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GLYOXAL DERIVATIVES—I[1]

CONJUGATED ALIPHATIC DIIMINES FROM GLYOXAL AND ALIPHATIC PRIMARY AMINES

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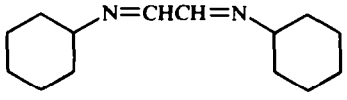
Abstract—Glyoxal reacts with primary aliphatic amines such as cyclohexylamine, n-butylamine, isopropylamine, isobutylamine and t-butylamine to give conjugated diimines whose conformations are shown to be *E*—*E*.

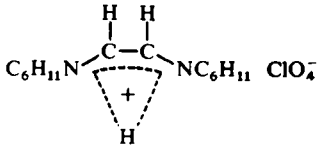
THE reports that glyoxal sulfate reacts with ethylamine to give N,N′-diethylglycinamide[2a] whereas aqueous glyoxal reacts either with cyclohexylamine to give N,N′-dicyclohexylethylenediimine,[2b,c] or with n-butylamine and isopropylamine to give tars from which no products could be isolated,[2c] has led to our study of the reaction between aliphatic amines and aqueous glyoxal.

In this paper we report the synthesis of conjugated aliphatic diimines and their conformations.

Glyoxal reacts rapidly with cyclohexylamine to give, as reported,[2b,c] a 95% yield of N,N′-dicyclohexylethylenediimine, **1**.

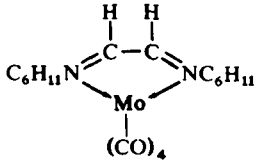


1



2

Titration of N,N′-dicyclohexylethylenediimine, **1**, with 0·1 N perchloric acid in acetic acid shows it to be essentially monobasic (1·15 nitrogen equivs per mole) and after several hours a 39% yield of crystalline precipitate of N,N′-dicyclohexylethylenediimine hydroperchlorate, **2**, is isolated. The structure of **2** is proposed to be a planar, highly-stabilized, 5-membered ring containing the proton and the diimine system. The conformational requirement upon the diimine is that it be capable of existing in an *E*-s-*cis*-*E* configuration,[3] **1b**. Similar conformational requirements are placed on these diimines in the formation of transition metal complexes. For example, compound **1** acts as a bidentate ligand with molybdenum tetracarbonyl:[4]



An inspection of a molecular model of **1** indicates that the sterically most stable conformation is *E*-s-*trans*-*E*, **1a**.

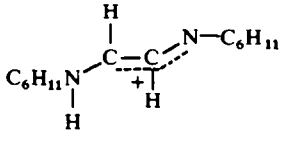
1a
E-s-*trans*-*E*

1b
E-s-*cis*-*E*

More recent studies on the structure of imines confirms the greater stability of the *E*-conformation and, in fact, the position of the resonance line in the nmr spectrum for the aldimine protons in **1** coincides with those observed for imines of the type

$(CH_3)_2CHC\underline{H}{=}NR$,[5a] $RC\underline{H}{=}NR'$[5b] and $(CH_3)_3CC\underline{H}{=}NC(CH_3)_3(E)$.[5c]

Conformation **1a** is probably preferred in solution; however, protonation leads to a less stable species with a positive charge delocalized along the diimine system:

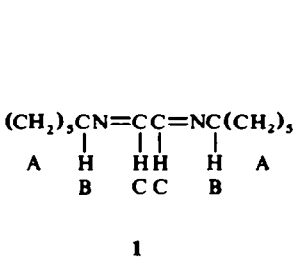


1c

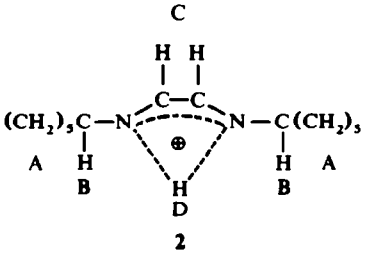
Free rotation around the carbon-carbon bond of **1c** will then give the resonance-stabilized, 5-membered ring. Further evidence for the structure of **2** is found in the comparison of its nmr spectrum with that of **1** (Table 1).

The huge, equivalent downfield shift of both B protons in **2** can only be explained in terms of equal deshielding by proton D. Owing to steric interaction, only an *E*-s-*cis*-*E* configuration affords the possibility of this effect. In addition, no additional

TABLE 1. NMR SPECTRA OF SCHIFF BASES 1 AND 2[a]



1

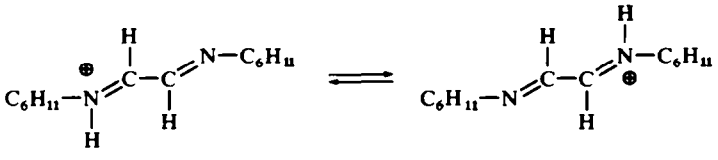


2

	A	B	C	D
1[b]	1·67 (m)	3·20 (m)	7·93 (s)	—
2[c]	1·94 (m)	4·90 (m)	7·86 (s)	10·00 (s)
2[d]	1·80 (m)	4·80 (m)	7·47 (s)	9·83 (s)

[a] 100 mH, in ppm from TMS
[b] $CDCl_3$
[c] CD_3CN
[d] CF_3CO_2H

splittings of either proton B or C are observed in 2, in either acetonitrile or trifluoro acetic acid, thereby ruling out the possibility of a tautomeric equilibrium:*



Further evidence that tautometric equilibria do not place an important role in the protonation of these conjugated diimines is also evidence by the "normal" addition of two moles of perchloric acid by N,N'-dibenzylidineethylenediamine, 3, and by comparison in Table 2 of its NMR spectrum in CS_2 and trifluoroacetic acid in which exchange clearly does take place.

$$C_6H_5CH{=}NCH_2CH_2N{=}CHC_6H_5$$

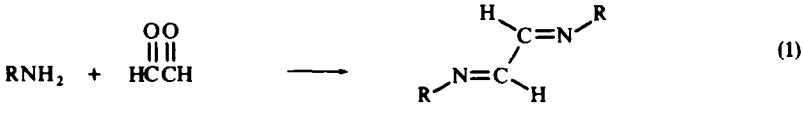
3

* Protonated amines in trifluoracetic acid display multiplicities due to slowing down (on the NMR time scale) of exchange reactions. Thus, the methyls of trimethyl ammonium chloride in trifluoroacetic acid appear as a doublet, $J = 3$ c/s. Unpublished results.

TABLE 2. NMR SPECTRA OF COMPOUND 3

Solvent	HCN=	HC=N
CS_2	4·08 (s)	7·97 (s)
CF_3CO_2H	3·80 (broad)	8·72 (s)
	4·58 (broad)	9·65 (s)

Other primary amines that react with glyoxal to give diimines with the *E*-s-*trans*-*E* conformation are given in Eq. 1:



(1)

R = n-C_4H_9 (**4**); i-C_4H_9 (**5**); i-C_3H_7 (**6**); t-C_4H_9 (**7**)

Titration of compounds **4**–**6** with 0·1 N perchloric acid results in the same monobasic behavior as compound **1**. Unlike compounds **1**, **4**, **5** and **6**, compound **7** is dibasic to 0·1 N perchloric acid. This is caused by an acid-catalyzed hydrolysis of the diimine as evidenced by the isolation of t-butylammonium acetate from its reaction with acetic acid.

The ultraviolet spectra of these conjugated diimines show a weak absorption at 268–278 mμ and are given in Table 3.*

TABLE 3. UV ABSORPTION OF CONJUGATED DIIMINES[a]

Compound	λ, mμ	Log ε
1	268	2·29
4	272	2·33
5	272	2·33
6	272	2·30
7	278	2·29

[a] 95% EtOH

EXPERIMENTAL**

N,N'-*Dicyclohexylethylenediimine*, **1**. A soln of 40·5 g (0·40 mole) of cyclohexylamine in 100 ml MeOH was mixed with 27·0 g of 40% aqueous glyoxal (0·20 mole) and cooled (0°). The white solid that separated was collected on a filter. Recrystallization of this material from MeOH/water gave 42·0 g needles, m.p.

* Aliphatic nonconjugated azomethines have a weak $n \rightarrow \pi^*$ transition occuring around 230–250 mμ.[6]

** All m.ps and b.ps are uncorrected. The IR spectra were determined on Perkin–Elmer Model 21 and Baird Model 455 spectrophotometers; the UV spectra were determined on a Cary 14 spectrophotometer; the NMR spectra were determined on Varian A60 and HA100 spectrometers; and the mass spectra were determined on a CEC21-130 mass spectrometer by Messrs. W. H. Joyce, C. M. Lovell, C. B. Strow, Jr., and B. E. Wilkes. Microanalysis were performed by Mr. S. Gottlieb and his associates.

145–147° (Lit.1 148–149°), 95% yield. The NMR spectrum ($CDCl_3$) showed, in ppm from TMS, the following peaks: 1·67 (m 20H) 3·20 (m 1·9H) 7·93 (s 1·9H). The IR spectrum (KBr) had a strong band at 6·15 μ (C=N).

N,N'-*Dicyclohexylethylenediimine hydroperchlorate*, 2. N,N'-Dicyclohexylethylenediimine (1·0 g, 0·006 mole) was dissolved in 50 ml AcOH and 100 ml 0·1 N perchloric acid in AcOH was added. The clear soln was allowed to stand overnight. Filtration of the resulting needles gave 0·55 g hydroperchlorate, m.p. 225° dec, 39% yield. (Found: C, 51·92; H, 7·24; Cl, 11·19; N, 8·06. Calc for $C_{14}H_{25}ClN_2O_4$: C, 52·42; H, 7·80; Cl, 11·08; N, 8·74%). The NMR spectrum (CD_3CN) shows, in ppm from TMS, the following peaks: 1·94 (m 20H); 4·90 (m 2H); 7·86 (s 2H); 10·00 (s 1H).

N,N'-*Di-n-butylethylenediimine*, 4. Glyoxal (145·0 g, 40% aqueous, 1·0 mole) was added dropwise to 293·0 g (4·0 mole) n-butylamine at 0–10°. After addition was complete, the pasty mixture was heated to reflux for an hr and then allowed to stand for 2 days, after which time two layers had formed. The top layer was separated and distilled giving 56·0 g of tan liquid, b.p. 93–95° at 10 mm Hg, 34% yield. Redistillation through a Nester-Faust spinning-band column gave 29·9 g of colourless product, b.p. 95–96° at 10 mm Hg, n_D^{25} 1·4548. (Found: C, 71·29; H, 11·90; N, 16·40. Calc for $C_{10}H_{20}N_2$: C, 71·43; H, 11·90; N, 16·67%).

The IR spectrum (KBr) contained a strong band at 6·14 μ (C=N). The NMR spectrum ($CDCl_3$) showed, in ppm from TMS, peaks at 0·95 (m); 1·42 (m); 3·50 (tr, J = 6·0 c/s); and 7·78 (s).

N,N'-*Diisobutylethylenediimine*, 5. Glyoxal (145·0 g, 40% aqueous, 1·0 mole) was added dropwise to 146·0 g (2·0 mole) isobutylamine at 0°. A solid formed initially but soon dissolved. After the addition was complete, the soln was warmed gently and two layers formed. These were separated, the lower aqueous layer washed with ethyl ether, and the washings added to the organic layer. This soln was dried with Na_2SO_4 and distilled, giving 47·5 g of light yellow liquid, b.p. 78–83° at 10 mm Hg, n_D^{25} 1·4515, yield 28%. The product was redistilled through a Nester-Faust spinning-band column giving 43·6 g of colorless liquid, b.p. 80–81° at 10 mm Hg, n_D^{25} 1·4518. (Found: C, 71·29; H, 11·99; N, 16·37. Calc for $C_{10}H_{20}N_2$: C, 71·43; H, 11·70; N, 16·67%).

The NMR spectrum ($CDCl_3$) of this compound, in ppm from TMS, had peaks at 0·90 (d, J = 6·5 c/s, 12·3 H); 1·88 (m, J = 6·3 c/s, 2·0 H); 3·30 (d, J = 6·5 c/s, 3·8 H); and 7·77 (s, 1·9 H). The IR spectrum (film) showed a strong band at 6·12 μ (C=N).

N,N'-*Diisopropylethylenediimine*, 6. Glyoxal (72·5 g, 40%, 0·50 mole) was added dropwise to 59·0 g (1·0 mole) isopropylamine at 0°. After addition was complete, the mixture was allowed to warm to room temp, and after 2 days, it solidified. Gentle warming of the solid mass gave two layers. Separation in a warmed separatory funnel afforded the top layer which upon cooling resolidified. It was dissolved in warm ethyl ether and allowed to stand in dry ice (−80°). Filtration of the resultant ppt gave 54·0 g of tan lacrimatory needles, m.p. 48–50°, 77% yield. A small portion was sublimed (35° at 1 mm Hg) for analysis. (Found: C, 68·48; H, 11·39; N, 20·03; Mol wt. 140 (mass spec). Calc for $C_8H_{16}N_2$: C, 68·57; H, 11·43; N, 20·00%: Mol. wt. 140).

The IR spectrum (KBr) had a strong band at 6·16 μ (C=N). The NMR spectrum ($CDCl_3$) of this compound, in ppm from TMS, showed the following peaks: 1·18 (d, J = 7·0 c/s, 12·2 H); 3·50 (sept, J = 7·0 c/s, 2·0 H); and 7·97 (s, 2·0 H).

N,N'-*Di-t-butylethylenediimine*, 7. t-Butylamine (146·0 g, 2·0 moles) was added dropwise to 145·0 g, 40% aqueous glyoxal (1·0 mole) at 0°. The reactants soon solidified and 50 cc of water was added to break up the solid mass. The white solid was isolated by filtration, dissolved in 500 cc ethyl ether, and dried with $MgSO_4$. The volume of the resultant ether soln was reduced by evaporation to 200 cc and cooled in dry ice (−80°). Filtration afforded 86·8 g of extremely lacrimatory white solid, m.p. 39–43°. A second crop, 18·6 g m.p. 34–40°, was also obtained. Sublimation, 40° at 1 mm Hg, gave an analytical sample. The total yield was 63%. (Found: C, 71·60; H, 11·60; N, 16·47; Mol. wt. 168 (mass spec). Calc for $C_{10}H_{20}N_2$: C, 71·43; H, 11·90; N, 16·67%; Mol wt. 168).

The NMR spectrum ($CDCl_3$) of this compound, in ppm from TMS, had peaks at 1·26 (s, 18·2 H); 7·96 (s, 1·8 H). The IR spectrum (KBr) had a strong band at 6·14 μ (C=N).

Perchloric acid titrations. The standard[7] perchloric acid in AcOH method for amines and Schiff Bases was used with crystal violet indicator.

An appropriate amount of diimine was dissolved in enough glacial AcOH so that no precipitation of perchlorates took place. A few drops of 1% crystal violet in AcOH was added, and the soln titrated with 0·1 N perchloric acid in AcOH to the green color. This endpoint represented the total basicity of the diimine in question.

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