ISSN 1070-4280, Russian Journal of Organic Chemistry, 2008, Vol. 44, No. 5, pp. 709–714. © Pleiades Publishing, Ltd., 2008.
Original Russian Text © N.E. Gavrilova, V.V. Zalesov, N.A. Pulina, 2008, published in Zhurnal Organicheskoi Khimii, 2008, Vol. 44, No. 5, pp. 718–723.

4-Aryl-2-hydroxy-4-oxobut-2-enoic Acids *N*-(2-Pyridyl)amides in Reactions with Diazo Compounds

N. E. Gavrilova[a], V. V. Zalesov[a], and N. A. Pulina[b]

[a]*Perm State University, Perm, 614900 Russia*
[b]*Perm State Pharmaceutical Academy, Perm, 614900 Russia*
e-mail: pulina_jane@mail.ru

Received October 16, 2007

Abstract—Reactions of 4-aryl-2-hydroxy-4-oxobut-2-enoic acids *N*-(2-pyridyl)amides with diazomethane, diazoethane, diaryldiazomethanes, and diazofluorene lead to the formation of 2-alkoxy-4-aryl-4-oxobut-2-enoic acids *N*-(2-pyridyl)amides, 3-aroyl-5-methylpyrazole-4-carboxylic acids *N*-(2-pyridyl)amides, and 3-alkoxy-3-(2-aryl-2-oxoethyl)-2,3-dihydro-2-oxoimidazo[1,2-*a*]pyridines. The composition and structure of compounds obtained depend on the nucleophilic nature of the diazo compound and on the character of substituents in the aryl and pyridine parts of the substrate.

DOI: 10.1134/S1070428008050138

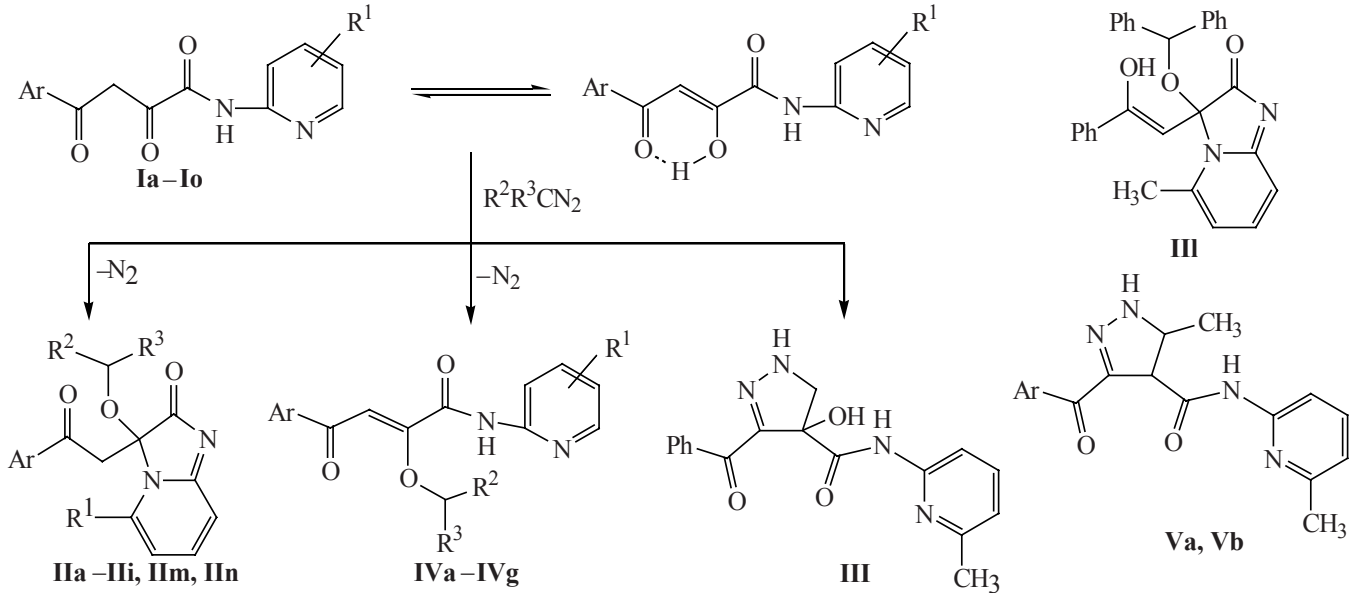
We formerly reported on cyclization of 4-aryl-2-hydroxy-4-oxobut-2-enoic acids *N*-(2-thiazolyl)amides and *N*-(2-pyridyl)amides effected by diazoalkanes giving derivatives of imidazo[2,1-*b*]thiazoles and imidazo-[1,2-*a*]pyridines respectively. Therewith a simultaneous process was observed of O-alkylation of the initial amides [1–3]. In extension of the research on the intramolecular cyclization of heterylamides under the action of diazo nucleophiles we aimed in this study to investigate the reaction of 4-aryl-2-hydroxy-4-oxobut-2-enoic acids *N*-(2-pyridyl)amides having substituents in aryl and pyridine fragments with diazomethane, diazoethane, diaryldiazomethanes, and diazofluorene.

Firstly by analogy with the cyclization of 4-aryl-2-hydroxy-4-oxobut-2-enoic acids *N*-(2-pyridyl)amides **Ia–Id** into imidazo[1,2-*a*]pyridines [2] we investigated the reaction of amides **Ie–Im** with diazomethane at a ratio 1:4. The reaction of *N*-(6-methyl-2-pyridyl)amides **Ie–Ii** with diazomethane took several routes to produce a complex mixture of compounds (from 4 to 9 according to TLC). In all events save in reaction of amide **Ii** derivatives of imidazo[1,2-*a*]pyridine were detected in the reaction mixture owing to their blue fluorescence under UV irradiation. This property permits the reliable detection of their formation in the course of reaction and checking their presence or absence during isolation [4]. However we succeeded in isolation of only two compounds of this series, 3-(2-aryl-2-oxoethyl)-5-methyl-3-methoxy-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridines **IIa** and **IIb**, in 11–15% yield (Scheme 1). Spectral characteristics of compounds **IIa** and **IIb** are consistent with the corresponding data of the previously obtained imidazo[1,2-*a*]pyridines [2]. Besides from the reaction products of amide **Ie** alongside the compound **IIa** 3-benzoyl-4-hydroxy-4,5-dihydropyrazole-4-carboxylic acid N-(6-methyl-2-pyridyl)amide (**III**) was isolated. The formation of pyrazole **III** occurred by 1,3-dipolar cycloaddition of diazomethane across the multiple $C^2=C^3$ bond of the initial pyridylamide **Ie**. From the reaction products of amide **Ii** 4-(2,4-dimethylphenyl)-2-methoxy-4-oxobut-2-enoic acid *N*-(6-methyl-2-pyridyl)amide (**IVa**) was isolated in a good yield (Scheme 1).

In going in the reaction with diazomethane from amides **Ie–Ii** to *N*-(5-bromo-2-pyridyl)amides **Ij–Im** its main direction became the α-O-methylation providing compounds **IVb–IVe**.

For O-methyl derivative **IVb** a presence in the solution of its ring form, 1-(5-bromo-2-pyridyl)-5-hydroxy-2,5-dihydro-3-methoxy-5-phenylpyrrol-2-one **A**, was proved, but we failed to isolate and characterize the pyrrolone. The existence of arylamides of 4-aryl-2-hydroxy-4-oxobut-2-enoic acids with a substituent in the position *3* in both ring and open-chain forms was reported earlier [5] (Scheme 2).

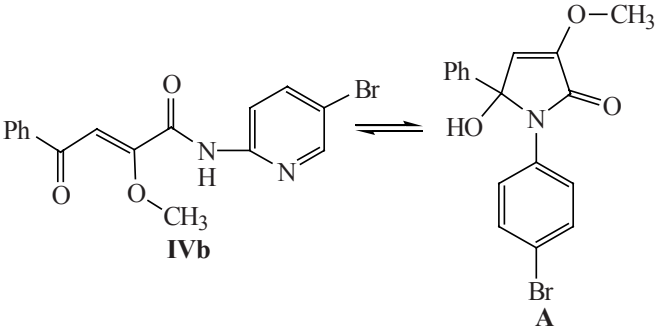
Scheme 1.



I, R^1 = H, Ar = Ph (**a**), 4-MeC_6H_4 (**b**), 4-$MeOC_6H_4$ (**c**), 4-BrC_6H_4 (**d**); R^1 = 6-Me, Ar = Ph (**e**), 4-MeC_6H_4 (**f**), 4-$EtOC_6H_4$ (**g**), 4-ClC_6H_4 (**h**), 2,4-$Me_2C_6H_3$ (**i**); R^1 = 5-Br, Ar = Ph (**j**), 4-$MeOC_6H_4$ (**k**), 4-ClC_6H_4 (**l**), 4-BrC_6H_4 (**m**); **II**, R^1 = Me, R^2 = R^3 = H, Ar = Ph (**a**), 4-ClC_6H_4 (**b**); R^1 = H, R^2 = R^3 = Ph, Ar = Ph (**c**), 4-MeC_6H_4 (**d**), 4-BrC_6H_4 (**e**); R^1 = Me, R^2 = R^3 = Ph, Ar = 4-MeC_6H_4 (**f**); R^1 = H, R^2 = Ph, R^3 = 4-BrC_6H_4, Ar = Ph (**g**), 4-MeC_6H_4 (**h**), R^1 = Me, R^2 = Ph, R^3 = 4-BrC_6H_4, Ar = 4-MeC_6H_4 (**i**); R^1 = H, R^2, R^3 = 9-fluorenyl, Ar = Ph (**k**), 4-$MeOC_6H_4$ (**l**); **IV**, R^1 = 6-Me, R^2 = R^3 = H, Ar = 2,4-$Me_2C_6H_3$ (**a**); R^1 = 5-Br, R^2 = R^3 = H, Ar = Ph (**b**), 4-$MeOC_6H_4$ (**c**), 4-ClC_6H_4 (**d**), 4-BrC_6H_4 (**e**); R^2 = H, R^3 = Me, Ar = Ph (**f**), 4-$MeOC_6H_4$ (**g**); **V**, Ar = Ph (**a**), 4-$EtOC_6H_4$ (**b**).

We established that in reactions of heterylamides **Ie, Ig, Ij**, and **Ik** with diazoethane in ratios 1:4 and 1:6 the type of the resulting product depended primarily on the substituent in the pyridine ring. For instance, the main reaction products obtained from amides **Ie** and **Ig** were 3-aroyl-5-methylpyrazole-4-carboxylic acids *N*-(6-methyl-2-pyridyl)amides **Va** and **Vb**, and from *N*-(5-bromo-2-pyridyl)amides **Ij** and **Ik**, O-ethyl derivatives **IVf** and **IVg**. Therewith we did not isolate from the reaction mixture compounds arising from the attack of the second diazoethane molecule on the ketone carbonyl C^4=O in the already alkylated 2-pyridylamide as was reported in [2].

Scheme 2.



The IR spectra of compounds **Va** and **Vb** contained a broadened absorption band of the stretching vibrations of amide and keto carbonyl groups in the region 1675–1678 cm^{-1} and also two absorption bands of NH groups in the region 3175–3179 and 3534–3565 cm^{-1}. In the ^1H NMR spectrum of compound **Va** alongside the singlet of the methyl group protons and multiplets of the protons of aromatic and pyridine rings and also of the substituent attached thereto appeared a singlet of NH group proton at 11.31 ppm and a singlet from the proton of the NH group of the heterocycle at 13.72 ppm.

Thus the chemical behavior of *N*-(2-pyridyl)amides I**a–Im** in reactions with diazomethane and diazoethane is essentially affected by the substituents in the pyridine ring, and the yield of the final products depends also on the substituent in the aroyl residue.

We found that amides **Ia, Ib, Id,** and **If** reacted at heating in equimolar quantities with diphenyldiazomethane, and amides **Ia, Ib,** and **If**, with (4-bromophenyl)phenyldiazomethane, yielding 3-(2-aryl-2-oxoethyl)-3-diphenyl-

methoxy-2-oxo-2,3-dihydroimidazo-[1,2-*a*]-pyridines **IIc–IIf** and 3-(2-aryl-2-oxoethyl)-3-[(4-bromophenyl)phenyl]-methoxy-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridines **IIg–IIi** respectively. The IR spectra of compounds **IIc–IIi** contain absorption bands of the stretching vibrations of lactam and keto carbonyl groups in the region 1697–1709 and 1675–1690 cm^{-1}, of C=C and C=N bonds at 1580–1615 cm^{-1}, and the absorption band of the NH group is absent. In the ^1H NMR spectra of compounds **IIc–IIi** alongside the multiplet of the protons of aromatic and heterocyclic rings appear a singlet of the methine proton from the diarylmethyl fragment at 5.44–5.55 ppm and a quartet at 4.08–4.25 ppm from two protons of the methylene group at the chiral carbon atom of the heterocycle.

The reaction of amide **Ie** with diphenyldiazomethane also led to the formation of imidazopyridine, 3-(2-hydroxy-2-phenylethenyl)-3-diphenylmethoxy-5-methyl-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridine (**IIj**), but unlike compounds **IIa–IIi** the carbonyl group of the benzoyl substituent was completely enolized as showed the spectral characteristics of the substance.

The application of diazofluorene to the reaction with *N*-(2-pyridyl)amides **Ia** and **Ic** did not change its direction, and the main products were 3-aroylmethyl-2-oxo-3-(9-fluorenylmethoxy)-2,3-dihydroimidazo-[1,2-*a*]pyridines **IIk** and **III**, but the process required more severe conditions. IR and ^1H NMR spectra of compounds **IIk** and **III** are in agreement with those of compounds **IIa–IIi**.

The formation of imidazo[1,2-*a*]pyridines **II** is likely to commence by the protonation of the diazo nucleophile with the hydrogen of the enol hydroxy group and the rearrangement of the 2-pyridylamide fragment into pyridoimide moiety forming intermediate **B**. The building up of the imidazole ring involved the insertion of the diazo carbocation into the multiple bond $C^2=C^3$, nitrogen elimination, and hydrogen migration to the atom C^3 (Scheme 3).

N-(5-Bromo-2-pyridyl)amides **Ij–Im** do not enter into reaction with diaryldiazomethanes and 9-diazofluorene even at prolonged heating.

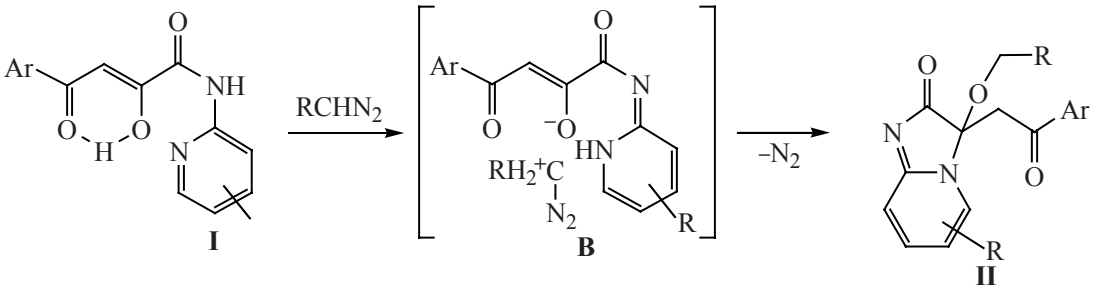
EXPERIMENTAL

IR spectra were recorded on a spectrophotometer FSM-1201 from mulls in mineral oil. ^1H NMR spectra were registered on a spectrometer Bruker DRX-500 (500 MHz), internal reference HMDS. Mass spectra were measured on a Varian MAT-311 instrument at the ionizing electrons energy 70 eV and direct probe admission into the ion source. UV spectra were taken on a spectrophotometer SF-121 from ethanol solutions of concentration 10^{-2} mol l^{-1}. The reaction progress was monitored and the purity of compounds obtained was checked by TLC on Silufol UV-254 plates in a system ether–benzene–acetone, 10:9:1, development in iodine vapor.

5-Methyl-3-methoxy-3-(2-aryl-2-oxoethyl)-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-ones (IIa and IIb). To a solution of 0.01 mol of amide **Ie** or **Ih** in 20 ml of anhydrous toluene was added a solution of 0.17 g (0.04 mol) of diazomethane in 6 ml of ether at 0–5°C, and the mixture was maintained for 48 h at 25°C. The mother liquor was evaporated, the residue was dissolved in chloroform and applied on Kieselgel G plates (10 × 12 cm) activated for 1 h at 110°C. The chromatography was carried out by ascending method, eluent acetonitrile. The spots were visualized by UV irradiation resulting in a characteristic fluorescence of the target compound. The purification was performed by chromatography on a column packed with Kieselgel 40, eluents chloroform, acetone, ethanol; the fraction collected had R_f 0.38 (**IIa**) or 0.40 (**IIb**). The solvents were removed under a vacuum of a water-jet pump. We obtained colorless oily product.

5-Methyl-3-methoxy-3-(2-oxo-2-phenylethyl)-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one

Scheme 3.



(IIa). Yield 0.33 g (11%). IR spectrum, ν, cm^{-1}: 1709 br (NC=O, C=O), 1625, 1605 (C=C, C=N). ^{1}H NMR spectrum, ppm: 2.99 g (3H, CH_3), 3.73 g (3H, CH_3O), 4.09 q (2H, CH_2, *J* 8.0 Hz), 7.15–7.78 m (7H, C_6H_4 + C_5H_3N). Found, %: C 68.97; H 5.49; N 9.30. $C_{17}H_{16}N_2O_3$. Calculated , %: C 68.91; H 5.44; N 9.45.

5-Methyl-3-methoxy-3-[2-oxo-2-(4-chlorophenyl)-ethyl]-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IIb). Yield 0.49 g (15%). IR spectrum, ν, cm^{-1}: 1729 br (NC=O, C=O), 1635, 1605 (C=C, C=N). Mass spectrum, *m/z* (I_{rel}, %): 332/330 (22.6) $[M]^+$, 317/315 (7.1), 225/223 (29.9), 219 (52.0), 191 (83.2), 141/139 (36.9), 135 (100), 113/111 (22.5), 92 (39.8). Found, %: C 61.95; H 4.79; Cl 10.90; N 8.30. $C_{17}H_{15}ClN_2O_3$. Calculated , %: C 61.73; H 4.67; Cl 10.72; N 8.48. *M* 330.77.

3-Diphenylmethoxy-3-(2-aryl-2-oxoethyl)-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IIc–IIe). A solution of 0.01 mol of 4-aryl-2-hydroxy-4-oxobut-2-enoic acid *N*-(2-pyridyl)amide **Ia, Ib**, or **Id** and 1.94 g (0.01 mol) of diphenyldiazomethane in 20 ml of anhydrous toluene was maintained at room temperature for 72 h, then the reaction mixture was evaporated, and the residue was recrystallized from benzene.

3-Benzoylmethyl-3-diphenylmethoxy-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IIc). Yield 2.52 g (58%), t.decomp. 167–168°C. IR spectrum, ν, cm^{-1}: 1700 (NC=O), 1690 (C=O), 1620, 1580 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 4.24 q (2H, CH_2, *J* 8.0 Hz), 5.44 s (1H, CH), 7.10–7.85 m (19H, $3C_6H_5$ + C_5H_4N). UV spectrum, λ_{max}, nm (log ε): 250 (4.04), 367 (3.41). Found, %: C 77.34; H 5.05; N 6.52. $C_{28}H_{22}N_2O_3$. Calculated , %: C 77.40; H 5.10; N 6.45.

3-Diphenylmethoxy-3-[2-oxo-2-(4-methylphenyl)ethyl]-2-oxo-2,3-dihydroimidazo[1,2-*a*]-pyridine (IId). Yield 2.87 g (64%), t.decomp. 179–180°C. IR spectrum, ν, cm^{-1}: 1709 (NC=O), 1675 (C=O), 1610, 1590 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6–CCl_4, 1:3), δ, ppm: 2.42 s (3H, CH_3), 4.08 q (2H, CH_2, *J* 8.0 Hz), 5.49 s (1H, CH), 7.15–7.90 m (18H, $2C_6H_5$ + C_6H_4 + C_5H_4N). UV spectrum, λ_{max}, nm (log ε): 256 (4.49), 366 (3.82). Found, %: C 77.93; H 5.30; N 6.18. $C_{29}H_{24}N_2O_3$. Calculated , %: C 77.66; H 5.39; N 6.25.

3-Diphenylmethoxy-3-[2-oxo-2-(4-bromophenyl)-ethyl]-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IId). Yield 1.85 γ (36%), t.decomp. 174–176°C. IR spectrum, ν, cm^{-1}: 1697 (NC=O), 1686 (C=O), 1615, 1600 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 4.20 q (2H, CH_2, *J* 8.0 Hz), 5.55 s (1H, CH), 7.10–7.90 m (18H, $2C_6H_5$ + C_6H_4 + C_5H_4N). UV spectrum, λ_{max}, nm (lgε): 257 (4.28), 368 (3.64). Found, %: C 65.45; H 4.18; Br 15.38; N 5.52. $C_{28}H_{21}BrN_2O_3$. Calculated , %: C 65.50; H 4.12; Br 15.56; N 5.46.

3-Diphenylmethoxy-5-methyl-3-[2-(4-methylphenyl)-2-oxoethyl]-2-oxo-2,3-dihydroimidazo-[1,2-*a*]-pyridin-2(3*H*)-one (IIe). A solution of 2.97 g (0.01 mol) of amide **If** and 1.94 g (0.01 mol) of diphenyldiazomethane in 25 ml of anhydrous toluene was maintained at room temperature for 72 h, then the reaction mixture was evaporated. The residue was dissolved in chloroform and and applied on Kieselgel G plates (10×12 cm) activated for 1 h at 110°C. The chromatography was carried out by ascending method, eluent acetonitrile. The spots were visualized by UV irradiation resulting in a characteristic fluorescence of the target compound. The purification was performed by chromatography on a column packed with Kieselgel 40, eluents chloroform, acetone, ethanol; the fraction collected had R_f 0.42. The solvents were removed under a vacuum of a water-jet pump to obtain colorless oily product. Yield 1.48 g (32%). IR spectrum, ν, cm^{-1}: 1728 br (NC=O, C=O), 1620, 1605 (C=C, C=N). Found, %: C 77.98; H 5.42; N 6.23. $C_{30}H_{26}N_2O_3$. Calculated , %: C 77.90; H 5.66; N 6.06.

3-(4-Bromophenyl)phenylmethoxy-2,3-dihydro-3-(2-aryl-2-oxoethyl)-2-oxoimidazo[1,2-*a*]pyridin-2(3*H*)-ones IIg–IIi. A solution of 0.01 mol of compound **Ia, Ib**, or **If** and 2.73 g (0.01 mol) of (4-bromophenyl)-phenyldiazomethane in 20 ml of anhydrous toluene was boiled for 1 h, then it was evaporated, and the residue was recrystallized from toluene.

3-Benzoylmethyl-3-[4-bromophenyl(phenyl)methoxy]-2-oxo-2,3-dihydroimidazo[1,2-*a*]-pyridin-2(3*H*)-one (IIg). Yield 3.54 g (69%), t.decomp. 181–182°C. IR spectrum, ν, cm^{-1}: 1701 (NC=O), 1690 (C=O), 1605, 1595 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 4.25 q (2H, CH_2, *J* 8.0 Hz), 5.50 s (1H, CH), 7.15–7.95 m (18H, $2C_6H_5$ + C_6H_4 + C_5H_4N). UV spectrum, λ_{max}, nm (lgε): 249 (4.24), 367 (3.60). Found, %: C 65.48; H 4.20; Br 15.50; N 5.53. $C_{28}H_{21}BrN_2O_3$. Calculated , %: C 65.50; H 4.12; Br 15.56; N 5.46.

3-[4-Bromophenyl(phenyl)methoxy]-3-[2-(4-methylphenyl)-2-oxoethyl]-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IIh). Yield 2.42 g (46%), t.decomp. 187–188°C. IR spectrum, ν, cm^{-1}: 1709 (NC=O), 1695 (C=O), 1610, 1580 (C=C, C=N). UV spectrum, λ_{max}, nm (log ε): 257 (4.48), 366 (3.80). Found, %: C 66.15; H 4.23; Br 15.21; N 5.42. $C_{29}H_{23}BrN_2O_3$. Calculated , %: C 66.04; H 4.39; Br 15.15; N 5.31.

3-[4-Bromophenyl(phenyl)methoxy]-5-methyl-3-[2-oxo-2-(4-methylphenyl)ethyl]-2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridin-2(3*H*)-one (IIi). Yield 1.89 g (35%), t.decomp. 146–148°C. IR spectrum, ν, cm^{-1}: 1705 (NC=O), 1682 (C=O), 1605, 1595 (C=C, C=N). UV spectrum, λ_{max}, nm (log ε): 256 (3.60), 371 (2.84). Mass spectrum, *m/z* (I_{rel}, %): 269/267 (39.0), 259/257 (60.0), 241/239 (9.8), 199 (60.0), 185/183 (100), 157/155 (48.8). Found, %: C 66.45; H 4.59; Br 14.88; N 5.21. $C_{30}H_{25}BrN_2O_3$. Calculated , %: C 66.55; H 4.65; Br 14.76; N 5.17. *M* 541.44.

3-(2-Hydroxy-2-phenylethenyl)-3-diphenylmethoxy-5-methyl-2-oxo2,3-dihydroimidazo[1,2-*a*]-pyridine (IIj). A solution of 2.83 g (0.01 mol) of compound **Ie** and 1.94 g (0.01 mol) of diphenyldiazomethane in 30 ml of anhydrous toluene was boiled for 0.5 h and then evaporated, the residue was recrystallized from acetonitrile. Yield 2.77 g (62%), t.decomp. 161–163°C. IR spectrum, ν, cm^{-1}: 1725 (NC=O), 1632, 1600 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 2.22 s (3H, CH_3), 5.96 s (1H, CH), 6.38 (1H, =CH), 7.05–7.85 m (18H, $3C_6H_5 + C_5H_3N$). UV spectrum, λ_{max}, nm (lgε): 219 (4.19), 287 (4.06). Found, %: C 77.95; H 5.09; N 6.34. $C_{29}H_{23}N_2O_3$. Calculated , %: C 77.83; H 5.18; N 6.26.

3-(2-Aryl-2-oxoethyl)-3-(9-fluorenylmethoxy)2-oxo-2,3-dihydroimidazo[1,2-*a*]pyridines IIk and III. A solution of 0.01 mol of compound **Ia** or **Ic** and 1.92 g (0.01 mol) of 9-diazofluorene in 30 ml of anhydrous toluene was boiled for 72 h and then evaporated, the residue was recrystallized from benzene.

2-Oxo-3-(2-oxo-2-phenylethyl)-3-(9-fluorenylmethoxy)-2,3-dihydroimidazo[1,2-*a*]pyridine (IIk). Yield 1.47 g (34%), t.decomp. 166–168°C. IR spectrum, ν, cm^{-1}: 1697 (NC=O), 1685 (C=O), 1610, 1585 (C=C, C=N). UV spectrum, λ_{max}, nm (lgε): 279 (4.24). Found, %: C 77.93; H 4.82; N 6.39. $C_{28}H_{20}N_2O_3$. Calculated , %: C 77.76; H 4.66; N 6.47.

3-[2-(4-Methoxyphenyl)-2-oxoethyl]-2-oxo-3-(9-fluorenylmethoxy)-2,3-dihydroimidazo[1,2-*a*]-pyridine (III). Yield 2.17 g (47%), t.decomp. 172–174°C. IR spectrum, ν, cm^{-1}: 1713 (NC=O), 1667 (C=O), 1610, 1590 (C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 3.17 s (3H, CH_3O), 4.23 q (2H, CH_2, *J* 6.0 Hz), 5.47 s (1H, CH), 7.05–7.95 m (16H, $3C_6H_4 + C_5H_4N$). Found, %: C 75.28; H 4.85; N 6.24. $C_{29}H_{22}N_2O_4$. Calculated , %: C 75.31; H 4.79; N 6.06.

3-Benzoyl-4-hydroxy-4,5-dihydropyrazole-4-carboxylic acid N-(6-methyl-2-pyridyl)amide (III). To a solution of 2.82 g (0.01 mol) of compound **Ie** in 20 ml of anhydrous toluene was added a solution of 0.17 g (0.04 mol) of diazomethane in 6 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the residue was recrystallized from ethanol. Yield 0.68 g (21%), mp 237–239°C. IR spectrum, ν, cm^{-1}: 3449 (OH), 3337 br (2NH), 1685 br (NC=O, C=O), 1605, 1690 (C=C, C=N) ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 2.41 s (3H, CH_3), 4.58 s (2H, CH_2), 6.98 s (1H, OH), 7.54–8.50 m (8H, C_6H_5 + C_5H_3N), 9.37 s (1H, NHC=O), 13.43 s (1H, NH). Found, %: C 63.00; H 5.46; N 17.10. $C_{17}H_{16}N_4O_3$. Calculated , %: C 62.95; H 5.15; N 17.27.

4-(2,4-Dimethyl-phenyl)-2-methoxy-4-oxobut-2-enoic acid *N*-(6-methyl-2-pyridyl)amide (IVa). To a solution of 3.10 g (0.01 mol) of amide **Ii** in 20 ml of anhydrous benzene was added a solution of 0.17 g (0.04 mol) of diazomethane in 6 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the residue was recrystallized from ethanol. Yield 1.98 g (61%), mp 142–144°C. IR spectrum cm^{-1}: 3400 br (NH), 1740 (NC=O), 1642, 1605 (C=O, C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 2.30 s (6H, $2CH_3$), 2.40 s (3H, CH_3), 3.75 (3H, CH_3O), 5.98 s (1H, CH), 7.15–7.65 m (6H, C_6H_3 + C_5H_3N), 11.80 br.s (1H, NH). UV spectrum, λ_{maqC}, nm (log ε): 235 (3.95), 366 (4.30). Found, %: C 70.20; H 6.15; N 8.81. $C_{19}H_{20}N_2O_3$. Calculated , %: C 70.35; H 6.22; N 8.64.

4-Aryl-2-methoxy-4-oxobut-2-enoic acid *N*-(5-bromo-2-pyridyl)amides IVb–IVd. To a dispersion of 0.01 mol of amide **Ij–Il** in 50 ml of anhydrous benzene was added a solution of 0.26 g (0.06 mol) of diazomethane in 9 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the dry residue was dissolved in 10 ml of toluene and subjected to chromatography on a column of internal diameter 2 cm packed with Silicagel LS 5/40, eluent 40% solution of benzene in petroleum ether. The fraction collected had R_f 0.90 (**IVb**), 0.53 (**IVc**), 077 (**IVd**), the solvent was evaporated, the residue was recrystallized from toluene.

2-Methoxy-4-oxo-4-phenylbut-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVb). Yield 0.76 g (21%), mp 176–178°C. IR spectrum, ν, cm^{-1}: 3214 br (NH), 1770 (NC=O), 1640, 1610 (C=O, C=C, C=N). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 4.03 s (3H, CH_3O), 7.64 s (1H, CH), 7.20–7.71 m (8H, C_6H_5 + C_5H_3BrN), 11.78 br.s (1H, NH). UV spectrum, λ_{max}, nm (log ε): 211 (4.36), 253 (4.12). Found, %: C 53.04; H 3.47; Br 21.95;

N 7.58. $C_{16}H_{13}BrN_2O_3$. Calculated , %: C 53.31; H 3.63; Br 22.12; N 7.76.

2-Methoxy-4-(4-methoxyphenyl)-4-oxobut-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVc). Yield 0.70 g (18%), mp 134–136°C. IR spectrum, ν, cm^{-1}: 3380 br (NH), 1695 (NC=O), 1675 (C=O), 1615, 1605 (C=C, C=N). UV spectrum, λ_{max}, nm (log ε): 221 (4.54), 283 (4.50), 328 (4.36). Found, %: C 52.02; H 4.00; Br 20.60; N 6.95. $C_{17}H_{15}BrN_2O_4$. Calculated , %: C 52.19; H 3.87; Br 20.42; N 7.16.

2-Methoxy-4-oxo-4-(4-chlorophenyl)but-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVd). Yield 0.51 g (13%), mp 92–94°C. IR spectrum, ν, cm^{-1}: 3374 br (NH), 1730 (NC=O), 1660, 1615 (C=O, C=C, C=N). Found, %: C 48.51; H 2.90; Hlg 28.25; N 6.89. $C_{16}H_{12}ClBrN_2O_3$. Calculated , %: C 48.57; H 3.06; Hlg 28.02; N 7.08.

4-(4-Bromophenyl)-2-methoxy-4-oxobut-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVe). To a dispersion of 4.27 g (0.01 mol) of amide **Im** in 40 ml of anhydrous toluene was added a solution of 0.26 g (0.06 mol) of diazomethane in 9 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the residue was recrystallized from a mixture hexane–benzene, 1:1. Yield 0.97 g (22%), mp 77–79°C. IR spectrum, ν, cm^{-1}: 3380 br (NH), 1730 (NC=O), 1655, 1610 (C=O, C=C, C=N). UV spectrum, λ_{max}, nm (log ε): 255 (4.42). Mass spectrum, *m/z* (I_{rel}, %): 442/440 (17.0) $[M]^+$, 269/267 (39.1), 259/257 (60.5), 241/239 (9.8), 201/199 (60.3), 185/183 (100), 175/173 (15.0), 157/155 (49.2). Found, %: C 43.50; H 2.59; Br 36.50; N 6.22. $C_{16}H_{12}Br_2N_2O_3$. Calculated , %: C 43.66; H 2.75; Br 36.31; N 6.37. *M* 440.09.

4-Aryl-4-oxo-2-ethoxybut-2-enoic acid *N*-(5-bromo-2-pyridyl)amides IVf and IVg. To a dispersion of 0.01 mol of compound **Ij** or **Ik** in 60 ml of anhydrous benzene was added a solution of 0.34 g (0.06 mol) of diazoethane in 11 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the residue was recrystallized.

4-Oxo-4-phenyl-2-ethoxybut-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVf). Yield 1.66 g (46%), mp 172–174°C (MeCN). IR spectrum, ν, cm^{-1}: 3326 (NH), 1697 (NC=O), 1675 (C=O), 1615, 1605 (C=C, C=N). ^1H NMR spectrum ($CDCl_3$), δ, ppm: 1.47 t (3H, CH_3, *J* 7.4 Hz), 4.27 q (2H, CH_2 *J* 7.4 Hz), 6.81 s (1H, CH), 7.21–7.85 m (8H, $C_6H_5 + C_5H_3BrN$), 9.53 s (1H, NH). UV spectrum, λ_{max}, nm (lgε): 229 (4.34), 302 (4.10). Found, %: C 54.27; H 3.85; Br 21.49; N 7.30. $C_{17}H_{15}BrN_2O_3$. Calculated , %: C 54.42; H 4.03; Br 21.30; N 7.47.

4-Oxo-(4-methoxyphenyl)-2-ethoxybut-2-enoic acid *N*-(5-bromo-2-pyridyl)amide (IVg). Yield 0.44 g (11%), mp 126–128°C (C_2H_5OH). IR spectrum, ν, cm^{-1}: 3380 br (NH), 1686 (NC=O), 1665 (C=O), 1620, 1605 (C=C, C=N). ^1H NMR spectrum (DMSO-d_6), δ, ppm: 1.27 t (3H, CH_3, *J* 7.4 Hz), 3.82 q (2H, CH_2, *J* 7.4 Hz), 3.91 s (3H, CH_3O), 6.46 s (1H, CH), 7.20–7.89 m (7H, $C_6H_4 + C_5H_3BrN$), 9.58 s (1H, NH). UV spectrum, λ_{max}, nm (log ε): 249 (4.22), 289 (4.03). Found, %: C 53.17; H 4.07; Br 19.91; N 7.02. $C_{18}H_{17}BrN_2O_4$. Calculated , %: C 53.35; H 4.23; Br 19.72; N 6.91.

3-Aroyl-5-methylpyrazole-4-carboxylic acid *N*-(6-methyl-2-pyridyl)amides Va and Vb. To a solution of 0.01 mol of compound **Ie** or **Ig** in 20 ml of anhydrous toluene was added a solution of 0.23 g (0.04 mol) of diazoethane in 7.5 ml of ether at 0–5°C, and the reaction mixture was maintained for 48 h at 25°C, then it was evaporated, the residue was recrystallized from toluene.

3-Benzoyl-5-methylpyrazole-4-carboxylic acid *N*-(6-methyl-2-pyridyl)amide (Va). Yield 0.74 g (23%), mp 230–232°C. IR spectrum, ν, cm^{-1}: 3565 (NH_{Ht}), 3175 (NH), 1675 br (NC=O, C=O), 1605, 1595 (C=C, C=N). ^1H NMR spectrum (DMSO-d_6), δ, ppm: 2.34 s (3H, CH_3), 2.51 s (3H, CH_3), 7.18–7.95 m (8H, $C_6H_5 + C_5H_3N$), 11.31 s (1H, NHCO), 13.72 br.s (1H, NH). UV spectrum, λ_{max}, nm (log ε): 248 (4.52). Mass spectrum, *m/z* (I_{rel}, %): 320 (13.0) $[M]^+$, 215 (31.0), 213 (70.4), 108 (85.2), 105 (58.5), 77 (100). Found, %: C 67.51; H 4.88; N 17.60. $C_{18}H_{16}N_4O_2$. Calculated , %: C 67.49; H 5.03; N 17.49. *M* 320.35.

5-Methyl-3-(4-ethoxybenzoyl)pyrazole-4-carboxylic acid *N*-(6-methyl-2-pyridyl)amide (Vb). Yield 0.69 g (19%), mp 181–183°C. IR spectrum, ν, cm^{-1}: 3534 (NH_{Ht}), 3179 (NH), 1678 br (NC=O, C=O), 1610, 1600 (C=C, C=N). UV spectrum, λ_{max}, nm (log ε): 291 (4.37). Found, %: C 66.11; H 5.45; N 15.50. $C_{20}H_{20}N_4O_3$. Calculated , %: C 65.92; H 5.53; N 15.38.

REFERENCES

1. Gavrilova, N.E., Zalesov, V.V., and Kashin, D.N., *Khim. Geterotsikl. Soedin.,* 2002, p. 853.
2. Kataev, S.S., Gavrilova, N.E., and Zalesov, V.V., *Khim. Geterotsikl. Soedin.,* 2003, p. 1506.
3. Aliev, Z.G., Atovmyan, L.O., Kataev, S.S., and Zalesov, V.V., *Khim. Geterotsikl. Soedin*., 2007, p. 464.
4. Zalesov, V.V. and Kataev, S.S., RF Patent 213772, 1998; *RF Byull. Izobr.*, 1999, no. 26.
5. Maslivets, A.N., Tarasova, O.P., and Andreichikov, Yu.S., *Zh. Org. Khim*., 1992, no. 28, p. 1287.