

NITROGEN-15 MAGNETIC RESONANCE SPECTROSCOPY. III. CONFIGURATIONAL ASSIGNMENTS IN N-NITROSOHYDROXYLAMINES.

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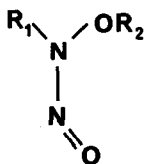
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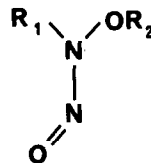
The phenomenon of restricted rotation about partial double bonds has been extensively studied by nmr spectroscopy (1). In nitroso compounds, it is generally accepted that  $\pi$ -bonding in the N-N bond of N-nitrosamines (2) and in the N-C bond of nitrosobenzenes (3) results in restricted rotation about these bonds on the nmr time scale. Configurational isomerism can readily be observed in the nmr spectra of these systems.

Recent studies in these laboratories have shown that N-nitrosohydrazines similarly exhibit restricted rotation about the N-NO bond (4). The anisotropy of the nitrosamino group causes  $\alpha$ -protons situated in the plane of this group to experience deshielding while protons above or below this plane are shielded (5). Thus, depending on the orientation of the nitroso-oxygen atom and the conformation adopted by the  $\alpha$ -substituent, the cis- and trans- $\alpha$ -protons have different chemical shifts. Successful configurational assignments in the nitrosamine series based on isomer ratios and solvent effects have been made (6,7).

The present report deals with the study of N-nitrosohydroxylamines in which we have obtained evidence for the existence of an equilibrium between the trans-(I) and cis-(II)



I (trans)



II (cis)

configurational isomers. Although N-nitrosohydroxylamines have been known for considerable time (8-11) the existence of geometric isomers in these systems has not been previously reported.

In earlier work, we have demonstrated that nitrogen-15 substitution in the nitroso group of *N*-nitrosamines (12) and *N*-nitrosohydrazines (4) can be conveniently applied to the problem of configurational assignments in these systems. It has been found that H-C-N-N<sup>15</sup> coupling for the trans- $\alpha$ -protons ( $J=2-3$  cps) is larger than that for the cis- $\alpha$ -protons ( $J \approx 0$  cps).

In this study, a series of *O,N*-dialkyl-*N*-nitrosohydroxylamines was investigated. In each case, the <sup>15</sup>N-nitroso-labeled analog having an isotopic enrichment of 99% was prepared. The chemical shift values for the  $\alpha$ -protons and the isomer ratios present at equilibrium for the several *N*-nitroso hydroxylamines studied are summarized in Table I.

TABLE I  
Isomer Ratios and Chemical Shift Values in  
Cis- and Trans-*N*-Nitrosohydroxylamines<sup>a</sup>

R <sub>1</sub> N(NO)OR <sub>2</sub>		trans		cis		T, °C <sup>b</sup>	% trans/cis
R <sub>1</sub>	R <sub>2</sub>	R <sub>1</sub>	R <sub>2</sub>	R <sub>1</sub>	R <sub>2</sub>		
CH <sub>3</sub>	CH <sub>3</sub>	3.91	3.87	3.46	4.13	-30	80/20
CH <sub>3</sub>	PhCH <sub>2</sub>	3.52	4.92	3.19	5.16	-25	85/15
PhCH <sub>2</sub>	CH <sub>3</sub>	5.31	3.62	5.06	3.96	-40	92/8
PhCH <sub>2</sub>	PhCH <sub>2</sub>	5.62	5.05	5.45	5.39	-40	95/5
CH <sub>3</sub> CH <sub>2</sub>	PhCH <sub>2</sub>	3.99	4.99	≈ 3.9 <sup>d</sup>		-20	98/2
Ph(CH <sub>3</sub> )CH	CH <sub>3</sub>	5.71	3.58			+35 <sup>e</sup>	100/0
PhCH <sub>2</sub>	H	5.20	9.83			+35 <sup>e</sup>	100/0

<sup>a</sup> Spectra were measured in CDCl<sub>3</sub> solution in ppm from internal TMS using a Varian A60 spectrometer. <sup>b</sup> Temperature at which measurements were made. <sup>c</sup> In dimethylformamide solution. <sup>d</sup> Obscured by trans-methylene signal. <sup>e</sup> Spectra not temperature-dependent.

Generally, it is possible to observe the signals due to the cis- and trans-*N*-nitrosohydroxylamines only at low temperatures where the rate of rotation about the N-NO bond is sufficiently retarded. In a typical case, the temperature dependent nmr spectrum of *N*-nitroso-*N*-methyl-*O*-benzylhydroxylamine is shown in Figure I. The room temperature spectrum of this compound exhibits two broad singlets at  $\delta 3.50$  and  $\delta 4.96$  which are in the ratio 3:2. These signals are assigned to the N-CH<sub>3</sub> and O-CH<sub>2</sub>Ph protons, respectively. In addition, a small temperature independent peak due to the presence of some unreacted starting material is evident at  $\delta 4.63$ . As the temperature is lowered, the signals at  $\delta 3.50$  and  $\delta 4.96$  broaden further and then four distinct signals begin to emerge. At -20°C, the four signals corresponding to the two configurational isomers are well resolved. It is evident from the spectrum that the equilibrium mixture consists predominantly of one

configurational isomer (85%).

In Table II, there are presented the cis- and trans- H-C-N-N<sup>15</sup> coupling constants that were determined in the several <sup>15</sup>N-labeled nitrosohydroxylamines investigated.

TABLE II  
Coupling Constants in N-[<sup>15</sup>N-Nitroso]-Hydroxylamines

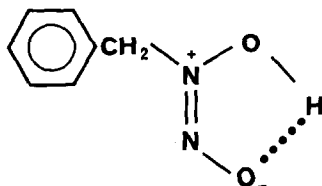
R <sub>1</sub> N( <sup>15</sup> NO)OR <sub>2</sub>		J <sub>HCNN<sup>15</sup></sub>		T, °C <sup>c</sup>
R <sub>1</sub>	R <sub>2</sub>	trans	cis	
CH <sub>3</sub>	CH <sub>3</sub>	2.0	0.7	-30
CH <sub>3</sub>	PhCH <sub>2</sub>	2.2	0.7	-25
PhCH <sub>2</sub>	CH <sub>3</sub>	2.0	0	-40
PhCH <sub>2</sub>	PhCH <sub>2</sub>	2.0	0	-30
CH <sub>3</sub> CH <sub>2</sub>	PhCH <sub>2</sub>	2.1	-	+35
Ph(CH <sub>3</sub> )CH	CH <sub>3</sub>	1.6	-	+35
PhCH <sub>2</sub>	H	2.6	-	+35

<sup>a</sup> All constants are expressed in cps. <sup>b</sup> The uncertainty in these values is estimated to be  $\pm 0.2$  cps. <sup>c</sup> Temperature at which measurements were made.

By analogy with our previous findings in nitrosamines (12) and nitrosohydrazines (4) where trans-H-C-N-N<sup>15</sup> coupling was greater than the corresponding cis- coupling, it is possible to conclude that a similar situation exists in the N-nitrosohydroxylamine series.

On this basis, the more abundant N-CH<sub>3</sub> signal ( $\delta 3.52$ ) in the spectrum of N-nitroso-N-methyl-O-benzylhydroxylamine (Figure I) is assigned to the trans-isomer, since it is coupled ( $J=2.2$  cps) in the <sup>15</sup>N-analog (bottom spectrum). That the trans-isomer is in fact predominant is reasonable on steric grounds since this configuration has the nitroso group oriented away from the N-substituent and towards the less space-demanding alkoxy group.

An interesting point worth noting is the presence of only one configurational isomer, even at low temperatures ( $-40^{\circ}\text{C}$ ), in the spectrum of N-nitroso-N-benzylhydroxylamine. It is clear from the observed H-C-N-N<sup>15</sup> coupling ( $J=2.6$  cps) that we are dealing with the trans-isomer. The absence of the cis-isomer can be attributed to the importance of intramolecular hydrogen bonding represented in III, a situation similar to that which has been observed in N-nitrosohydrazines (4).



III

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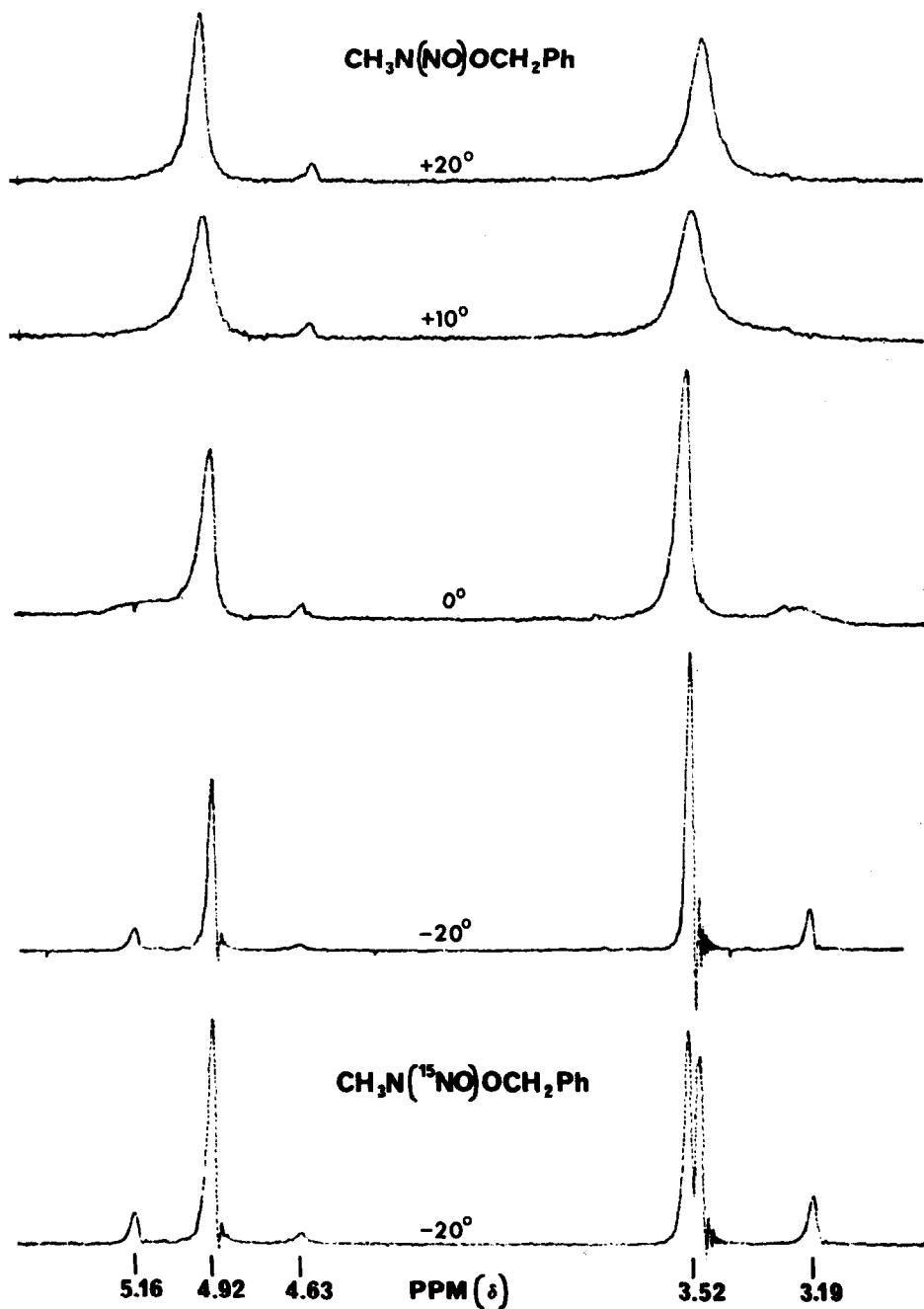


Figure 1. Temperature-dependent 60-Mc spectrum of N-nitroso-N-methyl-o-benzylhydroxylamine.