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NN-Di-(1-cyanoalkyl)hydroxylamines. Part IV.¹ Isolation of Acyclic Nitrones and their Reaction with Hydrogen Cyanide

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a-Hydroxyamino-nitriles react with aldehydes to give the corresponding crystalline N-alkylidene-N-(1-cyanoalkyl) N-oxides. These acyclic nitrones are monomeric and fairly stable. The reaction of the nitrones with hydrogen cyanide gives NN-di-(1-cyanoalkyl)hydroxylamines almost quantitatively.

In the preparation of NN-di-(1-cyanoalkyl)hydroxylamines, the existence of a nitrone intermediate was demonstrated by u.v. and i.r. spectroscopy, polarography, and an asymmetric synthesis of NN-di-(1-cyanoalkyl)hydroxylamines.² The kinetics of aliphatic nitrone formation on the addition of N-alkylhydroxylamine to aliphatic aldehydes have been studied.³ However, the aliphatic nitrone itself could not be isolated. In general, aliphatic nitrones are believed to be much more unstable than aromatic and alicyclic nitrones, particularly in the presence of water or even alcohol⁴ though several have been claimed to have been obtained as hydrogen RESULTS

It has been reported that nitrones, in general, are isomerised to isonitrones by light or heat,^{5,7} and aliphatic and alicyclic nitrones are readily dimerised.^{5,8} Nitrones, however, are readily differentiated from these compounds by their u.v. absorption spectra. The u.v., i.r., and n.m.r. spectra of N-alkylidene-N-(1-cyanoalkyl) N-oxides are shown in Table 2. The values $\lambda_{max.} = 245-246$ mµ and $\varepsilon_{max} = 9600 - 9800$ are in good agreement with those reported for other aliphatic and alicyclic nitrones. The i.r. absorptions at about 3060-3070 and 3000, 1582-1590, and 1110-1116 cm.-1 are assigned to -CH=, -C=N-, and $N \longrightarrow O$, respectively. The n.m.r. spectrum of the nitrone

			N-Alkyl	TA idene-N-(1-	BLE l cyanoal	kyl) N	-oxides					
$R^2-CH=N-CH(CN)-R^1$												
Compound (I) (III) (III) (IV) (V) (V) (VI)	R ² Et Pr ⁿ Et Pr ⁿ Pr ⁱ	R ¹ Pr ⁿ Pr ⁿ Pr ⁱ Pr ⁱ Pr ⁱ	Yield (%) 37 37 56 45 38 65	M. p. 4648° 41-542 6265 5356 3536 9394	F 62·3 64·1 64·3 62·3 64·75 64·5	Dund (% H 9.0 9.3 9.5 9.15 9.45 9.45	$\frac{18\cdot1}{16\cdot3}$ 18.2 16.6 16.6	Formula C ₈ H ₁₄ N ₂ O C ₉ H ₁₆ N ₂ O	Rec C 62·3 64·3 64·3 62·3 64·3 64·3 64·3	quired (H 9.2 9.6 9.6 9.2 9.6 9.6 9.6	%) N 18·2 16·7 16·7 18·2 16·7 16·7	

chlorides, picrates, or in an oily state.⁵ The only crystalline aliphatic nitrone known is that derived from cyclohexylhydroxylamine.6

We here describe some stable aliphatic nitrones with a cyano-group on the carbon attached to the nitrone nitrogen. The existence of these nitrones was suggested in previous Papers of this series. To test this, the addition reaction of the nitrones with hydrogen cyanide was carried out, and the NN-di-(1-cyanoalkyl)hydroxylamines were obtained almost quantitatively.

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(III), measured in deuteriochloroform using tetramethylsilane as an internal reference, shows a doublet at 6.85p.p.m. and a triplet at 4.73 p.p.m. both corresponding to one proton; these are assigned to R²-CH=N- and $R^1-CH(CN)-N-$, respectively. The mass spectrum of the nitrone (II) (details of which will be reported later) showed a weak molecular ion peak at m/e 168 and no larger peak, showing that the nitrone was monomeric. Though specific absorption bands of -C=N-, N → O, -C-N=, and -CH= bonds in aromatic nitrones have been reported,⁹ only the absorption peak of the -C=N- stretching mode has been reported 4d in the aliphatic series. It has been found that the -C=N- stretching absorption is strong and appears at 1550-1600 cm.⁻¹ with aromatic nitrones and 1570-1620 cm.⁻¹ with aliphatic and alicyclic nitrones. The aliphatic nitrones obtained show a strong band at about 1600 cm.⁻¹.

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The strong absorptions of the N --- O group of aromatic keto-nitrones⁹ and aldo-nitrones¹⁰ were stated to appear at about 1200-1300 and 1050-1170 cm.-1, respectively. In the i.r. spectra of the present aliphatic nitrones and the N-cyclohexyl-N-ethylidene N-oxide, the strongest absorption band was observed at about 1110 cm.⁻¹. From the above reported values and those observed for the $N \longrightarrow O$ absorption of amine N-oxides (aromatic, 1200-1300; aliphatic, 950-970 cm.⁻¹), this band at 1110 cm.⁻¹ is ascribed to the N \longrightarrow O bond of the nitrones.

hexylamine N-oxide) was prepared by the method reported by Krimm.⁶ Aldehydes were left for 1 day with calcium chloride and sodium hydrogen carbonate and then redistilled twice just before use.

N-Alkylidene-N-(1-cyanoalkyl)-N-Oxides. — General method. An α -hydroxyamino-nitrile was mixed with an aldehyde at room temperature. The mixture became syrupy and heat was generated. Excess of aldehyde was distilled off under reduced pressure (3-4 mm.), and a crystalline solid was obtained almost quantitatively. Recrystallisation from

TABLE 2 Spectra of N-alkylidene-N-(1-cyanoalkyl) N-oxides

				T = (am	N.m.r.				
	U.v.			1.r. (cm	-CH=	-CH(CN)-N-			
Compound	$\lambda_{\max} m \mu (\epsilon_{\max})$	-CH=		C≡N	-C=N-	N — 🏲 O	τ (J c./sec.)	τ (<i>J</i> c./sec.)	
(I)		(Nujol)	307 0w	2260vw	1590s	1110s			
(ÌÌ)	240 (9800) *	(Nujol)	3060w	2260vw	1590s	1110s	3·02t (6·0)	5·29t (6·6)	
(ÎII)	242 (9650) *	(KBr)	3060w 3000m	2260vw	1587s	1111s	3·15d (7·2)	5·27t (6·6)	
()	246 (9700) †	(CCI_)	3065w		1582s	1116s	· · ·		
(IV)	241 (9700) *	(KBr)	3065w 3000m	2260vw	1594s	1113s	2·97t (6·0)	5.50d (6.6)	
	245 (9700) †	(CCl_)	3065w	2260vw	1586s	1114s	· ·	· · ·	
(V)	239 (9600) *	(KBr)	3070w 3000m	2255 vw	1590s	1112s	2·97t (6·0)	5·49d (6·6)	
	246 (9700) †	(CCl ₄)	307 0w	2255 vw	1585s	1116s	· · ·		
(VI)	239 (9740) *	(KBr)	3060w 3000m	2255 vw	1590s	1113s	3·17d (7·2)	5·55d (7·2)	
	245 (9800) †	(CCl ₄)	3070w		1582s	1113s			

* In ethanol. † In hexane.

Reaction of the Nitrones with Hydrogen Cyanide.—Of the many examples of 1,3-addition reactions of nitrones, two involve hydrogen cyanide; one is that producing cyanoimines from hydrogen cyanide and aromatic nitrones,¹¹ and the other is that yielding 1-hydroxy-2-cyanopyrrolidine from hydrogen cyanide and Δ^1 -pyrroline N-oxide.^{4b} The present reaction resembled the latter and the corresponding secondary hydroxylamines were obtained almost quantitatively from the N-cyclohexyl-N-ethylidene N-oxide and N-alkylidene-N-(1-cyanoalkyl) N-oxides.

EXPERIMENTAL

The instruments used for i.r., u.v., and n.m.r. spectra are described in previous Papers.¹ A Hitachi RMU-7HR mass spectrometer was used. Thoroughly purified α hydroxyaminovaleronitrile (m. p. $103-104^{\circ}$) and α hydroxyaminoisovaleronitrile (m. p. 93-94°) were used.12 The N-cyclohexyl-N-ethylidene N-oxide (N-ethylidenecyclo-

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ether at -10 to -15° gave colourless needles. The nitrones prepared are shown in Table 1.

N-Cyclohexyl-N-(1-cyanoethyl)hydroxylamine.-Liquid hydrogen cyanide (0.5 ml.) was added to N-ethylidenecyclohexylamine N-oxide (130 mg.) and the mixture was stored at $0-5^{\circ}$ for 2 days in a sealed vessel. Excess of hydrogen cyanide was removed, and the residue on recrystallisation from cyclohexane gave colourless plates (80 mg.), m. p. 99.5—100.5°, ν_{max} (KBr) 3378 (OH), 2242 (C=N), 1456 (cyclohexyl), 1403, 1375 (CH or OH), 954, 898, 863, 834, and 804 cm.⁻¹ (Found: C, 64·4; H, 9·4; N, 16·9. C₁₉H₁₆N₂O requires C, 64.3; H, 9.6; N, 16.7%).

NN-Di-(1-cyanoalkyl)hydroxylamines.-Excess of hydrogen cyanide (2 mol.) was added to the nitrones and the mixture was treated as above. Recrystallisation from water-ethanol gave the corresponding known² hydroxylamine derivatives. The yields were almost quantitative.

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