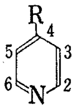
TABLE IV.[a] Corrected and Assumed ^1H Shifts (ppm), ρ_{NMR} and $\rho_{calcd.}$ of 4-Substituted Pyridines

R	C$_3$–H δ ppm	C$_3$–H ρ_{NMR}	C$_3$–H ρ calcd.	C$_2$–H δ ppm	C$_2$–H ρ_{NMR}	C$_2$–H $\rho_{calcd.}$
NO_2	−0.26	0.976		−0.75	0.930	
CN	−0.10	0.991	1.0041[b]	−0.68	0.936	0.8796[b]
CO_2Me	−0.07	0.994		−0.65	0.939	
COMe	−0.18	0.983		−0.70	0.935	
Me	+0.48	1.045		−0.43	0.959	
OMe	+0.83	1.078		−0.29	0.973	
OH	+0.93	1.086		−0.23	0.976	
NH_2	+1.07	1.100		−0.16	0.985	
NMe_2	+1.28	1.200		−0.06	0.995	
H	+0.33	1.031	1.020[c]	−0.50	0.953	0.955[c]
			1.010[d]			0.951[d]
			1.0137[b]			0.8997[b]

a) The ^1H position numbers are as follows:



b) H.E. Popkie and J.B. Moffat, *Canad. J. Chem.*, **43**, 624 (1965)
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d) R. McWeeny and T.E. Peacock, *Proc. Phys.Soc.* (London), Sec. *A*, **70**, 41 (1957)

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Mass Spectra of Acyclic Nitrones

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The photochemistry and thermal rearrangement of amine N-oxides were studied and results are reported in the literature.[2] Cyclic amine N-oxide rearranged to a tri-substituted hydroxylamine analog, that is a 1,2-oxaza ring compound,[3] and aromatic amine N-oxide to an oxazepine or an amide derivative via an unstable oxaziran intermediate.[4] There have been several papers on the mass spectra of amine N-oxide in the past few years, and an ion peak corresponding to loss of oxygen (M-16) is clearly seen with many other strong ion peaks which can be expected from the products produced by photochemical and thermal reactions.[5] Grigg and Odell described the mass spectra of alicyclic nitrones,[5a] reporting that the abundance of M-16 ions is drastically affected by an alkyl substituent at the 2-position and the base peak corresponds to an alkyl fragment.

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1) Location: *Toneyama, Toyonaka, Osaka.*
2) A.H. Wragg, T.S. Stevens and D.M. Ostle, *J. Chem. Soc.*, **1958**, 4057.
3) L.D. Quin and F.A. Shelburne, *J. Org. Chem.*, **30**, 3135 (1965).
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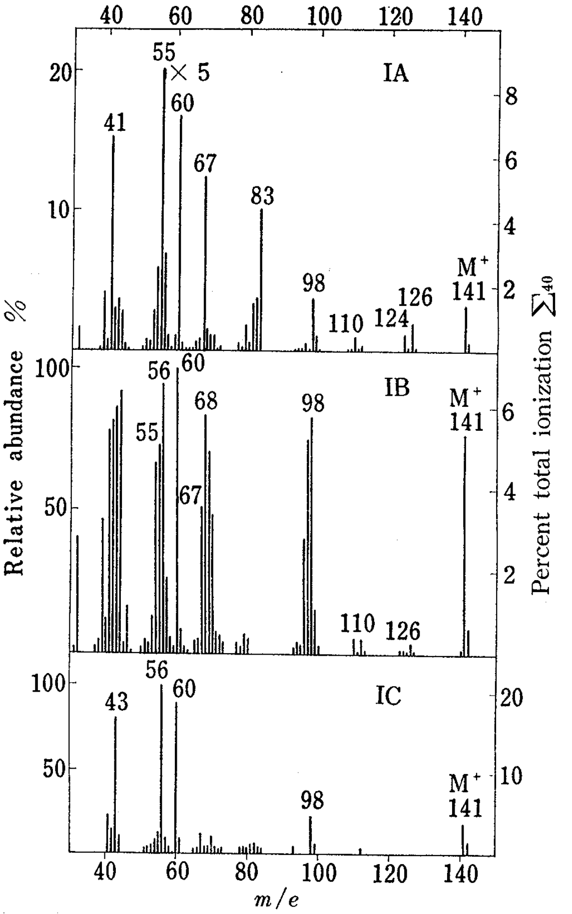


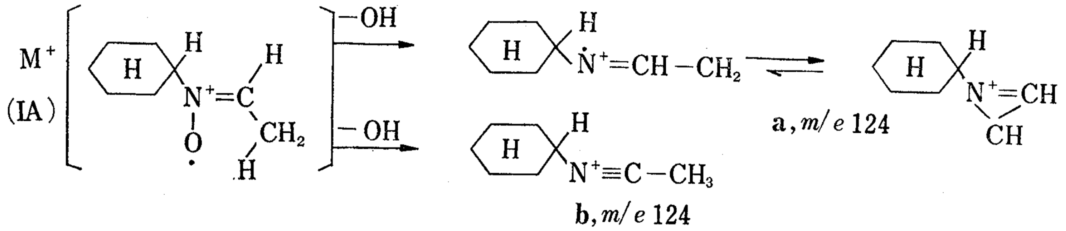
Fig. 1. Mass spectra of N-Ethylidene Cyclohexylamine N-Oxide (IA), 2-Cyclohexyl-3-methyl-oxazirane (IB) and N-Acethyl Cyclohexylamine (IC)

Among the reactions of nitrones other than acyclic aliphatic nitrones, rearrangements to an oxime⁶⁾ and to an oxazirane,⁷⁾ which is thermally rearranged to the original nitrone⁸⁾ or to an amide,⁹⁾ are known. Hence, we studied the behaviours in mass spectrometry of the acyclic nitrones which have not been studied in these respects, since they have similarities in photochemical and mass spectral behaviour.

N-Ethylidene Cyclohexylamine N-Oxide and Its Analogs

In Fig. 1 the mass spectra of the nitrone (IA), isonitrone (IB) which is considered to be a rearrangement product of the nitrone (IA) and N-acethylcyclohexylamine (IC) which has been thoroughly studied by Djerassi, *et al.* are shown.¹⁰⁾ The peaks at *m/e* 98, 60, 56 and 43 of IC are also seen in the spectra of IA and IB, so a little of the nitrone probably becomes rearranged forming the isonitrone and then the amide.

The peaks at *m/e* 126, 124, 110, 83, 67 and 55 in the spectrum of IA are weak or absent in the spectrum of amide IC, and hence they are considered to represent fragments derived directly from IA and IB. In contrast to amine N-oxide the *m/e* 125 (M-16) ion is hardly seen, but the intensity of the M-OH ion at *m/e* 124 is rather strong. Because the *m/e* 124 ion is also scarecely detectable in the spectrum of IB, the M-OH ion may be a spectral characteristic of only IA among the three isomers. Considering a recent communication¹¹⁾ on the aromatic nitrone which proposed that the source of the hydrogen atom in the M-OH ion is the α-carbon atom, and the suggestion that the alkyl substituent at the 2-position in pyridine N-oxides is responsible for the M-OH ion,⁵ᵃ⁾ the following reactions may occur:



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6) A.H. Blatt, *J. Org. Chem.*, **15**, 869 (1950); A.C. Cope and A.C. Haven Jr., *J. Am. Chem. Soc.*, **72**, 4896 (1950); A.H. Wragg and T.S. Stevens, *J. Chem. Soc.*, **1956**, 461.
7) J.S. Splitter and M.Calvin, *J. Org. Chem.*, **23**, 651 (1958); K. Koyano and I. Tanaka, *J. Phys. Chem.*, **69**, 2545 (1965).
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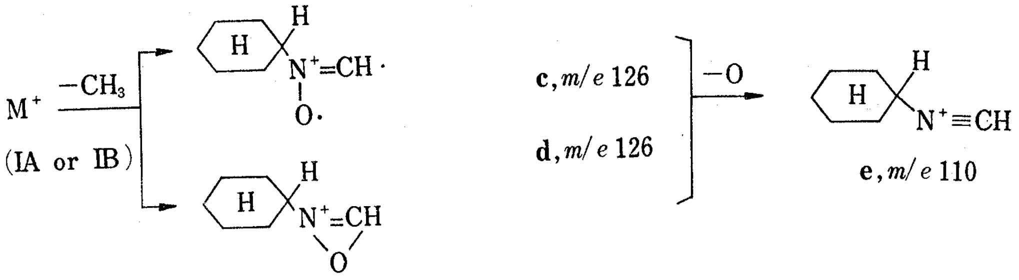
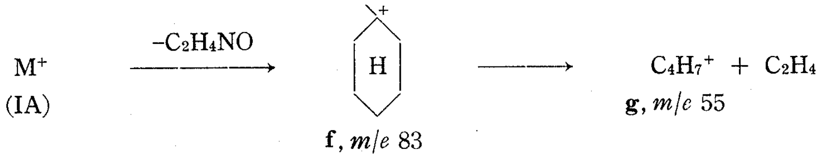
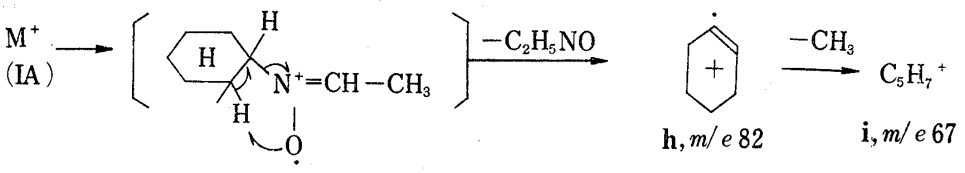
The ions at *m/e* 126 (M-15) and *m/e* 110 are observed both with IA and IB, and the explanation for this fragmentation is that an α cleavage, analogous to that of azomethine,[12] occurs first and then a deoxygenation. A similar mode of cleavage at α C–C is observed generally in acyclic aliphatic nitrones as will be described later.



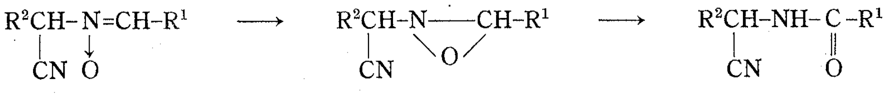
The peaks at *m/e* 55 (55.0551), 67 (67.0562) and 83 (83.0849) in IA are shown by high resolution measurements to correspond to $C_4H_7^+$ (55.0548), $C_5H_7^+$ (67.0548) and $C_6H_{11}^+$ (83.0847), respectively. The metastable ion at *m/e* 36.4 shows *m/e* 83→55, which is known in cyclohexane and also observed generally in aliphatic hydrocarbons, and the presence of these ions is in agreement with the result on aliphatic azomethine compounds[12] and thermal cleavage of the C–N bond in aromatic nitrones.[6] The absence of *m/e* 83 ion in the spectrum of IB indicates that cleavage takes place directly from the nitrone IA without its previous rearrangement to IB. *m/e* 67 ($C_5H_7^+$) ion may be assumed to be derived in the following way as in cyclohexanole and cyclohexylacetate.[13]





N-Alkylidene-N-(1-cyanoalkyl) N-Oxides

The cyano group is at the α-carbon atom to the nitrogen, so the mass spectrum is more complicated than that of the above nitrone, but the results described above greatly assist in studies on the fragmentation processes. The mass spectra are shown in Fig. 2. As with nitrone IA, these nitrones (A) can also become rearranged to the corresponding oxaziranes (B) and amides (C).



II—VIIIA B C

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[10] Z. Pelah, M.A. Kielczewski, J.M. Wilson, M. Ohashi, H. Budzikiewicz and C. Djerassi, *J. Am. Chem. Soc.*, **85**, 2470 (1963).

[11] T.H. Kinstle and J.G. Stam, *Chem. Commun.*, **1968**, 185; J.H. Bowie and R.G. Cooks, *Tetrahedron*, **24**, 5193 (1968).

[12] M. Fischer and C. Djerassi, *Chem. Ber.*, **99**, 1541 (1966).

[13] C.G. Macdonald, J.S. Shannon and G. Sugowdz, *Tetrahedron Letters*, **13**, 807 (1963).

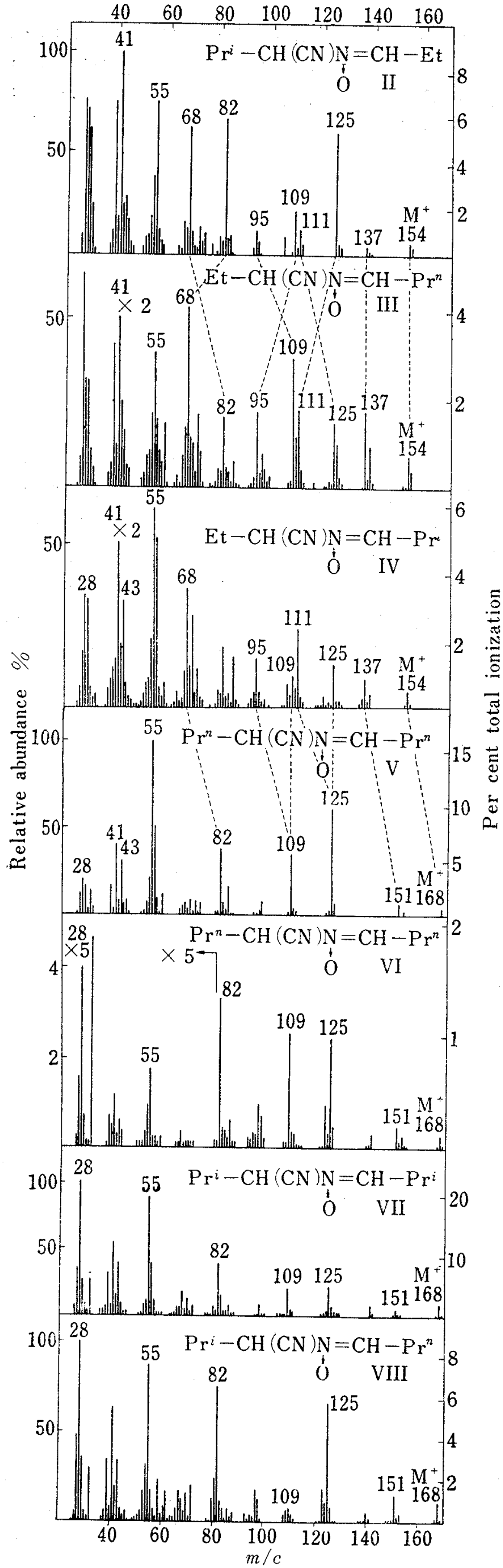
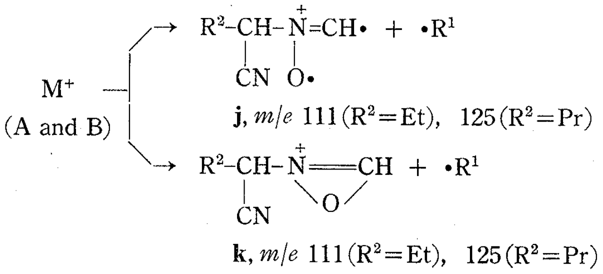


Fig. 2. Mass Spectra of N-Alkylidene N(1-Cyanoalkyl) N-Oxide

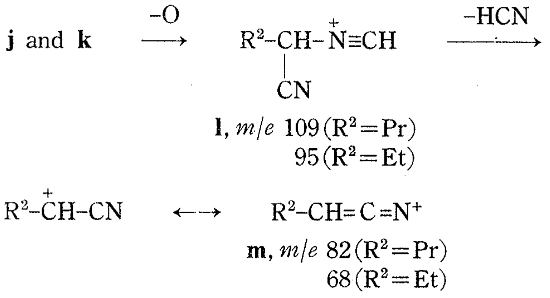
In these nitrones as in nitrone IA, the M-OH ion is much more abundant than the M-O ion,and the intensity of the peak corresponding to M-R^1 is strong. A metastable ion *m/e* 101.5 is observed in the spectrum of IIA, indicating a fragmentation *m/e* 154 (M$^+$)→125 (M$^+$-R^1). The following reaction, which is path similar to that for IA and IB, is therefore suggested to occur.



j, *m/e* 111(R^2=Et), 125(R^2=Pr)

k, *m/e* 111(R^2=Et), 125(R^2=Pr)

The probability that the M$^+$-R^1 ion is derived from the isomeric amide is rather small, because cleavage of the C–C bond α to the carbonyl group occurs only in special cases where a stable carbonium ion is produced by the fission.[14] The *m/e* 109 (when R^2=Pr) and 95 (when R^2=Et) ions and *m/e* 82 and 68 correspond to M$^+$–R^1–O and M$^+$–R^1–43 respectively, and hence they are interpreted by the following scheme similar to that in IA and IB.



l, *m/e* 109(R^2=Pr)
95(R^2=Et)

m, *m/e* 82(R^2=Pr)
68(R^2=Et)

Ion *m* corresponds to the M$^+$–1 ion observed in aliphatic nitriles and is known to be very stable.[15] There is also the possibility of cleavage like that in IA.

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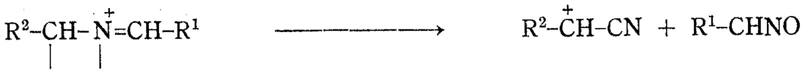
[14] K.G. Das, P.T. Funke and A.K. Bose, *J. Am. Chem. Soc.*, **86**, 3729 (1964); J.A. Gilpin, *Anal. Chem.*, **31**, 935 (1962).

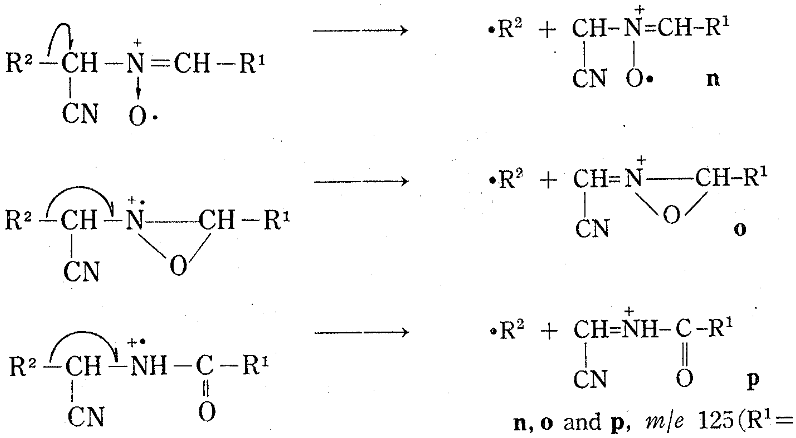
[15] F.W. McLafferty, *Anal. Chem.*, **34**, 26 (1958).



$$R^2\text{-}\underset{\text{CN}}{\text{CH}}\text{-}\underset{\text{O}\bullet}{\overset{+}{\text{N}}}\text{=CH-}R^1 \longrightarrow R^2\text{-}\overset{+}{\text{C}}\text{H-CN} + R^1\text{-CHNO}$$

m

Because a peak corresponding to M^+–R^2 appears in the spectrum, though its intensity is lower than that of M^+–R^1, the following fragmentation path should also be considered. The cleavage of a C–C bond β to a cyano group[15] and to a carbonyl carbon in amide is well known.[14]



n, **o** and **p**, *m/e* 125(R^1=Pr), 111(R^1=Et)

M^+–R^2–O ions are also present, and hence

n and **o** $\xrightarrow{-\text{O}}$ NC-CH=$\overset{+}{\text{N}}$=CH-R^1 **q**, *m/e* 109(R^1=Pr), 95(R^1=Et)

The path **p**→**q** is highly improbable.

In the mass spectra of aliphatic hydrocarbons a series of ions, namely *m/e* 28, 41, 43, 55 *etc.*, are generally observed. In the acyclic nitrones, a similar series of ions are observed as shown in Fig. 2. The ions at *m/e* 28 (28.01244 and 28.0313), 41 (41.0388), 43 (43.0586) and 55 (55.0539 and 55.0422) in the spectra of IIA and VIIIA were shown by high resolution measurements to correspond to CH_2N^+ (28.0187) 50% plus $C_2H_4^+$ (28.0313) 50%, $C_3H_5^+$ (41.0391), $C_3H_7^+$ (43.0548) and $C_4H_7^+$ (55.0548) 80% plus $C_3H_5N^+$ (55.0422) 20%, respectively, and the intensity of these ions is relatively strong. The same general pattern is seen in the spectrum of IIIA—VIIA. The pathways giving CH_2N^+ and $C_3H_5N^+$ and the sources of the nitrogen in these ions are not clear.

Experimental

Materials——N-Ethylidenecyclohexylamine N-oxide, 2-cyclohexyl-3-methyl oxazirane[16] and N-alkylidene-N-(1-cyanoalkyl) N-oxide[17] were prepared by known methods. The mass spectra (expect for those of Ic[10]) and high resolution measurements were determined with a Hitachi RMU-6D mass spectrometer operating with an ionization energy of 70eV. The temperature of the ion source was 200° except with IB, VA and VIA. The spectra of the latter compounds were measured at 80eV and 250°.

Acknowledgement We thank the members of the Chemical Research Laboratories of Takeda Chemical Industries for measurement of the spectra.

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16) H. Krimm, *Chem. Ber.*, **91**, 1057 (1958).

17) M. Masui and C. Yijima, *J. Chem. Soc.* (C), **1967**, 2202.