

### 3-( $\alpha$ -Arylhydrazono)methyl-2-oxo-1,2-dihydroquinoxalines between Hydrazone Imine and Diazenyl Enamine Forms [1]

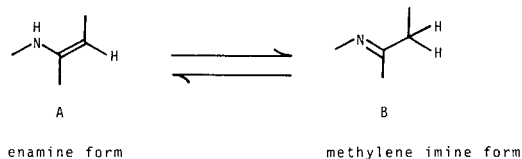
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3-( $\alpha$ -Chlorophenylhydrazono-1,3,4-oxadiazol-2-ylmethyl)-2-oxo-1,2-dihydroquinoxalines **4a-d** and 3-( $\alpha$ -chlorophenylhydrazono)methoxycarbonylmethyl-2-oxo-1,2-dihydroquinoxalines **5a-c** have been clarified to exhibit the characteristic tautomeric equilibria between the hydrazone imine form **C** and the diazenyl enamine form **D** with a long-range prototropy by means of the pmr and  $^{13}\text{C}$ -nmr spectroscopies.

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The tautomeric equilibria between the enamine form **A** and the methylene imine form **B** (Scheme 1) have been investigated in the quinoxaline derivatives **1a-c** (Scheme 2)



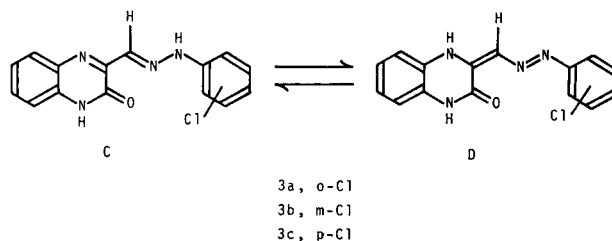
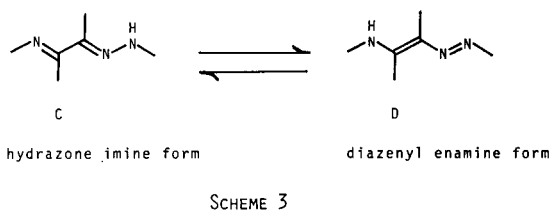
SCHEME 1



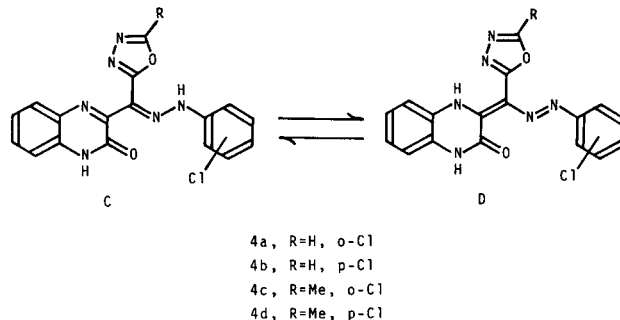
1a, R=COR'  
1b, R=1,3,4-Oxadiazol-2-yl  
1c, R=1,2,4-Triazol-2-yl

SCHEME 2

by Mondelli *et al.* [2] and the author's group [3-5] by means of pmr and uv spectroscopies. Namely, the pmr spectra of **1a-c** in dimethylsulfoxide (DMSO) demonstrated that the two tautomers, the enamine form **A** and the methylene imine form **B**, coexist in the media. Moreover, the pmr spectra of **1a,c** in trifluoroacetic acid showed the predominance of the methylene imine form **B**. Thus, the tautomeric behaviors of the **1a-c** type of compounds have been well established by means of the various spectral data. However, there have been reported few papers on the tautomeric equilibria of the quinoxaline derivatives between the hydrazone imine form **C** and the diazenyl enamine form **D** (Scheme 3). Romanenko *et al.* [6] reported the species **2a** (**C** form), **2b** (**D** form) and **2c** (**D** form), which existed as a single tautomeric species in the

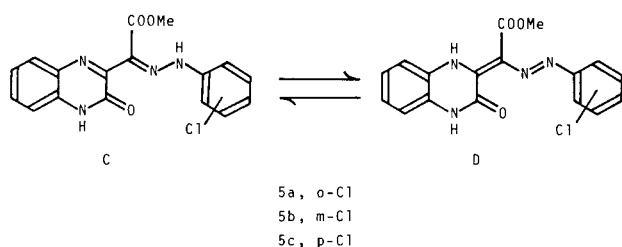


SCHEME 4 Tautomeric Equilibria of 3a-c in DMSO



SCHEME 5 Tautomeric Equilibria of 4a-d in DMSO

ethanol solutions (Chart 1). In recent studies, we have synthesized the **2** type of compounds such as 3-formyl-2-oxo-1,2-dihydroquinoxaline chlorophenylhydrazones **3a-c** [7] (Scheme 4), 3-( $\alpha$ -chlorophenylhydrazono-1,3,4-oxadiazol-2-ylmethyl)-2-oxo-1,2-dihydroquinoxalines **4a-d** [1] (Scheme 5) and 3-( $\alpha$ -chlorophenylhydrazono)methoxycarbonylmethyl-2-oxo-1,2-dihydroquinoxalines **5a-c** [8] (Scheme 6). In



SCHEME 6 Tautomeric Equilibria of 5a-c in DMSO

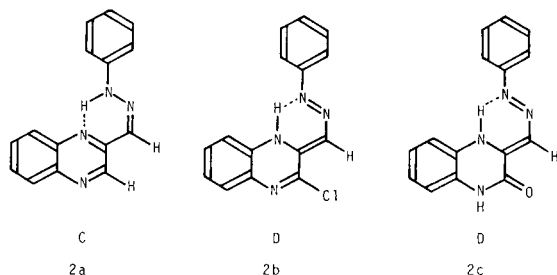


CHART 1

contrast to the above data for the species **2a-c** in the ethanol solutions, compounds **3b,c** were reported to exhibit the characteristic tautomeric equilibria between the **C** and **D** form in the DMSO solutions [7]. That is, the pmr spectrum of **3a** represented the hydrazone NH ( $\delta$  14.75 ppm) and hydrazone CH ( $\delta$  7.87 ppm) proton signals, while the pmr spectra of **3b,c** exhibited the hydrazone NH [ $\delta$  14.45 (**3b**), 14.53 (**3c**) ppm] and hydrazone CH [ $\delta$  7.78 (**3b**), 7.73 (**3c**) ppm] proton signals together with the  $N_4$ -H [ $\delta$  11.33 (**3b**), 11.26 (**3c**) ppm] and diazenyl CH [ $\delta$  8.40 (**3b**), 8.37 (**3c**) ppm] proton signals. Moreover, compounds **4a-d** and **5a-c** were also found to show the tautomeric equilibria between the **C** and **D** forms in the DMSO solutions. This paper describes the tautomeric behaviors of compounds **4a-d** and **5a-c** in DMSO with a long-range prototropy based on the pmr and  $^{13}\text{C}$ -nmr spectral data.

#### Tautomeric Equilibria of 4a-d.

In consideration of the above data for **3a-c**, the pmr spectral data for **4a-d** (Table 1) also indicated their tautomeric equilibria between the **C** and **D** forms in the DMSO solutions, as described below. The pmr spectrum of **4a**

Table 1

The PMR Spectral Data for 4a-d

Compound	Tautomer Ratio [a]		Chemical Shift $\delta$ (ppm) NH	$C_5$ -H or -Me	Aromatic
	C	D			
<b>4a</b>	2	1	14.35 (s, 2/3 H, =N-NH-) [b] 12.45 (s, 1/3 H, $N_4$ -H) [c] 12.80 (s, 1H, $N_1$ -H)	9.30 (s, 2/3 H, $C_5$ -H) [b] 9.47 (s, 1/3 H, $C_5$ -H) [c]	8.03-6.80 (m, 8H)
<b>4b</b>	5	1	11.45 (s, 5/6 H, =N-NH-) [b] 11.97 (s, 1/6 H, $N_4$ -H) [c] 12.80 (s, 1H, $N_1$ -H)	9.27 (s, 5/6 H, $C_5$ -H) [b] 9.42 (s, 1/6 H, $C_5$ -H) [c]	8.07-7.10 (m, 8H)
<b>4c</b>	1	1	14.22 (s, 1/2 H, =N-NH-) [b] 12.42 (s, 1/2 H, $N_4$ -H) [c] 12.77 (s, 1H, $N_1$ -H)	2.57 (s, 3H, $C_5$ -Me)	8.00-6.93 (m, 8H)
<b>4d</b>	4	1	11.18 (s, 4/5 H, =N-NH-) [b] 11.95 (s, 1/5 H, $N_4$ -H) [c] 12.76 (s, 1H, $N_1$ -H)	2.59 (s, 3H, $C_5$ -Me)	8.07-7.17 (m, 8H)

[a] Calculated from integral curves of hydrazone NH,  $N_4$ -H and  $C_5$ -H proton signals. [b] Signals due to the tautomer **C**. [c] Signals due to the tautomer **D**.

Table 2

The  $^{13}\text{C}$ -NMR Spectral Data for 4c,d

Compound	Chemical Shift $\delta$ (ppm)
<b>4c</b>	163.11, 163.07, 162.81, 162.34, 159.11, 154.22, 153.32, 151.62, 148.72, 139.05, 138.79, 132.54, 132.34, 131.82, 131.76, 131.53, 130.55, 129.67, 129.24, 128.59, 128.51, 128.15, 124.18, 124.09, 123.83, 123.54, 122.52, 122.27, 119.29, 118.54, 115.77, 115.19, 115.08, 95.50, 10.67, 10.48
<b>4d</b>	163.36, 162.65, 162.49, 154.20, 154.18, 153.80, 153.65, 151.81, 151.17, 142.53, 141.79, 132.80, 132.45, 132.11, 131.88, 131.71, 131.27, 129.40, 129.31, 129.13, 126.52, 125.26, 124.23, 123.75, 123.58, 121.01, 116.11, 115.69, 115.19, 95.52, 10.71, 10.50,

Table 3  
The PMR Spectral Data for **5a-c**

Compound	Tautomer Ratio [a]		Chemical Shift $\delta$ (ppm)		
	C	D	NH	Me	Aromatic
<b>5a</b>	9	2	13.72 (s, 9/11 H, =N-NH-) [b] 12.53 (s, 2/11 H, N <sub>4</sub> H) [c] 12.83 (s, 1H, N <sub>1</sub> -H)	3.83 (s, 3H)	8.00-6.93 (m, 8H)
<b>5b</b>	10	1	11.15 (s, 10/11 H, =N-NH-) [b] 11.87 (s, 1/11 H, N <sub>4</sub> H) [c] 12.67 (s, 1 H, N <sub>1</sub> -H)	3.75 (s, 3H)	8.00-6.90 (m, 8H)
<b>5c</b>	8	1	11.17 (s, 8/9 H, =N-NH-) [b] 11.90 (s, 1/9 H, N <sub>4</sub> H) [c] 12.64 (s, 1H, N <sub>1</sub> -H)	3.73 (s, 3H)	8.00-7.17 (m, 8H)

[a] Calculated from integral curves of hydrazone NH and N<sub>4</sub>-H proton signals. [b] Signals due to the tautomer C. [c] Signals due to the tautomer D.

Table 4  
The <sup>13</sup>C-NMR Spectral Data for **5a,b**

Compound	Chemical Shift $\delta$ (ppm)
<b>5a</b>	164.83, 162.73, 154.66, 153.64, 153.57, 149.18, 138.92, 138.50 132.40, 132.17, 131.84, 131.70, 131.19, 130.57, 130.11, 129.64 129.13, 128.62, 128.19, 124.23, 123.75, 123.67, 118.99, 118.51 115.81, 115.68, 114.88, 114.73, 52.50, 52.31,
<b>5b</b>	163.76, 153.86, 152.34, 144.92, 144.51, 133.99, 133.92, 132.63 132.55, 132.33, 132.03, 131.66, 131.55, 131.36, 131.20, 131.18 131.07, 129.86, 129.31, 129.09, 123.72, 122.24, 121.59, 115.78 115.66, 115.54, 114.14, 113.68, 113.59, 113.29, 112.72, 52.16

showed the hydrazone NH ( $\delta$  14.35 ppm) and N<sub>4</sub>-H ( $\delta$  12.45 ppm) proton signals together with the two C<sub>5</sub>-H [ $\delta$  9.30 (due to **C** form), 9.47 (due to **D** form) ppm] proton signals. The spectrum of **4b** also represented the two C<sub>5</sub>-H [ $\delta$  9.27 (due to **C** form), 9.42 (due to **D** form) ppm] proton signals, whose values were similar to those of **4a**. In the case of **4b**, the hydrazone NH and N<sub>4</sub>-H proton signals were observed at  $\delta$  11.45 and 11.97 ppm, respectively. The spectra of **4c** and **4d** exhibited the hydrazone NH [ $\delta$  14.22 (**4c**), 11.18 (**4d**) ppm] and N<sub>4</sub>-H [ $\delta$  12.42 (**4c**), 11.95 (**4d**) ppm] proton signals at similar magnetic fields to those observed in **4a** and **4b**, respectively. The C<sub>5</sub>-Me proton signals of the **C** and **D** forms coalesced at  $\delta$  2.57 and 2.59 ppm in **4c** and **4d**, respectively. Moreover, the <sup>13</sup>C-nmr spectrum of **4c** exhibited the thirty-six carbon signals due to the **C** (eighteen carbons) and **D** (eighteen carbons) forms of **4c**, wherein the C<sub>5</sub>-Me carbon signals were observed at  $\delta$  10.67 and 10.48 ppm (Table 2). The <sup>13</sup>C-nmr spectrum of **4d** also showed the thirty-two carbon signals due to the **C** (eighteen carbons) and **D** (eighteen carbons) forms of **4d**, wherein the C<sub>5</sub>-Me carbon signals were observed at  $\delta$  10.71 and 10.50 ppm.

The tautomer ratios of the **C** form versus the **D** form in **4a-d** were 2:1, 5:1, 1:1 and 4:1, respectively, when calculated from the integral curves of the hydrazone NH, N<sub>4</sub>-H and C<sub>5</sub>-H proton signals.

#### Tautomeric Equilibria of **5a-c**.

The pmr spectral data for **5a-c** (Table 3) were similar to those for **4a-d** with respect to values of the hydrazone NH and N<sub>4</sub>-H proton signals, indicating the tautomeric equilibria of **5a-c** between the **C** and **D** forms in DMSO. The pmr spectrum of **5a** represented the hydrazone NH and N<sub>4</sub>-H proton signals at  $\delta$  13.72 and 12.53 ppm, respectively, whose values were similar to those of **4a,c**. The pmr spectra of **5b,c** exhibited the hydrazone NH [ $\delta$  11.15 (**5b**), 11.17 (**5c**) ppm] and N<sub>4</sub>-H [ $\delta$  11.87 (**5b**), 11.90 (**5c**) ppm] proton signals at similar magnetic fields to those observed in **4b,d**. The methyl proton signals of the **C** and **D** forms coalesced at  $\delta$  3.83, 3.75 and 3.73 ppm in **5a**, **5b** and **5c**, respectively. Furthermore, the <sup>13</sup>C-nmr spectrum of **5a** showed the thirty carbon signals due to the **C** (seventeen carbons) and **D** (seventeen carbons) forms of **5a**, wherein the methyl carbon signals were observed at  $\delta$  52.50 and

52.31 ppm (Table 4). The  $^{13}\text{C}$ -nmr spectrum of **5b** also exhibited the thirty-two carbon signals due to the **C** (seventeen carbons) and **D** (seventeen carbons) forms of **5b**, wherein the methyl carbon signals coalesced at  $\delta$  52.16 ppm.

The tautomer ratios of the **C** form versus the **D** form in **5a-c** were 9:2, 10:1 and 8:1, respectively.

#### EXPERIMENTAL

The pmr and  $^{13}\text{C}$ -nmr spectra were measured in deuteriodimethylsulfoxide at  $34^\circ$  with an EM-390 and XL-400 spectrometers at 90 and 400 MHz, respectively, using tetramethylsilane as an internal standard. The concentration of the samples were near 10%. The syntheses of all samples employed herein were described in previous papers [1,8].

#### REFERENCES AND NOTES

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