Chemistry of Heterocyclic Compounds, Vol. 41, No. 9, 2005

INVESTIGATIONS ON 2,3'-BIQUINOLINE. 17*. REGIOSELECTIVITY OF THE HALOGENATION OF 2,3'-BIQUINOLINE DERIVATIVES

N. V. Demidova[1], N. Ts. Karaivanov[1], V. I. Goncharov[2], and A. V. Aksenov[1]

A method has been developed for the synthesis of bromo and chloro derivatives of 2,3'-biquinoline and 2,3'-biquinolones based on the bromination and chlorination in various media. It was found that the bromination of 2,3'-biquinoline in strongly acidic medium occurred on the 2-quinoline fragment and in weak acid on the 3-quinoline and that it takes place via a stage of formation of a dihydro derivative. 1'-Alkyl-1',4'-dihydro-2,3'-biquinolin-4'-ones and 1'-alkyl-1',2'-dihydro-2,3'-biquinolin-2'-ones are halogenated at position 6'.

Keywords: 1'-alkyl-1',2'-dihydro-2,3'-biquinolin-2'-ones, 1'-alkyl-1',4'-dihydro-2,3'-biquinolin-4'-ones, 2,3'-biquinoline, bromination, chlorination, electrophilic substitution

It is known that the halogenation of quinoline in strongly acidic medium occurs at position 5 and 8 forming a 1:1 ratio of isomers. It is thought that such an orientation is a consequence of the deactivation of the pyridine ring due to protonation [2, 3].

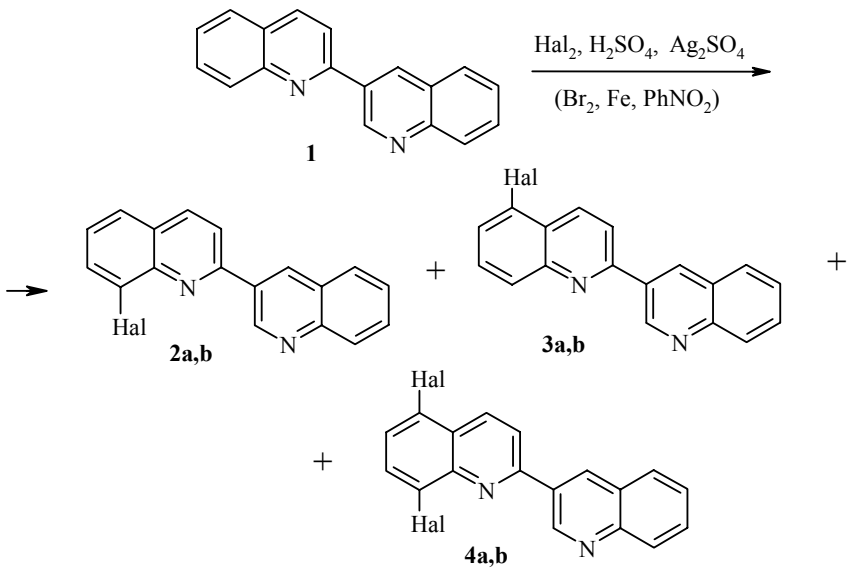
In the case of less strong acid the quinoline is initially substituted at position 3 and then at position 6 and 8 and this arises from its initial conversion to the quinolinium cation which reacts with a nucleophile at position 2 to form a 1,2-dihydroquinoline. Subsequent addition of the electrophile occurs at position 3 etc [2, 3].

2,3'-Biquinoline was of interest as a model compound for the investigation of electrophilic substitution in quinolines because, as a result of its asymmetry, a monoprotonation principally at one of the nitrogen atoms might be expected. In this case the reaction of a first kind would occur on a nonprotonated quinoline fragment and permit an evaluation of the regioselectivity of the electrophilic substitution in the quinoline free base and in the second kind on the other ring.

We have previously shown [4] that the 2,3'-biquinoline **1** is nitrated by potassium nitrate in sulphuric acid on the 2-quinoline fragment and this agrees with a direction of monoprotonation of 2,3'-biquinoline at the nitrogen atom in position 1'. With the above in mind the halogenation of 2,3'-biquinoline in the presence of acid would be expected to occur in the 2-quinoline fragment at positions 5 and 8. In fact, treatment of compound **1** with bromine or chlorine in sulphuric acid in the presence of Ag_2SO_4 gives a mixture of the 8-halo-2,3'-biquinoline **2**, the 5-halo-2,3'-biquinoline **3**, and the 5,8-dihalo-2,3'-biquinoline **4** in the ratio 2:1:4 (from ^{1}H NMR spectroscopic data).

* For Communication 16 see [1].

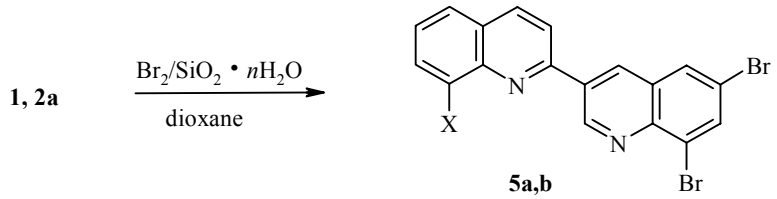
[1] Stavropol State University, Stavropol 355009, Russia; e-mail: k-biochem-org@stavsu.ru. [2] Stavropol State Medical Academy, Stavropol 355017, Russia; e-mail: sgma@statel.stavropol.ru. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1372-1377, September, 2005. Original article submitted May 21, 2004.



2-4 a Hal = Br, **b** Hal = Cl

Bromination of compound **1** using bromine in nitrobenzene gives 8-bromo-2,3'-biquinoline **2** and traces of 5-bromo-2,3'-biquinoline **3**.

The bromination of compound **1** did not occur in faintly acidic medium (dioxane dibromide, Br_2 in acetic acid). Unexpectedly, we have found that bromination of 2,3'-biquinoline can readily occur using dioxane dibromide in dioxane on Silochrom* to give the 6',8'-dibromo derivative in 71-76% yield.



5 a X = H, **b** X = Br

The bromination does not happen in the absence of Silochrom. It is likely that the reaction involves the formation of dihydro derivatives of 2,3'-biquinoline. A similar conclusion can be reached from the fact that the regioselectivity of the reaction is similar to the halogenation of the dihydro derivatives [6].

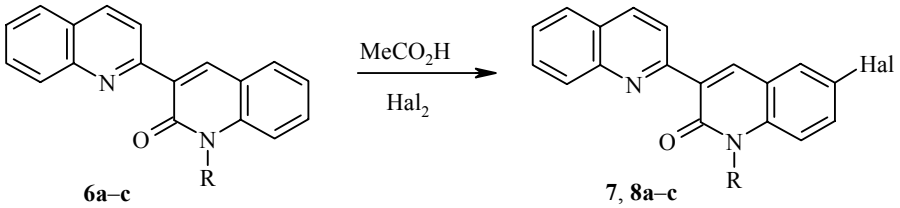
A study of the chlorination of 2,3'-biquinoline in alcohol or glacial acetic acid has shown that the process occurs much less selectively. According to ^{1}H NMR data it leads to products of complete chlorination of the 3-quinoline fragment, the structure of which has not been established.

In a study of the halogenation of the dihydro derivatives of 2,3'-biquinoline it was found that they readily undergo oxidation [6].

The closest in structure to the dihydroquinolines and stable to oxidation are the 1'-alkyl-1',4'-dihydro-2,3'-biquinolin-4'-ones **9** and 1'-alkyl-1',2'-dihydro-2,3'-biquinolin-2'-ones **6**.

We have found that the halogenation of compounds **6** by chlorine or bromine in acetic acid gives the 6'-chloro and 6'-bromo derivatives **7** and **8**.

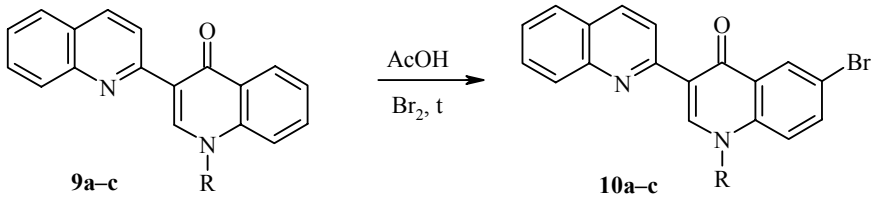
* For a preliminary report see [5].



6a–c **7**, **8a–c**

6-8 **a** R = Me; **b** R = Et; **c** R = Bu; **7** Hal = Br; **8** Hal = Cl

The halogenation of the biquinolones **9** occurs somewhat differently. Refluxing them with excess bromine in the presence of sodium acetate in glacial acetic acid gives the 6'-bromo derivative **10** but bromine water in the presence of sodium acetate in dichloroethane yields a complex mixture of polybromination products.



9a–c **10a–c**

9, **10** **a** R = Me, **b** R = Et, **c** R = Bu

EXPERIMENTAL

^{1}H NMR spectra were recorded on a Bruker WP-200 instrument (200 MHz) with TMS as internal standard. IR spectra were obtained on a Hitachi 215 instrument. Mass spectra were recorded on a Varian CH 7 instrument. Monitoring of the course of the reaction and the purity of the compounds prepared was carried out on Silufol UV-254 plates with the solvent system ethyl acetate–hexane (1:1). Column chromatography was performed on L 40/100 silica gel. Flash chromatography was carried out using the method in [7] (column: d = 60 mm, l = 50 mm) with benzene as the low polarity and ethyl acetate as the polar solvent.

Bromination of 2,3'-Biquinoline. A. A mixture of 2,3'-biquinoline (5 mmol) and Ag_2SO_4 (0.8 g, 2.5 mmol) in conc. H_2SO_4 (5 ml) was stirred for 5 h at about 20°C. The reaction mixture was poured into water (50 ml) with ice and ammonia solution (25%) was added to give a weakly basic reaction mixture. The precipitate was filtered off. The dried mixture was separated by flash chromatography (benzene and ethyl acetate). The first fraction was 5,8-dibromo-2,3'-biquinoline and the second 8-bromo-2,3'-biquinoline.*

B. A mixture of 2,3'-biquinoline (1.2 mmol) and reducing iron powder (2.4 mmol) in nitrobenzene (10 ml) was heated to 125-130°C and bromine (0.15 ml) was added with stirring at this temperature. The mixture was stirred for 30 min, a further amount of iron (2.4 mmol) and bromine (0.15 ml) were added, and the product was held for 2 h. The hot reaction mixture was then filtered to remove iron. Conc. HCl (10 ml) and water (15 ml) were added to the filtrate and stirring continued for 0.5 h. The precipitated product was filtered and washed with benzene (3 × 10 ml). The precipitate was transferred to a beaker, benzene (ethyl acetate) (20 ml), water (20 ml), and 25% ammonia solution (15 ml) were added, and the product was stirred with heating

* 5,8-Dibromo-2,3'-biquinoline can be separated by fractional crystallization from a mixture of ethyl acetate and methanol.

to 70-75°C. The benzene layer was separated and the aqueous layer was extracted with benzene (2 × 15 ml). The benzene extracts were combined, washed with water (15 ml), and evaporated to give gray-white crystals of 5,8-dibromo-2,3'-biquinoline. 8-bromo-2,3'-biquinoline could be separated from the filtrate.

5-Bromo-2,3'-biquinoline (3a). A. Yield 0.18 g (11%). B. Yield 0.036 g (9%). Light-beige crystals with mp 214-216°C (alcohol–ethyl acetate). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 7.66 (1H, dd, $J_{6'7'}$ = 7.21, $J_{5'6'}$ = 8.02, H-6'); 7.79 (1H, dd, J_{67} = 7.72, J_{78} = 8.32, H-7); 7.81 (1H, dd, $J_{6'7'}$ = 7.21, $J_{7'8'}$ = 8.40, H-7'); 7.87 (1H, d, J_{67} = 7.72, H-6); 8.05 (1H, d, $J_{5'6'}$ = 8.02, H-5'); 8.11 (1H, d, $J_{7'8'}$ = 8.40, H-8'); 8.19 (1H, d, J_{78} = 8.32, H-8); 8.24 (1H, d, J_{34} = 8.81, H-3); 8.84 (1H, d, J_{34} = 8.81, H-4); 9.03 (1H, d, $J_{2'4'}$ = 2.20, H-4'); 9.87 (1H, d, $J_{2'4'}$ = 2.20, H-2'). Found, %: C 64.62; H 3.25; N 8.31. $C_{18}H_{11}BrN_2$. Calculated, %: C 64.50; H 3.31; N 8.36.

8-Bromo-2,3'-biquinoline (2a). A. Yield 0.4 g (24%). B. Yield 0.11 g (27%). White crystals with mp 149-151°C (alcohol). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 7.47 (1H, t, *J* = 7.70, H-6); 7.66 (1H, dd, $J_{6'7'}$ = 7.21, $J_{5'6'}$ = 8.02, H-6'); 7.81 (1H, dd, $J_{6'7'}$ = 7.21, $J_{7'8'}$ = 8.40, H-7'); 7.95 (1H, dd, J_{67} = 7.70, J_{57} = 1.10, H-7); 8.05 (1H, d, $J_{5'6'}$ = 8.02, H-5'); 8.11 (1H, d, $J_{7'8'}$ = 8.40, H-8'); 8.12 (1H, dd, J_{56} = 7.70, J_{57} = 1.10, H-5); 8.24 (1H, d, J_{34} = 8.80, H-3); 8.43 (1H, d, J_{34} = 8.80, H-4); 9.03 (1H, d, $J_{2'4'}$ = 2.20, H-4'); 9.87 (1H, d, $J_{2'4'}$ = 2.20, H-2'). Mass spectrum (70 eV), *m/z* (I_{rel}, %): 335 $[M]^+$ (100), 255 $[M^+–Br]$ (34). Found, %: C 64.68; H 3.23; N 8.32. $C_{18}H_{11}BrN_2$. Calculated, %: C 64.50; H 3.31; N 8.36.

5,8-Dibromo-2,3'-biquinoline (4a). A. Yield 0.97 g (47%). B. Yield 0.19 g (38%). Grayish crystals with mp 222-224°C (alcohol). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 7.72 (1H, ddd, $J_{6'5'}$ = 7.02, $J_{6'7'}$ = 6.71, $J_{6'8'}$ = 1.22, H-6'); 7.87 (1H, ddd, $J_{6'7'}$ = 6.71, $J_{7'8'}$ = 7.02, $J_{5'7'}$ = 1.22, H-7'); 7.91 (1H, d, J_{67} = 8.24, H-7); 8.13 (1H, dd, $J_{7'8'}$ = 7.02, $J_{6'8'}$ = 1.22, H-8'); 8.15 (1H, d, J_{67} = 8.24, H-6); 8.18 (1H, dd, $J_{5'6'}$ = 7.02, $J_{5'7'}$ = 1.22, H-5'); 8.61 (1H, d, J_{34} = 8.85, H-4); 8.71 (1H, d, J_{34} = 8.85, H-3); 9.27 (1H, d, $J_{2'4'}$ = 2.14, H-4'); 9.93 (1H, d, $J_{2'4'}$ = 2.14, H-2'). Found, %: C 52.37; H 2.37; N 6.61. $C_{18}H_{10}Br_2N_2$. Calculated, %: C 52.21; H 2.43; N 6.76.

Chlorination of 2,3'-Biquinoline in Sulfuric Acid in the Presence of Silver Sulphate (General Method). A current of dry chlorine was passed through a mixture of 2,3'-biquinoline (1.28 g, 5 mmol) and Ag_2SO_4 (0.8 g, 2.5 mmol) in conc. H_2SO_4 (5 ml) for 1.5 h with stirring. The reaction mixture was poured into water (50 ml) with ice and 25% ammonia was added to give a weakly basic reaction. The precipitate was filtered off and recrystallized from ethyl acetate with petroleum ether.

5-Chloro-2,3'-biquinoline (3b). Yield 0.17 g (12%). Light-beige crystals with mp 203-204°C (alcohol–ethyl acetate). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 7.65 (1H, dd, $J_{6'7'}$ = 7.21, $J_{5'6'}$ = 8.02, H-6'); 7.80 (1H, dd, J_{67} = 7.72, J_{78} = 8.32, H-7); 7.83 (1H, dd, $J_{6'7'}$ = 7.21, $J_{7'8'}$ = 8.40, H-7'); 7.87 (1H, d, J_{67} = 7.72, H-6); 8.07 (1H, d, $J_{5'6'}$ = 8.02, H-5'); 8.11 (1H, d, $J_{7'8'}$ = 8.40, H-8'); 8.17 (1H, d, J_{78} = 8.32, H-8); 8.23 (1H, d, J_{34} = 8.81, H-3); 8.82 (1H, d, J_{34} = 8.81, H-4); 9.01 (1H, d, $J_{2'4'}$ = 2.20, H-4'); 9.87 (1H, d, $J_{2'4'}$ = 2.20, H-2'). Found, %: C 74.19; H 3.89; N 9.74. $C_{18}H_{11}ClN_2$. Calculated, %: C 74.36; H 3.81; N 9.64.

8-Chloro-2,3'-biquinoline (2b). Yield 0.39 g (27%). White crystals with mp 131-132°C (alcohol). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 7.45 (1H, t, *J* = 7.70, H-6); 7.64 (1H, dd, $J_{6'7'}$ = 7.21, $J_{5'6'}$ = 8.02, H-6'); 7.83 (1H, dd, $J_{6'7'}$ = 7.21, $J_{7'8'}$ = 8.40, H-7'); 7.92 (1H, dd, J_{67} = 7.70, J_{57} = 1.10, H-7); 8.05 (1H, d, $J_{5'6'}$ = 8.02, H-5'); 8.11 (1H, d, $J_{7'8'}$ = 8.40, H-8'); 8.12 (1H, dd, J_{56} = 7.70, J_{57} = 1.10, H-5); 8.25 (1H, d, J_{34} = 8.80, H-3); 8.43 (1H, d, J_{34} = 8.80, H-4); 9.03 (1H, d, $J_{2'4'}$ = 2.20, H-4'); 9.90 (1H, d, $J_{2'4'}$ = 2.20, H-2'). Found, %: C 74.21; H 3.87; N 9.73. $C_{18}H_{11}ClN_2$. Calculated, %: C 74.36; H 3.81; N 9.64.

5,8-Dichloro-2,3'-biquinoline (3b). Yield 0.7 g (43%). White crystals with mp 205-209°C (alcohol). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 7.69 (1H, d, J_{67} = 7.93, H-7); 7.74 (1H, ddd, $J_{5'6'}$ = 8.85, $J_{6'7'}$ = 7.02, $J_{6'8'}$ = 1.83, H-6'); 7.86 (1H, ddd, $J_{6'7'}$ = 7.02, $J_{7'8'}$ = 7.63, $J_{5'7'}$ = 1.52, H-7'); 7.91 (1H, d, J_{67} = 7.93, H-6); 8.13 (1H, dd, $J_{7'8'}$ = 7.63, $J_{6'8'}$ = 1.83, H-8'); 8.16 (1H, dd, $J_{5'6'}$ = 8.85, $J_{5'7'}$ = 1.52, H-5'); 8.43 (1H, d, J_{34} = 8.85, H-4); 8.81 (1H, d, J_{34} = 8.85, H-3); 9.12 (1H, d, $J_{2'4'}$ = 2.45, H-4'); 9.90 (1H, d, $J_{2'4'}$ = 2.45, H-2'). Found, %: C 66.30; H 3.05; N 8.72. $C_{18}H_{10}Cl_2N_2$. Calculated, %: C 66.48; H 3.10; N 8.61.

Bromination of 1',2'-Dihydro-2,3'-biquinolin-2-ones and 1',4'-Dihydro-2,3'-biquinolin-4'-ones (General Method). A. A mixture of the corresponding biquinolone (1 mmol) and bromine (0.4 g, 2.5 mmol) in acetic acid (15 ml) was refluxed for 5 h in the presence of anhydrous sodium acetate (2.5 mmol). The reaction mixture was poured into water (50 ml) and 25% ammonia solution was added to give a weakly basic reaction. The product was then extracted with benzene (3 × 30 ml). The organic layer was separated, dried over Na_2SO_4, and evaporated.

B. Bromine (0.4 g, 2.5 mmol) and a five-fold excess of sodium acetate were added with vigorous stirring to a mixture of the corresponding biquinolone (1 mmol), dichloroethane (5 ml), and water (2.5 ml). After stirring for 30 min at about 20°C the product was poured into water (50 ml) and 25% ammonia solution was added to give a weakly basic reaction. It was then extracted with benzene (3 × 30 ml) and the organic layer was separated, dried over Na_2SO_4, and evaporated.

6'-Bromo-1'-methyl-1',2'-dihydro-2,3'-biquinolin-2'-one (7a) (from 1'-methyl-1',2'-dihydro-2,3'-biquinolin-2'-one). A. Yield 0.31 g (86%). B. Yield 0.32 g (88%). Light-yellow crystals with mp 177-178°C (alcohol). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 3.82 (3H, s, CH_3); 7.30 (1H, d, $J_{7'8'}$ = 8.85, H-8'); 7.56 (1H, dd, J_{56} = 7.94, J_{67} = 7.71, H-6); 7.70 (1H, dd, $J_{7'8'}$ = 8.85, $J_{5'7'}$ = 2.44, H-7'); 7.74 (1H, dd, J_{67} = 7.71, J_{78} = 8.31, H-7); 7.86 (1H, d, J_{56} = 7.94, H-5); 7.90 (1H, d, $J_{5'7'}$ = 2.44, H-5'); 8.16 (1H, d, J_{78} = 8.31, H-8); 8.23 (1H, d, J_{34} = 8.55, H-4); 8.43 (1H, d, J_{34} = 8.55, H-3); 8.60 (1H, s, H-4'). Found, %: C 62.55; H 3.49; N 7.72. $C_{19}H_{13}BrN_2O$. Calculated, %: C 62.48; H 3.59; N 7.67.

6'-Bromo-1'-ethyl-1',2'-dihydro-2,3'-biquinolin-2'-one (7b) (from 1'-ethyl-1',2'-dihydro-2,3'-biquinolin-2'-one). A. Yield 0.31 g (82%). B. Yield 0.31 g (83%). Yellow crystals with mp 169-170°C (alcohol). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 1.32 (3H, t, *J* = 7.05, 1'-$CH_2C\underline{H}_3$); 4.45 (2H, q, *J* = 7.05, 1'-$C\underline{H}_2CH_3$); 7.30 (1H, d, $J_{7'8'}$ = 8.85, H-8'); 7.56 (1H, dd, J_{56} = 7.94, J_{67} = 7.71, H-6); 7.70 (1H, dd, $J_{7'8}$ = 8.85, $J_{5'7'}$ = 2.44, H-7'); 7.74 (1H, dd, J_{67} = 7.71, J_{78} = 8.31, H-7); 7.86 (1H, d, J_{56} = 7.94, H-5); 7.90 (1H, d, $J_{5'7'}$ = 2.44, H-5'); 8.16 (1H, d, J_{78} = 8.31, H-8); 8.23 (1H, d, J_{34} = 8.55, H-4); 8.43 (1H, d, J_{34} = 8.55, H-3); 8.60 (1H, s, H-4'). Found, %: C 63.42; H 3.87; N 7.44. $C_{20}H_{15}BrN_2O$. Calculated, %: C 63.34; H 3.99; N 7.39.

6'-Bromo-1'-methyl-1',4'-dihydro-2,3'-biquinolin-4'-one (10a) (from 1'-methyl-1',4'-dihydro-2,3'-biquinolin-4'-one). A. Yield 0.28 g (78%). B. Yield 0.31 g (85%). Beige crystals with mp 230-231°C (alcohol). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 4.00 (3H, s, CH_3); 7.57 (1H, dd, J_{56} = 8.24, J_{67} = 7.15, J_{68} = 1.10, H-6); 7.63 (1H, d, $J_{7'8'}$ = 8.80, H-8'); 7.76 (1H, dd, J_{67} = 7.15, J_{78} = 8.24, J_{57} = 1.10, H-7); 7.90 (1H, dd, $J_{7'8'}$ = 8.80, $J_{5'7'}$ = 2.20, H-7'); 7.93 (1H, d, J_{56} = 8.24, J_{57} = 1.10, H-5); 8.07 (1H, d, J_{78} = 8.24, J_{68} = 1.10, H-8); 8.30 (1H, d, J_{34} = 8.80, H-4); 8.62 (1H, d, $J_{5'7'}$ = 2.20, H-5'); 8.79 (1H, d, J_{34} = 8.80, H-3); 9.04 (1H, s, H-2'). Found, %: C 62.52; H 3.51; N 7.70. $C_{19}H_{13}BrN_2O$. Calculated, %: C 62.48; H 3.59; N 7.67.

6'-Bromo-1'-ethyl-1',4'-dihydro-2,3'-biquinolin-4'-one (10b) (from 1'-ethyl-1',4'-dihydro-2,3'-biquinolin-4'-one). A. Yield 0.3 g (80%). B. Yield 0.32 g (84%). Beige crystals with mp 206-207°C (alcohol). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 1.44 (3H, t, *J* = 7.12, 1'-$CH_2C\underline{H}_3$); 4.53 (2H, q, *J* = 7.12, 1'-$C\underline{H}_2CH_3$); 7.56 (1H, dd, J_{56} = 8.24, J_{67} = 7.02, J_{68} = 1.22, H-6); 7.75 (1H, dd, J_{67} = 7.02, J_{78} = 8.24, J_{57} = 1.22, H-7); 7.87 (1H, d, $J_{7'8'}$ = 8.85, H-8'); 7.95 (1H, dd, $J_{7'8'}$ = 8.85, $J_{5'7'}$ = 2.30, H-7'); 7.95 (1H, d, J_{56} = 8.24, J_{57} = 1.22, H-5); 8.05 (1H, d, J_{78} = 8.24, J_{68} = 1.22, H-8); 8.35 (1H, d, J_{34} = 8.55, H-4); 8.47 (1H, d, $J_{5'7'}$ = 2.30, H-5'); 8.70 (1H, d, J_{34} = 8.55, H-3); 9.09 (1H, s, H-2'). Found, %: C 63.46; H 3.95; N 7.30. $C_{20}H_{15}BrN_2O$. Calculated, %: C 63.34; H 3.99; N 7.39.

6'-Bromo-1'-butyl-1',4'-dihydro-2,3'-biquinolin-4'-one (10c) (from 1'-butyl-1',4'-dihydro-2,3'-biquinolin-4'-one). A. Yield 0.35 g (85%). B. Yield 0.35 g (87%). Beige crystals with mp 186-187°C (alcohol). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 0.95 (3H, t, *J* = 7.32, 1'-$CH_2CH_2CH_2C\underline{H}_3$); 1.42 (2H, m, 1'-$CH_2CH_2C\underline{H}_2CH_3$); 1.84 (2H, m, 1'-$CH_2C\underline{H}_2CH_2CH_3$); 4.46 (2H, t, *J* = 7.32, 1'-$C\underline{H}_2CH_2CH_2CH_3$); 7.55 (1H, dd, J_{56} = 8.24, J_{67} = 7.02, J_{68} = 1.22, H-6); 7.74 (1H, dd, J_{67} = 7.02, J_{78} = 8.24, J_{57} = 1.52, H-7); 7.84 (1H, d, $J_{7'8'}$ = 8.85, H-8'); 7.92 (1H, dd, $J_{7'8'}$ = 8.85, $J_{5'7'}$ = 2.45, H-7'); 7.95 (1H, d, J_{56} = 8.24, J_{57} = 1.52, H-5); 8.04 (1H, d, J_{78} = 8.24, J_{68} = 1.22, H-8); 8.34 (1H, d, J_{34} = 8.80, H-4); 8.49 (1H, d, $J_{5'7'}$ = 2.45, H-5'), 8.69 (1H, d,

J_{34} = 8.80, H-3); 9.05 (1H, s, H-2'). Found, %: C 65.00; H 4.65; N 6.82. $C_{22}H_{19}BrN_2O$. Calculated, %: C 64.88; H 4.70; N 6.88.

Chlorination of 1',2'-Dihydro-2,3'-biquinolin-2'-ones and 1',4'-dihydro-2,3'-biquinolin-4'-ones (General Method). A small stream of chlorine was passed through a stirred solution of the corresponding biquinolone (1 mmol) in acetic acid or methanol (15 ml) at 50°C and the reaction was followed by TLC (about 20 min). The product was poured into water (50 ml) and 25% ammonia solution was added to a weakly basic reaction. It was then extracted with benzene (3 × 30 ml). The organic layer was separated, dried over Na_2SO_4, evaporated, and the product was recrystallized from a mixture of ethyl acetate and petroleum ether (1:1).

6'-Chloro-1'-methyl-1',2'-dihydro-2,3'-biquinolin-2'-one (8a) (from 1'-methyl-1',2'-dihydro-2,3'-biquinolin-2'-one). Yield 0.28 g (86%). Beige crystals with mp 208-210°C (alcohol). ^{1}H NMR spectrum (CD_3CN), δ, ppm (*J*, Hz): 3.75 (3H, s, CH_3); 7.50 (1H, d, $J_{7'8'}$ = 9.39, H-8'); 7.61 (1H, dd, J_{56} = 7.68, J_{67} = 7.71, H-6); 7.63 (1H, dd, $J_{7'8'}$ = 9.39, $J_{5'7'}$ = 2.56, H-7'); 7.77 (1H, dd, J_{67} = 7.71, J_{78} = 8.96, H-7); 7.85 (1H, d, $J_{5'7'}$ = 2.56, H-5'); 7.94 (1H, d, J_{56} = 7.68, H-5); 8.09 (1H, d, J_{78} = 8.96, H-8); 8.31 (1H, d, J_{34} = 8.54, H-4); 8.37 (1H, d, J_{34} = 8.54, H-3); 8.60 (1H, s, H-4'). Found, %: C 71.25; H 4.02; N 8.65. $C_{19}H_{13}ClN_2O$. Calculated, %: C 71.14; H 4.08; N 8.73.

6'-Chloro-1'-ethyl-1',2'-dihydro-2,3'-biquinolin-2'-one (8b) (from 1'-ethyl-1',2'-dihydro-2,3'-biquinolin-2'-one). Yield 0.3 g (89%). Light-yellow crystals with mp 167-169°C (alcohol). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 1.29 (3H, t, *J* = 7.02, 1'-$CH_2C\underline{H}_3$); 4.40 (2H, q, *J* = 7.02, 1'-$C\underline{H}_2CH_3$); 7.63 (1H, dd, J_{56} = 8.24, J_{67} = 7.02, J_{68} = 1.22, H-6); 7.70 (1H, dd, $J_{7'8'}$ = 8.24, $J_{5'7'}$ = 1.93, H-7'); 7.70 (1H, d, $J_{7'8'}$ = 8.24, H-8'); 7.80 (1H, dd, J_{67} = 7.02, J_{78} = 8.24, J_{57} = 1.22, H-7); 8.02 (1H, d, J_{56} = 8.24, J_{68} = 1.22, H-5); 8.10 (1H, d, J_{78} = 8.24, J_{68} = 1.22, H-8); 8.12 (1H, d, $J_{5'7'}$ = 1.93, H-5'); 8.33 (1H, d, J_{34} = 8.55, H-3); 8.42 (1H, d, J_{34} = 8.55, H-4); 8.68 (1H, s, H-4'). Found, %: C 71.87; H 4.47; N 8.29. $C_{20}H_{15}ClN_2O$. Calculated, %: C 71.75; H 4.52; N 8.37.

1'-Butyl-6'-chloro-1',2'-dihydro-2,3'-biquinolin-2'-one (8c) (from 1'-butyl-1',2',-dihydro-2,3'-biquinolin-2'-one). Yield 0.31 g (85%). Light-yellow crystals with mp 208-210°C (alcohol). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 0.97 (3H, t, *J* = 7.33, 1'-$CH_2CH_2CH_2C\underline{H}_3$); 1.45 (2H, m, 1'-$CH_2CH_2C\underline{H}_2CH_3$); 1.70 (2H, m, 1'-$CH_2C\underline{H}_2CH_2CH_3$); 4.37 (2H, t, *J* = 7.33, 1'-$C\underline{H}_2CH_2CH_2CH_3$); 7.62 (1H, dd, J_{56} = 8.24, J_{67} = 7.02, J_{68} = 1.53, H-6); 7.65 (1H, d, $J_{7'8'}$ = 9.16, H-8'); 7.70 (1H, dd, $J_{7'8'}$ = 9.16, $J_{5'7'}$ = 2.44, H-7'); 7.79 (1H, dd, J_{67} = 7.02, J_{78} = 8.24, J_{57} = 1.22, H-7); 8.00 (1H, d, J_{56} = 8.24, J_{57} = 1.22, H-5); 8.08 (1H, d, $J_{5'7'}$ = 2.44, H-5'); 8.10 (1H, d, J_{78} = 8.24, J_{68} = 1.53, H-8); 8.32 (1H, d, J_{34} = 8.85, H-4); 8.39 (1H, d, J_{34} = 8.85, H-3); 8.67 (1H, s, H-4'). Found, %: C 72.91; H 5.21; N 7.23. $C_{22}H_{19}ClN_2O$. Calculated, %: C 72.82; H 5.28; N 7.72.

REFERENCES

1. A. V. Aksenov, A. V. Sarapii, O. A. Antonova, I. V. Borovlev, and V. I. Goncharov, *Khim. Geterotsikl. Soedin.*, 1208 (2005).
2. D. H. R. Barton and W. D. Ollis, *Comprehensive Organic Chemistry* [Russian translation], Vol. 8, Khimiya, Moscow (1985), p. 216.
3. A. R. Katritzky (editor), *Physical Methods in the Chemistry of Heterocyclic Compounds* [Russian translation], Khimiya, Moscow (1966), p. 140.
4. N. V. Demidova and A. V. Aksenov, *Khim. Geterotsikl. Soedin.*, 1047 (2002).
5. N. V. Demidova, O. P. Demidov, and A. V. Aksenov, *Khim. Geterotsikl. Soedin.*, 557 (2001).
6. A. V. Aksenov and N. V. Demidova, *Khim. Geterotsikl. Soedin.*, 1051 (2002).
7. J. T. Sharp, J. Gosney, and A. G. Rowley, *Practical Organic Chemistry* [Russian translation], Mir, Moscow (1993), p. 193.