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INVESTIGATIONS ON 2,3'-BIQUINOLYLS. 12*. ALKYLATION AND ARYLATION OF 2,3'-BIQUINOLYL DIANION WITH ORGANOMETALLIC COMPOUNDS. NEW TYPE OF REACTION FOR DIANIONS OF AROMATIC COMPOUNDS

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2,3'-Biquinolyl dianion reacts with organolithium and organomagnesium compounds with the formation, after treatment of the reaction mixture with water, of 2'-alkyl(aryl)-1',2'-dihydro-2,3'-biquinolyls, and, after treatment of the reaction mixture with alkyl halides, of 1'-alkyl-2'-alkyl(aryl)-1',2'-dihydro-2,3'-biquinolyls. The reaction includes attack of the nucleophilic reagent with an electron transfer to a molecule of solvent.

Keywords: 2,3'-biquinolyl, dianion, 1',2'-dihydro-2,3'-biquinolyls, organolithium compounds, alkylation, arylation, nucleophilic substitution, one-electron transfer.

Reactions with electrophilic reagents are typical for dianions of aromatic compounds [2-5]. Reactions with nucleophilic reagents have not been reported.

The reaction of the dianion of 2,3'-biquinolyl (**3**) with organomagnesium and organolithium compounds has been studied in the present work. We assumed that owing to the high possibility for delocalization of the negative charge and to conformational rotation about the $C_{(2)}$–$C_{(3')}$ bond, the dianion **3** is capable of reacting not only with electrophiles but also with nucleophilic reagents. As reaction with electrophilic reagents occurs at the 3'-quinolyl fragment with the formation of addition products at position 4 (**4**) [2-4] then reaction with nucleophilic reagents might be expected to form products of addition to the 2-quinolyl fragment **5** (Scheme 1).

Unexpectedly dianion **3**, obtained by us by reacting 2,3'-biquinolyl with metallic potassium (at a molar ratio of 1:2.5) in THF [2], reacts with organolithium compounds forming 2'-R-1',2'-dihydro-2,3'-biquinolyls **7a-d** in 79-84% yield after treatment of the reaction mixture with water. After treatment of the reaction mixture with MeI 2'-R-1'-methyl-1',2'-dihydro-2,3'-biquinolyls **8a-c** were formed (Scheme 2).

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* For Part 11 see [1].

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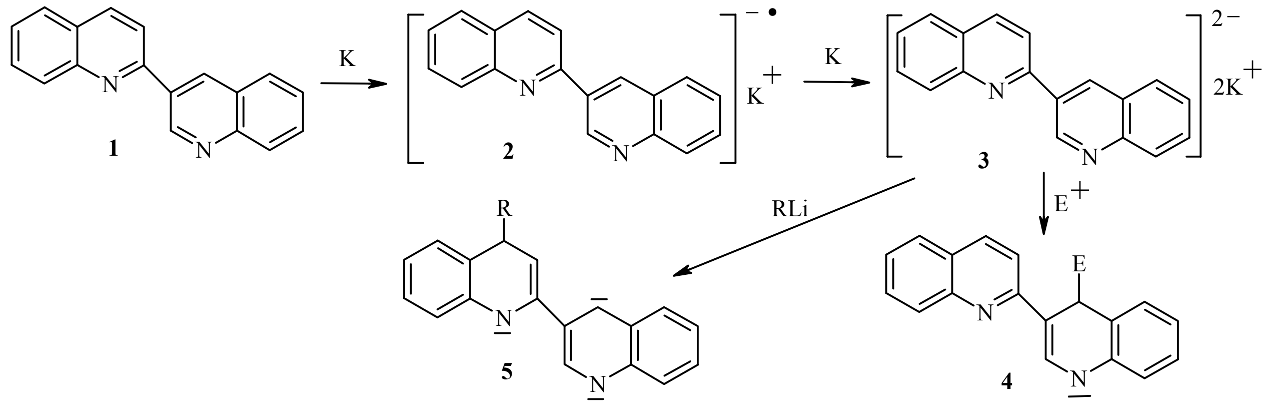
Scheme 1



Scheme 2

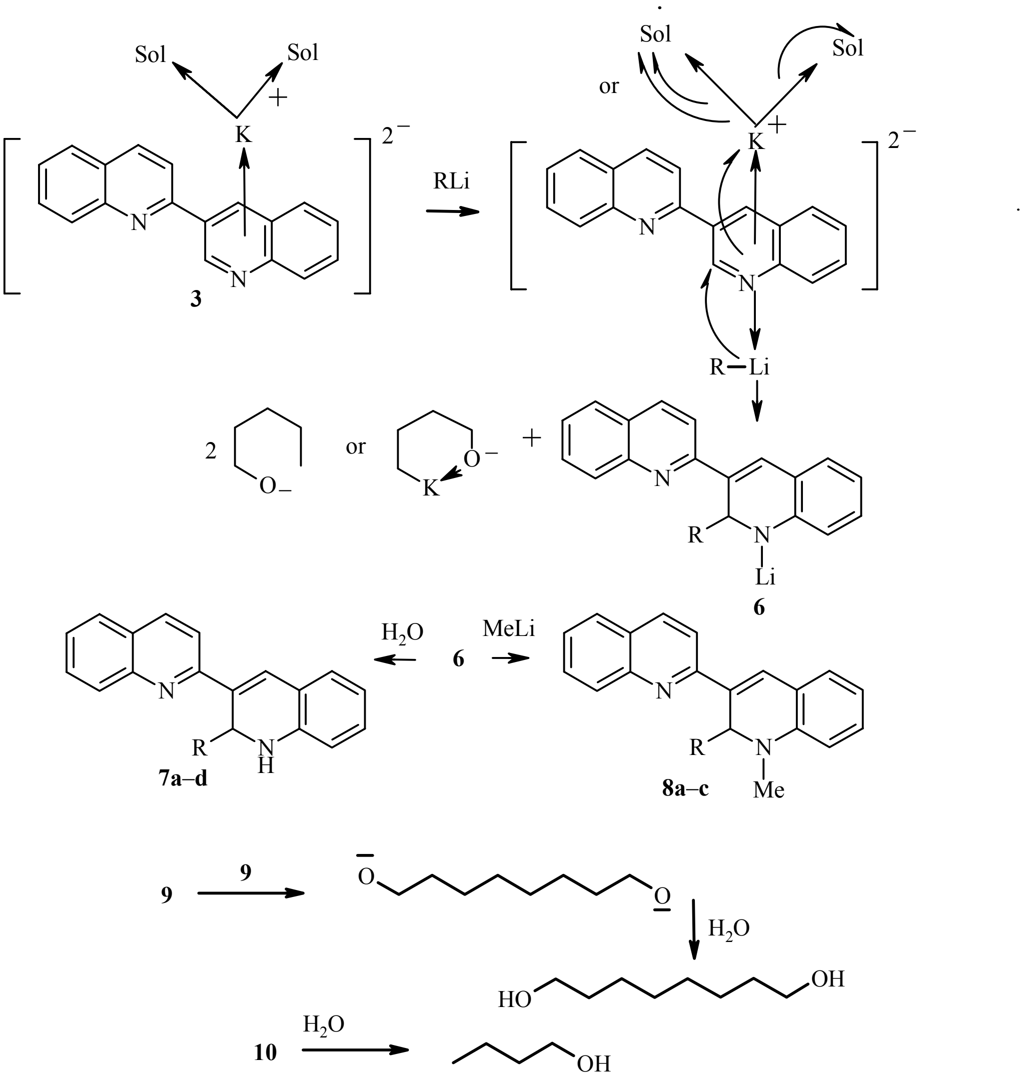


TABLE 1. Reaction of Dianion **3** with RLi and RMgX

Reagent	Reaction product	R	Yield, %
MeLi	**7a**	Me	81
MeMgCl	**7a**	Me	68
BuLi	**7b**	Bu	84
BuMgI	**7b**	Bu	62
PhLi	**7c**	Ph	82
1-$C_{10}H_7Li$	**7d**	1-Naphthyl	81
MeLi	**8a**	Me	81
PhLi	**8b**	Ph	76
1-$C_{10}H_7Li$	**8c**	1-Naphthyl	72

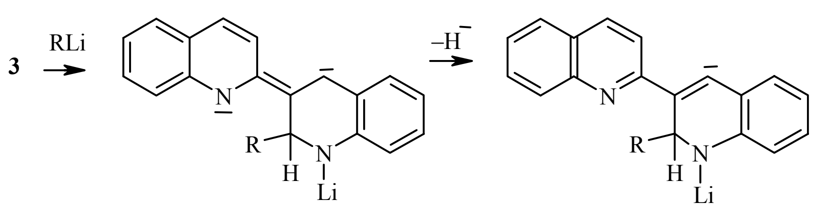
The use of a Grignard reagent in place of the organolithium compound leads to the same products but in lower yields (Table 1).

Allowing for the structures of similar dianions [5] we suggest a mechanism for the reaction which includes complex formation of the organometallic compound with dianion **3** and subsequent attack of the nucleophile at position 2' with synchronous electron transfer through the metal cation to a solvent molecules of the solvation sheath (Scheme 2). This mechanism, previously unreported in the literature, we call a nucleophilic substitution with synchronous one-electron transfer (S_nET).

The following experimental data may be put forward in favor of this mechanism.

1. 2,3'-Biquinolyl **1** reacts with organolithium and organomagnesium compounds with the formation of 4'-R-1',4'-dihydro-2,3'-biquinolyls [6,7]. Consequently compounds **7a-d** are not formed directly from 2,3'-biquinolyl.
2. If a sample taken from the reaction mixture obtained by reacting 2,3'-biquinolyl with potassium (molar ratio 1:2.5) is treated with D_2O and the remaining portion is reacted with butyllithium, then the main products of these two reactions are 4'-D-1',4'-dihydro-2,3'-biquinolyl (92% yield, 95% deuterium exchange) and 2'-butyl-1',2'-dihydro-2,3'-biquinolyl respectively. It follows that the formation of compounds **7a-d** occurs through the stage of forming dianion **3** [2].
3. If 18-crown-6-ether (5 mmol) is added to the reaction mixture obtained from 2,3'-biquinolyl (1.25 mmol) and metallic potassium (2.7 mmol) no subsequent reaction with butyllithium occurs. The action of the crown ether may be taken off by adding KI (1.5 mmol). Consequently complex formation of the organolithium compound with the dianion plays a decisive role in the reaction process.
4. An alternative mechanism shown in Scheme 3 was rejected on the basis of the following experiments.

Scheme 3



11 **12**

a) Treatment of the reaction mixture at the final stage (after adding butyllithium) with D_2O leads to the formation of 2'-butyl-1',2'-dihydro-2,3'-biquinolyl **7b** containing no carbon-deuterium bonds. Consequently the addition of butyllithium to dianion **3** is not accompanied by the formation of C-anions.

b) Treatment of the reaction mixture at the final stage (after adding butyllithium) with MeI does not lead to a C-methylation products.

c) The use of 4'-D-2,3'-biquinolyl as starting material leads to the formation of compound **7b** with the same amount of deuterium as in the initial biquinolyl.

5. If lithium is used in place of potassium to generate dianion **3** then the subsequent interaction with butyllithium proceeds significantly more slowly. Consequently the nature of the ion pair (solvate-divided in the case of lithium, tight ionic in the case of potassium [5]) plays a significant role in the reaction found.

6. According to the data of chromato-mass spectrometry the reaction mixture contains butanol {94.3% calculated on the initial 2,3'-biquinolyl, *m/z* 74 (7%) [M^+], 73 (19) [M-H], 56 (100) [M-H_2O]} and 1,8-octanediol {8.2%, *m/z* 115 (3) [M-CH_2OH], 114 (17), 101 (45), 85 (100), 71 (57), 59 (68), 57 (69)}. Consequently electrons are transferred to solvent molecules.

EXPERIMENTAL

The NMR spectra were recorded on Bruker AM 300 (300 MHz) and Bruker WP 200 (200 MHz) spectrometers using TMS as internal standard. The IR spectra were obtained on a Hitachi 215 instrument and mass spectra on a Varian CH-7 instrument at 70 eV. The chromato-mass spectrometric investigations were carried out on a Hewlett Packard 5890 chromatograph with a mass-selective detector and HP-5 capillary column. A check of the reaction course and the homogeneity of the compounds synthesized was effected on Silufol UV-254 plates, solvent system was ethyl acetate–hexane, 1:1. Column chromatography was carried out on silica gel L 40/100. Absolute solvents were obtained by redistillation over benzophenoneketyl.

2'-R-1',2'-Dihydro-2,3'-biquinolyls (7a-d). General Procedure. A mixture of 2,3'-biquinolyl (0.64 g, 2.5 mmol) and metallic potassium (0.25 g, 6.4 mmol) in absolute THF (12 ml) was stirred at room temperature for 1 h, and then on refluxing in an argon atmosphere for 4 h. Then a solution of the organometallic compound (7 mmol) in ether or hexane was then added carefully. The reaction mixture was stirred for 15 min in an atmosphere of argon, then treated with water (30 ml), extracted with benzene (3 × 30 ml), and the extract dried over Na_2SO_4. The benzene was evaporated in vacuum, and the residue purified by column chromatography and recrystallization.

2'-Methyl-1',2'-dihydro-2,3'-biquinolyl (7a). Yield 0.55 g (81%); mp 138-139°C (alcohol). Lit. [6] mp 138-139°C. IR spectrum (thin film), ν, cm^{-1}: 3480 (N-H). ^1H NMR spectrum (300 MHz; DMSO-d_6), δ, ppm, *J* (Hz): 1.22 (3H, d, $J_{Me\text{-}2'}$ = 6.20, Me); 5.23 (1H, dq, $J_{2'\text{-}Me}$ = 6.20, $J_{2'\text{-}NH}$ = 2.23, 2'-H); 6.24 (1H, br. d, $J_{NH\text{-}2'}$ = 2.23, NH); 6.54 (1H, dd, $J_{6'\text{-}5'}$ = 7.41, $J_{6'\text{-}7'}$ = 7.38, 6'-H); 6.60 (1H, d, $J_{8'\text{-}7'}$ = 7.96, 8'-H); 7.00 (1H, dd, $J_{7'\text{-}6'}$ = 7.38, $J_{7'\text{-}8'}$ = 7.96, 7'-H); 7.10 (1H, d, $J_{5'\text{-}6'}$ = 7.41, 5'-H); 7.49 (1H, s, 4'-H); 7.55 (1H, dd, $J_{6\text{-}5}$ = 8.23, $J_{6\text{-}7}$ = 7.08, 6-H); 7.74 (1H, dd, $J_{7\text{-}6}$ = 7.08, $J_{7\text{-}8}$ = 8.47, 7-H); 7.92 (1H, d, $J_{5\text{-}6}$ = 8.23, 5-H); 7.97 (1H, d, $J_{8\text{-}7}$ = 8.47, 8-H); 8.04 (1H, d, $J_{3\text{-}4}$ = 8.77, 3-H); 8.31 (1H, d, $J_{4\text{-}3}$ = 8.77, 4-H). ^{13}C NMR spectrum (50.3 MHz; $CDCl_3$), δ, ppm: 22.44 (q), 47.60 (d), 113.57 (d), 117.66 (d), 117.72 (d), 120.76 (s), 125,62 (d), 126.01 (d), 127.02 (s), 127.37 (d), 128.21 (d), 129.37 (d), 129.58 (d), 129.83 (d), 135.68 (d), 136.34 (s), 143.83 (s), 148.01 (s), 155.20 (s). Mass spectrum: 272 [M^+] (26%), 271 (26), 270 (43), 269 (100), 268 (44), 257 (88), 128 (26). Found, %: C 84.04; H 5.81; N 10.15. $C_{19}H_{16}N_2$. Calculated, %: C 83.82; H 5.88; N 10.29.

2'-Butyl-1',2'-dihydro-2,3'-biquinolyl (7b). Yield 0.66 g (84%); mp 108-109°C (alcohol). Lit. [6] mp 108-109°C. IR spectrum (thin film), ν, cm^{-1}: 3470 (N-H). ^1H NMR spectrum (300 MHz; DMSO-d_6), δ, ppm, *J* (Hz): 0.82 (3H, t, *J* = 7.02, Me); 1.28 (2H, m, $CH_2CH_2\underline{CH_2}CH_3$); 1.39 (2H, m, $CH_2\underline{CH_2}CH_2CH_3$); 1.61 (2H, m, $\underline{CH_2}CH_2CH_2CH_3$); 5.14 (1H, m, 2'-H); 6.36 (1H, br. d, $J_{NH\text{-}2H}$ = 2.71, NH); 6.51 (1H, dd, $J_{6'\text{-}5'}$ = 7.37, $J_{6'\text{-}7'}$ = 7.31, 6-H); 6.65 (1H, d, $J_{8'\text{-}7'}$ = 7.96, 8-H); 6.99 (1H, dd, $J_{7'\text{-}6'}$ = 7.31, $J_{7'\text{-}8'}$ = 7.96, 7-H); 7.08 (1H, d, $J_{5'\text{-}6'}$ = 7.37, 5-H); 7.48 (1H, s, 4'-H); 7.54 (1H, dd, $J_{6\text{-}5}$ = 8.09, $J_{6\text{-}7}$ = 7.34, 6-H); 7.74 (1H, dd, $J_{7\text{-}6}$ = 7.34, $J_{7\text{-}8}$ = 8.39, 7-H); 7.92 (1H, d, $J_{5\text{-}6}$ = 8.09, 5-H); 7.93 (1H, d, $J_{8\text{-}7}$ = 8.39, 8-H); 8.03 (1H, d, $J_{3\text{-}4}$ = 8.76, 3-H); 8.29 (1H, d, $J_{4\text{-}3}$ = 8.76, 4-H). ^{13}C NMR spectrum (50.3 MHz; $CDCl_3$), δ, ppm: 13.91 (q), 22.44 (t), 27.74 (t), 31.14 (t), 52.00 (d), 117.65

(d), 123.85 (s), 124.99 (d), 126.20 (d), 126.40 (d), 126.79 (d), 127.30 (s), 127.82 (d), 128.07 (d), 129.54 (d), 129.79 (d), 130.05 (d), 136.13 (d), 137.96 (s), 142.37 (s), 148.14 (s), 154.31 (s). Mass spectrum: 314 [M$^+$] (8%), 283 (42), 281 (14), 272 (22), 271 (35), 270 (74), 269 (94), 268 (72), 258 (47), 257 (100), 256 (13), 128 (30). Found, %: C 84.40; H 6.91; N 8.69. $C_{22}H_{22}N_2$. Calculated, %: C 84.07; H 7.01; N 8.92.

2'-Phenyl-1',2'-dihydro-2,3'-biquinolyl (7c). Yield 0.69 g (82%); mp 207-209°C (alcohol). Lit. [6] mp 207-209°C. IR spectrum (thin film), ν, cm^{-1}: 3480 (N-H). ^{1}H NMR spectrum (200 MHz; acetone-d$_6$), δ, ppm, *J* (Hz): 6.15 (1H, br s, $J_{NH-2'}$ = 2.13, NH); 6.51 (1H, d, $J_{2'-NH}$ = 2.13, 2'-H); 6.60 (1H, dd, $J_{6'-5'}$ = 7.41, $J_{6'-7'}$ = 7.38, 6'-H); 6.62 (1H, d, $J_{8'-7'}$ = 7.96, 8'-H); 7.01 (1H, dd, $J_{7'-6'}$ = 7.38, $J_{7'-8'}$ = 7.96, 7'-H); 7.15 (3H, m, 3"-H, 4"-H, 5"-H); 7.18 (1H, d, $J_{5'-6'}$ = 7.41, 5'-H); 7.50 (1H, dd, J_{6-5} = 8.23, J_{6-7} = 7.08, 6-H); 7.52 (2H, d, *J* = 8.23, 2"-H, 6"-H); 7.69 (1H, dd, J_{7-6} = 7.08, J_{7-8} = 8.47, 7-H); 7.74 (1H, s, 4'-H); 7.86 (1H, d, J_{5-6} = 8.23, 5-H); 7.97 (1H, d, J_{8-7} = 8.47, 8-H); 8.04 (1H, d, J_{3-4} = 8.96, 3-H); 8.22 (1H, d, J_{4-3} = 8.96, 4-H). ^{13}C NMR spectrum (50.3 MHz; CDCl$_3$), δ, ppm: 58.97 (d), 113.21 (d), 117.27 (d), 122.20 (s), 123.72 (d), 126.07 (d), 126.34 (s), 126.78 (d), 127.21 (2d), 127.27 (d), 127.35 (d), 128.41 (2d), 128.93 (d), 129.28 (d), 129.60 (d), 130.74 (d), 132.49 (s), 134.02 (d), 138.08 (s), 143.39 (s), 145.04 (s), 158.28 (s). Mass spectrum: 334 [M$^+$] (15%), 333 (100), 331 (41), 271 (21), 204 (25). Found, %: C 86.32; H 5.31; N 8.37. $C_{24}H_{18}N_2$. Calculated, %: C 86.23; H 5.39; N 8.38.

2'-(1-Naphthyl)-1',2'-dihydro-2,3'-biquinolyl (7d). Yield 0.70 g (81%); mp 166-167°C (alcohol). Lit. [6] mp 166-167°C. IR spectrum (thin film), ν, cm^{-1}: 3460 (N-H). ^{1}H NMR spectrum (300 MHz; DMSO-d$_6$), δ, ppm, *J* (Hz): 6.48 (1H, d, $J_{8'-7'}$ = 8.05, 8'-H); 6.55 (1H, dd, $J_{6'-5'}$ = 7.73, $J_{6'-7'}$ = 7.32, 6'-H); 6.69 (1H, br. d, $J_{NH-2'}$ = 2.63, NH); 6.95 (1H, dd, $J_{7'-6'}$ = 7.32, $J_{7'-8'}$ = 8.05, 7'-H); 7.24 (1H, d, $J_{5'-6'}$ = 7.73, 5'-H); 7.26 (1H, d, $J_{2'-NH}$ = 2.63, 2'-H); 7.30 (1H, d, *J* = 7.78, 4"-H); 7.43 (2H, m, 6"-H, 7"-H); 7.57 (1H, dd, J_{6-5} = 8.27, J_{6-7} = 7.58, 6-H); 7.59 (2H, d, *J* = 6.67, 5"-H, 8"-H); 7.74 (2H, m, 7-H, 3"-H); 7.81 (1H, d, $J_{2''-3''}$ = 8.07, 2"-H); 7.89 (1H, d, J_{5-6} = 8.27, 5-H); 7.94 (1H, s, 4'-H); 8.03 (1H, d, J_{3-4} = 8.83, 3-H); 8.21 (1H, d, J_{4-3} = 8.83, 4-H); 8.84 (1H, J_{8-7} = 8.84, 8-H). ^{13}C NMR spectrum (50.3 MHz; CDCl$_3$), δ, ppm: 50.84 (d), 113.45 (d), 117.57 (d), 117,81 (d), 120.18 (s), 123.11 (d), 125.21 (d), 125.45 (d), 125.94 (2d), 126.46 (d), 126.97 (s), 127.14 (d), 127.62 (d), 127.84 (d), 128.32 (d), 129.03 (d), 129.20 (d), 129.59 (d), 130.10 (d), 133.34 (s), 134.33 (s), 135.67 (d), 135.71 (s), 139.09 (s), 143.32 (s), 147.73 (s), 154.83 (s). Mass spectrum: 384 [M$^+$] (52%), 383 (65), 382 (88), 381 (100), 380 (20), 379 (43), 269 (15), 257 (45), 256 (47), 128 (22). Found, %: C 87.58; H 5.14; N 7.28. $C_{28}H_{20}N_2$. Calculated, %: C 87.50; H 5.21; N 7.29.

1'-Methyl-2'-R-1',2'-dihydro-2,3'-biquinolyl (8a-c). General Procedure. A mixture of 2,3'-biquinolyl (0.64 g, 2.5 mmol) and metallic potassium (0.25 g, 6.4 mmol) in absolute THF (12 ml) was stirred at room temperature for 1 h and then refluxing in an atmosphere of argon for 4 h. A solution of the organometallic compound (7 mmol) in ether or hexane was then added carefully. The reaction mixture was stirred for 15 min in an atmosphere of argon, MeI (0.1 g, 7 mmol) in THF (10 ml) was added, and the mixture stirred for 30 min. Water (30 ml) was then added, the mixture extracted with benzene (3 x 30 ml), and the extract was dried over Na_2SO_4. The benzene was evaporated in vacuum, and the residue was purified by column chromatography and recrystallization.

1',2'-Dimethyl-1',2'-dihydro-2,3'-biquinolyl (8a). Yield 0.58 g (81%); mp 168-169°C (benzene–hexane). Lit. [8] mp 168-169°C. ^{1}H NMR spectrum (200 MHz; CDCl$_3$), δ, ppm, *J* (Hz): 1.22 (3H, d, *J* = 6.41, 2'-Me); 3.06 (3H, s, 1'-Me); 5.27 (1H, q, *J* = 6.41, 2'-H); 6.59 (1H, d, $J_{8'-7'}$ = 8.10, 8'-H); 6.70 (1H, dd, $J_{6'-5'}$ = 7.52, $J_{6'-7'}$ = 7.37, 6'-H); 7.13 (1H, d, $J_{5'-6'}$ = 7.61, 5'-H); 7.19 (1H, dd, $J_{7'-6'}$ = 7.37, $J_{7'-8'}$ = 8.16, 7'-H); 7.29 (1H, s, 4'-H); 7.48 (1H, dd, J_{6-5} = 8.09, J_{6-7} = 7.14, 6-H); 7.68 (1H, dd, J_{7-6} = 7.14, J_{7-8} = 8.41, 7-H), 7.77 (1H, d, J_{5-6} = 8.09, 5-H); 7.83 (1H, d, J_{3-4} = 9.04, 3-H); 8.05 (1H, d, J_{8-7} = 8.41, 8-H); 8.09 (1H, d, J_{4-3} = 9.04, 4-H). ^{13}C NMR spectrum (50.3 MHz; CDCl$_3$), δ, ppm: 22.44 (q), 36.31 (q), 49.24 (d), 113.64 (d), 117.76 (d), 117.78 (d), 120.74 (s), 125.59 (d), 126.11 (d), 127.09 (s), 127.42 (d), 128.22 (d), 129.37 (d), 129.54 (d), 129.78 (d), 135.66 (d), 136.43 (s), 143.85 (s), 148.08 (s), 154.89 (s). Mass spectrum: 286 [M$^+$] (43%), 272 (33), 271 (100), 269 (85), 257 (16), 128 (24). Found, %: C 83.98; H 6.17; N 9.85. $C_{20}H_{18}N_2$. Calculated, %: C 83.92; H 6.29; N 9.79.

1'-Methyl-2'-phenyl-1',2'-dihydro-2,3'-biquinolyl (8b). Yield 0.66 g (76%); mp 138-139°C (alcohol). Lit. [8] mp 138-139°C. ^{1}H NMR spectrum (200 MHz; $CDCl_3$), δ, ppm, J (Hz): 2.93 (3H, s, Me); 6.34 (1H, s, 2'-H); 6.50 (1H, d, $J_{8'-7'}$ = 8.13, 8'-H); 6.70 (1H, dd, $J_{6'-5'}$ = 7.53, $J_{6'-7'}$ = 7.33, 6'-H); 7.12 (1H, d, $J_{5'-6'}$ = 7.53, 5'-H); 7.15 (1H, dd, $J_{7'-6'}$ = 7.33, $J_{7'-8'}$ = 8.13, 7'-H); 7.17 (3H, m, 3"-H, 4"-H, 5"-H); 7.42 (1H, s, 4'-H); 7.44 (2H, d, J = 7.14, 2"-H, 6"-H); 7.45 (1H, dd, J_{6-5} = 8.22, J_{6-7} = 7.04, 6-H); 7.65 (1H, dd, J_{7-6} = 7.04, J_{7-8} = 8.51, 7-H); 7.71 (1H, d, J_{5-6} = 8.22, 5-H); 7.76 (1H, d, J_{3-4} = 8.85, 3-H); 8.00 (1H, d, J_{4-3} = 8.85, 4-H); 8.04 (1H, d, J_{8-7} = 8.51, 8-H). ^{13}C NMR spectrum (50.3 MHz; $CDCl_3$), δ, ppm: 36.41 (q), 63.76 (d), 110.50 (d), 116.64 (d), 117.95 (d), 121.84 (s), 126.09 (2d), 127.03 (s), 127.15 (2d), 127.36 (d), 127.48 (d), 128.19 (2d), 128.38 (d), 129.40 (d), 129.45 (d), 130.61 (d), 134.36 (s), 135.64 (d), 141.31 (s), 145.39 (s), 147.45 (s), 154.89 (s). Mass spectrum: 348 [M$^+$] (72%), 334 (77), 333 (100), 332 (21), 331 (39), 272 (43), 271 (84), 269 (15), 256 (19), 255 (33), 128 (48). Found, %: C 86.27; H 5.64; N 8.09. $C_{25}H_{20}N_2$. Calculated, %: C 86.21; H 5.75; N 8.04.

1'-Methyl-2'-(1-naphthyl)-1',2'-dihydro-2,3'-biquinolyl (8c). Yield 0.72 g (72%); mp 225-226°C (alcohol). Lit. [8] mp 225-226°C. ^{1}H NMR spectrum (200 MHz; $CDCl_3$), δ, ppm, J (Hz): 2.80 (3H, s, 1'-Me); 6.43 (1H, d, $J_{8'-7'}$ = 7.95, 8'-H); 6.72 (1H, dd, $J_{6'-5'}$ = 7.55, $J_{6'-7'}$ = 7.34, 6'-H), 7.16 (1H, dd, $J_{7'-6'}$ = 7.34, $J_{7'-8'}$ = 7.95, 7'-H); 7.22 (1H, d, $J_{5'-6'}$ = 7.55, 5'-H); 7.24 (1H, d, J_{5-6} = 7.71, 4"-H); 7.33 (1H, s, 2'-H); 7.36 (2H, m, 6"-H, 7"-H); 7.50 (2H, m, 6-H, 3"-H); 7.56 (1H, s, 4'-H); 7.61 (2H, d, J = 6.61, 5"-H, 8"-H); 7.74 (2H, m, 7-H, 2"-H); 7.79 (2H, d, J = 8.54, 3-H, 5-H); 7.94 (1H, d, J_{4-3} = 8.54, 4-H); 9.10 (1H, d, J_{8-7} = 8.54, 8-H). ^{13}C NMR spectrum (50.3 MHz; $CDCl_3$), δ, ppm: 36.12 (q), 57.78 (d), 110.58 (d), 116.60 (d), 117.54 (d), 121.69 (s), 124.65 (d), 125.19 (d), 125.31 (d), 125.78 (d), 125.85 (2d), 126.32 (d), 126.94 (s), 127.15 (d), 128.07 (d), 128.24 (d), 128.44 (d), 129.17 (d), 129.36 (d), 130.63 (d), 130.83 (s), 133.35 (s), 135.46 (d), 135.82 (s), 138.67 (s), 144.87 (s), 147.59 (s), 154.81 (s). Mass spectrum: 398 [M$^+$] (76%), 384 (65), 383 (100), 382 (37), 381 (53), 272 (31), 271 (91), 269 (15), 256 (13), 255 (37), 128 (30). Found, %: C 87.52; H 5.41; N 7.07. $C_{29}H_{22}N_2$. Calculated, %: C 87.44; H 5.53; N 7.03.

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