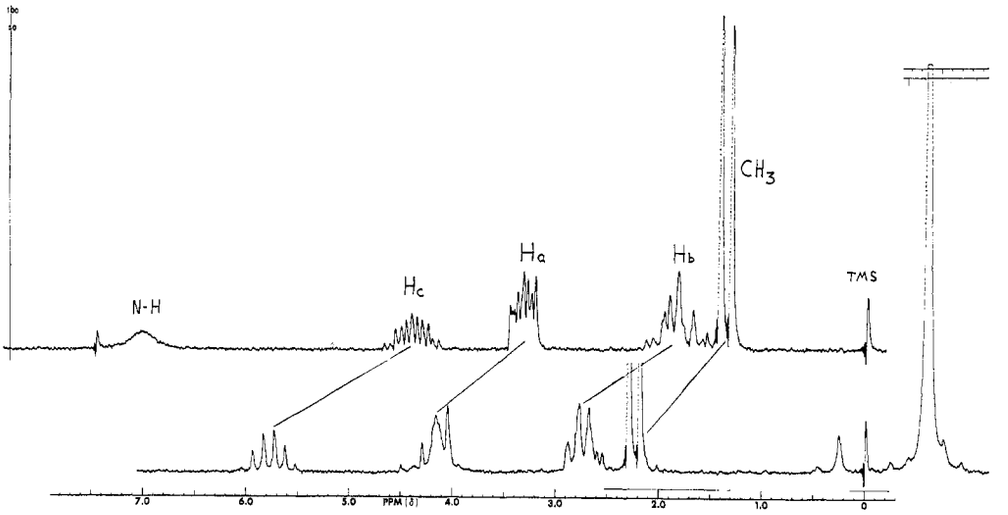

Figure 1.—Effect of Eu(dpm)$_3$ on the nmr spectrum of 6-methyltetrahydro-2*H*-1,3-oxazin-2-one: upper spectrum, no shift reagent; lower spectrum, Eu/substrate = 0.148.

protons (H_c) leaves little doubt as to the assigned structure; $-CH_2NHC{=}O$ is reported in the range of δ 3.0–3.5, whereas $-CH_2OC{=}O$ is reported at δ 4.1–4.3.[6]

Proton assignments in II were confirmed by proton–proton decoupling studies and shift enhancement with Eu(dpm)$_3$. The paramagnetic shift reagent was particularly useful in this work because it provided simplification of the complex, non-first-order spectra of the ring protons as well as resolution of overlapping multiplets. As an example, Figure 1 shows the unshifted and shifted spectra of II. In the shifted spectrum, run at a molar ratio of Eu/substrate of only 0.148, the NH proton occurs at δ 9.3, off the low-field end of the spectrum. H_c, shifted from δ 4.4 to 5.8, is clearly a sextet, coupled to the methyl group and the H_b methylene protons. The H_b multiplet, shifted from δ 1.9 to 2.7, is now clearly recognizable as a quartet, although some evidence of non-first-order coupling is still present at this Eu/substrate ratio. In the case of I, run at a similar Eu(dpm)$_3$/substrate ratio, the NH proton was observed at δ 9.1 and H_a was shifted from δ 1.9 to 2.9 and H_c from δ 4.2 to 5.8. In the shifted spectrum of I, the proton multiplets were also simplified, although they were not completely first order, and area measurements were significantly improved.

The only synthesis of 4-methyltetrahydro-2*H*-1,3-oxazin-2-one in the literature involves the condensation of 1,3-butanediol with urea.[7] Since this reagent would be expected to yield a mixture of isomers, and in any case could not be considered an unequivocal synthesis, we chose to prepare it by the reaction of diethyl carbonate and purchased "3-amino-1-butanol."[8] It is most unlikely that an isomerization would take place under the reaction conditions used, and, since there is no doubt that the product obtained is the 6-methyl isomer, the starting material must therefore have been 4-amino-2-butanol.[9]

(6) L. M. Jackman and S. Sternhell, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," 2nd ed, Pergamon Press, Elmsford, N. Y., 1969, p 164.
(7) A. M. Paquin, *Z. Naturforsch.*, **1**, 518 (1946).
(8) K & K Laboratories, Inc.
(9) Unfortunately, the structure of the amino alcohol was not investigated at the time the preparation was run, and the compound is no longer available.

Experimental Section

6-Methyltetrahydro-2*H*-1,3-oxazin-2-one (II).—To a solution of 12.3 g (0.14 mol) of "1-amino-3-butanol"[8] in 35.1 g (0.30 mol) of diethyl carbonate was added 10 mg of sodium. The reaction was heated at 130–140° and ethanol was distilled off through a short Vigreux column as it formed. The white crystals which formed on cooling in a deep freeze were filtered and recrystallized once from acetone, mp 91–92° (6.30 g, 39% of theory). One recrystallization from benzene raised the melting point to 98.5–99.5° (lit.[6] mp 91°).

Anal. Calcd for $C_5H_9O_2N$: C, 52.16; H, 7.88; N, 12.17. Found: C, 52.15, 52.10; H, 7.98, 7.80; N, 12.05, 12.23.

Nmr spectra were run at 90 MHz on a Bruker HFX-90 spectrometer and at 60 MHz on a Varian A-60A spectrometer in standard 5-mm-o.d. sample tubes, using $CDCl_3$ as a solvent and tetramethylsilane as an internal reference and lock signal.

Registry No.—I, 42202-88-0; II, 42202-89-1; *n*-octadecyl azidoformate, 822-04-8; *n*-octadecyl *N*-cyclohexylcarbamate, 16307-63-4; 4-*n*-hexadecyloxazolidin-2-one, 16392-84-0; 1-amino-3-butanol, 39884-48-5.

Quinazolines and 1,4-Benzodiazepines. LXII.[1] Reaction of Oxaziridines with Water or Alcohols Catalyzed by Iron Salts

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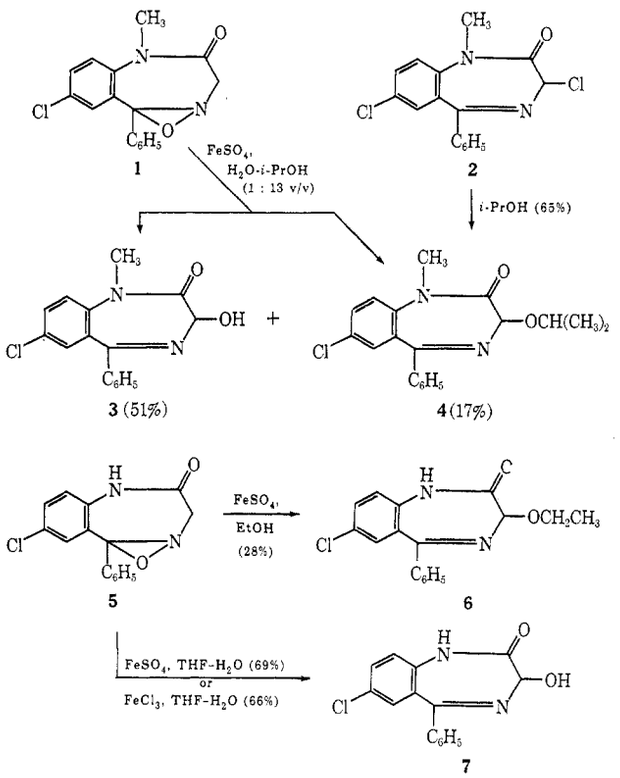
We have reported[2–4] on the preparation and chemistry of oxazirinobenzodiazepinones **1** and **5**. It was found[3] that **5** undergoes ring contraction reactions to form quinazolinones when alcoholic or aqueous solutions were simply allowed to stand at room temperature. We wish to report here that, when ferrous sulfate or

(1) Paper LXI: R. Y. Ning, P. B. Madan, and L. H. Sternbach, *J. Heterocycl. Chem.*, in press.
(2) R. Y. Ning, G. F. Field, and L. H. Sternbach, *J. Heterocycl. Chem.*, **7**, 475 (1970).
(3) R. Y. Ning, I. Douvan, and L. H. Sternbach, *J. Org. Chem.*, **35**, 2243 (1970).
(4) R. Y. Ning, W. Y. Chen, and L. H. Sternbach, *J. Org. Chem.*, **36**, 1064 (1971).

ferric chloride is added to solutions of **1** or **5** in alcohol or aqueous tetrahydrofuran, 3-alkoxy- or 3-hydroxybenzodiazepinones of types **3**, **4**, **6**, and **7** are formed as main products. Other oxaziridines have been reported[5-11] to react with ferrous salts, in one-electron-transfer chain reactions, to yield carbonyl compounds and, in many cases, complex mixtures. The reaction of **1** and **5** with ferrous sulfate appeared sluggish and required more than 1 equiv of the ferrous salt to bring about complete reactions.

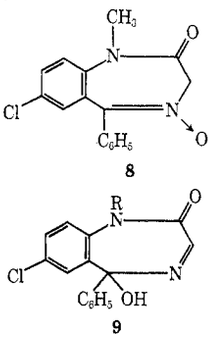
When a solution of 7-chloro-4,5-epoxy-1-methyl-5-phenyl-1,3,4,5-tetrachloro-2*H*-1,4-benzodiazepin-2-one (**1**) in isopropyl alcohol containing a small amount of water and 1.5 mol equiv of ferrous sulfate was stirred at room temperature for 2 days, two major products were formed. One, isolated in 51% yield, was found to be 7-chloro-1,3-dihydro-3-hydroxy-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one (**3**)[12] and the other, isolated in 17% yield, was 7-chloro-1,3-dihydro-3-isopropyloxy-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one (**4**). The structure of **4**, indicated by spectral data, was confirmed by a synthesis from the reaction of



the corresponding 3-chloro compound **2**[4] with isopropyl alcohol. Analogously, the treatment of 7-chloro-4,5-epoxy-5-phenyl-1,3,4,5-tetrahydro-2*H*-1,4-benzodiazepin-2-one (**5**) with ferrous sulfate in aqueous ethanol afforded the 3-ethoxy compound **6** (28%). Although the 3-hydroxy compound **7** appeared, by tlc, to be the other major product of this reaction, we did not isolate it. By replacing aqueous ethanol with aqueous tetrahydrofuran, **5** was converted to **7** by ferrous sulfate in at least 69% yield.

Being aware of the special sensitivity of some oxaziridines to ferrous salts,[5-11] we proceeded to study this reaction with ferric chloride, nickel chloride ($NiCl_2$), cupric sulfate, and cobalt chloride ($CoCl_2$) in place of ferrous sulfate. Under the same reaction conditions, (aqueous tetrahydrofuran), **5** was quite stable toward the latter three salts. With ferric chloride, however, the conversion to **7** proceeded just as well as it did with ferrous sulfate.

We have ruled out the formation of nitrones,[13] such as **8**, as intermediates in these reactions. **8**[12] was quite stable toward ferrous sulfate under these conditions. It is likely[4] that the 1,5-dihydrobenzodiazepinones **9** are



intermediates in these reactions. An attempt at the preparation of **9** by treating **5** with ferric chloride hexahydrate in tetrahydrofuran without added water resulted only in the 3-hydroxy compound **7**.

Experimental Section[14]

7-Chloro-1,3-dihydro-3-hydroxy-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one[12] (**3**) **and 7-Chloro-1,3-dihydro-3-isopropyloxy-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one** (**4**).—To a solution of 7-chloro-4,5-epoxy-1-methyl-5-phenyl-1,3,4,5-tetrahydro-2*H*-1,4-benzodiazepin-2-one[8] (**1**, 200 mg, 0.67 mmol) in isopropyl alcohol (90 ml) was added an aqueous solution of ferrous sulfate heptahydrate (Baker reagent grade, 1.0 mmol in 7 ml of water). The mixture was stirred at room temperature for 2 days under nitrogen. The reaction mixture was evaporated to dryness. The residue was partitioned between methylene chloride and saturated brine. The methylene chloride layer was washed with water and dried (Na_2SO_4). The methylene chloride was evaporated to dryness. The residue was separated by preparative tlc (four silica gel plates measuring 20 cm × 20 cm × 1.5 mm; ethyl alcohol–pentane–ether in 1:2:7 ratio of volumes used as developer).

3 (R_f 0.4), obtained as colorless needles after recrystallization from ether–pentane, weighed 103 mg (51%), mp 125–126°. It was found to be identical (ir, tlc, mixture melting point) with an authentic sample of **3** prepared by the method of Bell and Childress.[12]

4 (R_f 0.5), obtained as colorless prisms after recrystallization from ether–pentane, weighed 40 mg (17%): mp 210–212°;

(5) W. D. Emmons, *J. Amer. Chem. Soc.*, **79**, 5739 (1957).
(6) E. Schmitz, *Advan. Heterocycl. Chem.*, **2**, 83 (1963).
(7) W. D. Emmons in "The Chemistry of Heterocyclic Compounds, A. Weissberger, Ed., Vol. 19, Part I, Interscience, New York, N.Y., 1964, Chapter 4.
(8) J. F. Dupin, *Bull. Soc. Chim. Fr.*, 3085 (1967).
(9) E. Schmitz and D. Murawski, *Chem. Ber.*, **98**, 2525 (1965).
(10) F. Minisci, M. Cerere, and R. Galli, *Chim. Ind. (Milan)*, **50**, 225 (1968).
(11) F. Minisci, M. Cerere, and R. Galli, *Gazz. Chim. Ital.*, **98**, 358 (1968).
(12) S. C. Bell and S. J. Childress, *J. Org. Chem.*, **27**, 1691 (1962).
(13) Oxaziridines rearrange readily to nitrones under some conditions; see ref 6–8.
(14) General experimental details are as noted in the corresponding footnote in ref 4. Thin layer chromatography was performed on glass plates coated with Mallinckrodt silica 7GF5 (with fluorescent indicator) in the case of analytical tlc and Merck silica gel PF254 in the case of preparative tlc. All plates were activated by heating to 100° for 1 hr and then stored at 20–50°. The chromatograms were developed over a distance of 10 cm and then viewed or photographed under uv light.

ir (KBr) 1680 cm^{-1} (CO); uv max (CH_3CN) 231 nm (ϵ 33,900), 255 (sh) (17,500), 317 (2740); nm ($CDCl_3$) δ 1.33 (t, 6, 2 CH_3), 3.43 (s, 3, NCH_3), 4.12 (m, 1, $CH(CH_3)_2$), 4.88 (s, 1, H-3), 7.2–7.8 ppm (m, 8, aromatic); molecular ion *m/e* 342 (calcd 342).

Anal. Calcd for $C_{19}H_{19}ClN_2O_2$: C, 66.56; H, 5.58; N, 8.17; Cl, 10.34. Found: C, 66.60; H, 5.84; N, 8.04; Cl, 10.43.

The structure of **4** was confirmed by a synthesis from the corresponding 3-chloro compound **2**[4] as shown.

A solution of 3,7-dichloro-1,3-dihydro-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one[4] (**2**, 164 mg, 0.50 mmol) in isopropyl alcohol (20 ml) was heated on a steam bath for 20 min. The solution was evaporated to dryness. Crystallization of the residue from ether–pentane afforded 112 mg (65%) of **4** as prisms, mp 210–211°, identical with that prepared above by ir, tlc, and mixture melting point.

7-Chloro-1,3-dihydro-3-ethoxy-5-phenyl-2*H*-1,4-benzodiazepin-2-one (6).[12]—To a solution of 7-chloro-4,5-epoxy-5-phenyl-1,3,4,5-tetrahydro-2*H*-1,4-benzodiazepin-2-one[3] (**5**, 574 mg, 2.0 mmol) in ethyl alcohol (500 ml) was added an aqueous solution of ferrous sulfate heptahydrate (834 mg, 3.0 mmol, in 10 ml of water). The mixture was stirred at room temperature for 20 hr under nitrogen. Solvent was evaporated. The residue was partitioned between methylene chloride and brine. The methylene chloride layer was washed with water, dried (Na_2SO_4), and evaporated to dryness. The residue was applied to a column of 50 g of Florisil with methylene chloride. Elution with 1.5 l. of ethyl acetate followed by 500 ml of acetone afforded pure **6** (R_f 0.37 on silica gel tlc, using ether). Crystallization from methylene chloride–ether afforded 180 mg (28%) of colorless flakes, mp 222–224°, identical (tlc and mixture melting point) with a sample of **6** prepared by the literature procedure.[12]

7-Chloro-1,3-dihydro-3-hydroxy-5-phenyl-2*H*-1,4-benzodiazepin-2-one (7).[12] **A. With Aqueous Ferrous Sulfate.**—To a solution of 7-chloro-4,5-epoxy-5-phenyl-1,3,4,5-tetrahydro-2*H*-1,4-benzodiazepin-2-one[3] (**5**, 143 mg, 0.50 mmol) in tetrahydrofuran (100 ml) was added an aqueous solution of ferrous sulfate heptahydrate (208 mg, 0.75 mmol, in 20 ml of water). The mixture was stirred under nitrogen at room temperature for 3 days. The solvent was evaporated. The residue was partitioned between methylene chloride and saturated brine. The methylene chloride layer was washed with water, dried (Na_2SO_4), and evaporated to dryness. Crystallization of the residue from ether afforded 100 mg (69%) of **7** as colorless prisms, mp 208–210°. This material was found identical (ir, tlc, mixture melting point) with a sample of **7** prepared by the known[12] procedure.

B. With Aqueous Ferric Chloride.—To a solution of **5** (144 mg, 0.50 mmol) in tetrahydrofuran (150 ml) was added an aqueous solution of ferric chloride hexahydrate (Baker reagent grade, 0.75 mmol, in 20 ml of water). The mixture was stirred under nitrogen at room temperature for 7 days. The product was isolated in the same manner as described above in A. The yield of **7**, isolated as colorless prisms from ether, was 94 mg (65%), mp 206–208°. It was identified by ir, tlc, and mixture melting point.

C. With Ferric Chloride Hexahydrate.—To a solution of **5** (1.44 g, 5.0 mmol) in tetrahydrofuran (800 ml) was added solid ferric chloride hexahydrate (2.03 g, 7.5 mmol). The mixture was stirred under nitrogen at room temperature for 1 day. Isolation of the product in the same manner as described in A afforded 580 mg (40%) of **7**, identified by ir, tlc, and mixture melting point.

Stability of 7-Chloro-1,3-dihydro-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one 4-Oxide (8) toward Ferrous Sulfate.—To a solution of 1.5 g (5.0 mmol) of **8** in 1 l. of isopropyl alcohol was added an aqueous solution of ferrous sulfate heptahydrate (2.09 g, 7.5 mmol, in 50 ml of water). After 2 days of stirring at room temperature, under nitrogen, tlc indicated no signs of reaction. After evaporation of solvent and partitioning the residue between methylene chloride and water, **8** was quantitatively recovered.

Acknowledgment.—We thank Dr. R. P. W. Scott and his staff in our Physical Chemistry Department, in particular, Dr. W. Benz for mass spectra, Dr. F. Scheidl for elemental analyses, Dr. V. Toome for uv measurements, Mr. S. Traiman for ir spectra, and Dr. T. Williams for nmr spectra.

Registry No.—**1**, 24605-70-7; **2**, 23433-96-7; **3**, 846-50-4; **4**, 42077-69-0.

Addition of Trimethyl Phosphite to β-Nitrostyrene

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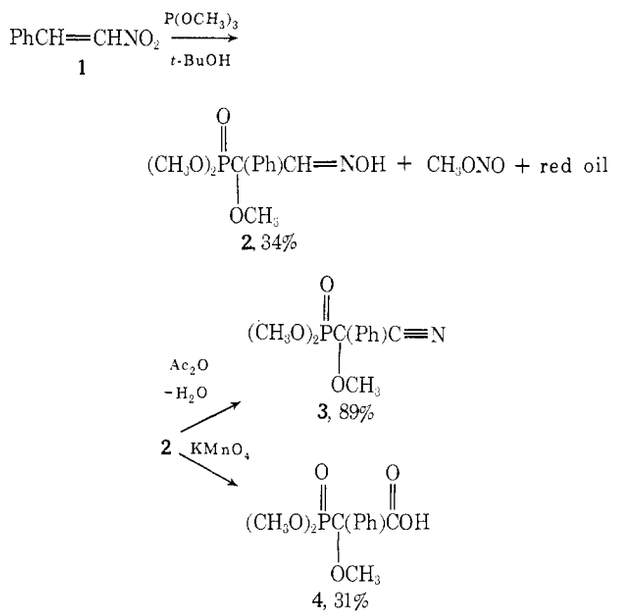
In connection with a general study of the deoxygenation of nitroalkenes with trivalent phosphorus compounds, β-nitrostyrene (**1**) was treated with trimethyl phosphite in *tert*-butyl alcohol at room temperature. The exothermic reaction formed a white solid in 34% yield. This solid was not the product of the intermediate nitrene expected of deoxygenation, nor was it similar to the product of the reaction of β-nitrostyrene with triethyl phosphite.[1] The chemical and physical data support **2** as the structure of this compound; the other products of this reaction include an unidentified red oil and an undetermined amount of methyl nitrite[2] (Chart I).

CHART I



Elemental analyses gave an empirical formula of $C_{11}H_{16}NO_5P$, a 1:1 adduct of the starting materials, and was in agreement with the mass spectrum which showed a molecular ion of M^+ 273. The presence of the phosphonate ester group was established by the ^{31}P nmr, δ −20.5 ppm (heptet, J_{H-P} = 10.6 Hz), by ^1H nmr (Table I), by the mass spectrum with a base peak at *m/e* 164, corresponding to the loss of O=P-$(OCH_3)_2$,[3] and by the infrared spectral bands at 1280 (vs) and 1065 cm^{-1} (vs). The ^1H nmr also indicated the presence of a third methoxyl at 3.48 ppm.

(1) G. L. Behelfer, J. R. Maloney, and W. E. Krueger, Abstracts, 163rd National Meeting of the American Chemical Society, Boston, Mass., April 1972, ORGN-157.

(2) The determination of yield of methylnitrite was complicated by the fact that nitrites react with phosphites: J. H. Boyer and J. D. Woodyard, *J. Org. Chem.*, **33**, 3329 (1968).

(3) J. L. Occolowitz and J. M. Swan, *Aust. J. Chem.*, **19**, 1187 (1966).