^{1}H-NMR Study on the Tautomer Ratios between the Hydrazone Imine and Diazenylenamine Forms in 3-(Arylhydrazono)-methyl-2-oxo-1,2-dihydroquinoxalines

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The *o*-substituted 3-(arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines **1a-c** and **2a,c** were synthesized to investigate the tautomeric behavior between the hydrazone imine **A** and diazenylenamine **B** forms in a series of mixed dimethyl sulfoxide/trifluoroacetic acid media. The chemical shifts of the hydrazone NH, N_4-H, hydrazone CH, and diazenyl CH protons for *o*-, *m*-, and *p*-substituted 3-(arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines **1** and **2** synthesized so far are summarized in Tables 3 and 4, respectively, which are found to be useful for the specification of the proton signals due to the hydrazone imine form **A** (hydrazone NH, hydrazone CH) and diazenylenamine form **B** (N_4-H, diazenyl CH).

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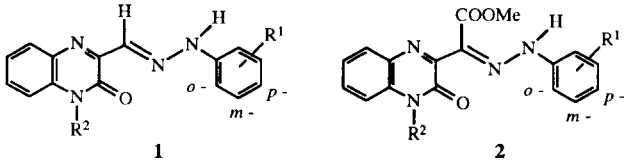
In previous papers [1-4], we reported that the nmr spectra of the *p*- and *m*-substituted 3-(arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines 1 and 2 (Chart 1) showed tautomeric equilibria between the hydrazone imine **A** and diazenylenamine **B** forms in a solution (Scheme 1).

Chart 1



1 **2**

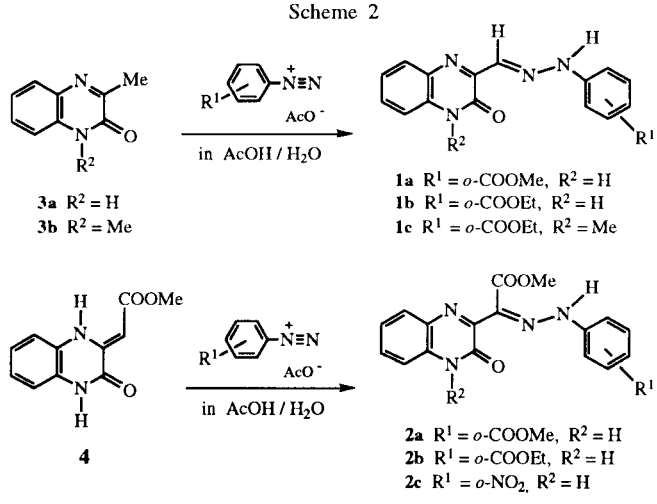
R^1 = *o*-, *m*-, *p*-Substituent, R^2 = H, Me

Scheme 1

A Hydrazone Imine Form **B** Diazenylenamine Form

Moreover, the correlation of the Hammett σ_p and σ_m constants with the tautomeric equilibrium constants K_T ([A]/[B]) was found in the dimethyl sulfoxide media of compounds **1** [2,3], although such a correlation was not observed in compounds **2** having the ester group on the hydrazone carbon [3]. On the other hand, our accumulating pmr data for *p*- and *m*-substituted compounds **1** provided the chemical shifts to be diagnostic of the hydrazone imine form **A** [hydrazone NH (δ 14.53-14.42 ppm), hydrazone CH (δ 7.86-7.68 ppm)] and the diazenylenamine form **B** [N_4-H (δ 11.90-11.15 ppm), diazenyl CH (δ 8.49-8.31 ppm)] [1]. The pmr data for *p*- and *m*-substituted compounds **2** also gave the chemical shifts to be diagnostic of the hydrazone imine form **A** [hydrazone NH (δ 11.36-11.07 ppm)] and the diazenylenamine form **B** [N_4-H (δ 11.87-11.83 ppm)]. However, there have been few data for the *o*-substituted compounds **1** and **2** in order to provide the chemical shifts to be diagnostic of the hydrazone imine **A** and diazenylenaine **B** forms. Accordingly, some *o*-substituted compounds **1** and **2** were synthesized in the present investigation. This paper describes the synthesis of the *o*-substituted 3-(arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines **1a-c** and **2a,c** (Scheme 2), the behavior of

Scheme 2



3a R^2 = H
3b R^2 = Me

1a R^1 = *o*-COOMe, R^2 = H
1b R^1 = *o*-COOEt, R^2 = H
1c R^1 = *o*-COOEt, R^2 = Me

4

2a R^1 = *o*-COOMe, R^2 = H
2b R^1 = *o*-COOEt, R^2 = H
2c R^1 = *o*-NO_2, R^2 = H

compounds **1a,b** and **2a,b** in a series of mixed dimethyl sulfoxide/trifluoroacetic acid (Tables 1,2), and the characteristic proton chemical shifts of *o*-, *m*-, and *p*-substituted compounds **1** and **2** to be diagnostic of the hydrazone imine **A** and diazenylenamine **B** forms (Tables 3,4).

2b (R^1 = *o*-COOEt, R^2 = H) was reported in a previous paper [5], which, however, contained the incorrect tautomer ratios [6] and signal assignment. Accordingly, the reliable data obtained from the HMBC and HMQC spectra are described in this paper.

Table 1

Selected PMR Spectral Data for Compounds **1a** and **1b**

Compound	R	TFA % in DMSO [a]	Tautomer Ratio A	Tautomer Ratio B	C_5-H A	C_5-H B	Hydrazone CH A	Diazenyl CH B	$C_{2'}$-Ester CH_2 A	$C_{2'}$-Ester CH_2 B	$C_{2'}$-Ester Me A	$C_{2'}$-Ester Me B
1a	Me	0	100	0	8.37	---	7.86	---	---	---	3.96	---
		25	100	0	8.36	---	7.84	---	---	---	3.87	---
		50	70	30	8.32	7.87	7.76	[b]	---	---	3.77	3.73
		75	0	100	---	7.74	---	8.12	---	---	---	3.60
		100	0	100	---	7.90	---	8.29	---	---	---	3.79
1b	Et	0	83	17	8.35	7.92	7.87	[b]	4.44	4.37	1.40	1.36
		25	57	43	8.33	7.90	7.83	[b]	4.35	4.28	1.30	1.26
		50	56	44	8.30	7.84	7.76	[b]	4.27	4.20	1.22	1.19
		75	13	87	7.81	7.76	7.60	8.12	4.07	4.07	1.05	1.04
		100	0	100	---	7.94	---	8.29	---	4.24	---	1.22

[a] TFA: trifluoroacetic acid; DMSO: deuteriodimethyl sulfoxide; 100% TFA in DMSO: deuteriotrifluoroacetic acid. [b] Overlapped with other signals.

Table 2

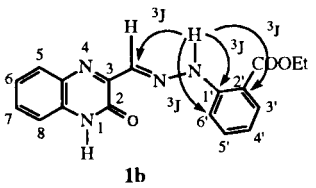
Selected PMR Spectral Data for Compounds **2a** and **2b**

Compound	R	TFA % in DMSO [a]	Tautomer Ratio A	Tautomer Ratio B	C_5-H A	C_5-H B	Ester Me A	Ester Me B	$C_{2'}$-Ester CH_2 A	$C_{2'}$-Ester CH_2 B	$C_{2'}$-Ester Me A	$C_{2'}$-Ester Me B
2a	Me	0	80	20	8.22	7.94	3.76	3.77	---	---	3.86	3.91
		25	79	21	8.20	7.88	3.69	3.70	---	---	3.78	3.82
		50	77	23	8.16	7.82	3.61	3.62	---	---	3.70	3.74
		75	23	77	8.04	7.76	3.59	3.70	---	---	3.56	3.65
		100	0	100	---	8.06	---	4.09	---	---	---	3.90
2b	Et	0	80	20	8.20	7.96	3.76	3.77	4.33	4.38	1.32	1.36
		25	79	21	8.19	7.90	3.69	3.70	4.26	4.30	1.24	1.27
		50	71	29	8.15	7.84	3.61	3.62	4.19	4.19	1.17	1.20
		75	27	73	7.94	7.72	3.58	3.70	3.99	4.10	1.06	1.10
		100	0	100	---	7.99	---	4.01	---	4.29	---	1.23

[a] TFA: trifluoroacetic acid; DMSO: deuteriodimethyl sulfoxide; 100% TFA in DMSO: deuteriotrifluoroacetic acid.

The reaction of 3-methyl-2-oxo-1,2-dihydroquinoxaline **3a** with *o*-methoxycarbonylbenzene diazonium salt or *o*-ethoxycarbonylbenzene diazonium salt gave 3-(*o*-methoxycarbonylphenylhydrazono)methyl-2-oxo-1,2-dihydroquinoxaline **1a** or 3-(*o*-ethoxycarbonylphenylhydrazono)methyl-2-oxo-1,2-dihydroquinoxaline **1b**, respectively (Scheme 2), while the reaction of 1,3-dimethyl-2-oxo-1,2-dihydroquinoxaline **3b** with *o*-ethoxycarbonylbenzene diazonium salt afforded 3-(*o*-ethoxycarbonylphenylhydrazono)-methyl-1-methyl-2-oxo-1,2-dihydroquinoxaline **1c**. The reaction of 3-methoxycarbonylmethylene-2-oxo-1,2,3,4-tetrahydroquinoxaline **4** with *o*-methoxycarbonylbenzene diazonium salt or *o*-nitrobenzenediazonium salt provided 3-[α-(*o*-methoxycarbonylphenylhydrazono)methoxycarbonyl-methyl]-2-oxo-1,2-dihydroquinoxaline **2a** or 3-[α-(*o*-nitrophenylhydrazono)methoxycarbonylmethyl]-2-oxo-1,2-dihydroquinoxaline **2c**, respectively. The synthesis of compound

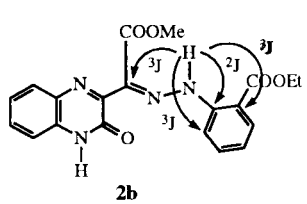
Chart 2



1b

Hydrazone Imine Form **A**

Hydrazone NH (δ 15.25)
Hydrazone CH (δ 7.87)
Hydrazone C (δ 125.3)
$C_{1'}$ (δ 145.7)
$C_{2'}$ (δ 112.2)
$C_{6'}$ (δ 114.1)



2b

Hydrazone Imine Form **A**

Hydrazone NH (δ 14.16)
Hydrazone C (δ 130.8)
$C_{1'}$ (δ 144.7)
$C_{2'}$ (δ 112.8)
$C_{6'}$ (δ 114.4)

HMBC Spectral Data for Compounds **1b** and **2b**

On the other hand, compounds **1** or **2** with the electron-donating substituent at *o*-position (R^1 = *o*-Me, *o*-Et, *o*-OMe) were hardly obtained by the above diazotization method.

Table 3

Selected PMR Spectral Data for Compounds **1** [a]

R^1	R^2	Hydrazone NH	N_4-H	Hydrazone CH	Diazenyl CH	Reference
o-COOMe	H	15.24	---	7.86	---	This work
o-COOEt	H	15.25	11.10	7.87	[b]	This work
o-COOEt	Me	15.21	---	7.90	---	This work
o-Cl	H	14.73	---	7.87	---	[7], [8]
m-CN	H	14.42	11.43	7.76	8.37	[4]
m-Cl	H	14.45	11.33	7.74	8.34	[7], [8]
m-OMe	H	14.44	11.20	7.71	8.33	[4]
m-Et	H	14.47	11.16	7.68	8.33	[4]
p-NO_2	H	14.53	11.90	7.86	8.49	[1]
p-CN	H	14.45	11.59	7.81	8.41	[2]
p-SO_2NH_2	H	14.50	11.49	7.78	8.41	[2]
p-COOEt	H	14.49	11.54	7.79	8.44	[1]
p-Cl	H	14.53	11.26	7.73	8.37	[7], [8]
p-F	H	14.48	11.21	7.68	8.31	[2]
p-H	H	14.50	11.21	7.70	8.33	[2]
p-Me	H	14.53	11.15	7.68	8.32	[1]
p-Et	H	14.53	11.17	7.68	8.33	[1]

[a] Measured in deuteriodimethyl sulfoxide. [b] Overlapped with other signals.

Table 4

Selected PMR Spectral Data for Compounds **2** [a]

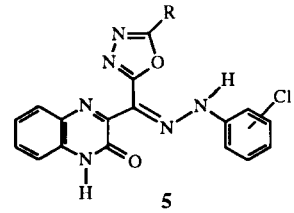
R^1	R^2	Hydrazone NH	N_4-H	Reference
o-NO_2	H	14.39	13.71	This work
o-COOMe	H	14.11	13.75	This work
o-COOEt	H	14.16	13.75	This work
o-Cl	H	13.72	12.53	[9]
m-Cl	H	11.07	11.83	[9]
p-NO_2	H	11.36	---	[1]
p-Cl	H	11.15	11.87	[9]
p-Me	H	11.13	---	[1]
p-NO_2	Me	11.29	---	[1]
p-Me	Me	11.00	---	[1]

[a] Measured in deuteriodimethyl sulfoxide.

The signals due to the hydrazone NH and hydrazone CH protons (tautomer A) and the N_4-H and diazenyl CH protons (tautomer B) of *o*-substituted compounds **1** were easily and accurately assigned by the HMBC and HMQC spectral data (Chart 2) [1,4]. Namely, the hydrazone NH proton signals observed at δ 15.25 (compound **1b**) and 14.16 (compound **2b**) ppm showed the coupling with the $C_{1'}$ (^{2}J), $C_{2'}$ (^{3}J), $C_{6'}$ (^{3}J), and hydrazone C (^{3}J) carbons. These data enabled the assignment of all proton signals, and hence the tautomer ratios of **A** to **B** were calculated from the integral curves of the hydrazone CH, diazenyl CH, C_5-H, and some other CH proton signals (Tables 1,2). Compounds **1a,b** and **2a,b** predominated as the hydrazone imine form **A** in dimethyl sulfoxide, but the tautomer **B** became predominant in 75 v/v% trifluoroacetic acid/dimethyl sulfoxide media. Moreover, compounds **1a,b** and **2a,b** exclusively occured as the diazenylenamine form **B** in trifluoroacetic acid. The tendency to increase the diazenylenamine form **B** with elevation of trifluoroacetic acid concentration in *o*-substituted compounds **1a,b** and **2a,b** was similar to that in *p*- and *m*-substituted compounds **1** and **2** [4].

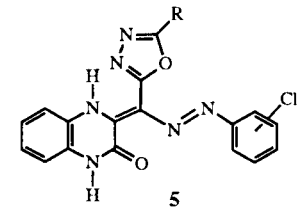
The chemical shifts of the hydrazone NH, N_4-H, hydrazone CH, and diazenyl CH protons for *o*-, *m*-, and *p*-substituted 3-(arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines **1** and **2** obtained so far are shown in Tables 3 and 4, respectively, whose data are diagnostic of the hydrazone imine **A** and diazenylenamine **B** forms as demonstrated later (Charts 3,4). In *o*-, *m*-, and *p*-substituted compounds **1**, the hydrazone NH proton signals (**A** form) were observed in a lower magnetic field than the N_4-H proton signals (**B** form), while the hydrazone CH proton signals (**A** form) were observed in a higher magnetic field than the diazenyl CH proton signals (**B** form). In *o*-substituted compounds **2**, the hydrazone NH proton signals (**A** form) were observed in a lower magnetic field than the N_4-H proton signals (**B** form). However, in *m*- and *p*-substituted compounds **2**, the hydrazone NH proton signals (**A** form) were

Chart 3



5

Hydrazone Imine Form **A**



5

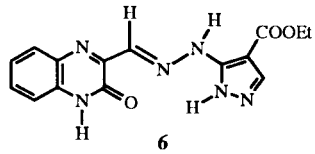
Diazenylenamine Form **B**

			Chemical Shift (δ) Hydrazone NH	N_4-H
5a	R = H	*o*-Cl	14.35	12.45
5b	R = Me	*o*-Cl	14.22	12.42
5c	R = H	*p*-Cl	11.44	11.97
5d	R = Me	*p*-Cl	11.18	11.95

observed in a higher magnetic field than the N_4-H proton signals (**B** form).

For example, the hydrazone NH and N_4-H proton signals of *o*- and *p*-substituted 3-(arylhydrazono)oxadiazolylmethyl-2-oxo-1,2-dihydroquinoxalines **5a-d** previously synthesized [10] (Chart 3) were easily inspected in comparison with those of *o*- and *p*-substituted 3-(arylhydrazono)-methoxycarbonylmethyl-2-oxo-1,2-dihydroquinoxalines **2** (Table 4), respectively. Namely, the hydrazone NH proton signals of compounds **5a,b** (*o*-Cl) (**A** form, δ 14.35-14.22) were observed in a lower magnetic field than the N_4-H proton signals of compounds **5a,b** (*o*-Cl) (**B** form, δ 12.45-12.42), while the hydrazone NH proton signals of compounds **5c,d** (*p*-Cl) (**A** form, δ 11.44-11.18) appeared in a higher magnetic field than the N_4-H proton signals of compounds **5c,d** (*p*-Cl) (**B** form, δ 11.97-11.95) (Chart 3). This tendency corresponds to that of compounds 2 [δ (hydrazone NH) lower than δ (N_4-H) in *o*-series; δ (hydrazone NH) higher than δ (N_4-H) in *p*-series] (Table 4). Furthermore, the 3-(pyrazolylhydrazono)methyl-2-oxo-1,2-dihydroquinoxaline **6** previously obtained [11] (Chart 4) was reported to exist as the hydrazone imine form **A** and to show the hydrazone CH proton signal at δ 7.82 ppm, whose assignment for the **A** form was also supported herein by the data represented in Table 3 [compounds **1**: hydrazone CH (δ 7.90-7.68), diazenyl CH (δ 8.49-8.31)].

Chart 4



6

Hydrazone Imine Form **A**

Hydrazone CH (δ 7.82)

EXPERIMENTAL

All melting points were determined on a Yazawa micro melting point BY-2 apparatus and are uncorrected. The ir spectra (potassium bromide) were recorded with a JASCO IRA-1 spectrophotometer. The mass spectra (ms) were determined with a JEOL JMS-01S spectrometer. The nmr spectra were obtained with a XL-400 spectrometer at 400 MHz and measured in deuteriodimethyl sulfoxide. Chemical shifts are given in δ scale. Elemental analyses were performed on a Perkin-Elmer 240B instrument.

3-(*o*-Methoxycarbonylphenylhydrazono)methyl-2-oxo-1,2-dihydroquinoxaline **1a**.

A solution of sodium nitrite (2.59 g, 37.6 mmoles) in water (50 ml) was added to a solution of methyl *o*-aminobenzoate (5.68 g, 37.6 mmoles) in acetic acid (50 ml) with stirring in an ice-water bath to give a clear solution, which was added to a solution of 3-methyl-2-oxo-1,2-dihydroquinoxaline (3 g, 18.8 mmoles) in acetic acid (50 ml). The mixture was heated on a boiling water bath for 30 minutes to precipitate orange needles **1a**, which were collected by suction filtration and washed with hot *N,N*-dimethylformamide/ethanol (1:1) and then *n*-hexane to provide an analytically pure sample (5.08 g, 84%), mp 328-329°; ir: ν cm^{-1} 1695, 1655; ms: m/z 322 (M^+); pmr: (hydrazone imine form **A**, 100%) 15.24 (s, 1H, hydrazone NH), 12.54 (br, 1H, N_1-H), 8.37 (dd, J = 8.0 Hz, J = 1.5 Hz, 1H, C_5-H), 7.94 (dd, J = 8.0 Hz, J = 1.5 Hz, 2H, $C_{3'}$-H and $C_{6'}$-H) 7.86 (s, 1H, hydrazone CH), 7.60 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, 1H, C_5-H), 7.53 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_7-H), 7.37 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, 1H, C_6-H), 7.28 (dd, J = 8.0 Hz, J = 1.5 Hz, 1H, C_8-H), 7.03 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, 1H, $C_{4'}$-H), 3.96 (s, 3H, CH_3).

Anal. Calcd. for $C_{17}H_{14}N_4O_3$: C, 63.35; H, 4.38; N, 17.38. Found: C, 63.32; H, 4.52; N, 17.21.

3-(*o*-Ethoxycarbonylphenylhydrazono)methyl-2-oxo-1,2-dihydroquinoxaline **1b**.

A solution of sodium nitrite (2.16 g, 31.3 mmoles) in water (30 ml) was added to a solution of ethyl *o*-aminobenzoate (5.16 g, 31.3 mmoles) in acetic acid (50 ml) with stirring in an ice-water bath to give a red clear solution, which was added to a solution of 3-methyl-2-oxo-1,2-dihydroquinoxaline (2 g, 12.5 mmoles) in acetic acid (50 ml). The mixture was heated on a boiling water bath for 1 hour to precipitate orange crystals **1b**, which were collected by suction filtration and washed with ethanol (3.79 g, 90%). Recrystallization from *N,N*-dimethylformamide/ethanol afforded orange needles as hemihydrate, mp 303-304°; ir: ν cm^{-1} 1680, 1650; ms: m/z 336 (M^+); pmr: (hydrazone imine form A, 83%) 15.25 (s, hydrazone NH), 12.50 (br, N_1-H), 8.35 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.96 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H and $C_{6'}$-H), 7.87 (s, hydrazone CH), 7.60 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.54 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_7-H), 7.37 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_6-H), 7.30 (dd, J = 8.0 Hz, J = 1.5 Hz, C_8-H), 7.04 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{4'}$-H), 4.44 (q, J = 7.0 Hz, CH_2), 1.40 (t, J = 7.0 Hz, CH_3); (diazenylenamine form **B**, 17%) 12.50 (br, N_1-H), 11.10 (s, N_4-H), 7.92 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.82 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.78 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{6'}$-H), 6.92 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{4'}$-H), 4.37 (q, J = 7.0 Hz, CH_2), 1.36 (t, J = 7.0 Hz, CH_3). Other minor proton signals were overlapped with the major proton signals.

Anal. Calcd. for $C_{18}H_{16}N_4O_3 \cdot 1/2H_2O$: C, 62.66; H, 4.96; N, 16.22. Found: C, 62.85; H, 4.73; N, 16.05.

3-(*o*-Ethoxycarbonylphenylhydrazono)methyl-1-methyl-2-oxo-1,2-dihydroquinoxaline **1c**.

A solution of sodium nitrite (2.37 g, 34.4 mmoles) in water (50 ml) was added to a solution of ethyl *o*-aminobenzoate (5.68 g, 34.4 mmoles) in acetic acid (50 ml) with stirring in an ice-water bath to give a red clear solution, which was added to a solution of 1,3-dimethyl-2-oxo-1,2-dihydroquinoxaline (3 g, 17.2 mmoles) in acetic acid (50 ml). The mixture was heated on a boiling water bath for 15 minutes to precipitate orange crystals **1c**, which were collected by suction filtration and washed with ethanol. Recrystallization from *N,N*-dimethylformamide/ethanol afforded orange needles (3.10 g, 51%), mp 210-211°; ir: ν cm^{-1} 1690, 1645, 1600; ms: m/z 350 (M^+); pmr: (hydrazone imine form **A**, 100%) 15.21 (s, 1H, hydrazone NH), 8.42 (dd, J = 8.0 Hz, J = 1.0 Hz, 1H, C_5-H), 7.95 (dd, J = 8.0 Hz, J = 1.0 Hz, 1H, $C_{3'}$-H), 7.93

(dd, J = 8.0 Hz, J = 1.0 Hz, 1H, $C_{6'}$-H), 7.90 (s, 1H, hydrazone CH), 7.64 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 10 Hz, 1H, C_7-H), 7.60 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.0 Hz, 1H, $C_{5'}$-H), 7.55 (dd, J = 8.0 Hz, J = 1.0 Hz, 1H, C_8-H), 7.45 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.0 Hz, 1H, C_6-H), 7.03 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.0 Hz, 1H, $C_{4'}$-H), 4.44 (q, J = 7.0 Hz, 2H, CH_2), 3.64 (s, 3H, N_1-CH_3), 1.39 (t, J = 7.0 Hz, 3H, CH_3).

Anal. Calcd. for $C_{19}H_{18}N_4O_3$: C, 65.13; H, 5.18; N, 15.99. Found: C, 65.08; H, 5.16; N, 16.01.

3-[α-(*o*-Methoxycarbonylphenylhydrazono)methoxycarbonylmethyl]-2-oxo-1,2-dihydroquinoxaline **2a**.

A solution of sodium nitrite (1.90 g, 27.6 mmoles) in water (50 ml) was added to a solution of methyl *o*-aminobenzoate (4.17 g, 27.6 mmoles) in acetic acid (50 ml) with stirring in an ice-water bath to give a clear solution, which was added to a suspension of 3-methoxycarbonylmethylene-2-oxo-1,2,3,4-tetrahydroquinoxaline (3 g, 13.8 mmoles) in acetic acid (50 ml). The mixture was heated on a boiling water bath for 30 minutes to precipitate orange needles. Evaporation of the solvent in vacuo afforded orange crystals **2a**, which were collected by suction filtration. Recrystallization from *N,N*-dimethylformamide/ethanol provided orange needles (2.13 g, 41%), mp 252-253°; ir: ν cm^{-1} 1730, 1650; ms: m/z 380 (M^+); pmr: (hydrazone imine form **A**, 80%) 14.11 (s, hydrazone NH), 12,75 (br, N_1-H), 8.22 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.91 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.84 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{6'}$-H), 7.64 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{5'}$-H), 7.61 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 H, C_7-H), 7.41 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_6-H), 7.35 (dd, J = 8.0 Hz, J = 1.5 Hz, C_8-H), 7.07 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{4'}$-H), 3.86 (s, $C_{2'}$-$COOCH_3$), 3.76 (s, OCH_3); (diazenylenamine form **B**, 20%) 13.75 (s, N_4-H), 12.75 (br, N_1-H), 7.94 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.85 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.77 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{6'}$-H), 3.91 (s, $C_{2'}$-$COOCH_3$), 3.77 (s, OCH_3). Other minor proton signals were overlapped with the major proton signals.

Anal. Calcd. for $C_{19}H_{16}N_4O_5$: C, 59.99; H, 4.24; N, 14.73. Found: C, 59.97; H, 4.38; N, 14.68.

3-[α-(*o*-Ethoxycarbonylphenylhydrazono)methoxycarbonylmethyl]-2-oxo-1,2-dihydroquinoxaline **2b**.

The pmr spectral data are: (hydrazone imine form **A**, 80%) 14.16 (s, hydrazone NH), 12.75 (br, N_1-H), 8.20 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.93 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.84 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{6'}$-H), 7.64 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{5'}$-H), 7.61 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_7-H), 7.40 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, C_6-H), 7.35 (dd, J = 8.0 Hz, J = 1.5 Hz, C_8-H), 7.07 (ddd, J = 8.0 Hz, J = 8.0 Hz, J = 1.5 Hz, $C_{4'}$-H), 4.33 (q, J = 7.0 Hz, $C_{2'}$-ester CH_2), 3.76 (s, OCH_3), 1.32 (t, J = 7.0 Hz, $C_{2'}$-ester CH_3); (diazenylenamine form **B**, 20%) 13.75 (s, N_4-H), 12.75 (br, N_1-H), 7.96 (dd, J = 8.0 Hz, J = 1.5 Hz, C_5-H), 7.85 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.77 (dd, J = 8.0 Hz, J = 1.5 Hz, $C_{6'}$-H), 4.38 (q, J = 7.0 Hz, $C_{2'}$-ester CH_2), 3.77 (s, OCH_3), 1.36 (t, J = 7.0 Hz, $C_{2'}$-ester CH_3). Other minor proton signals were overlapped with the major proton signals.

3-[α-(*o*-Nitrophenylhydrazono)methoxycarbonylmethyl]-2-oxo-1,2-dihydroquinoxaline **2c**.

A solution of sodium nitrite (3.80 g, 55.1 mmoles) in water (30 ml) was added to a solution of *o*-nitroaniline (7.60 g, 55.1 mmoles) in acetic acid (100 ml) with stirring in an ice-water bath to give a clear solution, which was added to a solution of 3-methoxycarbonylmethylene-2-oxo-1,2,3,4-tetrahydroquinoxaline (10 g, 45.9 mmoles) in acetic acid (250 ml). The mixture was heated on a boiling water bath for 30 minutes to precipitate orange crystals **2c**, which were collected by suction filtration (10.50 g, 62%). Recrystallization from *N,N*-dimethylformamide/ethanol afforded orange needles, mp 274-275°; ir: ν cm^{-1} 1730, 1645, 1600; ms: m/z 367 (M^+); pmr: (hydrazone imine form **A**, 87%) 14.39 (s, hydrazone NH), 12.80 (br, N_1-H), 8.19 (dd, J = 8.5 Hz, J = 1.5 Hz, $C_{3'}$-H), 8.07 (dd, J = 8.5 Hz, J = 1.5 Hz, C_5-H), 7.98 (dd, J = 8.5 Hz, J = 1.5 Hz, $C_{6'}$-H), 7.78 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, $C_{5'}$-H), 7.64 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, C_7-H), 7.44 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, C_6-H), 7.36 (dd, J = 8.5 Hz, J = 1.5 Hz, C_8-H), 7.16 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, $C_{4'}$-H), 3.78 (s, OCH_3); (diazenylenamine form **B**, 13%) 13.71 (s, N_4-H), 12.80 (br, N_1-H), 8.21 (dd, J = 8.5 Hz, J = 1.5 Hz, $C_{3'}$-H), 7.92 (dd, J = 8.5 Hz, J = 1.5 Hz, C_5-H), 7.86 (dd, J = 8.5 Hz, J = 1.5 Hz, $C_{6'}$-H), 7.74 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, $C_{5'}$-H), 7.60 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, C_7-H), 7.35 (dd, J = 8.5 Hz, J = 1.5 Hz, C_8-H), 7.17 (ddd, J = 8.5 Hz, J = 8.5 Hz, J = 1.5 Hz, $C_{4'}$-H), 3.80 (s, OCH_3). The C_6-H proton signal of the **B** form was overlapped with that of the **A** form.

Anal. Calcd. for $C_{17}H_{13}N_5O_5$: C, 55.59; H, 3.57; N, 19.07. Found: C, 55.72; H, 3.56; N, 19.35.

REFERENCES AND NOTES

[1] Y. Kurasawa, T. Hosaka, K. Ikeda, Y. Matsumoto, A. Ishikura, A. Takada, H. S. Kim, and Y. Okamoto, *J. Heterocyclic Chem.*, **31**, 527 (1994).

[2] Y. Kurasawa, T. Hosaka, A. Takada, H. S. Kim, and Y. Okamoto, *J. Heterocyclic Chem.*, **31**, 1661 (1994).

[3] Y. Kurasawa, T. Hosaka, A. Takada, H. S. Kim, and Y. Okamoto, *J. Heterocyclic Chem.*, **32**, 351 (1995).

[4] Y. Kurasawa, T. Hosaka, A. Takada, H. S. Kim, and Y. Okamoto, *J. Heterocyclic Chem.*, **32**, 445 (1995).

[5] H. S. Kim, Y. Kurasawa, and A. Takada, *J. Heterocyclic Chem.*, **26**, 1129 (1989).

[6] The tautomer ratio of **A** to **B** calculted from the integral ratios of the NH proton signals in reference [5] was inferior in accuracy to that calculated from the integral ratio of the CH proton signals in the present investigation.

[7] Y. Kurasawa, K. Yamazaki, S. Tajima, Y. Okamoto, and A. Takada, *J. Heterocyclic Chem.*, **23**, 957 (1986).

[8] Y. Kurasawa, M. Muramatsu, K. Yamazaki, S. Tajima, Y. Okamoto, and A. Takada, *J. Heterocyclic Chem.*, **23**, 1379 (1986).

[9] Y. Kurasawa, M. Muramatsu, K. Yamazaki, S. Tajima, Y. Okamoto, and A. Takada, *J. Heterocyclic Chem.*, **23**, 1245 (1986).

[10] Y. Kurasawa, M. Muramatsu, Y. Okamoto, and A. Takada, *J. Heterocyclic Chem.*, **23**, 637 (1986).

[11] Y. Kurasawa, H. S. Kim, K. Yonekura, A. Takada, and Y. Okamoto, *J. Heterocyclic Chem.*, **26**, 867 (1989).