ISSN 1070-4280, Russian Journal of Organic Chemistry, 2008, Vol. 44, No. 5, pp. 736–740. © Pleiades Publishing, Ltd., 2008.
Original Russian Text © A.A. Kalinin, V.A. Mamedov, 2008, published in Zhurnal Organicheskoi Khimii, 2008, Vol. 44, No. 5, pp. 744–748.

Polyfused Nitrogen Heterocycles: XIX.* Oxidative Imidazo-Fusion of 3-Benzoylquinoxalin-2-ones with Benzylamines in the Synthesis of Bis(imidazo[1,5-a]quinoxalin-1- and -5-yl) Derivatives

A. A. Kalinin and V. A. Mamedov

Arbuzov Institute of Organic and Physical Chemistry, Kazan Scientific Center, Russian Academy of Sciences, Kazan, 420088 Russia
e-mail: mamedov@iopc.knc.ru

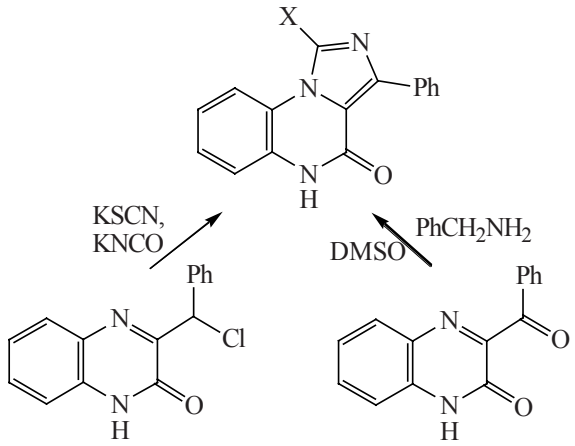
Received July 17, 2007

Abstract—Oxidative cyclocondensation of bis(3-benzoylquinoxalin-1-yl)alkanes and oxaalkanes with benzylamine and 3-benzoylquinoxalinones with *m*-xylylenediamine proceeded with the formation of bis-(imidazo[1,5-*a*]quinoxalinyl) derivatives where the hetaryl fragments were linked by a spacer both through the imidazole and quinoxaline fragments

DOI: 10.1134/S1070428008050187

Derivatives of imidazo[1,5-*a*]quinoxalines are used in the synthesis of pharmacologically active compounds as agonists and antagonists of the receptor of GABA/diazepine, inhibitors of CAMP and cGMP phosphodiesterases, agonists of receptors of A_1- and A_{2a}-adenosines [2–8]. Proceeding from quinoxalines 4 types of building up this tricyclic system are possible: by intramolecular cyclization of functionalized quinoxalines [9–12], and by reacting quinoxalines derivatives with synthetic equivalents of one-carbon [13, 14], carbon-nitrogen-carbon [15–20], and nitrogen-carbon [13, 21, 22] synthons. Although the performance of the first two types of processes requires functionalized quinoxaline derivatives that as a rule are prepared by multistage syntheses, and the third type is experimentally difficult the designing of the imidazo[1,5-*a*]quinoxaline system by these routes is relatively well documented.

We formerly developed a new assembling procedure for imidazo[1,5-*a*]quinoxaline system by introducing a C–N fragment into the structure of a quinoxaline derivative [13, 21, 22]. The method is based either on a reaction of 3-α-chlorobenzylquinoxalines with potassium thiocyanate or isothiocyanate [13, 21], or on a reaction of 3-benzoylquinoxalines with benzylamines [22] (oxidative imidazofusion), and it utilizes available reagents. This procedure is experimentally simple and provides the desired tricyclic compounds in high yields.



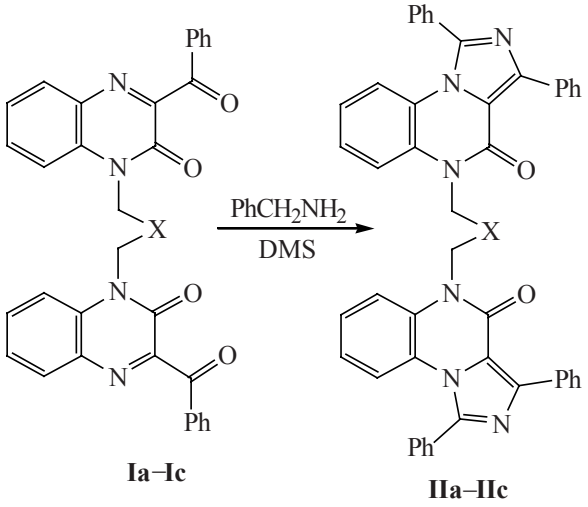
X = SH, OH, Ph.

This study is dedicated to the application of this method to the synthesis of bisimidazoquinoxalinones, bisanalogs of fused quinoxalines that as a rule are of biological activity similar to their monoanalogs [23].

Based on the reaction under consideration compounds with two imidazoquinoxaline fragments can be synthesized using two bifunctional compounds with terminal benzoylquinoxaline and benzylamine fragments. A reaction of benzylamine at heating in DMSO solution with α,ω-bis(3-benzoyl-2-oxoquinoxalin-

* For communication XVIII, see [1].

1-yl)alkanes and -oxaaalkanes (**I**) easily obtained by reacting 3-benzoylquinoxalin-2-ones with various α,ω-dibromoalkanes and oxaalkane [24] led to the formation of crystalline compounds whose IR spectrum contained a single absorption band of $\nu_{C=O}$ in the region 1645–1655 cm^{-1}. The presence in the electron ionization mass spectra of molecular ions $[M]^+$ 744 of compound **IIa**, $[M]^+$ 756 of compound **IIb**, and $[M]^+$ 788 of compound **IIc**, and in the ^1H NMR spectra of proton signals from aromatic fragments alongside the proton signals of methylene groups indicates the formation of α,ω-bis-(4-oxo-1,3-diphenylimidazo[1,5-*a*]-quinoxalin-5-yl)alkanes and -oxaalkanes (**II**).



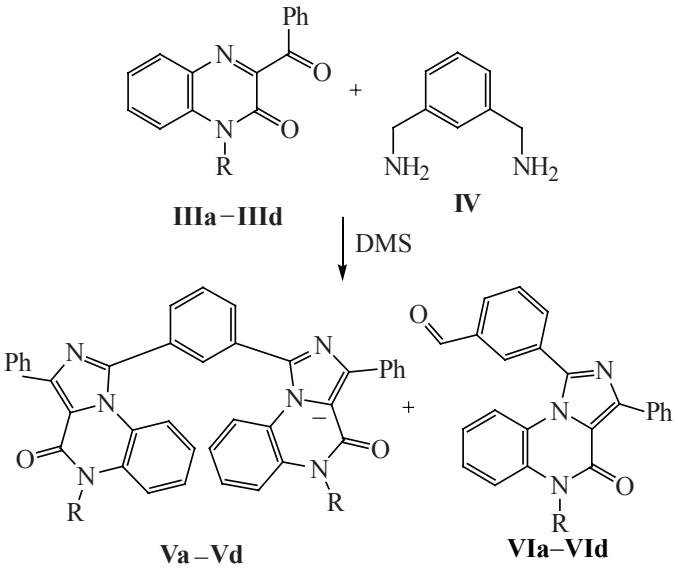
Ia–**Ic** **IIa**–**IIc**

X = CH_2OCH_2 (**a**), $(CH_2)_4$ (**b**), $CH_2OCH_2CH_2OCH_2$ (**c**).

The alteration of the character of N^4 atom in going into N^{10} atom from pyridine character in initial compounds **I** to pyrrole one in reaction products **II** is revealed in the ^1H NMR spectra by the upfield shift of all protons from the quinoxaline system of compounds **II** (to the region 6.9–7.6 ppm) compared to the signals of the quinoxaline protons of initial compounds **I** observed in the region 7.4–8.0 ppm.

Unlike benzoylquinoxalinone [22] that treated with equimolar amount of benzylamine easily transformed into 1,3-diphenylimidazo[1,5-*a*]quinoxalin-4(1*H*)-one benzoylquinoxalinonopodands required a longer reaction time and benzylamine excess to obtain the corresponding bis(imidazo[1,5-*a*]-quinoxalinyl) derivatives.

The second approach to the synthesis of bisimidazo-quinoxalines is based on the method we have former-ly developed involving a reaction of compounds con-taining two aminomethyl moieties in a benzene ring. The procedure makes it possible to obtain bisimidazo-quinoxalines linked by a spacer at the position *1*. A reaction of *m*-xylylenediamine (**IV**) with various N-alkylbenzoylquinoxalinones **III** results in the fusion of imidazole rings and in the formation of *m*-bisheterylbenzenes **V** as the main products and formylphenylimidazo[1,5-*a*]quinoxalinones **VI** as the side reaction products.

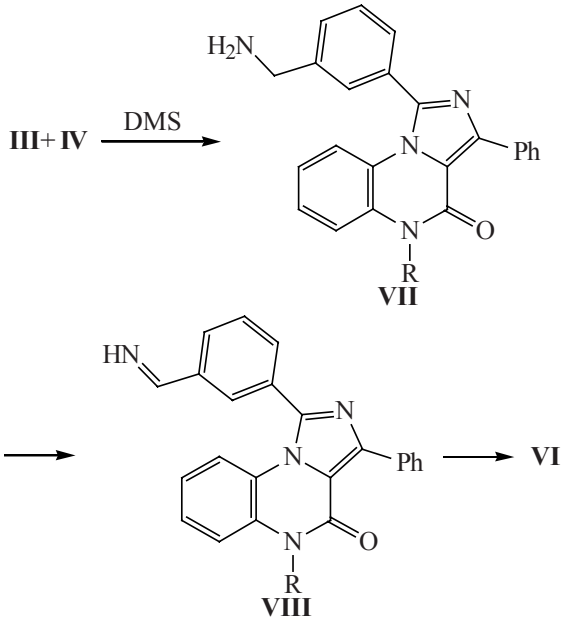


IIIa–**IIId** **IV**

Va–**Vd** **VIa**–**VId**

R = Me (**a**), Et (**b**), Pr (**c**), Bn (**d**).

The latter compounds form apparently from initially arising aminomethylphenylimidazoquinoxalines **VII** that under the reaction conditions are oxidized to imines **VIII** followed by hydrolysis to aldehydes **VI**.



VII

VIII

The structure of compounds **V** was established from IR, ^{1}H NMR, and mass spectra and from the data of ele-mental analysis. The IR spectra of compounds **V** lack absorption bands ν(CO_{ket}) in the region 1675–1690 cm^{-1}. In the electron ionization mass spectra molecular ions are present $[M]^+$ 624, 680, 776 of compounds **Va**, **Vc**, and **Vd** respectively. In the ^{1}H NMR spectrum 22 signals of aromatic protons are observed. The protons of the *m*-phenylene fragment appear separately from the other aromatic protons signals in weaker field (7.9–8.1 ppm) as a singlet of H^2, a doublet (H^4 and H^6, *J* 7.8 Hz), and a doublet of doublets (H^5, *J* 7.6, 7.6 Hz). They have intensity corresponding to a half of that of the phenyl rings protons and of quinoxaline systems. In the upfield region similar to compounds **II** appears a signal of H^8 proton of the quinoxaline system as a doublet of doublets (*J* ~8.0, ~7.6 Hz) at ~7.00 ppm. The formation of compounds **VIa–VId** was revealed by the electron ionization mass spectra, and compound **VIa** was isolated and characterized. The IR spectrum of imidazoquinoxaline **VIa** contained absorption bands of two carbonyl groups with ν(CO_{amide}) 1648 and ν(CO_{ald}) 1693 cm^{-1}. In the ^{1}H NMR spectrum the protons of 1,3-disubstituted benzene fragment appeared as four and not three signals characteristic of the ^{1}H NMR spectrum of compound **Va**; two of the signals, the singlet from proton H^6 at 8.29 ppm and the doublet (*J* 7.56 Hz) from proton H^4 at 8.18 ppm, are located more downfield due to the stronger electron-withdrawing effect of the aldehyde group. The aldehyde group signal appears at 10.14 ppm.

EXPERIMENTAL

Melting points were measured on a Boëtius heating block. IR spectra of compounds synthesized were recoded on a Fourier spectrometer Bruker Vector-22 from mulls in mineral oil. ^{1}H NMR spectra were registered on a spectrometer Avance-600 at operating frequency 600.00 MHz from solutions in DMSO-d_6. Mass spectra of electron ionization were taken on a quadrupole mass spectrometer TRACE MS, sample admission was performed directly through a system with water cooling.

α,ω-Bis(4-oxo-1,3-diphenylimidazo[1,5-*a*]-quinoxalin-5-yl)alkanes and -oxaalkanes II. A solution of 0.34 mmol of compound I and 1.4 mmol of benzylamine in 6 ml of DMSO was stirred at 140–150°C for 8 h, then it was cooled and poured into water. The separated crystals were filtered off, washed with water, and dried.

1,5-Bis(4-oxo-1,3-diphenylimidazo[1,5-*a*]-quinoxalin-5-yl)-3-oxapentane (IIa). Yield 48%, mp 174–176°C (DMSO). IR spectrum, ν, cm^{-1}: 694, 750, 781, 1053, 1108, 1180, 1255, 1300, 1324, 1337, 1447, 1485, 1503, 1610, 1655. ^{1}H NMR spectrum, δ, ppm: 3.85 t (4H, OCH_2, *J* 5.46 Hz), 4.39 t (4H, NCH_2, *J* 5.46 Hz), 6.87 d.d (2H, $H^8_{quinoxaline}$, *J* 8.10, 7.56 Hz), 7.10 d (2H, $H^9_{quinoxaline}$, *J* 8.34 Hz), 7.15 d.d (2H, $H^7_{quinoxaline}$, *J* 7.86, 7.32 Hz), 7.37 d.d (2H, $H^p_{1\text{-Ph}}$, *J* 7.32, 6.54 Hz), 7.41 d.d (4H, $H^m_{1\text{-Ph}}$, *J* 7.32, 7.08 Hz), 7.57 d (2H, $H^6_{quinoxaline}$, *J* 8.88 Hz), 7.60 d (4H, $H^o_{1\text{-Ph}}$, *J* 7.08 Hz), 7.64 d.d (2H, $H^p_{3\text{-Ph}}$, *J* 7.62, 6.78 Hz), 7.65 d (4H, $H^m_{3\text{-Ph}}$, *J* 7.62 Hz), 8.12 d (4H, $H^o_{3\text{-Ph}}$, *J* 7.56 Hz). Mass spectrum, *m/z* (I_{rel}, %): 746 (2), 745 (6), 744 $[M]^+$ (11), 757 (8), 407 (8), 381 (28), 363 (44), 337 (100), 260 (10), 234 (18), 219 (24), 205 (32), 102 (38). Found, %: C 77.32; H 4.95; N 11.36. $C_{48}H_{36}N_6O_3$. Calculated, %: C 77.40; H 4.87; N 11.28.

1,6-Bis(4-oxo-1,3-diphenylimidazo[1,5-*a*]-quinoxalin-5-yl)hexane (IIb). Yield 77%, mp 271–273°C (DMSO). IR spectrum, ν, cm^{-1}: 694, 704, 747, 781, 1050, 1121, 1250, 1300, 1335, 1395, 1447, 1485, 1503, 1611, 1655. ^{1}H NMR spectrum, δ, ppm: 1.45–1.55 m [4H, $(CH_2)_2(\underline{CH_2})_2(CH_2)_2$], 1.65–1.75 m [4H, $CH_2\underline{CH_2}(CH_2)_2\underline{CH_2}CH_2$], 4.24 t (4H, NCH_2, *J* 7.47 Hz), 6.97 d.d (2H, $H^8_{quinoxaline}$, *J* 8.34, 8.10 Hz), 7.19 d.d (2H, $H^9_{quinoxaline}$, *J* 8.37, 1.29 Hz), 7.43–7.47 m (4H, $H^7_{quinoxaline}$ and $H^p_{3\text{-Ph}}$), 7.44 d.d (4H, $H^m_{3\text{-Ph}}$, *J* 7.56, 7.32 Hz), 7.57 d (2H, $H^6_{quinoxaline}$, *J* 8.10 Hz), 7.60–7.68 m (6H, $H^{pm}_{1'\text{-Ph}}$), 7.72 d.d (4H, $H^o_{1\text{-Ph}}$, *J* 7.56, 1.56 Hz), 8.14 d.d (4H, $H^o_{3\text{-Ph}}$, *J* 7.68, 1.32 Hz). Mass spectrum, *m/z* (I_{rel}, %): 757 (7), 756 $[M]^+$ (11), 420 (32), 406 (44), 378 (50), 364 (57), 337 (70), 322 (16), 205 (16). Found, %: C 79.46; H 5.28; N 11.21. $C_{50}H_{40}N_6O_2$. Calculated, %: C 79.34; H 5.33; N 11.10.

1,8-Bis(4-oxo-1,3-diphenylimidazo[1,5-*a*]-quinoxalin-5-yl)-3,5-dioxaoctane (IIc). Yield 60%, mp 216–218°C (DMSO). IR spectrum, ν, cm^{-1}: 670, 695, 744, 777, 1005, 1033, 1101, 1124, 1178, 1246, 1257, 1300, 1326, 1352, 1393, 1445, 1485, 1504, 1591, 1609, 1645. ^{1}H NMR spectrum, δ, ppm: 3.59 C (4H, OCH_2CH_2O), 3.73 t (4H, $O\underline{CH_2}CH_2N$, *J* 6.04 Hz), 4.33 t (4H, NCH_2, *J* 6.04), 6.88 d.d (2H, $H^8_{quinoxaline}$, *J* 7.40, 7.36 Hz), 7.12 d (2H, $H^9_{quinoxaline}$, *J* 8.04 Hz), 7.28 d.d (2H, $H^7_{quinoxaline}$, *J* 8.04, 7.36 Hz), 7.32–7.70 m (18H, $H^6_{quinoxaline}$, 3-C_6H_5; $H^{pm}_{1'\text{-Ph}}$), 8.11 d (4H, $H^o_{3\text{-Ph}}$, *J* 6.68 Hz). Mass spectrum, *m/z* (I_{rel}, %): 788 $[M]^+$ (5), 452 (5), 425 (7), 394 (7), 364 (37), 337 (100), 322 (5), 234 (11), 219 (25), 205 (15). Found, %: C 76.27; H 5.23;

N 10.56. $C_{50}H_{40}N_6O_4$. Calculated, %: C 76.12; H 5.11; N 10.65.

1,3-Bis(5-alkyl-4-oxo-3-phenylimidazo[1,5-*a*]-quinoxalin-1-yl)benzenes (V). A solution of 0.9 mmol of compound **III** and 0.66 mmol of compound **IV** in 6 ml of DMSO was stirred at 140–150°C for 24 h, then it was cooled and poured into water, extracted with CH_2Cl_2 (3×10 ml), washed with water, the solvent was evaporated, and the residue was subjected to column chromatography on silica gel (eluent CH_2Cl_2–EtOH, 200:1).

1,3-Bis(5-methyl-4-oxo-3-phenylimidazo[1,5-*a*]-quinoxalin-1-yl)benzene (Va). Yield 31%, mp 321–323°C. IR spectrum, ν, cm^{-1}: 695, 750, 1104, 1259, 1303, 1333, 1348, 1396, 1502, 1591, 1656. ^{1}H NMR spectrum, δ, ppm: 3.60 s (6H, CH_3), 7.11 d.d.d (2H, $H^8_{quinoxaline.}$, *J* 8.16, 7.64 Hz), 7.35–7.50 m (10H, $H^{7,9}_{qunoxaline}$, $H^{m,p}_{Ph}$), 7.58 d (2H, $H^6_{quinoxaline}$, *J* 7.80 Hz), 7.89 m.d (1H, H^5, *J* 7.86, 7.56 Hz), 8.03 d (2H, $H^{4,6}$, *J* 7.86 Hz), 8.12 s (1H, H^2), 8.16 d (4H, H^o_{Ph}, *J* 7.08 Hz). Mass spectrum, *m/z* (I_{rel}, %): 625 (40), 624 $[M]^+$ (86), 521 (30), 381.1 (32), 337.0 (62), 312.2 (12), 273.0 (18), 233.1 (30), 218.8 (100), 205.0 (34), 150.8 (24), 106 (32), 97 (42), 94 (50), 54 (56). Found, %: C 76.85; H 4.61; N 13.32. $C_{40}H_{28}N_6O_2$. Calculated, %: C 76.91; H 4.52; N 13.45.

1,3-Bis(5-ethyl-4-oxo-3-phenylimidazo[1,5-*a*]-quinoxalin-1-yl)benzene (Vb). Yield 43%, mp 322–324°C. IR spectrum, ν, cm^{-1}: 695, 715, 728, 823, 859, 926, 1111, 1184, 1253, 1301, 1400, 1446, 1500, 1588, 1609, 1653. ^{1}H NMR spectrum, δ, ppm: 1.28 t (3H, CH_3, *J* 7.11 Hz), 4.29 q (2H, CH_2, *J* 7.11 Hz), 7.09 d.d (2H, $H^8_{quinoxaline.}$, *J* 8.34, 7.56 Hz), 7.35–7.50 m (10H, $H^{7,9}_{quinoxaline}$, $H^{m,p}_{Ph}$), 7.62 d (2H, $H^6_{quinoxaline}$, *J* 8.10 Hz), 7.88 d.d (1H, H^5, *J* 7.56, 7.56 Hz), 8.03 d (2H, $H^{4,6}$, *J* 7.80 Hz), 8.11 s (1H, H^2), 8.17 d (4H, H^o_{Ph}, *J* 7.08 Hz). Found, %: C 77.35; H 4.81; N 12.75. $C_{42}H_{32}N_6O_2$. Calculated, %: C 77.28; H 4.94; N 12.87.

1,3-Bis(5-propyl-4-oxo-3-phenylimidazo[1,5-*a*]-quinoxalin-1-yl)benzene (Vc). Yield 39%, mp 146–148°C. IR spectrum, ν, cm^{-1}: 694, 750, 783, 1075, 1114, 1144, 1181, 1228, 1252, 1298, 1485, 1591, 1611, 1662. ^{1}H NMR spectrum, δ, ppm: 0.98 t (6H, CH_3, *J* 7.36 Hz), 1.65–1.72 m (4H, $\underline{CH_2}CH_3$), 4.18 t (4H, NCH_2, *J* 7.36 Hz), 7.07 d.d (2H, $H^8_{quinoxaline}$, *J* 8.16, 7.64 Hz), 7.30–7.50 m (10H, $H^{7,9}_{quinoxaline}$, $H^{m,p}_{Ph}$), 7.59 d (2H, $H^6_{quinoxaline}$, *J* 8.72 Hz), 7.88 d.d (1H, H^5, *J* 7.64, 7.64 Hz), 8.02 d (2H, $H^{4,6}$, *J* 7.64 Hz), 8.11 s (1H, H^2), 8.14 d (4H, H^o_{Ph}, *J* 7.64 Hz). Mass spectrum, *m/z* (I_{rel}, %): 682 (2), 681 (10), 680 $[M]^+$ (24), 638 (6), 596 (8), 375 (10), 304 (16), 298 (36), 246 (25), 233 (29), 219 (49), 205 (100), 190 (18). Found, %: C 77.48; H 5.27; N 12.46. $C_{44}H_{36}N_6O_2$. Calculated, %: C 77.63; H 5.33; N 12.34.

1,3-Bis(5-benzyl-4-oxo-3-phenylimidazo[1,5-*a*]-quinoxalin-1-yl)benzene (Vd). Yield 32%, mp 143–145°C. IR spectrum, ν, cm^{-1}: 458, 670, 782, 960, 1028, 1076, 1128, 1257, 1300, 1401, 1485, 1495, 1592, 1612, 1656. ^{1}H NMR spectrum, δ, ppm: 5.40 C (4H, CH_2), 7.02 d.d (2H, $H^8_{quinoxaline}$, *J* 7.92, 7.86 Hz), 7.20–7.50 m (22H, $H^{6,7,9}_{quinoxaline}$, $H^{m,p}_{3\text{-}Ph}$, $CH_2\underline{Ph}$), 7.88 d.d (1H, H^5, *J* 7.92, 7.44 Hz), 8.05 d (2H, $H^{4,6}$, *J* 7.44 Hz), 8.15 c (1H, H^2), 8.16 d (4H, H^o_{Ph}, *J* 7.44 Hz). Mass spectrum, *m/z* (I_{rel}, %): 776 $[M]^+$ (2), 685 (6), 233 (3), 205 (7). Found, %: C 80.47; H 4.71; N 10.75. $C_{52}H_{36}N_6O_2$. Calculated, %: C 80.39; H 4.67; N 10.82.

5-Methyl-1-(3-formylphenyl)-3-phenylimidazo-[1,5-*a*]quinoxalin-4-one (VIa). Yield 8%, mp 237–239°C. IR spectrum, ν, cm^{-1}: 672, 696, 755, 804, 979, 1055, 1105, 1192, 1301, 1332, 1400, 1483, 1613, 1648, 1693. ^{1}H NMR spectrum, δ, ppm: 3.63 s (3H, CH_3), 7.03 d.d (1H, H^8, *J* 8.10, 7.56 Hz), 7.21 d (1H, H^9, *J* 8.34 Hz), 7.39–7.50 m (4H, H^7, $H^{m,p}_{Ph}$), 7.59 d (1H, H^6, *J* 8.34 Hz), 7.86 d.d (1H, $H^5_{phenylene}$, *J* 7.80, 7.62 Hz), 8.09 d (1H, $H^6_{phenylene}$, *J* 7.86 Hz), 8.18 d (1H, $H^4_{phenylene}$, *J* 7.56 Hz), 8.18 d (2H, H^o_{Ph}, *J* 7.56 Hz), 8.29 C (1H, $H^2_{phenylene}$), 10.14 C (1H, CHO). Mass spectrum, *m/z* (I_{rel}, %): 380 (24), 379 $[M]^+$ (94), 276 (100), 219 (68), 218 (18), 152 (14), 124 (34). Found, %: C 75.79; H 4.61; N 11.25. $C_{24}H_{17}N_3O_2$. Calculated, %: C 75.98; H 4.52; N 11.07.

The study was carried out under a financial support of the Russian Foundation for Basic Research (grant no. 07-03-00613-a) and of a grant of the President of the Russian Federation"Young Candidates of Sciences and their Scientific Supervisors" (grant MK-801.2006.3).

REFERENCES

1. Mamedov, V.A., Kalinin, A.A., Gubaidullin, A.T., and Litvinov, I.A., *Izv. Akad. Nauk, Ser. Khim.*, 2007, p. 2386.
2. Jacobsen, E.J., Stelzer, L.S., Belonga, K.L., Karter, D.B., Im, W.B., Tang, V.H., von Voigtlander, P.F., and Petke, J.D., *J. Med. Chem.*, 1996, vol. 39, p. 3820.
3. Davey, D.D., Erhardt, P.W., Cantor, E.H., Greenberg, S.S., Ingebretsen, W.R., and Wiggins, J., *J. Med. Chem.*, 1991, vol. 34, p. 2671.
4. Colltta, V., Cecchi, L., Catarzi, D., Filacchioni, G., Martini, C., Tacchi, P., and Lucacchini, A., *Eur. J. Med. Chem.,* 1995, vol. 30, p. 133.

5. Ohmori, J., Shimizu-Sasamata, M., Okada, M., and Sakamoto, S., *J. Med. Chem.*, 1997, vol. 40, p. 2053.
6. TenBrink, R.E., Jacobsen, E.J., and Gammill, R.B., US Patent 5541324, 1996; *Chem. Abstr.*, 1996, vol. 125, p. 195687.
7. Hansen, H.C. and Watjen, F., US Patent 344943, 1989; *Chem. Abstr.*, 1990, vol. 112, p. 216962.
8. Lee, T.D. and Brown, R.E., US Patent 4440929, 1984; *Chem. Abstr.*, 1984, vol. 101, p. 7202.
9. Ager, I.A., Barnes, A.C., Danswan, G.W., Hairsine, P.W., Kay, D.P., Kennewell, P.D., Matharu, S.S., Miller, P., Robson, P., Rowlands, D.A., and Tully, W.R., and Westwood, R., *J. Med. Chem.,* 1988, vol. 31, p. 1098.
10. Danswan, G.W., Hairsine, P.W., Rowlands, D.A., Taylor, J.B., and Westwood, R., *J. Chem. Soc., Perkin Trans. I,* 1982, p. 1049.
11. Kurasawa, Yo., Ichikawa, M., and Takada, A., *Heterocycles*, 1983, vol. 20, p. 269.
12. Benkovic, S.J., Barrows, T.H., and Farina, P.R., *J. Am. Chem. Soc*., 1973, vol. 95, p. 8414.
13. Mamedov, V.A., Kalinin, A.A., Azancheev, N.M., and Levin, Ya.A., *Zh. Org. Khim*., 2003, vol. 39, p. 135.
14. Benkovic, S.J., Benkovic, P.A., and Comfort, D.R., *J. Am. Chem. Soc.,* 1969, vol. 91, p. 5270.
15. Nispen, S.P.J.M., Mensink, C., and Leusen, A.M., *Tetrahedron Lett.*, 1980, vol. 21, p. 3723.
16. Chen, P., Barrish, J.C., Iwanovicz, E., Lin, J., Bednarz, M.S., and Chen, B.C., *Tetrahedron Lett*., 2001, vol. 42, p. 4293.
17. Jacobsen, E.J., TenBrink, R.E., Stelzer, L.S., Belonga, K.L., Carter, D.B., Im, H.K., Im, W.B., Sethy, V.H., Tang, A.H., von Voigtlander, P.F., and Petke, J.D., *J. Med. Chem.*, 1996, vol. 39, p. 158.
18. Jacobsen, E.J., Stelzer, L.S., TenBrink, R.E., Belonga, K.L., Carter, D.B., Im, H.K., Im, W.B., Sethy, V.H., Tang, A.H., von Voigtlander, P.F., Petke, J.D., Zhong, W.Z., and Mickelson, J.W., *J. Med. Chem.,* 1999, vol. 42, p. 1123.
19. TenBrink, R.E., Im, W.B., Sethy, V.H., Tang, A.H., and Carter, D.B., *J. Med. Chem*., 1994, vol. 37, p. 758.
20. Mickelson, J.W., Jacobsen, E.J., Carter, D.B., Im, H.K., Im, W.B., Schreur, P.J.K.D., Sethy, V.H., Tang, A.H., McGee, J.E., and Petke, J.D., *J. Med. Chem*., 1996, vol. 39, p. 4654.
21. Mamedov, V.A., Kalinin, A.A., Rizvanov, I.Kh., Azancheev, N.M., Efremov, Yu.Ya., and Levin, Ya.A., *Khim. Geterotsikl. Soedin*., 2002, p. 1279.
22. Mamedov, V.A., Kalinin, A.A., Gorbunova, E.A., Baier, I., and Khabikher, V.D., *Zh. Org. Khim.*, 2004, vol. 40, p. 1082.
23. Guillon, J., Grellier, P., Labaied, M., Sonnet, P., Leger, J.-M., Deprez-Poulain, R., Forfar-Bares, I., Dallemagne, P., Lemaýtre, N., Pehourcq, F., Rochette, J., Sergheraert, C., and Jarry, C., *J. Med. Chem*., 2004, vol. 47, p. 1997.
24. Mamedov, V.A., Kalinin, A.A., Gubaidullin, A.T., Gorbunova, E.A., and Litvinov, I.A., *Zh. Org. Khim.,* 2006, vol. 42, p. 1543.