

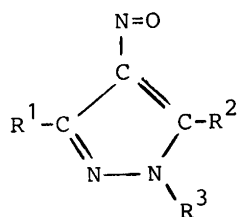
ESR Spectra of Nitroxide Radicals Formed from Some 4-Nitrosopyrazole Derivatives in the Trapping of $\cdot\text{CH}_2\text{OH}$ and $\cdot\text{CH}_3$ Radicals

Carl Lagercrantz

Department of Medical Physics, University of Göteborg, P.O. Box 33031, S-400 33 Göteborg, Sweden

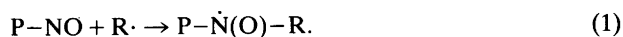
Lagercrantz, C., 1989. ESR Spectra of Nitroxide Radicals Formed from Some 4-Nitrosopyrazole Derivatives in the Trapping of $\cdot\text{CH}_2\text{OH}$ and $\cdot\text{CH}_3$ Radicals. – Acta Chem. Scand. 43: 503–505.

The spin traps 1-methyl-4-nitroso-3,5-diphenylpyrazole (**1**) and sodium 3-(4-nitroso-3,5-diphenyl-1-pyrazolyl)propane-1-sulfonate, introduced by Kaur and Perkins,¹ scavenge reactive radicals to give nitroxide radicals the ESR spectra of which may be readily interpreted. These spin traps have the advantage of being monomers and are relatively insensitive to irradiation by light.



- 1 R¹, R² = phenyl; R³ = methyl
- 2 R¹, R³ = methyl; R² = hydroxy
- 3 R¹, R³ = methyl; R² = phenyl
- 4 R¹, R² = phenyl; R³ = H

In connection with some experiments performed in this laboratory, the 4-nitrosopyrazole derivatives **1**, **3** and **4** [P–NO, eqn. (1)] were used as spin traps for $\cdot\text{CH}_2\text{OH}$ and $\cdot\text{CH}_3$ radicals (R \cdot) formed in the reaction between photochemically generated $\cdot\text{OH}$ radicals in the cleavage of H_2O_2 and methanol or dimethyl sulfoxide (DMSO). The ESR spectra of the resulting nitroxide radicals exhibited a number of narrow splittings in addition to those due to the interaction with magnetic nuclei of the trapped radical and the ¹⁴N nucleus of the nitroxide group.



The narrow splittings might be due to an interaction of the unpaired electron with magnetic nuclei of the pyrazole unit and/or substituents on the ring. However, it is also possible that the splittings originated from an interaction with hydrogen atoms of the solvent bound in a charge-transfer complex between the =N–O group of the nitroxide radical and methanol or DMSO. Recently, splittings due to such a charge-transfer complex have been observed in the ESR

spectra of the nitroxide radicals formed in the trapping of H \cdot radicals when using 1(2),3-dimethyl-4-nitrosopyrazole-5-ol (**2**). In addition to the hyperfine splittings originating from the trapped radical H \cdot , the spectra obtained in DMSO exhibited a number of narrow splittings, ca. 0.3 G, that could not be detected when the reaction was performed DMSO-*d*₆. The very special trapping reactions observed with **2** and the narrow splittings due to charge-transfer have been described in detail earlier.² The aim of this note is to establish the origin of the narrow splittings observed with the 4-nitrosopyrazole derivatives **1**, **3** and **4**.

Nitroxide radicals formed with 1(2),3-dimethyl-4-nitroso-5-phenylpyrazole (3). The ESR spectrum of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_2\text{OH}$ radicals is expected to give rise to 3×3 (1:2:1) lines due to the interaction with one ¹⁴N nucleus and two equivalent hydrogen atoms. However, the actual spectrum obtained in CH_2OH exhibited seven groups of lines due to partial overlaps. Fig.

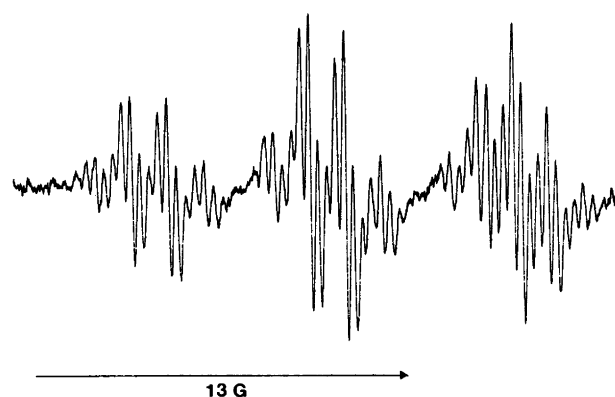


Fig. 1. ESR spectrum of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_2\text{OH}$ radicals using the spin trap 1(2),3-dimethyl-4-nitroso-5-phenylpyrazole (**3**) dissolved in CH_3OH . The $\cdot\text{CH}_2\text{OH}$ radicals were formed by abstraction of a hydrogen atom from methanol by photochemically generated $\cdot\text{OH}$ radicals in the cleavage of H_2O_2 . The three low-field groups of lines of a total of seven groups are shown. $a_{\text{N}} = 13.1$ G, $a_{\text{H1}} = 6.0$ G, $a_{\text{H2}}(\text{CH}_3) = 1.3$ G, $a_{\text{H3}} = \text{ca. } 0.3$ G.

part of the ESR spectrum, *viz.* the three low-field groups of lines of the seven groups. Each of the main lines of the primary splittings is split into a quartet (1:3:3:1) due to interaction with the hydrogen atoms of the methyl groups in position 3 of the pyrazole ring. Each of the quartet lines is further split into five narrow lines (ca. 0.3 G).

When the reaction was performed in CH_3OD , the five narrow lines were replaced by three incompletely resolved lines, Fig. 2. Evidently, the narrow splittings are due, at least in part, to an interaction with the hydrogen atom of the hydroxy group of methanol. However, it could not be determined from these experiments whether the interaction was connected with the hydrogen atom of the hydroxy group of the trapped radical, *i.e.* $\cdot\text{CH}_2\text{OH}$, or of a methanol molecule bound to the nitroxide radical in a charge-transfer complex. The incomplete resolution did not allow a complete assignment of the narrow splittings that might involve other magnetic nuclei, in addition to the hydrogen atom of the hydroxy group of methanol, such as those of the phenyl group in position 5 on the pyrazole ring.

Nitroxide radicals formed with 1-methyl-4-nitroso-3,5-diphenylpyrazole (1) and 4-nitroso-3,5-diphenylpyrazole (4). The ESR spectra of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_2\text{OH}$ or $\cdot\text{CH}_3$ radicals with **1** and **4** were almost identical. This indicates that the methyl group attached to one of the nitrogen atoms of the pyrazole unit has no significant influence on the spectra.

The primary splittings, *i.e.* the 3×4 (1:3:3:1) lines, observed in the spectra obtained in the trapping of $\cdot\text{CH}_3$ radicals with **1**, exhibited similar narrow splittings. Fig. 3 shows the three low-field lines of the 12 primary splittings. Each of the three lines is incompletely split into at least four narrow lines.

When the reaction was performed in $\text{DMSO-}d_6$, the spectrum exhibited 3×7 lines from the interaction with one ^{14}N nucleus and three equivalent deuterium atoms of the trapped $\cdot\text{CD}_3$ radical (cf. Ref. 3). Fig. 4 shows the low-field

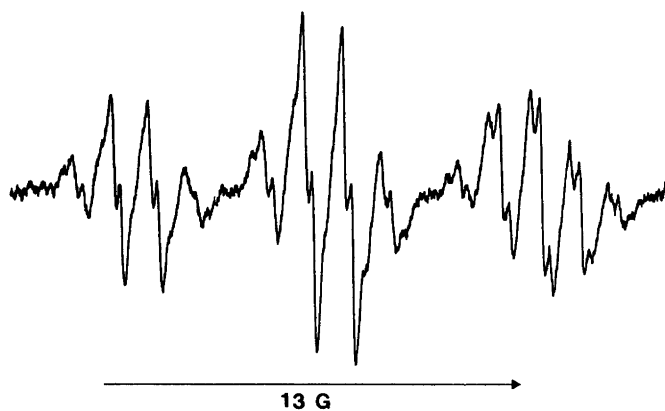


Fig. 2. ESR spectrum of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_2\text{OD}$ radicals using spin trap **3** dissolved in CH_3OD . The splittings a_{H_3} of Fig. 1 are replaced by an incompletely resolved three-line structure.

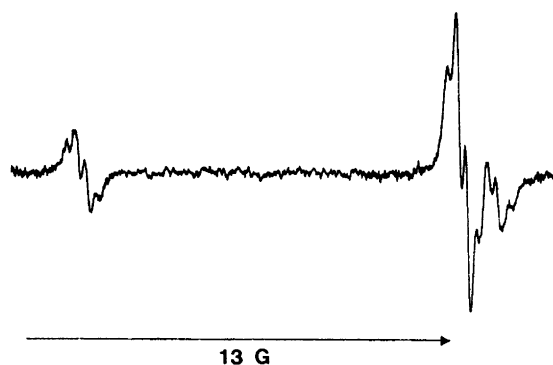


Fig. 3. ESR spectrum of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_3$ radicals using the spin trap 1-methyl-4-nitroso-3,5-diphenylpyrazole (**1**) dissolved in DMSO. The $\cdot\text{CH}_3$ radicals were formed in the photochemical reaction between H_2O_2 and DMSO. The three low-field lines of a total of 12 main lines are shown. $a_{\text{N}} = 12.9$ G, $a_{\text{H}_1}(\text{CH}_3) = 11.9$ G, $a_{\text{H}_2} = \text{ca. } 0.3$ G.

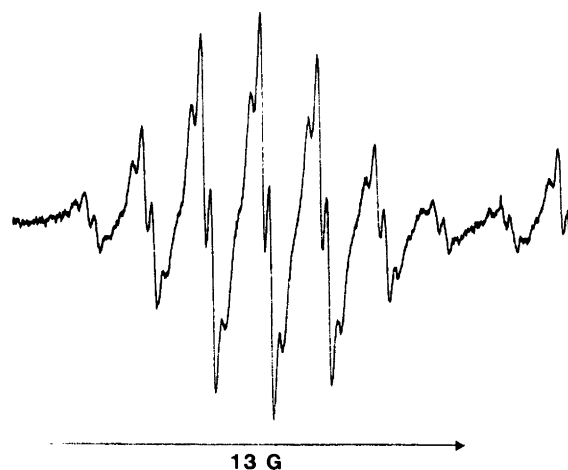


Fig. 4. ESR spectrum of the nitroxide radicals formed in the trapping of $\cdot\text{CD}_3$ radicals using the spin trap **1** dissolved in $\text{DMSO-}d_6$. The $\cdot\text{CD}_3$ radicals were formed in the photochemical reaction between H_2O_2 and $\text{DMSO-}d_6$. The low-field septet is shown. $a_{\text{N}} = 12.9$ G, $a_{\text{D}}(\text{CD}_3) = 1.7$ G, $a_{\text{H}_2} = \text{ca. } 0.3$ G.

septet of the three septets. Each of the septet lines was further incompletely split into at least four narrow lines (ca. 0.3 G). The experiments indicate that the narrow splittings observed with DMSO are not connected with a charge-transfer between the nitroxide radical and DMSO, since in this case the splittings should not have been present in $\text{DMSO-}d_6$.

One may therefore conclude that the narrow splittings observed in the ESR spectra of the nitroxide radicals formed in the trapping of $\cdot\text{CH}_3$ radicals by the spin traps **1** and **4** originate from an interaction between the unpaired electron with hydrogen atoms of the phenyl groups in positions 3 and 5 of the pyrazole ring and/or the nitrogen atoms of the pyrazole unit. Even if a detailed assignment is uncertain, it seems to be more likely that the narrow splittings are due to an interaction with hydrogen atoms of the

phenyl groups than with the nitrogen atoms of the pyrazole unit.

1(2),3-Dimethyl-4-nitroso-5-phenylpyrazole (3). 2-Oximino-1-phenyl-1,3-butanedione⁴ (2.88 g) was dissolved in 25 ml of ethanol and cooled to about -2°C . Methylhydrazine (1.45 g) was added with stirring over 15 min. Stirring and cooling were continued for 1/2 h. The green mixture was poured into 1 M HCl (200 ml), and the product was extracted with CH_2Cl_2 (2×50 ml). The extract was washed with H_2O (50 ml). The dried (Na_2SO_4) extract was evaporated under reduced pressure, to leave an oil (1.72 g) that solidified on cooling to room temperature. Crystallization from petroleum ether (b.p. $60-80^{\circ}\text{C}$) gave small needles, m.p. $77-79^{\circ}\text{C}$. Mass spectroscopy (Trio 2, Quadrupole) showed a molecular peak at 201, consistent with the formula $\text{C}_{11}\text{H}_{11}\text{N}_3\text{O}$. Found (Mikro Kemi AB): C 66.7; H 5.5; N 21.3. Calc. for $\text{C}_{11}\text{H}_{11}\text{N}_3\text{O}$: C 65.7; H 5.5; N 20.9.

1-Methyl-4-nitroso-3,5-diphenylpyrazole (1) was prepared as described by Boyd and Norris,⁵ and *4-nitroso-3,5-diphenylpyrazole* (4) according to Hüttel *et al.*⁶

Preparation of radicals. The 4-nitrosopyrazole derivatives were dissolved in methanol or dimethyl sulfoxide (DMSO) to a concentration between 10 and 20 mmol. Hydrogen

peroxide 25–50 μl , 30% in H_2O was added to 0.5 ml of a solution of the 4-nitrosopyrazole. The samples, contained in a flat cell, were irradiated with UV light from a mercury lamp (Osram HBO-200) *in situ* in the ESR cavity.

Electron spin resonance measurements. The ESR spectra were recorded using a Varian E-9 spectrometer at 20°C with a microwave power of 0.5–1 mW and 100 kHz modulation amplitude of 0.05–0.1 G. Hyperfine splitting constants were measured by comparison with the splittings of Fremy's radical ($a_{\text{N}} = 13.0$ G).

Acknowledgements. The author is indebted to Mr. W. Pimlott for mass spectra. This work was supported by grants from *Adlerbertska Forskningsfonden*.

References

1. Kaur, H. and Perkins, M. J. *Can. J. Chem.* 60 (1982) 1587.
2. Lagercrantz, C. *Acta Chem. Scand.* 43 (1989) 78.
3. Lagercrantz, C. and Forshult, S. *Acta Chem. Scand.* 23 (1969) 811.
4. Touster, O. *Org. React. (N.Y.)* 7 (1953) 327.
5. Boyd, G. V. and Norris, T. J. *Chem. Soc., Perkin Trans 1* (1974) 1028.
6. Hüttel, R., Büchele, F. and Jochum, P. *Chem. Ber.* 88 (1955) 1577.

Received January 1, 1989.