

STRUCTURAL STUDIES BY NUCLEAR MAGNETIC RESONANCE—XV

CONFORMATIONS AND CONFIGURATIONS OF OXIMES¹

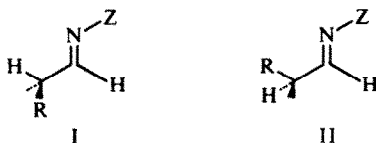
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Abstract— Conformations and configurations were assigned to oximes of several aldehydes and ketones from analysis of their 60-Mc. NMR spectra. Interpretation of the spin-spin coupling data from the *cis* isomers (hydroxy *cis* to hydrogen) of the aldoximes in terms of rotamers I and II, whereby a single bond eclipses the double bond, led to the following: For α -monosubstituted acetaldoximes, when R was changed from methyl to t-butyl, ΔH° for $I \rightleftharpoons II$ varied from +500 to +4,500 cal/mole. The α,α -disubstituted acetaldoximes behaved similarly. Interpretation of the analogous data from the *trans* isomers led to the conclusion that, whereas the eclipsing conformation XII is the most stable conformation of the α,α -disubstituted acetaldoximes, both eclipsing XIII and bisecting XIV conformations, or other conformations in-between the two, are important. From the chemical shift data, the *s-cis* conformation about the N—O bond is excluded as the equilibrium conformation of the oximes.

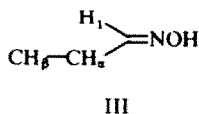
RECENTLY^{2,3} we investigated the effect that Z has on the relative stabilities of I and II and found that $\Delta H^\circ_{I \rightleftharpoons II}$ becomes more positive as the electronegativity of Z increases.



Our interests in problems arising from restricted rotation about single, double and partial double bonds, and particularly in the general problem of the relative stabilities of I and II as functions of Z and R, have led us to examine the NMR spectra of oximes (Z = OH). We wish, therefore, to present our results and compare them with those of oxime O-methyl ethers.²



RESULTS

Chemical shifts. In Table 1 are summarized the chemical shifts of few representative oximes. The rotation used to distinguish the various protons is shown in III. Each





proton is referred to as *cis* or *trans* with respect to the OH group. Assignments of hydrogens as *cis* and *trans* are based on arguments given previously.⁴ The chemical

TABLE I. CHEMICAL SHIFTS (τ -VALUES) OF OXIMES

$R_1R_2C=NOH$		Solvent	H_1		$H_2(CH)$		$H_2(CH_2)$		$H_2(CH_3)$		$H_2(CH_3)$		OH
R_1	R_2		cis	trans	cis	trans	cis	trans	cis	trans	cis	trans	
H	CH ₃	Neat	2.48	3.08			8.14	8.17					-0.02
H	CH ₃	C ₆ D ₆ (10%)	2.70	3.43			8.38	8.53					-0.13
H	CH ₂ CH ₃	Neat	2.53	3.25									
H	CH ₂ CH ₃	C ₆ D ₆ (10%)	2.61	3.48							8.95	8.95	
H	CH ₂ C(CH ₃) ₃	Neat	2.47	3.15							9.25	9.21	
H	CH ₂ C(CH ₃) ₃	C ₆ D ₆ (10%)	2.43	3.27			7.70	7.93			9.01 ^a	9.03 ^a	
H	CH ₂ C(CH ₃) ₃	Neat	2.58	3.18			7.69	8.05			9.18 ^a	9.21 ^a	
H	CH ₂ C ₆ H ₅	C ₆ H ₆ (10%)	^b	3.27			6.30	6.50					
H	CH ₂ C ₆ H ₅	Neat	2.61	3.41	6.82	7.53	6.36	6.73					
H	CH(CH ₃) ₂	C ₆ D ₆ (10%)	2.62	3.59	6.75	7.78					8.96	8.93	-0.13
H	CH(CH ₃) ₂	Neat	2.58	3.28	6.68	7.32					9.15	9.15	
H													-0.02
H		C ₆ D ₆ (10%)	2.57	3.45	6.55	7.47							
CH ₃	CH ₃	CCl ₄ (10%)					8.11	8.12					-0.55
CH ₃	CH ₃	C ₆ H ₆ (10%)					8.28	8.36					
CH ₃	CH ₂ CH ₃	Neat					8.16	8.16			8.94	8.94	-0.28
CH ₃	CH ₂ CH ₃	C ₆ H ₆ (10%)					8.24	8.34			9.11	9.11	
CH ₃	CH(CH ₃) ₂	Neat			6.49	7.45	7.60	7.78			8.97	8.92	+0.18
CH ₃	CH(CH ₃) ₂	C ₆ H ₆ (10%)			6.38	7.64	7.67	7.99			9.14	9.08	
CH ₃	CH ₂ C ₆ H ₅	CCl ₄ (50%)					6.24	6.49					0.00
CH ₃	CH ₂ C ₆ H ₅	C ₆ H ₆ (10%)					6.29	6.61					
CH ₃	C(CH ₃) ₃	CCl ₄ (10%)											
CH ₃	C(CH ₃) ₃	C ₆ H ₆ (10%)					8.15	8.37					
CH ₃	C(CH ₃) ₃	CCl ₄ (10%)					8.18				8.84		
CH(CH ₃) ₂	C(CH ₃) ₃	C ₆ H ₆ (10%)			7.40						9.01		0.03
CH(CH ₃) ₂	C(CH ₃) ₃	CCl ₄ (10%)			7.77						8.68 ^c	8.86 ^d	
C(CH ₃) ₃	C(CH ₃) ₃	C ₆ H ₆ (10%)									8.58 ^c	8.98 ^d	
C(CH ₃) ₃	C(CH ₃) ₃	CCl ₄ (10%)									8.57	8.73	0.17
C(CH ₃) ₃	C(CH ₃) ₃	C ₆ H ₆ (10%)									8.53	8.80	



^a γ -Methyl.^b Masked by benzene resonance.^c Isopropyl resonance.^d *t*-Butyl resonance.

TABLE 2. $\delta_{cis} - \delta_{trans} (\Delta\delta)$, IN PPM OF OXIMES^a

R ₁	R ₁ R ₂ C=NOH R ₂	$\Delta\delta(H_1)$		$\Delta\delta(\alpha-CH)$		$\Delta\delta(\alpha-CH_2)$		$\Delta\delta(\alpha-CH_3)$		$\Delta\delta(\beta-CH_3)$	
		Neat	C ₆ H ₆ ^b	Neat	C ₆ H ₆	Neat	C ₆ H ₆	Neat	C ₆ H ₆	Neat	C ₆ H ₆
H	CH ₃	-0.60	-0.73					-0.03	-0.15		+0.04
H	CH ₂ CH ₃	-0.72	-0.87								
H	(CH ₂) ₂ CH ₃	-0.69									
H	CH ₂ CH(CH ₃) ₂	-0.67									
H	CH ₂ C(CH ₃) ₃	-0.68	-0.84			-0.23	-0.32				
H	CH ₂ C ₆ H ₅	-0.60				-0.20	-0.36				
H	CH(CH ₃) ₂	-0.80	-0.97				-0.37				
H	CH(CH ₃)CH ₂ CH ₃	-0.78		-0.71	-1.03					+0.03	0.00
H	CH(CH ₃)(CH ₂) ₂ CH ₃	-0.77		-0.78	-1.02					+0.03	0.00
H	CH(CH ₂ CH ₃) ₂	-0.75		-0.61	-0.82					-0.04	0.00
H	CH(CH ₂ CH ₃)CH ₂ CH ₃	-0.75		-0.88	-1.02						
H	CH[CH(CH ₃) ₂] ₂	-0.75		-0.91	-1.05						
H		-0.76									
H		-0.70	-0.88	-0.64	-0.92						
H		-0.80									
CH ₃	CH ₃			-0.96	-1.26			-0.01 ^c	-0.08		
CH ₃	CH ₂ CH ₃					-0.18	-0.32	0.00	-0.10	0.00	0.00
CH ₃	CH ₂ C ₆ H ₅					-0.25 ^d	-0.32	0.00 ^d	-0.10		
CH ₃	CH(CH ₃) ₂							-0.05	-0.16	+0.05	+0.06
CH ₃	C ₆ H ₅							-0.22 ^c	-0.14		
CH ₂ CH ₃	CH ₂ CH ₃					-0.15	-0.32			0.00	0.00
CH ₂ CH ₃	C ₆ H ₅					-0.25	-0.36			0.00	0.00
C(CH ₃) ₃	C(CH ₃) ₃									-0.16 ^c	-0.27

^a Negative values mean that the *cis* to the hydroxy proton resonates at a lower field than the *trans*; positive reverse.^b Values from C₆D₆.^c Values from 10% solutions in carbon tetrachloride.^d Values from 50% solutions in carbon tetrachloride. All reported values in benzene are from 10% solutions.

TABLE 3. $\nu_{\text{in benzene}} - \nu_{\text{in neat}} (\Delta\nu)^a$ IN C/S, OF OXIMES

R_1	R_2	$\Delta\nu(H_1)$		$\Delta\nu(\alpha-CH)$		$\Delta\nu(\alpha-CH_2)$		$\Delta\nu(\alpha-CH_3)$		$\Delta\nu(\beta-CH_3)$	
		cis	trans	cis	trans	cis	trans	cis	trans	cis	trans
H	CH ₃	+13.2 ^b	+21.0					+14.4	+21.6		+15.6
H	CH ₂ CH ₃	+12.0	+13.8				+10.2				
H	(CH ₂) ₂ CH ₃		+10.8				+9.0				
H	CH ₂ CH(CH ₃) ₂		+9.0				+16.2				
H	CH ₂ C ₆ H ₅		+5.4			+3.6	+13.8				
H	CH ₂ C(CH ₃) ₃	-2.4	+7.2			-0.6	+7.2				
H	CH(CH ₃) ₂	+0.6	+10.8	-4.2	+15.0					+11.4	+13.2
H	CH(CH ₃)CH ₂ CH ₃		+9.6	-4.2	+10.2					+10.2	+12.0
H	CH(CH ₃)CH ₂ CH ₃		+9.6	-4.8	+7.8					+9.0	+11.4
H	CH(CH ₃)CH ₃		+10.8	-3.0	+5.4						
H	CH(CH ₂ CH ₃)CH ₃		+8.4	-5.4	+3.0						
H	CH[CH(CH ₃) ₂] ₂		+8.4								
H		-0.6	+10.2	-7.8	+9.0						
H			+6.6								
CH ₃	CH ₃ ^c							+10.2	+14.4		
CH ₃	CH ₂ CH ₃							+4.8	+10.8	+10.2	+10.2
CH ₃	CH ₂ C ₆ H ₅ ^c					+4.2	+12.6	+4.2	+10.2		
CH ₃	CH(CH ₃) ₂					+3.0	+7.2	+3.6	+10.2		
CH ₃	C(CH ₃) ₃ ^c			-6.6	+11.4			+1.8			
CH ₂ CH ₃	CH ₂ CH ₃										
CH ₂ CH ₃	C ₆ H ₅ ^c					+3.6	+13.8			+7.8	+7.8
CH(CH ₃) ₂	C(CH ₃) ₃ ^c					+3.0	+9.6			+3.0	+3.0
C(CH ₃) ₃	C(CH ₃) ₃ ^c			+22.2						-6.0 ^d	+7.2 ^e
										-2.4	-4.2

^a Positive values mean that resonance in benzene is at higher field; negative reverse.^b Values from C₆D₆.^c $\nu_{\text{in benzene}} - \nu_{\text{in carbon tetrachloride}}$.^d Isopropyl.^e *t*-Butyl.

shifts, calculated from first order spectral analysis, are accurate to ± 0.03 ppm, except those of ethyl, isopropyl and cyclopentyl groups, whose accuracy is less.

In Table 2 are listed the differences in the chemical shifts of *cis* and *trans* protons, $\Delta\delta$, which are accurate to ± 0.001 ppm. A positive $\Delta\delta$ means that *cis* protons resonate at higher fields than *trans*, a negative the reverse. The pertinent points are: (a) H_1 resonates at lower fields when *cis* to the hydroxy than when *trans* ($\Delta\delta \sim -0.7$ ppm). (b) Whereas α -methine protons resonate at appreciably lower fields when *cis* than when *trans* ($\Delta\delta \sim -0.8$), α -methylene protons do so to a smaller extent ($\Delta\delta \sim -0.2$) and α -Me protons show insignificant differences. The same trend was observed with the oxime O-methyl ethers.² In all cases $\Delta\delta$ values are more negative in benzene than in neat solution.

In Table 3 are summarized several $\Delta\nu$ ($\nu_{\text{in C}_6\text{H}_6} - \nu_{\text{in CCl}_4}$) values. A negative $\Delta\nu$ means that a proton resonates at a lower field in benzene than in carbon tetrachloride, a positive reverse. The most striking feature of the data is the lower field absorption of several protons in benzene, which generally causes upfield shifts, than in carbon tetrachloride. The features pertinent to subsequent discussion are: (a) Whereas both *cis* and *trans* α -methyl and α -methylene protons are shifted upfield, *cis* α -methine, but not *trans* α -methine, protons are shifted downfield. Notable exception is the *cis* α -methine of the isopropyl t-butyl ketone derivative. (b) Whereas both *cis* and *trans* β -methyl protons are shifted upfield, the *cis* isopropyl methyls of the isopropyl t-butyl ketone derivative and the *cis* t-butyl methyls of the *di*-t-butyl ketone derivative are shifted downfield.

Figure 1 shows how benzene dilution affects the chemical shifts of the various alkyl protons of butanone oxime. It is noteworthy that *trans* protons are shifted further upfield than *cis* protons. Thus, in this respect, oximes behave like those

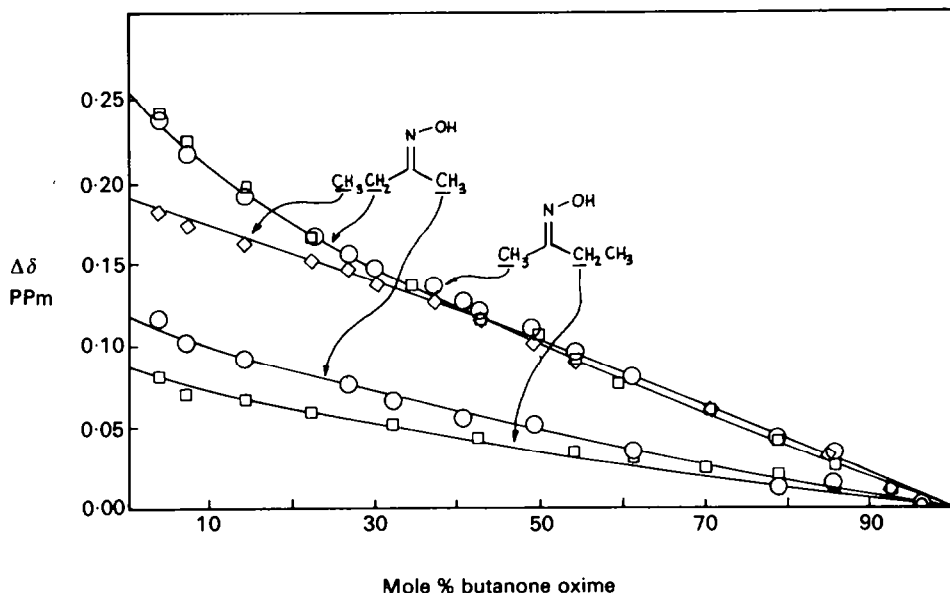




FIG. 1 Effect of benzene on the chemical shifts of butanone oxime.

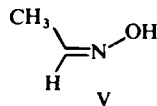
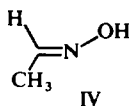
TABLE 4. *syn* AND *anti* PERCENTAGES AND ΔG_{40}° FOR *syn* \rightleftharpoons *anti* OF OXIMES^a

R ₁	R ₁ R ₂ C=NOH R ₂	% <i>syn</i> ^b	% <i>anti</i>	ΔG_{40}° (Kcal/mole)
H	CH ₃	39	61	-0.27
H	CH ₂ CH ₃	56	44	+0.15
H	CH ₂ CH ₂ CH ₃	54	46	0.10
H	CH ₂ CH(CH ₃) ₂	52	48	0.05
H	CH ₂ C(CH ₃) ₃	61	39	0.27
H	CH ₂ C ₆ H ₅ ^c	54	46	0.10
H	CH(CH ₃) ₂	73	27	0.61
H	CH(CH ₃)CH ₂ CH ₃	70	30	0.51
H	CH(CH ₃)(CH ₂) ₂ CH ₃	67	33	0.43
H	CH(CH ₂ CH ₃) ₂	67	33	0.43
H	CH(CH ₂ CH ₃)(CH ₂) ₃ CH ₃	67	33	0.43
H	CH[CH(CH ₃) ₂] ₂	71	29	0.55
H		64	36	0.35
H		70	30	0.51
CH ₃	CH ₂ CH ₃	74	26	0.64
CH ₃	CH(CH ₃) ₂	91	9	1.41
CH ₃	C(CH ₃) ₃ ^d	100	0	> 2.7
CH ₃	CH ₂ C ₆ H ₅ ^c	74	26	0.64
CH ₃	C ₆ H ₅ ^d	94	6	1.68
CH ₂ CH ₃	C ₆ H ₅ ^e	92	8	1.49
CH(CH ₃) ₂	C(CH ₃) ₃ ^d	100	0	> 2.7

^a Data from neat liquids. ^b *syn* is the isomer having the hydroxy *cis* to R₁. ^c Data from 10% solns in MeCN and CCl₄. ^d Data from 10% solns in CCl₄. ^e Data from 50% solns in CCl₄ tetrachloride.

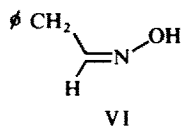
compounds that bear no acidic proton in Z, e.g. nitrosamines,⁴ oxime O-methyl ethers² and N-methylphenylhydrazones,³ rather than like those that do contain an acidic proton in Z, such as phenylhydrazones.⁵ On dilution with benzene the OH resonance also shifts downfield by more than 0.5 ppm.

syn and *anti* Isomers. In Table 4 we have summarized *syn* and *anti* percentages, whose accuracy is about $\pm 5\%$, and free energy differences, ΔG° , between these isomers at 40°. As observed with oxime O-methyl ethers,² IV is less stable than V by about 270 cal/mole.



Freshly prepared solutions of the solid, m.p. 98.5°, phenylacetaldoxime show only the low field methylene and high field H₁ resonances. When the solutions are let to stand at room temperature, the high field methylene and low field H₁ resonances

begin to appear. Equilibrium between the two isomers is slowly reached at room temperature after two (benzene solution) to five (acetonitrile solution) days, with the new resonances being more intense than the initial ones. The initially formed solid, therefore, is the thermodynamically less stable *anti* isomer VI.



Spin-spin coupling. In Table 5 is shown the effect of temperature (-30° to 90°) on $J_{H_1H_2}$, whose precision from several measurements is about ± 0.03 c/s, of several *cis* H_1 -hydroxy isomers, to which we will henceforth refer as the *syn* isomers. All

TABLE 5. SPIN-SPIN COUPLING CONSTANTS OF NEAT^a LIQUID

R ₁	R ₂	$J_{H_1H_2}$ (c/s)					
		-30°	0°	36°	50°	70°	90°
H	H	6.00	5.93	5.94	5.89	5.88	5.86
H	CH ₃	6.15	6.01	5.85	5.79	5.79	
H	CH ₂ CH ₃	6.42	6.31	6.10	6.08	6.07	6.00
H	CH(CH ₃) ₂	6.55	6.53	6.42	6.37	6.36	
H	C ₆ H ₅	6.69	6.53	6.49 ^b	6.46	6.39 ^c	
H	C(CH ₃) ₃	7.30	7.19	7.10	6.96		
CH ₃	CH ₃	6.80	6.64	6.33	6.18	6.07	5.97
CH ₃	CH ₂ CH ₃	7.90	7.55	7.19	7.00	6.87	6.79
CH ₃	(CH ₂) ₂ CH ₃	7.95	7.79	7.38	7.09	6.97	6.86
CH ₂ CH ₃	CH ₂ CH ₃	8.72	8.48	8.08	7.90	7.72	7.56
CH ₂ CH ₃	(CH ₂) ₃ CH ₃	8.75	8.59	8.15	7.95	7.79	7.73
		7.89	7.51	7.12	6.93	6.76	6.66
		6.50	6.32	6.15	6.00	5.87	5.76

^a Values at -30° and 0° were taken in 50% CCl₄ solns. ^b From 10% solns in CCl₄. ^c Value at 60° .

$J_{H_1H_\alpha}$'s decrease with temperature, including—although to a smaller extent— $J_{H_1H_\alpha}$ of acetaldoxime. Figure 2 shows the peculiar effect that solvent dilution produces on $J_{H_1H_\alpha}$ of acetaldoxime (2A) propionaldoxime (2B) and isobutyraldoxime (2C). These effects are explained, *vide infra*, in terms of disruption of the strong hydrogen bonding existing in the neat liquid.

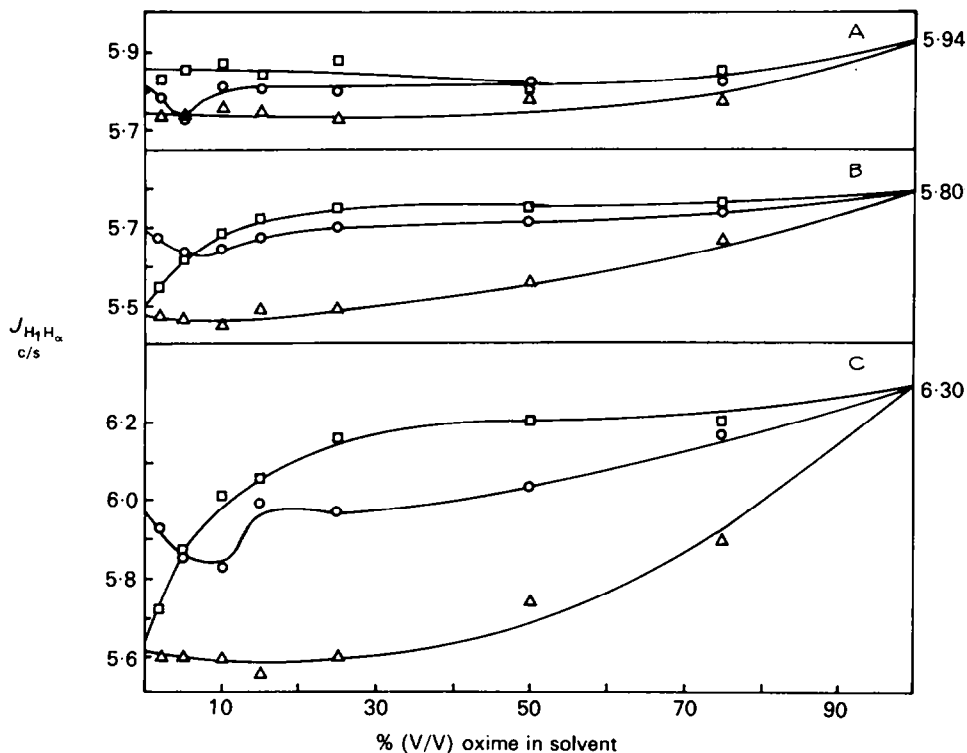




FIG. 2 Dependence of $J_{H_1H_\alpha}$ of acetaldoxime (A), propionaldoxime (B) and isobutyraldoxime (C) on concentration in pentance (□), acetonitrile (○) and dimethyl sulfoxide (Δ).

In Table 6 is shown the effect of temperature (-30° to 90°) on $J_{H_1H_\alpha}$ of the *trans* H_1 -hydroxy isomers, to which we will henceforth refer as the *anti* isomers. Several features of the data are worth noting and comparing with those of the data for the *syn* isomers. Firstly, there is an abrupt increase in $J_{H_1H_\alpha}$ in changing from mono-substituted to disubstituted acetaldoximes to the extent that $J_{H_1H_\alpha}$'s of the disubstituted derivatives are larger than those of the monosubstituted. Secondly, whereas $J_{H_1H_\alpha}$ of all *syn* isomers decreases with increasing temperature, $J_{H_1H_\alpha}$ of the *anti* isomers behaves irregularly.

TABLE 6. SPIN-SPIN COUPLING CONSTANTS OF NEAT^a LIQUID

$$\begin{array}{c} \text{R}_1\text{R}_2\text{CH}_2 \\ \diagup \\ \text{C}=\text{N}-\text{OH} \\ \diagdown \\ \text{H}_1 \end{array}$$

$\begin{array}{c} \text{R}_1\text{R}_2\text{CH}_2 \\ \diagup \\ \text{C}=\text{N}-\text{OH} \\ \diagdown \\ \text{H}_1 \end{array}$							
R ₁	R ₂	−30°	0°	<i>J</i> _{H₁H_α} (c/s)		70°	90°
				36°	50°		
H	H	5.56	5.49	5.51	5.54	5.53	5.50
H	CH ₃	5.33	5.38	5.49	5.43	5.47	5.46
H	CH ₂ CH ₃	5.36	5.50	5.47	5.45	5.52	5.53
H	CH(CH ₃) ₂	5.41	5.47	5.52	5.53	5.57	5.59
H	C ₆ H ₅			5.45 ^b	5.50	5.50	
H	C(CH ₃) ₃	5.84	5.92	5.82	5.92	5.91	5.90
CH ₃	CH ₃	7.22	7.35	7.33	7.11	7.20	7.12
CH ₃	CH ₂ CH ₃	7.70	7.78	7.80	7.55	7.61	7.59
CH ₃	(CH ₂) ₂ CH ₃	7.51	7.78	7.83	7.62	7.64	7.65
CH ₂ CH ₃	CH ₂ CH ₃	8.30	8.16	8.22	8.10	8.08	8.07
CH ₂ CH ₃	(CH ₂) ₃ CH ₃	8.30	8.30	8.31	8.18	8.16	8.15
		7.25	7.26	7.20	7.02	7.00	6.93
		7.36	7.15	7.27	7.17	7.12	7.09

^a Values at −30° and 0° were taken in 50% CCl₄ solns.^b From 10% soln in CCl₄.

DISCUSSION

Conformations of the syn isomers. Assuming that the stable conformations of the *syn* isomers are eclipsing (I and II), the relative stabilities of the various rotamers can be calculated from the temperature dependence of *J*_{H₁H_α}. Equation (1) expresses the coupling of acetaldoxime, where *J_i* is the

$$J_{\text{obs}} = \frac{1}{3}(J_t + 2J_g) \quad (1)$$

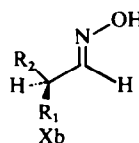
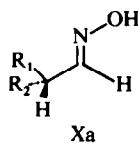
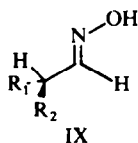
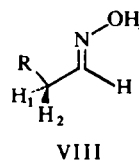
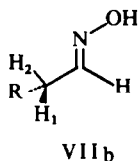
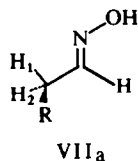
$$J_{\text{obs}}(\text{tBu}) = \frac{1}{2}(J_t + J_g) \quad (2)$$

trans coupling and *J_g* the *gauche*. From Eq. (1) and Eq. (2), which expresses the coupling of t-butylacetaldoxime,⁶ and by applying the appropriate 0.4 c/s alkyl correction,⁶ *J_t* = 13.0 c/s and *J_g* = 2.4 c/s. From Eq. (3),

$$J_{\text{obs}} = p(J_t + J_g)/2 + (1 - p)J_g \quad (3)$$

which expresses the coupling of monosubstituted acetaldoximes, where *p* is the fractional population of VII and (1 − *p*) that of VIII, the relative populations of VII and VIII can be calculated. Similarly, from Eq. (4),

$$J_{\text{obs}} = pJ_t + (1 - p)J_g \quad (4)$$



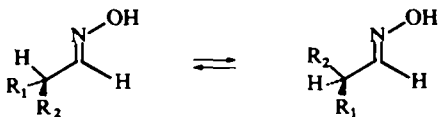


which expresses the coupling of disubstituted acetaldoximes, where p is the fractional population of IX and $(1 - p)$ that of X, the relative populations of IX and X can be calculated. These results are summarized in Table 7.

TABLE 7. ROTAMER POPULATION OF

R ₁	R ₂	-30°	0°	36°	50°	70°	90°
H	CH ₃	78	76	72	71	71	
H	CH ₂ CH ₃	83	81	77	77	76	75
H	CH(CH ₃) ₂	86	85	83	82	81	
H	C ₆ H ₅	88	85	84	84	83	
H	C(CH ₃) ₃	100	98	96	94		
CH ₃	CH ₃	49	48	45	43	42	41
CH ₃	CH ₂ CH ₃	60	56	53	51	50	49
CH ₃	(CH ₂) ₂ CH ₃	60	58	54	52	51	50
CH ₂ CH ₃	CH ₂ CH ₃	67	65	61	60	58	56
CH ₂ CH ₃	(CH ₂) ₃ CH ₃	68	66	62	60	58	57
		59	56	52	50	49	48
		46	44	43	42	40	39

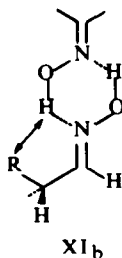
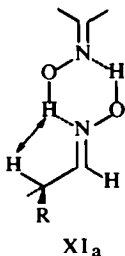
In Table 8 we have summarized the enthalpy differences, ΔH° , between the various rotamers. These differences were calculated from reasonably linear plots of $\log K_{eq}$ vs. $1/T$, where K_{eq} for the monosubstituted derivatives is equal to $2(1 - p)/p$ and

TABLE 8.

$R_1R_2CHCH=NOH$		ΔH° for	ΔH° (cal/mole)
R_1	R_2		
H	CH ₃		+ 500
H	CH ₂ CH ₃		+ 700
H	CH(CH ₃) ₂		+ 700
H	C ₆ H ₅		+ 700
H	C(CH ₃) ₃		+ 4500
CH ₃	CH ₃		+ 500
CH ₂ CH ₃	CH ₂ CH ₃		+ 800
			+ 700
			+ 400

for the disubstituted $(1 - p)/2p$. For reasons already discussed² the ΔH° values are probably reliable to $\pm 30\%$. As anticipated, these values closely parallel those of the oxime O-methyl ethers.²

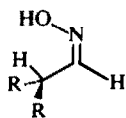
In previous investigations we have used the effect that the dielectric constant of the solvent has on $J_{H_1H_2}$ as complimentary evidence to support the eclipsing over the bisecting conformations. In oximes, the highest $J_{H_1H_2}$ is the one of the neat liquid; it decreases in all other solvents, regardless of their dielectric constants. The most reasonable explanation for this observation is the disruption with dilution of the strong hydrogen bonding that is known to exist among oxime molecules. For the sake of brevity we will use the data shown in Fig. 2 and the dimeric species XIa and XIb to illustrate our point (trimers and polymers instead of dimers can be used as



well). In the hydrogen-bonded species, the ratio XIa/XIb is increased over the normal ratio VII/VIII, as a result of stronger nonbonded repulsions ($R \leftrightarrow H$) in XIb than in XIa ($H \leftrightarrow H$). As dimethyl sulfoxide is far more efficient than pentane or acetonitrile in disrupting these hydrogen bonds, the coupling constants in dimethyl sulfoxide

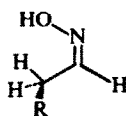
decrease sharply at high concentrations of the oximes and eventually level off. The coupling constants in the less efficient solvents pentane and acetonitrile decrease slowly with decreasing oxime concentration and change sharply only when the concentration of the oxime is quite low. It is interesting to note that at concentrations below 5% the coupling constants of propionaldoxime and isobutyraldoxime are higher, as expected, in acetonitrile (high dielectric constant) than in pentane (low dielectric constant). Above that concentration, however, the less efficient disruption of the hydrogen bonding by pentane results in higher coupling constants in the less polar solvent pentane than in acetonitrile.

Conformations of the anti isomers. The peculiar behavior of $J_{H_1H_2}$ of the *anti* isomers precludes any quantitative conclusions to be drawn regarding the stable conformations of these isomers. The same comment was made² in our studies of oxime O-methyl ethers. On the basis of steric considerations and the large coupling constants of the disubstituted acetaldoximes it is reasonable to conclude that the predominant conformation of the disubstituted derivatives is XII. For the same

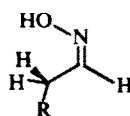


XII

reasons advanced in our discussion of oxime O-methyl ethers, both conformations XIII and XIV appear to be significant in the cases of monosubstituted acetaldoximes.

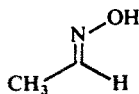


XIII

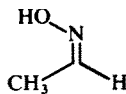


XIV

The erratic behavior of $J_{H_1H_2}$ of these compounds when the temperature changes is consonant with a low barrier of interconversion between XIII and XIV. This interpretation agrees with the recent finding⁷ that the barrier to rotation of the methyl group is 1840 cal/mole in XV and 350 cal/mole in XVI.

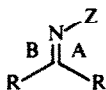


XV



XVI

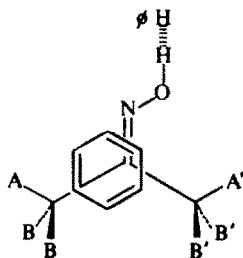
Chemical shifts. As in so many other compounds of the general structure XVII, region A is deshielded with respect to region B (both A and B in the plane of the



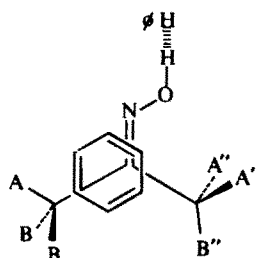
XVII

molecule). The interpretation that XII is the most stable rotamer of the *anti* disubstituted acetaldoximes finds further support in the fact that, whereas *cis* and *trans* α -methyl protons resonate at about the same field, *cis* α -methine protons resonate at appreciably lower fields than the corresponding *trans*.

Interpretation of solvent effects. The most striking feature of the chemical shifts is the effect of benzene on them; i.e. the downfield, instead of upfield, shift of several resonances. Any interpretation of this effect requires specific orientation of benzene by interaction with the oxime. The data are adequately accommodated in terms of XVIII and XIX, which were used² to interpret the similar chemical shifts of the

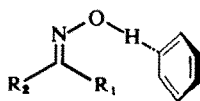


XVIII



XIX

oxime O-methyl ethers, whereby the benzene is attracted by the positive charge on the sp^2 -hybridized carbon and is closer to the group that is *trans* to the hydroxy group. The data exclude XX as the conformation of the hydroxy group, as in this



XX

conformation the *cis* R_1 group would suffer a greater upfield shift than the *trans* R_2 group.^{5,8} The *s-trans* conformation about the N—O bond conforms to the structure of formaldoxime⁹ and to the idea of $p - p$ lone electron pair repulsions.¹⁰ The downfield shift of the resonance of the hydroxy proton in benzene also agrees with the *s-trans* conformation. It should be pointed out, however, that the data do not differentiate between the *s-trans* conformation and any other conformation where the hydroxy proton is out of the plane of the molecule by less than 90° .

EXPERIMENTAL

Preparation of oximes. Oximes were prepared by reacting freshly distilled aldehydes or ketones with hydroxylamine hydrochloride and a suitable base.¹¹

NMR spectra were determined at 60-Mc on a Model A-60 Spectrometer (Varian Associates, Palo Alto, Calif). Undegassed solutions were used with TMS as internal reference.

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- ⁴ G. J. Karabatsos and R. A. Taller, *J. Am. Chem. Soc.* **86**, 4373 (1964) and previous papers in the series.
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- ⁶ For a detailed discussion see Ref. 2.
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