

No formation of the slightly soluble salt-like $[\text{VCp}_2(\text{CO})_2]\text{I}$ was observed under the conditions specified for reaction 2. Formation of $[\text{VCp}_2(\text{CO})_2]\text{I}$ occurs only in the presence of VCp_2 , which is, as said above, the precursor to $\text{VCp}_2(\text{CO})$ under carbon monoxide. For preparative purposes, $[\text{VCp}_2(\text{CO})_2]\text{I}$ was obtained at atmospheric pressure of CO from VCp_2I in the presence of a catalytic amount (about 10% by weight) of VCp_2 in toluene. *Anal.* Calcd for $\text{C}_{12}\text{H}_{10}\text{IO}_2\text{V}$: C, 39.59; H, 2.77. Found: C, 39.52; H, 2.51. This compound has two infrared C–O stretching vibrations at 2036 and 1988 cm^{-1} (Nujol), to be compared with the bands at 2050 and 2010 cm^{-1} reported³ for the $[\text{VCp}_2(\text{CO})_2]^+$ cation of the triiodide or tetraphenylborate salts.

All the compounds reported in this paper have similar infrared spectra (as Nujol mulls) suggestive¹⁴ of symmetrically bonded η^5 -cyclopentadienyl ligands, at least in the solid state.

The data presented in this paper may be of value for a better understanding of the energetics involved in the combination of CO with iron(II), both in natural and synthetic complexes.^{15–18}

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Electrophilicity of the 8 Position of the Isoalloxazine (Flavine) Ring System. Comment on the Mechanism of Oxidation of Dihydroisoalloxazine

Sir:

Bullock and Jardetsky¹ have shown that the CH_3 group substituted at the 8 position of the isoalloxazine ring system of FMN exchanges $-\text{H}$ for $-\text{D}$ in D_2O at pH 6.8 (90–95°) with a rate constant of $2.4 \times 10^{-4} \text{ sec}^{-1}$. This observation may be compared to that of Bowden and Stewart² showing lack of hydrogen exchange when TNT is treated with NaOD in D_2O (with minimum volume of DMSO to ensure solubility) for 5–15 min. From these results it becomes obvious that the 8 position of the isoalloxazine ring system must be unusually electrophilic. We wish to report herein a quantitative evaluation of the electrophilicity of the 8 position of the isoalloxazine ring.

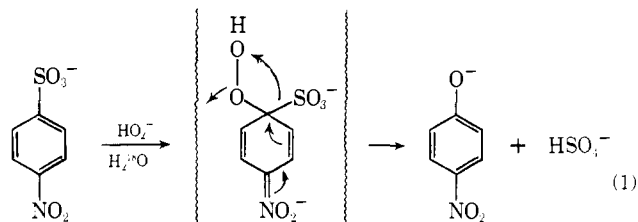
Vainstein, *et al.*,³ have reported a synthetic technique whereby electron deficient sulfonic acids may be converted to the corresponding phenols by treatment with alkaline hydrogen peroxide (eq 1). The reaction of **1**⁴

(1) F. J. Bullock and O. Jardetsky, *J. Org. Chem.*, **30**, 2056 (1965).

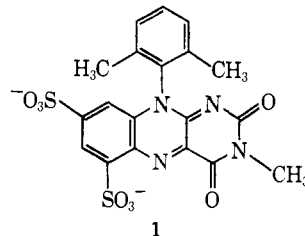
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and 2,4-dinitrobenzenesulfonic acid with excess hydrogen peroxide was compared. In the pH range of 10.0–11.25 (30°, $\mu = 1.0$ with KCl, H_2O solvent) it was found that the first-order rate constants (k_{obsd}) at a particular pH value for **1** ($k_{\text{obsd}}/[\text{H}_2\text{O}_2]_T = 8.4 \times$

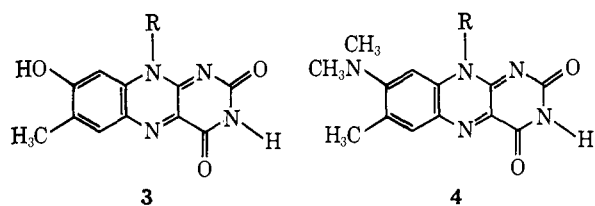


$10^{-3} \text{ M}^{-1} \text{ sec}^{-1}$ at pH 10) exceeded the k_{obsd} values obtained with 2,4-dinitrobenzenesulfonate by *ca.* 10^2 . The product (**2**) obtained from **1** possesses a pK_a of 4.45. The conjugate base of **2** exhibits a λ_{max} value of 480 nm. Based on the value of ϵ ($1.85 \times 10^4 \text{ M}^{-1} \text{ cm}^{-1}$) obtained from the isolated product⁵ yields of 85–90% of **2** were obtained at the completion of the kinetic run at pH 10.0 where hydrolysis of **1** is unimportant. Isolation and analysis⁵ of the product of the reaction of **1** with H_2O_2 indicated one SO_3H substituent of **1** to have been replaced. The spectra and pK_a of **2** closely resemble those of the 8-hydroxyisoalloxazines (**3**) whose structures have been established by alternate synthesis and analysis.⁶ Compound **4**, the 8-dimethylaminoisoalloxazine, whose structure has been solved by X-ray diffraction,⁷ also has a spectrum similar to that of

(5) **2** was synthesized and isolated by the following procedure. **1** (0.85 g) was dissolved in 200 ml of aqueous 0.1 M H_2O_2 buffered to pH 9.5 with 0.5 M ($\text{HCO}_3^- + \text{CO}_3^{2-}$). The reaction (6 hr at 25°) was followed by the appearance of λ_{max} 480 nm. At completion, the reaction solution was adjusted to pH 7.0 with HCl and 0.5 g of Pd on asbestos was added to decompose excess H_2O_2 . After 12 hr at 25° the Pd on asbestos was removed by filtration, the filtrate was acidified to pH 6.0 and evaporated *in vacuo*, and the residue was crushed and extracted three times with 100-ml volumes of 1-propanol saturated with dry hydrogen chloride. The remaining salt residue was dissolved in a minimum volume of hot water, 1-propanol was added, and the suspension was filtered. The 1-propanol solutions were combined and reduced to dryness *in vacuo*; the residue was taken up in a minimum volume of water and adjusted to pH 7.0 with a small amount of K_2CO_3 . The aqueous solution of the reaction products was loaded on a $1.8 \times 25 \text{ cm}$ water washed Bio-Rex 5 anion exchange column and eluted with a 0–1 M (potassium chloride) gradient. The fraction which eluted at about 0.8 M KCl or after about 500 ml contained **2**. This was taken to dryness, *in vacuo*, extracted with 1-propanol saturated with hydrogen chloride, and filtered and the filtrate was evaporated to dryness. The dissolution in 1-propanol, filtration, and evaporation was repeated two times to ensure the elimination of inorganic salt. Finally, pure **2** (6–26% yield) was obtained by crystallization from 2 M HCl in water–ethanol (1:1 v/v). The uv–visible spectra of **2** in water at 30°, $\mu = 1.0$ KCl, gives the following values: at pH 10.0, λ_{max} 's 252.5, 302, and 480 nm; ϵ 's 2.60×10^4 , 5.50×10^3 , and $1.85 \times 10^4 \text{ M}^{-1} \text{ cm}^{-1}$, respectively; at pH 2.0 λ_{max} 's 234, 262, 432, and 445 nm; ϵ 's 1.92×10^4 , 1.49×10^4 , 1.19×10^4 , and $1.13 \times 10^4 \text{ M}^{-1} \text{ cm}^{-1}$, respectively. The 100-MHz nmr of **2** in 3 M DCl–DMSO- d_6 solution exhibited singlets at 188 and 323 Hz of six and three protons, respectively, a degenerate multiplet at 738 Hz of three protons and a doublet of doublets at 600, 602.5, 762, and 764.5 Hz of two protons, TMS was used as an internal standard. *Anal.* Calcd for $\text{C}_{21}\text{H}_{21}\text{N}_5\text{O}_7\text{S}_2\text{K}$: C, 49.21; H, 4.10; N, 10.94; S, 6.25. Found: C, 49.88; H, 4.14; N, 11.29; S, 6.75.

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R = ribitol side chains

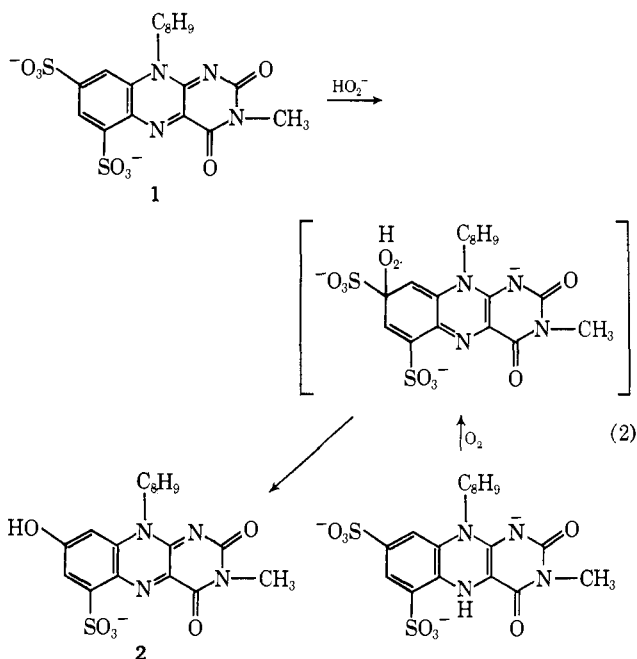
for 3, λ_{\max} 472 nm ($\epsilon = 4.15 \times 10^4 M^{-1} \text{ cm}^{-1}$)

for 4, λ_{\max} 496 nm ($\epsilon = 3.9 \times 10^5 M^{-1} \text{ cm}^{-1}$)

for 3, $pK_a = 4.8$

the basic form of 2. The analytical, nmr, spectral, and titrimetric data as well as the inability of the product to form a Cu(II) complex⁸ allows an assured assignment of the structure of the product as being that of the 8-hydroxy isomer (2).

The kinetics^{9,10} of the oxidation of 1,5-dihydroisoalloxazines (reduced flavines) have been logically interpreted to require the formation of an O₂-dihydroflavine adduct. Massey, Palmer, and Ballou¹⁰ have suggested O₂ addition to the 1,5-dihydroisoalloxazines at the 4a and 10a positions while Hemmerich and Müller¹¹ have provided arguments in support of addition of O₂ at the 4a and 8 or preferably 6 positions. The 10a position has been ruled out as an obligatory position of O₂ addition in this laboratory.^{12,13} If the dihydro form of 1



exists totally or in part as the 1,5-dihydro isomer, as is

(8) A property of 6-hydroxyisoalloxazines: G. Schöllnhammer and P. Hemmerich, *Z. Naturforsch. B*, **27**, 1030 (1972).

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(11) P. Hemmerich and F. Müller, *Ann. N. Y. Acad. Sci.*, **212**, 13 (1973).

(12) G. J. Kasperek, L. Main, and T. C. Bruice, *J. Chem. Soc., Chem. Commun.*, 847 (1972).

(13) At pH 6.4 (phosphate buffer), $\mu = 0.1$ with KCl and with $\sim 10^{-7}$ M superoxide dismutase and equimolar ratio of oxidized flavine and reduced flavine (5×10^{-6} M), the stopped flow-rate constants for the O₂ oxidation of 1,5-dihydroisoalloxazine and the 10a-blocked 1,5-dihydro-3-methyl-10-(2'-6'-dimethylphenyl)isoalloxazine are comparable (Robert F. Williams and T. C. Bruice, unpublished).

the case for other dihydroisoalloxazines,¹⁴ then O₂ addition to the 8 position would provide the same intermediate as HOO⁻ addition to oxidized 1. Thus, O₂ oxidation of reduced 1 should provide 2 just as does HOO⁻ treatment of oxidized 1 (eq 2). Experiments carried out at pH 5.0 and 9.5 established that 20 cycles of alternate dithionite reduction and O₂ oxidation of 1 gave a ca. 94% yield of unaltered 1. No absorbance at 480 nm could be detected at the end of either experiment. Therefore, the dihydro form of 1 does not undergo oxidation by addition of O₂ at either the 6 or 8 position.

It should be noted that the overall conversion of 1 to 2 represents a two-step synthesis of an 8-hydroxyisoalloxazine. Compound 2 is prepared by treatment of the corresponding isoalloxazine with sulfite in aqueous solution at ambient temperature.⁴

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(14) The structure of dihydroisoalloxazines is being investigated in this laboratory.

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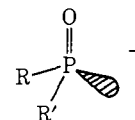
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The Trans Effect of the Good σ -Donor Ligands (CH₃O)₂-PO, (CH₃O)(C₆H₅)PO, and (C₆H₅)₂PO. Evidence for Complete Bond Breaking in the Transition State of S_N1_{im} Reactions of Dimethylphosphonatecobaloxime and Methylcobaloxime Complexes

Sir:

The interesting class of uninegative phosphorus donor ligands of the type



have received little attention.¹⁻⁶ Since the existence of such ligands is not widely recognized, it is not surprising that no rate or mechanistic studies have been reported on metal complexes of these ligands. We felt such a study might prove valuable because dialkylphosphonates (R = alkoxy) are known to be good σ donors and to have a substantial trans influence.⁶ We have therefore prepared some new cobaloxime complexes of the type RR'P(O)Co(DH)₂L, where L = neutral N- or P-donor ligand, DH = monoanion of dimethylglyoxime, and R and R' = CH₃O or C₆H₅. Cobaloximes (complexes containing the Co(DH)₂ moiety) are particularly suitable for a comparative mechanistic study because kinetic information is avail-

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(3) J. Bennet, A. Pidcock, C. R. Waterhouse, P. Coggan, and A. T. McPhail, *J. Chem. Soc. A*, 2094 (1970).

(4) R. J. Haines, I. L. Marais, and C. R. Nolte, *Chem. Commun.*, 547 (1970).

(5) R. J. Haines and C. R. Nolte, *J. Organometal. Chem.*, **24**, 725 (1970).

(6) G. G. Mather and A. Pidcock, *J. Chem. Soc., Dalton Trans.*, 560 (1973). The term trans influence is used to describe a ground state, not a kinetic, effect.