A convenient synthesis of new 1-pyrazolylquinoxalin-2-one derivatives from 1,5-benzodiazepine-2-thione

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Abstract

New pyrazole-, 1,3,4-oxadiazole-, and 1,2,4-triazole- conjugated pyrazolylquinoxalines were synthesized from 4-phenyl-1,5-benzodiazepine-2-thione. The identification of these compounds was carried out using ^{1}H- and ^{13}C- NMR, IR, and mass spectrometry.

Keywords: 1,5-Benzodiazepine, quinoxalines, 1,3,4-oxadiazole, 1,2,4-triazole

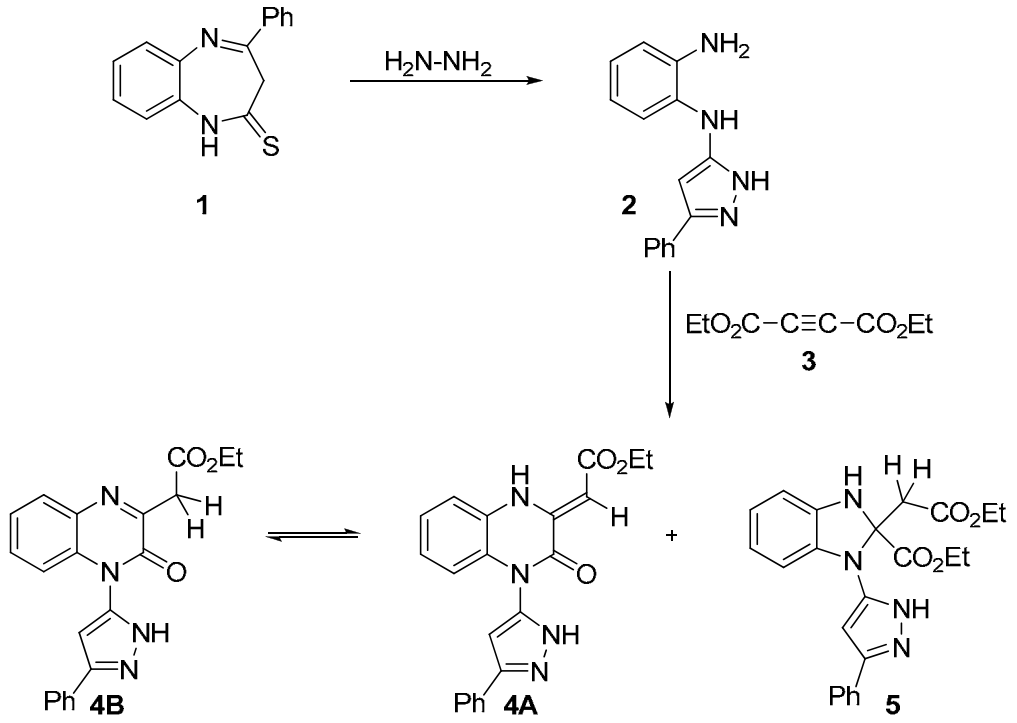
Introduction

The interest aroused by quinoxaline chemistry is based essentially on the different applications of these compounds in various fields. It is well known that the quinoxaline derivatives are used as dyes to detect metals and anions.[1,2] They are also used as agrochemicals,[3] anti-virals,[4] anti-microbials,[5] and for the treatment of tuberculosis,[6] and human cancer cell lines,[7] and herbicides.[8] We have continued our investigations and prepared new quinoxaline derivatives in the hope that they may possess various pharmacological activities. According to some reviews,[9-15] quinoxaline derivatives have been prepared by several methods. We describe here the synthesis of new quinoxaline derivatives, using 4-phenyl-l,5-benzodiazepine-2-thione, **1**, as starting material.

Result and Discussion

The pyrazolylquinoxaline derivatives **9**, **10**, and **12** described in this paper are prepared by the approach outlined in Schemes 2 and 3. The key step of these syntheses is based on the reactivity of the pyrazolyl-quinoxaline **6** towards triethyl orthoformate, carbon disulfide, or methyl isocyanate in presence of potassium hydroxide, to give the products **9**, **10** and **12.** In a previous

paper,[16] we reported that 4-phenyl-l,5-benzodiazepine-2-thione, **1**, reacts with hydrazine to give 3-*N*-(2-aminophenyl-amino)-5-phenylpyrazole **2** (Scheme 1). The reaction of **2** with diethyl acetylenedicarboxylate, **3,** in ethanol under stirring at room temperature afforded ethyl 2-(2-ethoxy-2-oxoethyl)-1-(3-phenyl-1*H*-pyrazol-5-yl)-2,3-dihydro-1*H*-benzimidazole-2-carboxylate, **5** (resulting from the attack of the NH_2 and NH groups of **2** on the triple bond of **3**) and 3-ethoxycarbonylmethylene-2-oxo-l-[3(5)-phenylpyrazol-5(3)-yl]-1,2,3,4-tetrahydroquinoxaline, **4**, in good yield. There exists a tautomeric equilibrium between the enamine form **A** and the methyleneimine form **B** as shown in Scheme 1. The identification of compounds **4** and **5** was carried out using ^{1}H- and ^{13}C- NMR, IR, and mass spectrometry.



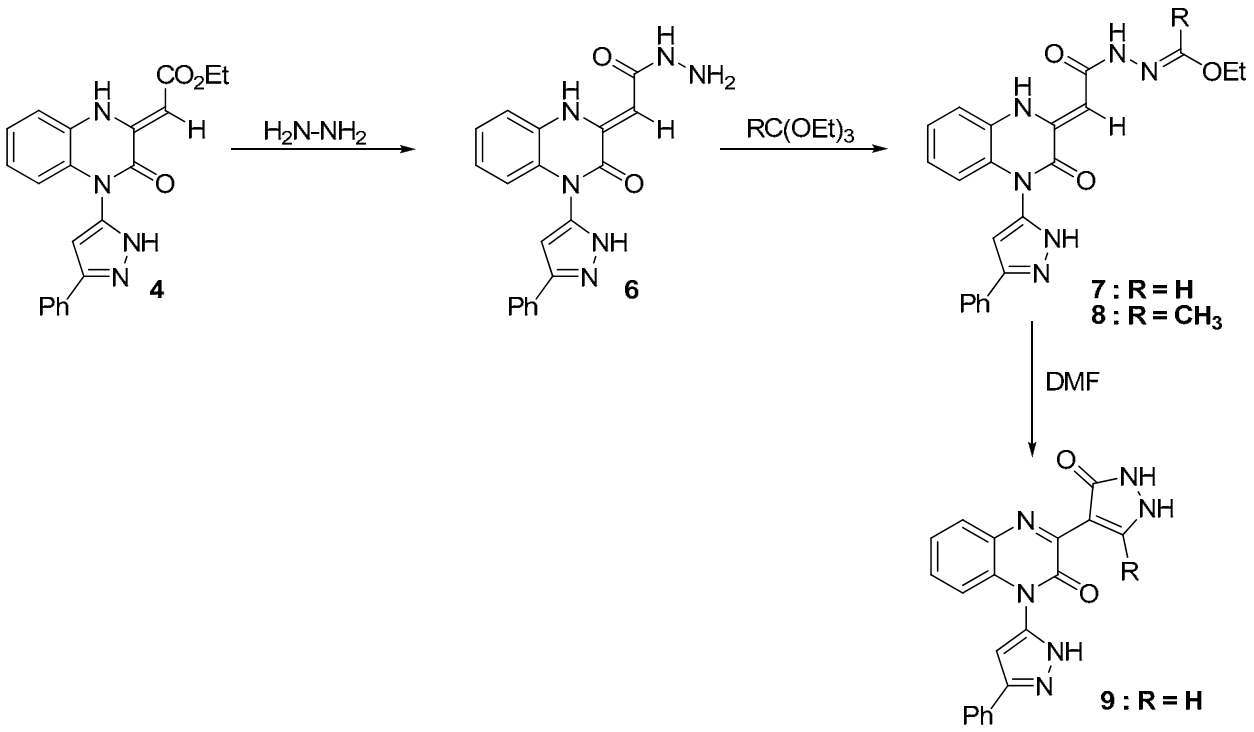
Scheme 1

The proton nuclear magnetic resonance spectrum of **4** in DMSO-d_6 revealed signals due to vinyl and methylene protons at δ 5.62 and 3.93 ppm respectively, and the integral ratio of the two signals was 1.2:1 suggesting predominance of the tautomer **A**. On the other hand, the ^{13}C-NMR also exhibited vinyl and methylene carbon signals respectively at δ 85.8 and 39.6 ppm in accord with this tautomeric equilibria.

In the ^{1}H NMR spectrum of product **5** in $CDCl_3$, the methylene hydrogens linked to C_2 appeared as an AB system at δ 2.98 and 2.65 ppm with *J*=16 Hz. The ^{13}C- NMR spectrum showed the carbon of this methylene group at δ 41.8 ppm. The mass spectrum of **5** taken in the desorption chemical ionization mode, showed the molecular peak *m/z* at 421, which helps confirm the structure of the product. It is interesting to note that compound **4**, obtained in a good

yield, possesses several reaction centers, and therefore it may be used as a precursor in the synthesis of more elaborate quinoxaline derivatives.

In relation to the above target compounds, we found that compound **4** was converted easily into the 3-hydrazidomethylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydro-quinoxaline, **6**, by reaction with an excess of hydrazine hydrate in ethanol under 3 hours reflux (Scheme 2).



Scheme 2

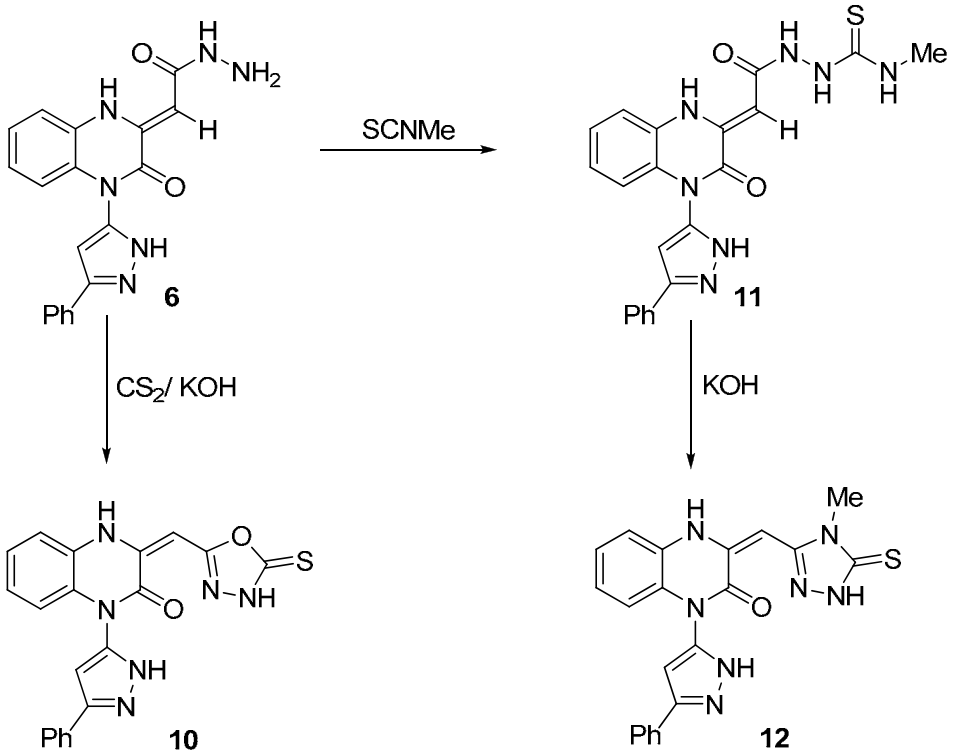
The structure of **6** was established on the basis of its ^{1}H- and ^{13}C- NMR, IR, and mass spectral data. The infrared (IR) absorption band of the hydrazido group was observed at 1673 cm^{-1} which is much lower than the ester carbonyl group. In the ^{1}H NMR spectrum the signals relating to vinyl and methylene protons were observed at δ 5.75 and 3.73 ppm respectively. Furthermore, the ^{13}C NMR also showed the co-existence of tautomer forms — the signals corresponding to the vinyl and methylene carbon appeared at δ 88.1 and 39.0 respectively. In addition, compound **6** was found to be a useful key intermediate, leading to novel pyrazole, 1,2,4-triazole- conjugated quinoxalines.

The reaction of compound **6** with triethyl orthoformate and triethyl orthoacetate in ethanol furnished exclusively 3-(*N*-ethoxymethylene)hydrazidomethylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline, **7,** and 3-(*N*-(1-ethoxyethylene) hydrazidomethylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline, **8,** respectively (Scheme 2),

the structures of which were attributed on the basis of their spectral data (^{1}H-, ^{13}C- NMR, IR, and mass spectra). Further refluxing of **7** in *N*,*N*-dimethylformamide induced cyclization leading to product **9** 3-(5-oxo-3-pyrazolin-4-yl)-2-oxo-1(3(5)-phenylpyrazol-5(3)-yl)-1,2-dihydro-quinoxaline (Scheme 2). In contrast, the cyclization did not occur when compound **8** was heated under reflux under the same reaction conditions. Presumably, owing to steric hindrance by the methyl group, this cyclization route cannot be realized. The structure of compound **9** was assumed satisfactorily on the basis of its spectral data. The ^{1}H NMR spectrum of **9** in DMSO-d_6 exhibits a signal due to the 3-H of the pyrazolone ring at 8.45 ppm, in accord with the structure assigned.

Various 1,3,4-oxadiazoles[17-19] and 1,2,4-triazoles[20] have been tested as herbicidal, fungicidal, bactericidal, antihistaminic, and plant-growth- regulatory agents. Accordingly, we undertook the synthesis of new 1-pyrazolylquinoxalines possessing 1,3,4-oxadiazolylmethylene and triazolylmethylene groups in the 3-position in order to test their activities.

Starting from compound **6** by a one-pot reaction with carbon disulfide in the presence of potassium hydroxide in water, we have prepared 3-(5-thioxo-4,5-(dihydro-1,3,4-oxadiazol-2-yl)methylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-l,2,3,4-tetrahydroquinoxaline, **10** (Scheme 3), whose structure was elucidated by means of spectroscopic data.



Scheme 3

The infrared spectrum of compound **10** showed no SH absorption band, but exhibited the C=S absorption band at 1160 cm^{-1}. The ^{1}H- NMR spectrum of **10** in DMSO-d_6 revealed signals

corresponding to the vinyl and methylene protons at δ 6.01 and 4.42 ppm respectively. These data are consistent with the structure of **10**, the vinyl and methylene protons of the aromatized 1,3,4-oxadiazole compounds being observed at lower magnetic field.[21]

Moreover, when methyl isothiocyanate reacted with **6** under reflux in dioxane, the corresponding thiosemicarbazide **11** was obtained. This later compound was heated under reflux in water, in the presence of potassium hydroxide. The dehydration led to 3-(4-methyl-3,4 dihydro-3-thioxo-2*H*-1,2,4-triazol-5-yl)methylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline, **12** (Scheme 3). The structure of compound **12** was confirmed on the basis of its ^{1}H-, ^{13}C- NMR, IR, and mass spectral data. The infrared spectrum of **12** showed the C=S absorption band at 1270 cm^{-1}, the mass spectrum (DCI/NH_3) exhibited a major peak at *m/z* = 416 (MH^+), and the ^{1}H NMR revealed, in addition to the signals due to vinyl and methylene protons at δ 6.08 and 4.37 ppm, respectively, a signal corresponding to the methyl group at 3.52 ppm. It has been noticed that these spectral data are consistent with the dihydrotriazole ring for the same reasons invoked for the compound **12**.[21]

In conclusion, we describe in this paper the synthesis of new heterocyclic conjugated quinoxalines using the 4-phenyl-1,5-benzodiazepine-2-thione, **1**, as starting material.

Experimental Section

General Procedures. Melting points were determined on a Büchi Tottoli apparatus and are uncorrected. Spectra were recorded using the following instruments: IR, Perkin-Elmer 577 (KBr disks); NMR, Bruker AC 250 spectrometer, 250 MHz for ^{1}H- and 62.89 MHz for ^{13}C), chemical shifts δ are given in ppm downfield from TMS internal standard; MS (DCI/NH_3) VARIAN MAT 311 A spectrophotometer. RT denotes room temperature.

Synthesis of 3-ethoxycarbonylmethylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline (4) and ethyl 2-(2-ethoxy-2-oxoethyl)-1-(3-phenyl-1*H*-pyrazol-5-yl)-2,3-dihydro-1*H*-benzimidazole 2-carboxylate (5). To a solution of **2**[15] (10^{-2} mole) in 100 mL of EtOH, 1.5 equiv. of diethyl acetylenedicarboxylate, **3**, was added slowly. The mixture was stirred at RT for 1 hour. The product **4** precipitated as yellow needles, which were collected by filtration. The filtrate was evaporated and the resulting crude material was chromatographed over silica gel column using 20:80 ethyl acetate: hexane as eluent to give an additional quantity of **4** and product **5**. Product **4**: 90% yield, m.p. 154-156°C; IR (KBr): 3291 cm^{-1} (NH); 1726 cm^{-1} (C=O); ^{1} H- NMR (DMSO-d_6): 1.30 (3H, t, *J* = 7 Hz); 3.93 (2H, *s*, C_3-CH_2); 4.18 (2H, *q*, *J* = 7 Hz); 5.62 (1 H, *s*, C_3=CH); 6.58 and 6.61 (1H, *s*, C_4-H); 6.67-7.86 (9H, *m*, H_{Ar}); 11.18 (1H, *s*, N_4H); 13.78 and 13.87(1H, *s*, $NH_{pyrazole}$). ^{13}C NMR (DMSO-d_6) δ 13.9, 14.2, 39.4, 59.2, 60.4, 85.0, 100.7, 115.6, 125.0, 127.3, 128.5, 144.4, 155.1, 155.5, 166.9, 166.9. MS (DCI/NH_3), *m/z* 375 $[MH]^+$. Anal. Calcd for $C_{21}H_{18}N_4O_3$, C, 67.37; H, 4.85; N, 14.96%. Found: C, 67.23; H, 4.79; N, 15.06%. Product **5**: 10% yield, m.p. 130-132°C; IR (KBr): 3331 cm^{-1} (NH); 1721 cm^{-1}

(C=O); ^{1}H- NMR ($CDCl_3$): 0.93 (3H, *t*, *J* = 7 Hz); 1.20 (3H, *t*, *J* = 7 Hz); 2.65 (1 H, *d*, *J* = 16 Hz); 2.98 (1H, *d*, *J* =16 Hz); 3.71 (2H, *q*, *J* = 7 Hz); 3.86 (2H, *q*, *J* = 7 Hz); 6.49 (1 H, *s*, C_4-H); 6.77-7.42 (9H, *m*, C_4-H, H_{Ar}); 11.56 (1H, *s*, $NH_{benzimidazole}$); 13.81 (1H, *s*, $NH_{pyrazole}$); ^{13}C NMR ($CDCl_3$): 13.7; 14.0; 41.8; 61.3; 62.8; 104.2; 117.5; 129.4; l30.3; 151.0; 170.9; 171.6. MS (DCI/NH_3): *m/z* 421 $[MH]^+$. Anal. Calc. for $C_{23}H_{24}N_4O_4$: C, 65.70; H, 5.75; N, 13.33. Found: C, 65.76; H, 5.69; N, 13.38%.

2-(3-Oxo-4-(3-phenyl-1*H*-pyrazol-5-yl)-3,4-dihydroquinoxalin-2(1*H*)-ylidene)-acetohydrazide (6). A solution of **4** (10^{-2} mole) and hydrazine hydrate (10^{-1} mole) in 80 mL of EtOH was heated under reflux for 3 h. The colorless product **6** precipitated and was collected by filtration. Evaporation of the filtrate gave an additional quantity of **6**. An analytically pure sample was obtained by washing with hot EtOH several times. Yield 90%, m.p. 249-251°C. IR (KBr) 3296 cm^{-1} (NH_2), 1673 cm^{-1} (C=O); ^{1}H NMR (DMSO-d_6): 3.73 (2H, *s*, C_3-CH_2); 4.36 (2H, *br*, *s*); 5.75 (1 H, *s*, C_3=CH); 6.48 and 6.51 (1 H, *s*, C_4,H); 6.80-7.85 (9H_{Ar}, *m*); 9.27 (1 H, *s*, $CONHNH_2$); 11.18 (1H, *s*, N_4H); 13.78 (1H, *s*, $NH_{pyrazole}$). ^{13}C NMR (DMSO-d_6): 38.7, 88.1, 100.6, 114.4, 125, 125.9, 126.9, 128.4, 130.0, 131.5, 133.9, 138.4, 146.2, 153.6, 156.4, 167.4. MS (DCI/NH_3): *m/z*: 361 $[MH]^+$. Anal. Calc. for $C_{19}H_{16}N_6O_2$ C, 63.32; H, 4.48; N, 23.32. Found: C, 63.26; H, 4.54; N, 23.28%.

3-(*N*-Ethoxymethylene)hydrazidomethylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl-)-1,2,3,4-tetrahydroquinoxaline (7) and 3-{2-[2-(1-ethoxyethylidene)hydrazino]-2-oxoethylidene}-2-oxo-1-(3(5)phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline (8). A solution of **6** (10^{-2} mole) and 20 mL of the appropriate ortho-ester in 100 mL of EtOH was heated under reflux for 3h. When triethyl orthoformate was employed, yellow needles of **7** precipitated during the reaction, and were collected by filtration. The filtrate was evaporated to provide an additional quantity of product **7**. The analytically pure sample was obtained by washing with hot EtOH several times. Yield 80%, m.p. 234-236°C. IR (KBr, cm^{-1}) 3279 (NH), 1680 (C=O). ^{1}H- NMR (DMSO-d_6): 1.27 (3H, *t*, *J* = 7 Hz), 3.76 (2H, *s*, C_3-CH_3), 4.14 (2H, *q*, *J* = 7 Hz), 5.74 (1 H, *s*, C_3=CH), 6.11 (1H, *s*); 6.50 (1 H, *s*, C_4H); 6.81-7.84 (9H, *m*, Ar); 10.60 (1 H, *s*, NH); 10.80 (1 H, *s*, NH); 11.97 (H, *s*, NH); 13.76 and 13.87 (1 H, *s*, $NH_{pyrazole}$). ^{13}C- NMR (DMSO-d_6): 14.0, 15.3, 28.9, 62.3, 66.7, 88.2, 100.8, 100.9, 114.7, 125.0, 125.7, 128.5, 128.7, 130.1, 133.7, 153.6, 156.5, 165.3. MS (DC/NH_3), *m/z* 417 $[MH]^+$. Anal. Calcd for $C_{22}H_{20}N_6O_3$: C, 63.45; H, 4.84; N, 20.18. Found: C, 63.53; H, 4.80; N, 20.25%. When triethyl orthoacetate was used, the solvent was evaporated off to afford yellow needles of **8**, which were collected by filtration and washed several times with hot EtOH to give an analytically pure sample. Yield 80%, m.p. 173-175°C; IR (KBr) 3227 cm^{-1} (NH); 1675 cm^{-1} (C=O); ^{1}H NMR (DMSO-d_6): 1.22 (3H, *t*, *J* = 7 Hz); 1.97 (3H, s); 3.83 (2H, s, C_3-CH_2); 4.08 (2H, *q*, *J* = 7 Hz); 5.94 (1H, *s*, C_3=CH); 6.48 and 6.52 (1 H, *s*, C_4,H); 6.84-7.85 (9 H_{Ar}, *m*); 10.04 (1H, *s*, NH); 10.11 (1 H, *s*, NH);11.92 (1H, *s*, NH); 13.75 and 13.85(1 H, *s*, $NH_{pyrazole}$). ^{13}C NMR (DMSO-d_6): 14.0; 14.6; 15.29; 39.0; 61.4; 64.1; 88.5; 100.8; 114.6; 125.0; 125.5; 127.3; 128.5; 130.1; 131.5; 153.7; 155.9; 156.4; 164.4; 165.0; 169.6; 169.8; MS (DCI/NH_3): *m/z*: 431 $[MH]^+$. Anal. Calc for $C_{23}H_{22}N_6O_3$: C, 64.17; H, 5.15; N, 19.52. Found: C, 64.11; H, 5.21; N, 19.62%.

3-(5-Oxo-3-pyrazolin-4-yl)-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2-dihydroquinoxaline (9). A solution of **7** (10^{-3} mole) in dimethylformamide (l00 mL) was heated at reflux for 20 h in an oil bath at 160-180°C. Thereafter the solvent was evaporated off and the resulting crude material was chromatographed on a silica gel column (eluent, 30:70 ethyl acetate: hexane) to give compound **9**. Yield 80%, m.p. 295-297°C. IR (KBr, cm^{-1}) 1620 (C=O), 1675 (C=O). ^{1}H NMR (DMSO-d_6): 6.84 (1H, *s*, C_4-H); 6.92-7.97 (9H, *m*, H_{Ar}); 8.45 (1 H, *s*, C_3'H); 10.77 (1H, *s*, NH); 12.47(1H, *s*, NH); 13.87(1 H, *s*, $NH_{pyrazole}$). ^{13}C NMR (DMSO-d_6): 100.7, 115.4, 117.1, 123.3, 125.2, 125.3, 127.4, 128.5, 129.4, 131.2, 132.4, 137.7, 140.1, 148.4, 150.1, 153.3, 157.6, 162.3, MS (FAB), *m/z*: 371 $[MH]^+$. Anal. Calcd for $C_{20}H_{14}N_6O_2$: C, 64.86; H, 3.81; N, 22.69%. Found: C, 64.76; H, 3.88; N, 22.62%.

3-(5-Thioxo-4,5-dihydro-1,3,4-oxadiazol-2-yl)methylene-2-oxo-1-(3(5)-phenylpyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline (10). To a solution of **6** ($2x10^{-3}$ mole) and 1.5 equiv. of KOH in 30 mL of H_2O, 10 mL of CS_2 was added slowly. The reaction mixture was heated at reflux for 1 h. Product **10** precipitated as a yellow powder and was purified over a silica gel column using 20:80 ethyl acetate:hexane as eluent to give an analytically pure sample. Yield 70%. m.p. 253-255°C. IR (KBr, cm^{-1}): 1680 (C=O), 1640 (C=N), 1160 (C=S). ^{1}H NMR (DMSO-d_6): 4.42 (2H, *s*, C_3-CH_2); 6.01 (1H, *s*, C_3=CH); 6.56 and 6.59 (1 H, *s*, C_4-H); 6.76-7.84 (9H, *m*, H_{Ar}), 9.85 (1H, *s*, N_4'H), 13.78 (1H, *br, s,* NH), 14.57 (1H, *br, s*, NH). ^{13}C NMR (DMSO-d_6): 30.9, 78.9, 100.8, 100.7, 115.5, 125.1, 125.3, 127.4, 128.5, 130.7, 131.2, 160.8, 175.5, 177.9. MS (DCI/NH_3): *m/z* 403 $[MH]^+$. Anal. Calc. for $C_{20}H_{14}N_6O_2S$: C, 59.69; H, 3.51; N, 20.88. Found: C, 59.74; H, 3.57; N, 20.80%.

Synthesis of the thiosemicarbazide (11). A suspension of **6** ($2x10^{-3}$ mole) and an equimolar amount of methyl isothiocyanate in 70 ml of dioxane was heated under reflux for 1 h: **11** precipitated as a yellow product. Trituration with hot ethanol afforded an analytically pure sample in 80% yield, m.p. 227-229°C. IR (KBr, cm^{-1}): 3300 (NH), 1670 cm^{-1} (C=O), 1221cm^{-1}(C=S), ^{1}H NMR (DMSO-d_6): 2.87 and 2.89 (3H, *d*, *J* = 4.5 Hz), 3.84 (2H, *s*, C_3-CH_2), 5.80 (1H, *s*, C_3=CH), 6,52 and 6.55 (1 H, *s*, C_4-H), 6.87-7.85 (9H, *m*, Ar), 7.88 (1H, *q*, *J* = 4.5 Hz, CSNHMe), 9.21 (1H, *s*, NH), 9.41 (1H, *s*, NH), 9.80 (1H, *s*, NH),11.69 (1H, *s*, NH),13.75 (1H, *s*, NH), 13.88 (1H, *s*, NH). ^{13}C NMR (DMSO-d_6): 30.6, 30.8, 87.2, 39.72, 100.6, 111.5, 125.0, 125.5, 127.1, 128.5, 128.7, 130.3, 115.0, 131.5, 131, 156.1, 167.7, 168.7, 181.9, 182.4. MS (DCl/NH_3). *m/z*: 434 $[MH]^+$. Anal. Calc. for $C_{21}H_{19}N_7O_2S$: C, 58.19; H, 4.42; N, 22.62. Found: C, 58.08; H, 4.49; N, 22.70%.

3-(4-Methyl-3,4-dihydro-3-thioxo-2*H*-1,2,4-triazol-5-yl)methylene-2-oxo-1-(3(5)-phenyl-pyrazol-5(3)-yl)-1,2,3,4-tetrahydroquinoxaline (12). A suspension of the thiosemicarbazide **11** ($0.5x10^{-3}$ mol) and 1.5 equiv. of KOH in 30 mL of H_2O was heated under reflux for 1 h to precipitate the product **12** as a yellow powder. This was collected by filtration and purified over a silica gel column using 10:90 ethyl acetate: hexane as eluent to give an analytically pure sample. Yield 80%, m.p. 302-304°C. IR (KBr cm^{-1}): 3128 (NH), 3066 (NH), 3015 (NH), 1680 (C=O), 1270 (C=S). ^{1}H-NMR (DMSO-d_6) 3.47-3.50 (3H, *s*); 4.37 (2H, *s*, C_3-CH_2); 6.08 (1H, *s*,

C_3=CH); 6.53 and 6.56 (1H, *s*, C_4-H); 6.88-7.84 (9H, *m*, H_{Ar}), 10.21 (1H, *s*, NH); 13.72 (1H, *s*, NH); 13.76 (1H, *s*, NH); 13.81 (1H, *s*, NH); 14.01(1H, *s*, NH). ^{13}C NMR (DMSO-d_6): 29.4, 30.2, 39.8, 81.1, 100.7, 114.9, 125.0, 127.3, 128.5, 129.1, 133.8, 134.7, 156.2, 165.6. MS (DCI/NH_3): *m/z* 416 $[MH]^+$. Anal. Calc. for $C_{21}H_{17}N_7OS$: C, 60.71; H, 4.12; N, 23.60%. Found: C, 60.69; H, 4.07; N, 23.67%.

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