillin aliphatic acids esters **Ia**–**k** behavior in the condensation with 6-aminoquinoline (**II**) and cyclic β-diketones, 1,3-cyclohexanedione (**III**) and 5,5-dimethyl-1,3-cyclohexane-dione (dimedone) (**IV**). The condensation was performed with esters of carboxylic acids (C_1–C_{12}) both with linear and branched chain, and also with esters of monochloro-acetic and 3-(4-methylphenoxy)propionic acids (see scheme).

Esters **Ia–k** were obtained in preparative yield (75–85%) from acyl chlorides and vanillin by heating at reflux in dichloromethane in the presence of pyridine. The condensation of esters **Ia–k** with 6-aminoquinoline (**II**) and 1,3-cyclohexanedione (**III**)[or dimedone (**IV**)] was carried out by heating at reflux in 1-butanol equimolar amounts of reagents without catalyst. The reaction afforded in 60–92% yield individual 2-methoxy-4-(11-oxo-7,8,9,10,11,12-hexahydrobenzo[*b*][4,7]phenanthrolin-12-yl)phenyl carboxylates (**Va–k**) and their dimethyl derivatives **VIa–k**. The formation of products of benzo[*b*]fusion indicates that in the three-component reagents mixture first diketone **III** or **IV** reacts with aldehyde **Ia–k** (*a*) or with amine **II** (*b*) affording respectively enol (A) or enamine (B). The reaction of intermediates (A) or (B) with the third component (**II** or **I**) results in formation of the same enaminoketoester (C) that on dehydration is converted into compounds **Va–k** or **VIa–k**. The theoretically presumable alternative (*c*) of a reaction going through isolation of azomethine that is observed at the use as CH-acids of cyclic monocarbonyl compounds [1, 3] does not occur in the reaction we study between vanillin carboxylates **I**, 6-aminoquinoline (**II**), and diketones **III** and **IV**, for this reaction pathway should have provided derivatives of benzo[*a*][4,7]phenanthroline (D).

The synthesized alkylphenoxycarbonyl derivatives of benzo[*b*][4,7]phenanthroline **Va–k** and **VIa–k** are colorless or light-yellow substances; their characteristics are

Scheme.



compiled in Table 1. As seen from Table 1, the structure of alkyl group R, the presence of a halogen atom or of a methylphenoxy substituent in the vanillin ester molecule, and also the introduction of methyl groups into the β-diketone molecule do not significantly affect the yield of the target products. The maximum yield was obtained with compounds **Vf** and **VIf** with alkyl group chain C_5. A considerably reduced yield of 4,7-phenanthrolines **VI** and **VIh, i** (R = C_7H_{15}, $C_{12}H_{23}$) is due apparently to losses at isolation caused by better solubility in alcohol. It is worth noting that at longer alkyl substituent and at introduction of methyl groups into the molecule of the phenanthroline ester its solubility in water grows. This fact increases the opportunities of the compounds for biological testing [9, 10] and finding substances with a wide range of physiological activity.

The structure of compounds **Va–k** and **VIa–k** was established on the force of IR, NMR, and mass spectra. In the IR spectra of phenanthrolines **Va–k** and **VIa–k** are present the characteristic bands of the stretching and bending vibrations of NH group at 3310–3300 and 1655–1650 cm^{-1} respectively. The stretching vibrations of the keto group conjugated with the enamine moiety appear at 1615–1610 cm^{-1}. The carbonyl of the ester group gives rise to a strong absorption band in the region 1640–1630 cm^{-1}. The shift of this band to low frequency region is obviously due to involvement of the ester group into intermolecular hydrogen bonds.

Table 1. Yields, melting points, and elemental analyses of 4,7-phenanthroline derivatives **Va–k** and **VIa–k**

Compd. no.	Yield, %	mp, °C	Found, %			Formula	Calculated, %		
			C	H	N (Hlg)		C	H	N (Hlg)
Va	77	296–297	72.31	5.11	6.53	$C_{25}N_{22}N_2O_4$	72.46	5.31	6.76
Vb	80	285–286	72.69	5.53	6.64	$C_{26}H_{24}N_2O_4$	72.90	5.61	6.54
Vc	81	273–274	73.19	5.91	6.11	$C_{27}H_{26}N_2O_4$	73.30	5.88	6.33
Vd	79	304–305	73.12	5.61	6.24	$C_{27}H_{26}N_2O_4$	73.30	5.88	6.33
Ve	86	266–267	73.49	5.94	6.02	$C_{28}H_{28}N_2O_4$	73.68	6.14	6.14
Vf	92	254–255	73.89	6.24	6.01	$C_{29}H_{30}N_2O_4$	74.38	6.61	5.79
Vg	82	230–231	74.21	6.53	5.61	$C_{30}H_{32}N_2O_4$	74.70	6.83	5.62
Vh	79	237–238	74.60	6.59	5.37	$C_{31}H_{34}N_2O_4$	74.70	6.83	5.62
Vi	63	192–193	76.11	7.23	5.08	$C_{36}H_{42}N_2O_4$	76.32	7.42	4.95
Vj	83		66.62	4.51	4.34 (7.74)	$C_{25}H_{21}Cl\ N_2O_4$	66.89	4.68	6.24 (7.92)
Vk	78	248–249	73.98	5.44	5.47	$C_{33}H_{30}\ N_2O_5$	74.16	5.62	5.24
VIa	78	282–283	73.18	6.04	5.99	$C_{27}H_{26}\ N_2O_4$	73.30	5.88	6.33
VIb	81	295–296	73.57	6.18	5.89	$C_{28}H_{28}\ N_2O_4$	73.68	6.14	6.14
VIc	80	269–270	73.72	6.23	5.61	$C_{29}H_{30}\ N_2O_4$	74.04	6.38	5.96
VId	78	262–263	73.84	6.19	5.67	$C_{29}H_{30}\ N_2O_4$	74.04	6.38	5.96
VIe	79	259–260	74.47	6.79	5.53	$C_{30}H_{32}\ N_2O_4$	74.38	6.61	5.79
VIf	87	236–237	74.61	6.64	5.29	$C_{31}H_{34}\ N_2O_4$	74.70	6.83	5.62
VIg	76	186–187	74.79	6.81	5.23	$C_{32}H_{36}\ N_2O_4$	75.00	7.03	5.47
VIh	67	203–204	75.11	7.06	5.24	$C_{33}H_{38}\ N_2O_4$	75.29	7.22	5.32
VIi	60	176–177	76.73	7.59	4.64	$C_{38}H_{46}\ N_2O_4$	76.77	7.74	4.72
VIj	76	197–197	68.12	5.34	5.64 (7.63)	$C_{27}H_{25}Cl\ N_2O_4$	68.00	5.25	5.88 (7.45)
VIk	89	232–233	74.65	5.84	4.76	$C_{35}H_{34}\ N_2O_5$	74.73	6.05	4.98

The latter involve alongside the ester groups also amino groups and the enolizable keto carbonyl. The C–O–C fragments present in the molecules of compounds **Va–k** and **VIa–k** appear as bands in the region 1240–1220 cm^{-1}. The stretching vibrations of alkyl groups and the cycloaliphatic CH bonds give rise to absorption at 2960–2840 cm^{-1}, those of CN bonds in aromatic rings at 3130–3030 cm^{-1}.

^1H NMR spectra of compounds **Va–k** and **VIa–k** (Table 2) according to position and multiplicity of proton signals from the benzophenanthroline skeleton are identical to the previously published spectra of 4,7-phenanthrolines [11]. The protons of alkyl(3-methoxyphenyl) ester fragment give rise to signals of methyl and methylene (methine for compounds **Vd** and **VId**) groups in the region 0.85–2.90 ppm (for chloroacetates **Vj** and **VIj** 4.28–4.32 ppm, for methylphenoxypropionates **Vk** and **VIk** 2.24–4.21 ppm). A singlet of methoxy group is observed at 3.69–3.74 ppm, two one-proton doublets at 6.48–6.53 and 6.60–6.64 ppm and a singlet at 7.09–7.12 ppm are characteristic of 1,3,4-trisubstituted benzene ring. In confirmation of the structure of compounds **Va–k** and **VIa–k** the combined analysis of ^1N and ^{13}C NMR two-dimensional spectra (COSY, NOESY, HSQC, and HMBS) revealed the coupling of proton N^7 attached to nitrogen and atom C^8 [that should not be present in the alternative (D) structure]; also the lack of the expected for structure (D) coupling between NH^7 and C^{12} atom linked to an aryl substituent, and with the C^{13} atom of the aryl substituent proper.

In the mass spectra of phenanthrolylphenyl esters **Va–k** and **VIa–k** appear molecular ion peaks $[M]^+$ (I_{rel} 11–18%). The most abundant (100%) peak in the spectra is that of the ion $[M - MeO - RCOOC_6H_3]^+$ (m/z 249 for esters **Va–k**, 277 for compounds **VIa–k)**. In the spectra of all phenanthrolines is present a peak 0f ion, m/z 193 (15–38%), corresponding to elimination from the ion $[M - MeO - RCOOC_6H_3]^+$ of a fragment CN_2CN_2CO for compounds **Va–k** and $(CN_3)_2CNCN_2CO$ for dimethyl derivatives **VIa–k**.

EXPERIMENTAL

Mass spectra were registered on FINNIGAN MAT. INCOS 50 instrument with ionizing electrons energy

Table 2. ^{1}H NMR spectra of benzo[*b*][4,7]phenanthroline derivatives **Va–k** and **VIa–k**, δ, ppm

Compd. no.	N^1, d (^3J 8.0 Hz)	N^2, d.d. (^3J 8.0, ^4J 2.8 Hz)	N^3, d (^3J 4.8 Hz)	N^5,N^6, 2d (^3J 8.9 Hz)	N^8, m (d.d., ^2J 16.0 Hz)	N^9, m (2Me, 2c)	H^{10}, m	N^{12}, s	NH, s	Protons of the fragment 3-OMe-4-RCOOC$_6$H$_3$		
										OMe, s	S_6H_3, 2d (^3J 8.1 Hz), s	R
Va	8.30	7.36	8.67	7.50, 7.88	2.30	1.96	2.60	5.78	9.62	3.72	6.50, 6.60, 7.12	2.30 m
Vb	8.29	7.31	8.63	7.51, 7.84	2.30	1.95	2.61	5.90	9.50	3.73	6.48, 6.61, 7.12	1.18 t, 2.49 m
Vc	8.28	7.32	8.62	7.50, 7.85	2.31	1.95	2.66	5.87	9.60	3.70	6.49, 6.63, 7.11	0.99 t, 1.68 m, 2.44 m
Vd	8.29	7.34	8.61	7.52, 7.84	2.29	1.99	2.60	5.88	9.63	3.73	6.50, 6.64, 7.10	1.20 d, 2.70 s
Ve	8.29	7.30	8.60	7.51, 7.82	2.30	1.98	2.61	5.87	9.56	3.71	6.50, 6.62, 7.11	0.92 m, 1.40 m, 1.65 m, 2.42 m
Vf	8.27	7.31	8.61	7.50, 7.85	2.31	1.96	2.61	5.89	9.54	3.72	6.49, 6.63, 7.10	0.92 m, 1.36 m, 1.65 t, 2.43 m
Vg	8.28	7.31	8.62	7.51, 7.84	2.30	1.97	2.60	5.90	9.53	3.71	6.50, 6.62, 7.10	0.90 m, 1.38 m, 1.64 m, 2.41 m
Vh	8.32	7.33	8.63	7.54, 7.86	2.32	1.96	2.61	5.86	9.59	3.73	6.49, 6.62, 7.12	0.89 m, 1.32 m, 1.61 m, 2.42 m
Vi	8.28	7.32	8.61	7.51, 7.83	2.30	1.95	2.61	5.89	9.56	3.72	6.49, 6.62, 7.10	0.89 m, 1.30 m, 1.49 m, 1.65 m, 2.43 m
Vj	8.35	7.30	8.62	7.52, 7.84	2.32	1.94	2.62	5.84	9.53	3.72	6.50, 6.60, 7.11	4.28 s
Vk	8.27	7.30	8.61	7.50, 7.82	2.31	1.96	2.61	5.85	9.50	3.70	6.51, 6.64, 7.10	2.24 m, 4.21 m, 6.75 d, 7.00 d
VIa	8.30	7.32	8.62	7.53, 7.85	(2.15)	(0.96, 1.12)	2.48	5.81	9.51	3.72	6.50, 6.63, 7.12	2.28 m
VIb	8.29	7.31	8.61	7.52, 7.80	(2.14)	(0.95, 1.11)	2.48	5.88	9.49	3.71	6.52, 6.62, 7.10	1.18 t, 1.68 m, 2.36 m
VIc	8.31	7.30	8.62	7.50, 7.82	(2.17)	(0.98, 1.10)	2.47	5.79	9.54	3.71	6.51, 6.62, 7.11	0.90 m, 2.69 m
VId	8.32	7.34	8.62	7.51, 7.85	(2.17)	(0.96, 1.11)	2.45	5.84	9.51	3.71	6.53, 6.62, 7.10	1.22 m, 2.68 m
VIe	8.30	7.31	8.60	7.53, 7.88	(2.16)	(0.91, 1.10)	2.46	5.85	9.57	3.73	6.50, 6.61, 7.12	0.85 s, 1.40 m, 1.63 m, 2.40 m
VIf	8.29	7.28	8.61	7.50, 7.81	(2.17)	(0.98, 1.10)	2.47	5.89	9.53	3.72	6.51, 6.60, 7.10	0.91 t, 1.37 m, 1.63 m, 2.41 m
VIg	8.32	7.30	8.63	7.51, 7.80	(2.18)	(0.99, 1.12)	2.48	5.86	9.56	3.70	6.50, 6.61, 7.11	0.90 t, 1.40 m, 1.68 m, 2.52 m
VIh	8.30	7.31	8.64	7.53, 7.82	(2.17)	(0.97, 1.15)	2.46	5.88	9.58	3.74	6.51, 6.60, 7.12	0.88 t, 1.36 m, 1.64 m, 2.40 m
VIi	8.31	7.29	8.62	7.52, 7.80	(2.14)	(0.94, 1.10)	2.49	5.87	9.40	3.70	6.52, 6.61, 7.10	0.88 m, 1.38 m, 1.63 m, 2.40 m
VIj	8.35	7.30	8.62	7.53, 7.86	(2.16)	(0.84, 1.10)	2.48	5.71	9.63	3.69	6.50, 6.60, 7.09	4.32 C
VIk	8.29	7.31	8.61	7.50, 7.84	(2.17)	(0.97, 1.10)	2.49	5.86	9.59	3.71	6.51, 6.63, 7.11	2.23 m, 4.21 m, 6.74 d, 7.01 d

70 eV. IR spectra were recorded on Fourier spectrometer Nicolet Protégé-460. NMR spectra were registered on spectrometers Bruker AC-500 (500 MHz) and Tesla BS-567 (100MHz) in DMCO-d_6, internal reference TMS. Melting points were measured on a Koeffler heating block..

3-Methoxy-4-formylphenyl Ia–k. To a solution of 0.2 mol of vanillin in 500 ml of anhydrous CH_2Cl_2 was charged 0.25 mol of anhydrous pyridine and by small portions with intermittent shaking of the reactor flask was added 0.2 mol of acyl chloride preliminary prepared in the following fasion: 1 mol of an appropriate carboxylic acid was boiled for 6 h with 1.3 mol of $SOCl_2$ in 500 ml of benzene with subsequent distilling off of benzene and distillation of the product (for tridecanoyl chloride in a vacuum) The reaction mixture was heated at reflux for 1 h, CH_2Cl_2 was distilled off at heating on a water bath, the residue was dissolved in 500 ml of benzene, thrice washed with water, thrice with 5% water solution of $NaHCO_3$, and dried with $CaCl_2$. The solvent was distilled off, the residue was distilled in a vacuum or recrystallized from a mixture benzene–hexane, 1:1. The residue of compounds **Ii–k** was uncrystallizable viscous substance.

Compound (Ia). Yield 92%, mp 78–79°C (publ.: mp 77–79°C [12]). ^{1}N NMR spectrum, δ, ppm: 2.32 s (Me), 3.92 m (OMe), 7.18 d, 7.48 m (3H, H arom), 9.92 s (CH).

Compound (Ib). Yield 79%, mp 33–34°C. ^{1}H NMR spectrum, δ, ppm: 1.25 t (Me), 2.52 q (CH_2), 3.84 s (OMe), 7.13 d, 7.42 m (3H, H arom), 9.88 s (CH). Found, %: C 63.29; H 5.73. $C_{11}H_{12}O_4$. Calculated, %: C 63.46; H 5.77.

Compound (Ic). Yield 81%, bp 137–138°C (0.5 mm Hg), n_D^{20} 1.5281. ^{1}N NMR spectrum, δ, ppm: 1.02 t (Me), 1.63 m (CH_2), 2.51 t (CH_2), 3.84 s (OMe), 7.15 d, 7.40 m (3H, H arom), 9.90 s (CH). Found, %: C 64.11; H 7.02. $C_{12}H_{16}O_4$. Calculated, %: C 64.28; H 7.14.

Compound (Id). Yield 89%, mp 29–30°C. ^{1}H NMR spectrum, δ, ppm: 1.35 d, 2.88 m (7H, *i*-Pr), 3.90 C (OMe), 7.21 d, 7.50 m (3H, H arom), 9.96 s (CH). Found, %: C 64.72; H 6.19. $C_{12}H_{14}O_4$. Calculated, %: C 64.86; H 6.31.

Compound (Ie). Yield 76%, bp 149–150°C (0.5 mm Hg), n_D^{20} 1.5273. ^{1}H NMR spectrum, δ, ppm: 0.96 t (Me), 1.20–1.90 m (2 CN_2), 2.62 t (CH_2), 3.96 s (OMe), 7.15 d, 7.38 m (3H, H arom), 9.90 s (CH). Found, %: C 65.31; N 7.42. $C_{13}H_{18}O_4$.Calculated, %: C 65.55; H 7.56.

Compound (If). Yield 85%, bp 155–156°C (0.5 mm Hg), n_D^{20} 1.5068. ^{1}H NMR spectrum, δ, ppm: 0.90 (Me), 1.12–1.90 m (3 CN_2), 2.58 m (CH_2), 3.88 s (OMe), 7.13 d, 7.44 m (3H, H arom), 9.95 s (CH). Found, %: C 66.39; H 7.73. $C_{14}H_{20}O_4$.Calculated, %: C 66.67; H 7.94.

Compound (Ig). Yield 82%, bp 163–164°C (0.5 mm Hg), n_D^{20} 1.5092. ^{1}H NMR spectrum, δ, ppm: 0.96 (Me), 1.15–1.88 m (4 CH_2), 2.51 m (CH_2), 3.86 s (OMe), 7.12 d, 7.45 m (3H, H arom), 9.91 s (CH). Found, %: C 67.48; H 8.19. $C_{15}H_{22}O_4$.Calculated, %: C 67.67; H 8.27.

Compound (Ih). Yield 77%, bp 170–171°C (0.5 mm Hg) , n_D^{20} 1.5079. ^{1}H NMR spectrum, δ, ppm: 0.92 (Me), 1.32 m (4 CN_2), 1.79 m (CN_2), 2.60 m (CN_2), 3.88 s (OMe), 7.14 d, 7.47 m (3H, H arom), 9.90 s (CH). Found, %: C 68.83; H 7.69. $C_{16}H_{22}O_4$. Calculated, %: C 69.06; H 7.91.

Compound (Ii). Yield 75%, viscous substance. ^{1}H NMR spectrum, δ, ppm: 0.89 (Me), 1.30 m (9 CH_2), 1.75 m (CH_2), 2.59 m (CH_2), 3.87 s (OMe), 7.16 d, 7.41 m (3H, H arom), 9.91 s (CH). Found, %: C 72.10; N 8.84. $C_{21}H_{32}O_4$. Calculated, %: C 72.41; H 9.19.

Compound (Ij). Yield 78%, viscous substance. ^{1}H NMR spectrum, δ, ppm: 3.88 s (OMe), 4.39 s (CH_2), 7.24 d, 7.50 m (3H, H arom) 9.89 s (CH). Found, %: C 52.36; H 3.98; Cl 15.40. $C_{10}H_9ClO_4$. Calculated, %: C 52.54: H 3.94: Cl 15.50.

Compound (Ik). Yield 76%, viscous substance. ^{1}H NMR spectrum, δ, ppm: 2.28 s (Me), 3.06 t (CH_2), 3.86 s (OCH_3), 4.35 t (CN_2), 6.63–7.52 m (8H, H arom), 9.90 C (CH). Found, %: C 71.22; H 5.94. $C_{17}H_{18}O_4$. Calculated, %: C 71.33; H 6.29 .

2-Methoxy-4-(11-oxo-7,8,9,10,11,12-hexahydrobenzo[*b*][4,7]phenanthrolin-12-yl)phenyl alkanoates (Va–k, VIa–k). A mixture of 0.005 mol of an appropriate ester **Ia–k**, 0.005 mol of 6-aminoquinoline (**II**), 0.005 mol of 1,3-cyclohexanedione (**III**) or dimedone (**IV**), and 20 ml of 1-butanol was boiled for 3–4 h. The precipitate of reaction product **Va–d** and **VIa–d** separated on cooling (for compounds **Ve–g, i, k, VIe–g, j, k** after evaporating solvent to 1/3–1/2 of reaction mixture volume) was filtered off, twice treated with ethyl ether to remove unreacted initial compounds, and dried. In case of phenanthrolines **Vh, VIh, i** the solvent was evaporated to formation of a resinuous residue that was ground with a glass rod under ether till crystallization, the separated crystals were filtered off and washed with ether.

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REGERENCES

1. Kozlov, N.G. and Basalaeva, L.I., *Zh. Obshch. Khim*.., 2001, vol. 71, p. 279.
2. Kozlov, N.G., Pashkovskii, F.S., Tereshko, A.B., Lokot', I.P., Gusak, K.N., and Lakhvich, F.A., *Zh. Or. Khim*., 2003, vol. 39, p. 125.
3. Kozlov, N.G., Popova, L.A., and Yakubovich, L.S., *Zh. Or. Khim*., 2000, 36, p. 1716.
4. Kozlov, N.S., Gusak, K.N., *Dokl. Akad. Nauk SSSR*, 1990, 314, p. 1419.
5. Mashkovskii, P.P.M, *Lekarstvennye veshchestva* (Medicines), Khar'kov: Torsing, 1998, p. 313.
6. Euroean Patent 13666, 1980; *Chem. Abstr*., 1981, vol. 94, 15704X.
7. Bicsak, T.A., Rann, L.R., Reiter, A., and Chase, T., *Arch. Biochem. Biophys*., 1982, vol. 216, p. 605.
8. Orekhov, A.P., *Khimiya alkaloidov* (Alkaloid Chemistry), Moscow: Izd. Akademii nauk, 1955, p. 237.
9. Kozlov, N.S., Sauts, R.D., Serzhanina, V.A., Kovalev, G.V., and Bocharova, I.A., *Dokl. Akad. Nauk BSSR*., 1980, vol. 24, p. 520.
10. Kozlov, N.S., *5,6-Benzokhinoliny* (5,6-Benzoquinolines), Minsk: Nauka, i, tekhnika, 1972, p. 111.
11. Kozlov, N.S., Gusak, K.N., and Serzhanina, V.A., *Dokl. Akad. Nauk SSSR*., 1986, 287, p. 1142.
12. *Beilst. H,* vol. 8, p. 258.