Chemistry of Heterocyclic Compounds, Vol. 44, No. 7, 2008

SYNTHESIS OF 1-(9-BUTYLCARBAZOL-3-YL)-5-OXOPYRROLIDINE-3-CARBOXYLIC ACID DERIVATIVES

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A series of condensation products of 1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide with 2-propanone, 2-butanone, 2,4-pentanedione, 2,5-hexanedione, ethyl 3-oxobutanoate, and aromatic aldehydes was obtained. Substituted oxadiazoles were synthesized from carbohydrazide or the corresponding hydrazone. Spectral properties of the synthesized compounds were examined.

Keywords: 1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide, 1,3,4-oxa-diazole, pyrazole, pyrrole, *Z*-, *E*-isomers.

In this paper we describe the synthesis of new substituted 9-butylcarbazole derivatives, which contain 5-oxopyrrolidine, 1,3,4-oxadiazole, pyrazole, or pyrrole ring systems, with the aim to obtain new compounds, which are expected to possess notable chemical and biological activities. Derivatives of 1,3,4-oxadiazole, 5-oxopyrrolidine, pyrazole, and pyrrole are well known to have a wide range of biological activities [1–11], and carbazole and 1,3,4-oxadiazole derivatives are the most widely employed electron-transporting and hole-blocking materials [12–16].

The starting product, 1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carboxylic acid **1,** was synthesized according to the known method by refluxing 3-amino-9-butylcarbazole with itaconic acid in toluene [17]. Later on 5-oxopyrrolidine **1** was esterified with methanol using sulfuric acid as a catalyst and the resulting ester **2** was refluxed with hydrazine hydrate in 2-propanol to give hydrazide **3**. Condensation of compound **3** with 2-propanone gave the corresponding N'-(propan-2-ylidene)-5-oxopyrrolidine-3-carbohydrazide **4**; with 2-butanone – N'-(butan-2-ylidene)-5-oxopyrrolidine-3-carbohydrazide **5**, and with aromatic aldehydes – 4-arylidene-hydrazinecarbonyl-1-(9-butylcarbazol-3-yl)-2-pyrrolidinones **6**–**9**.

Monosubstituted 1,3,4-oxadiazole derivative **10** was easily prepared from acid hydrazide **3** by reaction with an excess of triethyl orthoformate in refluxing mixture. The corresponding hydrazone **7** was oxidatively cyclized in the presence of oxidant $Pb(MeCOO)_4$ in dichloromethane at +2°C temperature to give 2,5-di-substituted 1,3,4-oxadiazole derivative **11** in good yield.

1-(9-Butylcarbazol-3-yl)-4-[(3,5-dimethyl-1H-pyrazol-1-yl)carbonyl]pyrro-lidin-2-one **12** was synthesized by condensation of hydrazide **3** with 2,4-pentanedione in ethanol in the presence of a catalytic amount of hydrochloric acid.

The reaction of hydrazide **3** with ethyl 3-oxobutanoate in refluxing ethanol in the presence of a catalytic amount of hydrochloric acid gave 3-substituted ethylbutanoate **13**, which was separated from the reaction mixture by column chromatography.

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Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 7, pp. 1009-1017, July, 2008. Original article submitted April 13, 2008.

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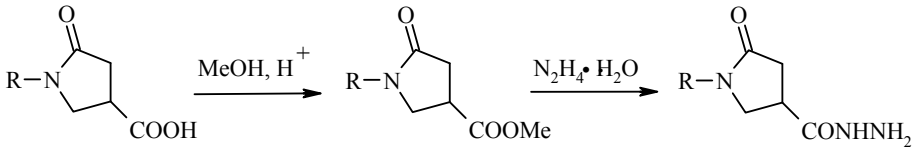
Pyrrole derivative **14** was prepared by condensation of hydrazide **3** with 2,5-hexanedione in the presence of glacial acetic acid as a catalyst in refluxing 2-propanol.

The structures of compounds **1-14** were elucidated on the basis of the elemental analysis data, and IR, mass, and ^{1}H, ^{13}C NMR spectra.



1 **2** **3**

1–3 R = 9-butylcarbazol-3-yl

Due to the influence of the substituent in position 4 of the pyrrolidinone ring geminal protons of methylene $COCH_2$ and NCH_2 groups are shielded unequally; therefore their signals in the ^{1}H NMR spectrum are observed as characteristic doublets and multiplets in the range of 2.90 and 4.07–4.25 ppm, respectively. The quintet of the CH group proton of pyrrolidinone ring is at 3.56 ppm. Protons of the carbazole moiety resonate in the range of 7.168.49 ppm, and the butyl group of heterocyclic moiety gives rise to two triplets at 0.95 and 4.43 ppm and two multiplets at 1.331.48 and 1.801.93 ppm. The IR spectrum of compound **1** showed the expected 2C=O and OH absorptions at 1692, 1731, and 3395 cm^{-1}, respectively. The ^{1}H NMR spectrum of ester **2** exhibits an extensive singlet with integration equivalent to 3 hydrogens at 3.70 ppm due to the methyl group. When compound **2** was converted to its hydrazide **3**, the signals belonging to the hydrazide group were observed at 9.40 and 4.42 ppm and in the IR spectrum not only absorption bands of C=O at 1653 and 1673 cm^{-1}, but also broad stretching vibration band in the range of 3307 cm^{-1} were present.

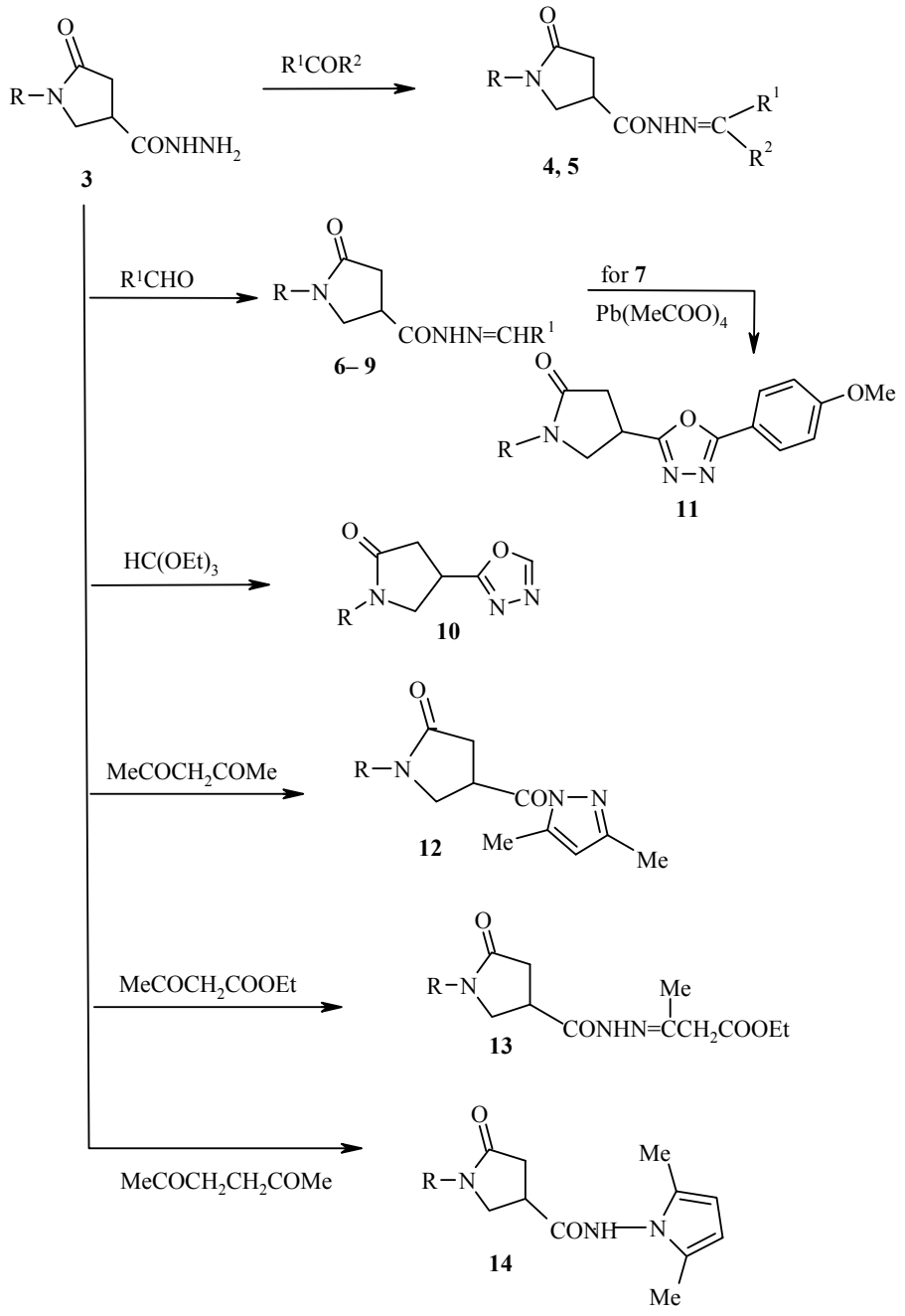
It is evident from the ^{1}H NMR spectra of compounds **6–9** that in DMSO-d_6 solution they exist as a mixture of *Z/E*-isomers, the proton signals of which have different intensities due to the possibility of different arrangements of the substituents with respect to the N=C bond. As a result of stronger shielding, the signals of the protons of the *Z*-isomers are observed at higher field [18]. On the basis of the intensities of the signals of the NH group proton it has been concluded that the *Z*-isomer always predominates in DMSO-d_6 solution. When a less polar solvent, $CDCl_3$, was used to record the ^{1}H NMR spectrum of compound **8,** the proton of NH group gave a single set of signals at 10.44 ppm.

In contrast to compounds **3**, no absorption band corresponding to the NH group was observed in the IR spectrum of 1,3,4-oxadiazoles **10**, **11.** Moreover, the signal belonging to carbonyl stretching was absent (CO), but a new peak at 1595 cm^{-1} due to the C=N frequency and peaks at 1233 and 1021 cm^{-1} due to the characteristic stretching vibrations of the =C–O–C= fragment of the oxadiazole ring were present. ^{1}H NMR spectra showed peaks due to aromatic protons and other substituents in the expected region (**11**), and the proton signal of the CH=N fragment in the oxadiazole moiety was observed downfield at 8.41 ppm (**10**).

The formation of the pyrazole ring in compound **12** has been proved by the characteristic signal of the proton in position 4 at 6.15 ppm and two singlets of protons of the CH_3 groups at 2.23 and 2.53 ppm in the ^{1}H NMR spectrum. Characteristic ^{13}C NMR resonances at 153, 145, and 112 ppm were assigned to the corresponding carbons of pyrazole ring.

The ^{1}H NMR spectrum of compound **13** in $(CD_3)_2CO$ besides the proton signal characteristic to the starting compound shows a triplet at 1.22 and a quadruplet at 4.15 ppm assigned to the ethyl group of the ester, and two singlets of the CH_3 and CH_2 group protons at 2.09 and 3.40 ppm, respectively. Moreover, broad singlets of different intensity assigned to the CONH group are observed at 9.63 and 9.78 ppm, which led to the conclusion that the compound existed as a mixture of *E*/*Z*-isomers in $(CD)_2CO$.

In the ^{1}H NMR spectrum of compound **14** not only the signal of the NH_2 protons at 4.42 ppm is absent, but also the signal of the CONH group proton is present, while this proton was resonating at lower field (10.97 ppm) in comparison to the spectrum of compound **3**. Apart from the signal of the protons of the carbazole and pyrrolidinone rings, an extensive singlet with integration equivalent to 2 hydrogens characteristic of the CH fragments of the pyrrole ring at 5.68 ppm and also signals of two methyl groups at 2.03 and 2.04 ppm are observed.



3–14 R = 9-butylcarbazol-3-yl; **4** $R^1 = R^2$ = Me; **5** R^1 = Me; R^2 = Et; **6** R^1 = 4-$Me_2NC_6H_4$; **7** R^1 = 4-$MeOC_6H_4$; **8** R^1 = Ph; **9** R^1 = 9-ethylcarbazol-3-yl

EXPERIMENTAL

The ^{1}H and ^{13}C NMR spectra were recorded on a Varian Unity Inova 300 spectro-meter (300 and 75 MHz respectively) in $(CD_3)_2CO$ (compounds **1**, **2**, **12**, **13**), DMSO-d_6 (compounds **3**–**7**, **9**, **11**, **14**), and $CDCl_3$ (compound **10**), operating in Fourier transform mode with TMS as an internal standard. Melting points were determined on an automatic melting point apparatus APA1 and are uncorrected. The IR spectra were determined in potassium bromide pellets on a Perkin–Elmer FT-IR system spectrum GX spectrometer. Mass spectral data were obtained by a Waters (Micromas) ZQ 2000 Spectrometer (APCI, 20 V). Silica gel plates (Silufol UV-254) were used for analytical purpose. Elemental analysis was carried out on the C,H,N Analyzer CE 440.

1-(9-Butylcarbazol-3-yl)-5-oxopyrrolidine-3-carboxylic acid (1) was prepared according to Ref. [17]. Yield 25.04 g (91%); mp 68–69.5°C (from toluene). IR spectrum, ν, cm^{-1}: 3395 (OH), 1731 (C=O), 1692 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.95 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.33–1.48 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.80-1.93 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.90 (2H, d, *J* = 8.4, $COCH_2$); 3.56 (1H, q, *J* =8.2, CH); 4.22-4.34 (2H, m, NCH_2); 4.43 (2H, t, *J* = 7.1, $NC\underline{H}_2CH_2CH_2CH_3$); 7.16–8.49 (7H, m, H_{Ar}). Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 351 $[M+H]^+$ (100). Found, %: C 72.74; H 6.51; N 8.04. $C_{21}H_{22}N_2O_3$. Calculated, %: C 71.98; H 6.33; N 7.99.

Methyl 1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carboxylate (2). A mixture of 5-oxopyrrolidine **1** (21 g, 60 mmol), methanol (100 ml), and a catalytic amount of conc. H_2SO_4 was refluxed for 5 h. Then the solvent was evaporated. The precipitated product was neutralized with 5% sodium bicarbonate solution, filtered off, and washed with 2-propanol. The crude product was recrystallized from 2-propanol. Yield 15.73 g (72%); mp 116.5-118°C. IR spectrum, ν, cm^{-1}: 1744 (C=O), 1688 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.84 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.17-1.33 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.64-1.78 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.70-2.91 (2H, m, $COCH_2$); 3.44-3.59 (1H, m, CH); 3.70 (3H, s, OCH_3); 4.09-4.22 (2H, m, NCH_2); 4.35 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 7.15-8.31 (7H, m, H_{Ar}). ^{13}C NMR spectrum, δ, ppm: 14.44, 20.51, 31.44, 35.89, 35.90, 42.78, 51.61, 52.89, 109.83, 110.12, 113.34, 119.36, 120.31, 121.15, 122.51, 122.67, 126.61, 131.74, 137.98, 141.21, 171.72, 173.99. Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 365 $[M+H]^+$ (100). Found, %: C 72.36; H 6.59; N 7.60. $C_{22}H_{24}N_2O_3$. Calculated, %: C 72.51; H 6.64; N 7.69.

1-(9-Butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (3). A mixture of ester **2** (5.1 g, 14 mmol), 2-propanol (20 ml), and 98% hydrazine hydrate (4 ml) was refluxed for 30 min. The reaction mixture was cooled and the precipitate was filtered off, washed with 2-propanol and ethyl ether, and purified by recrystallization from ethanol. Yield 3.98 g (78%); mp 181-183°C. IR spectrum, ν, cm^{-1}: 3307 (NH + NH_2), 1653 (C=O), 1673 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.84 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.16-1.34 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.65–1.80 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.73–2.85 (2H, m, $COCH_2$); 3.22-3.51 (1H, m, CH); 4.01-4.17 (2H, m, NCH_2); 4.34 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 4.42 (2H, s, NH_2); 7.16-8.36 (7H, m, H_{Ar}); 9.40 (1H, s, NH). Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 365 $[M+H]^+$ (100). Found, %: C 69.08; H 6.58; N 15.12. $C_{21}H_{24}N_4O_2$. Calculated, %: C 69.21; H 6.64; N 15.37.

N'-(Propan-2-ylidene)-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (4). To a mixture of compound **3** (2.0 g, 5.5 mmol) in dry 2-propanone (30 ml) a few drops of concentration hydrochloric acid were added. The mixture was refluxed for 5 h. The solvent was evaporated under reduced pressure, and the precipitated product was filtered off, washed with ethyl ether, and purified by recrystallization from ethanol. Yield 1.95 g (88%); mp 135-137°C. IR spectrum, ν, cm^{-1}: 3193 (NH), 1696 (C=O), 1681 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.89 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.23-1.37 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.69-1.82 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 1.90 (45%), 1.92 (55%) (3H, 2s, *Z*/*E* N=CC$\underline{H}_3$ 1.97 (3H, s, *Z*+*E* N=CC$\underline{H}_3$); 2.64-2.85 (2H, m, $COCH_2$); 4.00-4.25 (3H, m, NCH_2+CH); 4.41 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$);

7.15-8.35 (7H, m, H_{Ar}); 10.28, 10.33, 10.38 (1H, 3s, *Z*/*E* NH). Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 405 $[M+H]^+$ (100). Found, %: C 71.32; H 6.84; N 13.57. $C_{24}H_{28}N_4O_2$. Calculated, %: C 71.26; H 6.98; N 13.85.

N'-(Butan-2-ylidene)-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (5). A mixture of hydrazide 3 (2.0 g, 5.5 mmol) and 2-butanone (12 ml) was refluxed for 8.5 h. The solvent was evaporated under reduced pressure till dryness; the oily product was triturated with ethyl ether. The obtained solid was filtered off, washed with ethyl ether, and crystallized from 2-propanone. Yield 1.94 g (85%); mp 149-151°C. IR spectrum, ν, cm^{-1}: 3193 (NH), 1697 (C=O), 1677 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.86 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.04 (34%), 1.05 (66%) (3H, 2t, *J* = 7.4, *Z*/*E* $N=CCH_2C\underline{H}_3$); 1.20-1.35 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.67-1.80 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 1.87 (50%), 1.89 (37%), 1.93 (13%) (3H, 3s, *Z*+*E* $N=CC\underline{H}_3$); 2.20-2.36 (2H, m, $N=CC\underline{H}_2CH_3$); 2.69-2.82 (2H, m, $COCH_2$); 3.95-4.23 (3H, m, NCH_2 + CH); 4.38 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 7.15-8.32 (7H, m, H_{Ar}); 10.23, 10.38 (1H, 2s, *Z*/*E* NH). ^{13}C NMR spectrum, δ, ppm: 10.23, 10.66, 13.59, 15.94, 19.64, 30.57, 31.31, 31.42, 33.26, 34.50, 35.51, 41.88, 51.10, 51.83, 108.96, 109.24, 112.38, 112.45, 118.44, 119.39, 119.49, 120.28, 121.59, 121.76, 125.71, 131.02, 137.02, 140.30, 154.28, 159.40, 168.62, 171.73, 173.73. Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 419 $[M+H]^+$ (100). Found, %: C 71.62; H 7.27; N 13.38. $C_{25}H_{30}N_4O_2$. Calculated, %: C 71.74; H 7.22; N 13.39.

Hydrazones 6–9 (General Method). A mixture of hydrazide **3** (2.0 g, 5.5 mmol), the corresponding aldehyde (5.5 mmol), and ethanol (15-30 ml) was refluxed for 2-3 h. The reaction mixture was cooled and the precipitate was filtered off and washed with ethanol and hexane.

N'-{[4-(Dimethylamino)phenyl]methylidene}-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (6). Yield 2.31 g (85%); mp 210-212°C (ethanol). IR spectrum, ν, cm^{-1}: 3221 (NH), 1671 (C=O), 1681 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.85 (63%), 0.86 (37%) (3H, 2t, *J* = 7.3, *Z*/*E* $NCH_2CH_2CH_2C\underline{H}_3$); 1.19-1.34 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.67-1.79 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.75–2.87 (2H, m, $COCH_2$); 2.93, 2.96 (6H, 2s, $N(CH_3)_2$); 4.05-4.29 (3H, m, NCH_2 + CH); 4.37 (2H, t, *J* = 7.1, $NC\underline{H}_2CH_2CH_2CH_3$); 6.68-8.34 (12H, m, H_{Ar} + N=CH); 11.31, 11.36 (1H, 2s, *Z*/*E* NH). ^{13}C NMR spectrum, δ, ppm: 13.90, 19.95, 30.88, 33.31, 34.93, 35.26, 42.25, 51.54, 51.98, 109.28, 109.55, 112.00, 112.87, 118.78, 119.89, 120.59, 121.97, 122.13, 126.03, 128.30, 128.59, 131.32, 131.40, 137.40, 140.66, 144.58, 147.98, 151.52, 168.30, 171.80, 173.24. Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 496 $[M+H]^+$ (100). Found, %: C 72.63; H 6.67; N 13.98. $C_{30}H_{33}N_5O_2$. Calculated, %: C 72.70; H 6.71; N 14.13.

N'-[(4-Methoxyphenyl)methylidene]-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (7). Yield 1.64 g (62%); mp 195–197°C (ethanol). IR spectrum, ν, cm^{-1}: 3206 (NH), 1686 (C=O), 1662 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.87 (63%), 0.88 (37%) (3H, 2t, *J* = 7.3, *Z*/*E* $NCH_2CH_2CH_2C\underline{H}_3$); 1.22-1.37 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.69-1.82 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.75–2.90 (2H, m, $COCH_2$); 3.77, 3.79 (3H, 2s, OCH_3); 4.08-4.30 (3H, m, NCH_2 + CH); 4.36 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 6.94–8.35 (12H, m, H_{Ar} + N=CH); 11.48, 11.55 (1H, 2s, *Z*/*E* NH). ^{13}C NMR spectrum, δ, ppm: 13.62, 19.69, 30.62, 33.01, 34.67, 35.02, 35.42, 41.98, 51.22, 51.64, 55.17, 109.01, 109.28, 112.53, 112.62, 114.22, 118.52, 119.52, 119.63, 120.33, 121.71, 121.86, 125.77, 126.66, 128.36, 128.60, 131.10, 137.14, 140.39, 143.42, 146.82, 160.57, 160.77, 168.46, 171.28, 171.49, 173.00. Mass spectrum (ESI), *m*/*z* (I_{rel}, %): 483 $[M+H]^+$ (100). Found, %: C 72.01; H 6.25; N 11.58. $C_{29}H_{30}N_4O_3$. Calculated, %: C 72.18; H 6.27; N 11.61.

N'-(Phenylmethylidene)-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (8). Yield 1.56 g (63%); mp 199-200°C (ethanol). IR spectrum, ν, cm^{-1}: 3178 (NH), 1712 (C=O), 1677 (C=O). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 0.86 (57%), 0.87 (43%) (3H, 2t, *J* = 7.3, *Z*/*E* $NCH_2CH_2CH_2C\underline{H}_3$); 1.21-1.38 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.68-1.81 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.77–2.91 (2H, m, $COCH_2$); 4.09-4.30 (3H, m, NCH_2 + CH); 4.39 (2H, t, *J* = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 7.18-8.39 (13H, m, H_{Ar} + N=CH); 11.61, 11.68 (1H, 2s, *Z*/*E* NH). ^{13}C NMR spectrum, δ, ppm: 13.35, 19.41, 30.34, 32.72, 34.38, 34.77, 41.70, 50.89, 51.30, 108.75, 109.02, 112.27, 112.36, 118.25, 119.37, 120.05, 121.42, 121.57, 125.49, 126.51, 126.72, 128.46, 129.52, 130.80, 133.77, 136.87, 140.12, 143.27, 146.65, 168.42, 170.97, 171.16, 173.36. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 0.92 (3H, t, *J* = 7.2, $NCH_2CH_2CH_2C\underline{H}_3$); 1.28-1.43 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$);

1.75-1.87 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.98-3.24 (2H, m, $COCH_2$); 4.14-4.40 (3H, m, NCH_2 + CH); 4.26 (2H, t, J = 7.1, $NC\underline{H}_2CH_2CH_2CH_3$); 7.17–8.23 (13H, m, H_{Ar} + N=CH); 10.44 (1H, s, NH). Mass spectrum (ESI), *m/z* (I_{rel}, %): 453 $[M+H]^+$ (100). Found, %: C 74.19; H 6.22; N 12.26. $C_{28}H_{28}N_4O_2$. Calculated, %: C 74.31; H 6.24; N 12.38.

N'-[(9-Ethylcarbazol-2-yl)methylidene]-1-(9-butylcarbazol-3-yl)-5-oxopyrrolidine-3-carbohydrazide (9).Yield 1.06 g (34%); mp 144-146°C (ethanol). IR spectrum, ν, cm^{-1}: 3203 (NH), 1682 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.84 (53%), 0.85 (47%) (3H, 2t, J = 7.3, *Z*/*E* $NCH_2CH_2CH_2C\underline{H}_3$); 1.29 (3H, t, J = 7.3, $NCH_2C\underline{H}_3$); 1.15-1.38 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.63-1.79 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.81-2.98 (2H, m, $COCH_2$); 3.39-3.53 (1H, m, CH); 4.10-4.38 (4H, m, $NC\underline{H}_2CH_3$ + NCH_2); 4.44 (2H, t, J = 7.0, $NC\underline{H}_2CH_2CH_2CH_3$); 7.10-8.54 (15H, m, H_{Ar}+N=CH); 11.56, 11.63 (1H, 2s, *Z*/*E* NH). Mass spectrum (ESI), *m/z* (I_{rel}, %): 570 $[M+H]^+$ (100). Found, %: C 75.70; H 6.05; N 12.08. $C_{36}H_{35}N_5O_2$. Calculated, %: C 75.90; H 6.19; N 12.29.

1-(9-Butylcarbazol-3-yl)-4-(1,3,4-oxadiazol-2-yl)pyrrolidin-2-one (10). A mixture of compound **3** (3.0 g, 8.2 mmol) and triethyl orthoformate (15 ml) was refluxed for 24 h. After cooling, the obtained oily viscous liquid was washed with water and decanted. The residue was dissolved in chloroform, the solution was dried over Na_2SO_4 and filtered off, and the solvent was removed on a rotary evaporator. The obtained crude material was chromatographed over a silica gel column (propanone–hexane, 1.5:1). R_f 0.73. Yield 1.39 g (45%); mp 161-162°C. IR spectrum, ν, cm^{-1}: 1702 (C=O), 1595 (C=N), 1233, 1020 (=C–O–C=). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.86 (3H, t, J = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.22-1.35 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.67-1.79 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.88-3.08 (2H, m, $COCH_2$); 3.82–3.95 (1H, m, CH); 4.12-4.22 (4H, m, $NC\underline{H}_2CH_2CH_2CH_3$ + NCH_2); 7.15-8.13 (7H, m, H_{Ar}); 8.41 (1H, s, CH). ^{13}C NMR spectrum, δ, ppm: 13.70, 20.28, 28.37, 30.47, 36.03, 42.61, 52.15, 108.71, 108.81, 113.22, 118.72, 119.68, 120.33, 122.28, 122.48, 125.86, 130.05, 137.92, 140.72, 153.63, 166.34, 170.54. Mass spectrum (ESI), *m/z* (I_{rel}, %): 375 $[M+H]^+$ (100). Found, %: C 70.52; H 6.10; N 14.85. $C_{22}H_{22}N_4O_2$. Calculated, %: C 70.57; H 5.92; N 14.96.

1-(9-Butylcarbazol-3-yl)-4-[5-(4-methoxyphenyl)-1,3,4-oxadiazol-2-yl]pyrrolidin-2-one (11). To an ice-cooled (to 2°C) magnetically stirred vessel 40 ml dichloromethane $Pb(MeCOO)_4$ (1.77 g, 4 mmol) was added and the contents stirred for 5 min. Then hydrazone **7** (0.96 g, 2 mmol) was added in portions. The reaction mixture was stirred at +2°C for 8 h. Then it was filtered off and dichloromethane was removed on a rotary evaporator. The crude product was poured into water and the mixture was heated up to the boiling point; afterwards, the mixture was cooled and the water was decanted. The obtained crude material was chromatographed over a silica gel column (acetylacetate–hexane–methanol, 6:3:1). R_f 0.62. Yield 0.58 g (61%); mp 109-110°C. IR spectrum, ν, cm^{-1}: 1699 (C=O), 1613 (C=N), 1265, 1020 (=C–O–C=). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.85 (3H, t, J = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.19-1.35 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.66-1.80 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.98–3.18 (2H, m, $COCH_2$); 3.83 (3H, s, OCH_3); 4.15-4.27 (1H, m, CH); 4.30-4.48 (4H, m, $NC\underline{H}_2CH_2CH_2CH_3$ + NCH_2); 7.10–8.35 (11H, m, H_{Ar}). ^{13}C NMR spectrum, δ, ppm: 14.14, 20.22, 28.55, 31.14, 36.25, 42.51, 52.26, 55.93, 109.57, 109.84, 113.29, 115.23, 116.22, 119.09, 120.20, 120.82, 122.25, 122.38, 126.33, 128.84, 131.35, 137.78, 140.94, 162.42, 164.86, 166.90, 171.19. Mass spectrum (ESI), *m/z* (I_{rel}, %): 481 $[M+H]^+$ (100). Found, %: C 72.62; H 5.92; N 11.47. $C_{29}H_{28}N_4O_3$. Calculated, %: C 72.48; H 5.87; N 11.66.

1-(9-Butylcarbazol-3-yl)-4-[(3,5-dimethylpyrazol-1-yl)carbonyl]pyrrolidin-2-one (12). A mixture of hydrazide **3** (1.0 g, 2.7 mmol), 2,4-pentanedione (0.92 g, 9.1 mmol), ethanol (12 ml), and catalytic amount of hydrochloric acid was refluxed for 3 h. The solvent was evaporated under reduced pressure to dryness, and the oily product was triturated with ethyl ether. The obtained solid was filtered off and washed with ethyl ether. The crude product was purified by column chromatography (acetone–hexane, 1:2). R_f 0.52. Yield 0.77g (66%); mp 120-121°C. IR spectrum, ν, cm^{-1}: 1735 (C=O), 1693 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.91 (3H, t, J = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.30-1.44 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.77-1.90 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.23, 2.53 (6H, 2s, $2CH_3$); 2.85-3.04 (2H, m, $COCH_2$); 4.18-4.43 (2H, m, NCH_2); 4.39 (2H, t, J = 7.2, $NC\underline{H}_2CH_2CH_2CH_3$);

4.56–4.68 (1H, m, CH); 6.15 (1H, s, C=CH); 7.15–8.37 (7H, m, H_{Ar}). ^{13}C NMR spectrum, δ, ppm: 14.60, 14.88, 15.14, 21.73, 32.61, 36.55, 37.71, 43.98, 52.97, 110.38, 110.72, 112.90, 113.98, 120.23, 121.10, 121.91, 124.06, 124.26, 127.38, 133.41, 139.24, 142.57, 145.77, 153.94, 172.44, 174.39. Mass spectrum (ESI), *m/z* (I_{rel}, %): 429 $[M+H]^+$ (100). Found, %: C 72.71; H 6.45; N 12.98. $C_{26}H_{28}N_4O_2$. Calculated, %: C 72.87; H 6.59; N 13.07.

Ethyl 3-{[(5-oxo-1-(9-butylcarbazol-3-yl)pyrrolidin-3-yl)carbonyl]hydrazono}butanoate (13). A mixture of hydrazide **3** (2.0 g, 5.5 mmol), ethyl 3-oxobutanoate (0.71 g, 5.5 mmol), ethanol (25 ml), and a catalytic amount of hydrochloric acid was refluxed for 7.5 h. Then it was cooled, and the precipitated product was filtered off, washed with ethanol, and purified by column chromatography (acetone–hexane, 1:2). R_f 0.68. Yield 1.88 g (72%); mp 99–101°C. IR spectrum, ν, cm^{-1}: 3276 (NH), 1731 (C=O), 1695 (C=O), 1669 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.91 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.22 (3H, t, *J* = 7.5, $COOCH_2C\underline{H}_3$); 1.30-1.44 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.78-1.90 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.09 (3H, s, CH_3); 2.71–2.95 (2H, m, $COCH_2$); 3.40 (2H, s, $C\underline{H}_2COOCH_2CH_3$); 4.00–4.29 (3H, m, NCH_2+CH); 4.15 (2H, q, *J* = 7.2, $COOC\underline{H}_2CH_3$); 4.40 (2H, t, *J* = 7.2, $NC\underline{H}_2CH_2CH_2CH_3$); 7.13–8.39 (7H, m, H_{Ar}); 9.63, 9.78 (1H, 2s, NH). Mass spectrum (ESI), *m/z* (*I*, %): 477 $[M+H]^+$ (100). Found, %: C 68.06; H 6.79; N 11.70. $C_{27}H_{32}N_4O_4$. Calculated, %: C 68.05; H 6.77; N 11.76.

1-(9-Butylcarbazol-3-yl)-N-(2,5-dimethylpyrrol-1-yl)-5-oxopyrrolidine-3-carboxamide (14). To a solution of hydrazide **3** (1.0 g, 2.7 mmol) in 2-propanol (14 ml) 2,5-hexanedione (0.78 g, 6.8 mmol) and glacial acetic acid (0.5 ml) were added. The reaction mixture was stirred and refluxed for 2 h. Then it was cooled to room temperature. The precipitated product was filtered off, washed with ethyl ether and recrystallized from 2-propanol. Yield 0.86 g (71%); mp 183–184°C. IR spectrum, ν, cm^{-1}: 3261 (NH), 1687 (C=O), 1666 (C=O). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.86 (3H, t, *J* = 7.3, $NCH_2CH_2CH_2C\underline{H}_3$); 1.21-1.35 (2H, m, $NCH_2CH_2C\underline{H}_2CH_3$); 1.68-1.80 (2H, m, $NCH_2C\underline{H}_2CH_2CH_3$); 2.03, 2.04 (6H, 2s, $2CH_3$); 2.73-2.98 (2H, m, $COCH_2$); 3.48-3.62 (1H, m, CH); 4.09-4.32 (2H, m, NCH_2); 4.38 (2H, t, *J* = 6.5, $NC\underline{H}_2CH_2CH_2CH_3$); 5.68 (2H, s, 2CH); 7.15-8.37 (7H, m, H_{Ar}); 10.97 (1H, s, NH). ^{13}C NMR spectrum, δ, ppm: 10.94, 13.68, 19.74, 30.67, 34.32, 35.44, 42.02, 51.50, 103.05, 109.12, 109.36, 112.80, 118.60, 119.72, 120.39, 121.75, 121.87, 125.86, 126.71, 130.94, 137.26, 140.45, 171.04, 171.98. Mass spectrum (ESI), *m/z* (I_{rel}, %): 443 $[M+H]^+$ (100). Found, %: C 73.05; H 6.86; N 12.31. $C_{27}H_{30}N_4O_2$. Calculated, %: C 73.28; H 6.83; N 12.66.

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