(1) (10.0 g, 0.033 mol) was dissolved in 250 ml of methanol. The solution was cooled to 5° and 70 ml of glacial acetic acid was added. Sodium nitrite (20 g, 0.29 mol) dissolved in 200 ml of water was added to the stirred solution in several portions over a period of 5 min, the temperature of the reaction mixture being maintained below 10° during the addition. The reaction mixture was stirred for 15 min and then poured onto ice. The product was extracted into ligroin. The extract was evaporated to a red oil and then dissolved in 350 ml of methanol. To the stirred solution, 20 ml of concentrated nitric acid was added in five equal portions. After the reaction mixture had been stirred for 1 hr, it was poured onto water and extracted with ether. The ether extract was dried and evaporated. The crude product was chromatographed on 170 g of silica. Elution was carried out with hexane–chloroform (95:5, then 90:10). The red solid product weighed 4.5 g (39.4%), mp 82–84°, mmp (with fermentation sample) 82–84°.

Anal. Calcd for $C_{20}H_{31}NO_4$: C, 68.7; H, 9.0; N, 4.0; mol wt, 349.4. Found: C, 68.4; H, 9.1; N, 4.0; mol wt, 341.

Preparation of 2,2,4-Trimethyl-7-*tert*-octylchroman-4,6-dione (3).—To a stirred solution containing 10 g (0.033 mol) of **1** in 50 ml of methanol was added 30 ml of nitric acid in six equal portions. The reaction mixture was stirred for 1 hr, poured onto 500 ml of water, and extracted with ether. The ether extract was dried and evaporated to red oil. The oil was chromatographed on 170 g of silica. Elution was carried out with increasing concentrations of chloroform in hexane. The red solid product weighed 8.7 g (83%), mp 92–94°, mmp (with fermentation product) 92–94°.

Anal. Calcd for $C_{20}H_{30}O_3$: C, 75.4; H, 9.5; mol wt, 318.4. Found: C, 75.7; H, 9.5; mol wt, 312.

8,9-Dihydro-2,7,7,9-tetramethyl-4-*tert*-octyl-7*H*-pyrano[3,2-*e*]-benzoxazole (4).—Compound **2** (0.46 g, 0.0013 mol) was dissolved in 9 ml of a 1:1 mixture of acetic anhydride and pyridine. The reaction mixture was stirred 2.5 hr at 55° and then poured onto ice water. The diluted reaction mixture was extracted with ether and the extract dried and evaporated to an oil. The oil was dissolved in 100 ml of ethanol and 0.2 g of 15% palladium on charcoal was added. The mixture was hydrogenated at 500 psi for 4–5 hr (room temperature). After removal of the catalyst and evaporation of the solvent, **4** was isolated on a Varian Aerograph Autoprep gas chromatograph using a $^3/_8$ in. by 20 ft aluminum column of 10% Se-30, 250° column temperature, and 150-ml/min He flow. The product has a 9-min retention time. Compound **4**, an off-white solid, weighed 0.078 g (22%): mp 84–87°; $\tau_{tms}^{CDCl_3}$ 7.4 (s, 3, $CH_3C(O)=N$), 3.4 (s, 1, aromatic).

Anal. Calcd for $C_{22}H_{33}NO_2$: C, 77.1; H, 9.7; N, 4.1; mol wt, 343.5. Found: C, 76.9; H, 9.4; N, 4.4; mol wt, 329.

2,3-Dihydro-1,3,3-trimethyl-6-*tert*-octyl-1*H*-pyrano[3,2-*a*]-phenazine (5).—In a mixture of 75 ml of glacial acetic acid and 300 ml of toluene were dissolved 3.0 g (0.0093 mol) of **3** and 2.0 g (0.0186 mol) of *o*-phenylenediamine.[9] During a 26-hr reflux, 2.2 ml of water was collected. The solvent mixture was evaporated to 50 ml. The concentrated solution was dissolved in ether and the resulting solution washed with water. The combined water wash was neutralized with sodium bicarbonate and extracted with ether. The ether extracts were combined, washed with a saturated sodium bicarbonate solution and then with water, dried, and evaporated to an oil. The oil was chromatographed on 75 g of silica. Elution was carried out with increasing concentrations of chloroform in hexane. The yellow solid product weighed 0.37 g (10.2%): mp 48–50°; $\tau_{tms}^{CDCl_3}$ 2.8 (s, 4, C=CHC=C), 2.9 (symmetrical multiplet around 2.1, 4, aromatic).

Anal. Calcd for $C_{26}H_{34}N_2O$: C, 80.0; H, 8.8; N, 7.2; mol wt, 390.6. Found: C, 80.0; H, 8.5; N, 7.2; mol wt, 375.

Registry No.—**1**, 18403-59-3; **2**, 30469-74-0; **3**, 30469-75-1; **4**, 30469-76-2; **5**, 30469-77-3.

Acknowledgment.—We wish to thank Drs. M. H. Stern and T. H. Regan for their advice and suggestions, Mr. D. Maier for interpretation of the mass spectra, and Mr. R. E. Stevens, Mr. H. A. Risley, and Mr. R. E. Sceusa for technical assistance.

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The Conversion of Hydroxamic Acids to *N,O*-Diacylhydroxylamines

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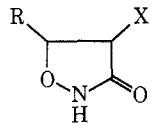
As an approach to the synthesis of substituted 3-isoxazolidones (**1**), it was predicted that the treatment of α,β-unsaturated hydroxamic acids (**2**) with electrophilic reagents would cause a cyclization to the desired compounds. This reaction would be analogous to the halolactonization reactions of β,γ-unsaturated acids.[2-4]



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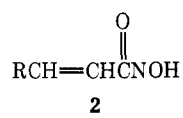
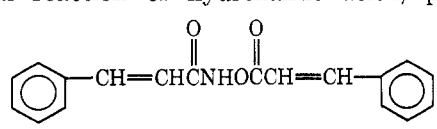


2

3, R = C_6H_5

Cinnamohydroxamic acid **3** was the initial compound with which this reaction was attempted. A suspension of **3** in sodium bicarbonate was treated with potassium triiodide; however, the product isolated was not the expected 3-isoxazolidone but rather *N,O*-dicinnamoylhydroxylamine (**4**). In order to determine if this is a general reaction of hydroxamic acids, potassium



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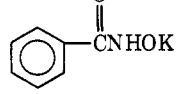
benzohydroxamate (**5**) was treated under the same conditions and was found to be converted to *N,O*-dibenzoylhydroxylamine (**6**). When this same reaction



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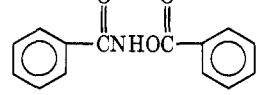
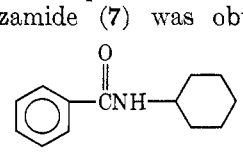


6

was repeated in the presence of cyclohexylamine, *N*-cyclohexylbenzamide (**7**) was obtained. Hydroxamic acids are readily converted to the corresponding carboxylic acids and nitrogen or nitrous oxide by such reagents as bromine water and aqueous periodic acids.[5,6] On the basis of these observations and of the products obtained, a plausible mechanistic interpretation of this reaction is as follows.



7

(1) Taken in part from the theses presented by N. A. Dahle, 1965, and V. D. Warner, Sept 1970, to the Graduate School of the University of Kansas in partial fulfillment of the requirements for the Doctor of Philosophy Degree.

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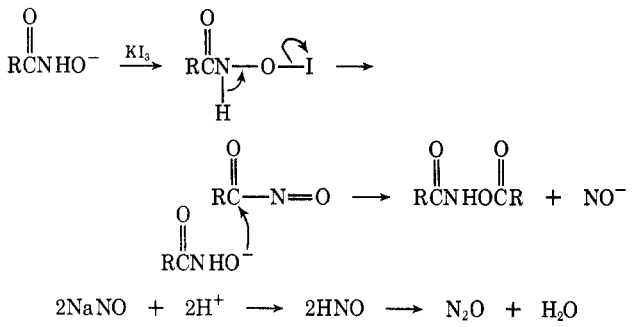

$$2NaNO + 2H^+ \longrightarrow 2HNO \longrightarrow N_2O + H_2O$$

Experimental Section[7]

Cinnamohydroxamic Acid (3).—This compound was prepared in 47% yield by the method of Jones and Mason.[8]

***N,O*-Dicinnamoylhydroxylamine (4).**—To a stirred suspension of cinnamohydroxamic acid (**3**) (3.00 g, 0.019 mol) in 100 ml of 0.5 *M* $NaHCO_3$ was added KI (20.0 g, 0.12 mol) and I_2 (10.2 g, 0.04 mol) in 100 ml of H_2O. The reaction mixture was stirred at 25° for 9 hr and extracted with $CHCl_3$ (three 50-ml portions). The combined $CHCl_3$ extracts were washed with 20% $Na_2S_2O_3$ (two 50-ml portions) and dried (Na_2SO_4), and the solvent was removed. The residue was recrystallized (MeOH) to yield 0.93 g (33%) of **4**, mp 161–162°.

Anal. Calcd for $C_{18}H_{15}NO_3$: C, 73.78; H, 5.23; N, 4.78. Found: C, 74.18; H, 5.23; N, 4.78.

An authentic sample of *N,O*-dicinnamoylhydroxylamine was prepared by treating cinnamohydroxamic acid with cinnamoyl chloride[9]. Its spectra were identical with those of **4**.

Dibenzoylhydroxylamine (6).—This compound was prepared by the same method as *N,O*-dicinnamoylhydroxylamine (**4**, 44%) and was found to be identical with an authentic sample prepared by the method of Renfrow and Hauser.[9]

***N*-Cyclohexylbenzamide (8).**—To a solution of benzohydroxamic acid (**7**) (2.75 g, 0.020 mol) in 25 ml of pyridine was added I_2 (2.53 g, 0.010 mol) and KI (4.98 g, 0.030 mol) in 10 ml of H_2O. To this reaction mixture was added 5 ml of cyclohexylamine followed by 200 ml of H_2O. After cooling, the insoluble material was removed by filtration and recrystallized (EtOH) to give 0.32 g (7.8%) of **8**, mp 142–147° (lit.[10] 148°), whose spectra were identical with those of an authentic sample.

Registry No.—**4**, 30345-94-9; **8**, 1759-68-8.

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(7) Melting points were obtained on a calibrated Thomas-Hoover Unimelt and are corrected. Ir data were recorded on a Beckman IR-10 spectrophotometer and nmr data on Varian Associates A-60 and A-60A spectrometers (TMS). Microanalyses were performed by Midwest Microlab, Inc., Indianapolis, Ind., and on an F & M 185 C, H, N, analyzer, University of Kansas.

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The Preparation and Properties of a Seven-Membered Heterocyclic Phosphinic Acid[1]

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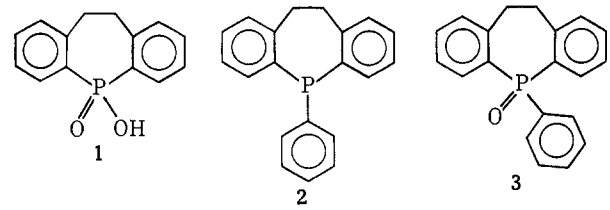
Although numerous heterocyclic derivatives of phosphorus have been prepared in recent years,[2] there are still relatively few phosphinic acids in which the phosphorus atom is a member of a ring system. Thus, a recent survey[1] indicates that only 38 such phosphinic acids have been described in the chemical literature; in these compounds the phosphorus atom was a member of a four-, five-, or six-membered ring. The present paper is concerned with the preparation and properties of the seven-membered heterocyclic phosphinic acid **1**.



Since the tertiary phosphine **2** and the phosphine oxide **3** have been previously reported,[3] we used these compounds as precursors to the desired phosphinic acid **1**. The fusion of a tertiary phosphine oxide with sodium hydroxide leads to cleavage of a carbon–phosphorus bond and the formation of the sodium salt of a phosphinic acid (eq 1).[4] When phosphine oxides of the

$$R_3PO + NaOH \longrightarrow R_2PO_2Na + RH \quad (1)$$

type $R_2R'PO$ are used, the group that is preferentially cleaved is the one that can form the more stable carbanion. This rule is usually followed when the phosphorus atom is a member of a ring system;[5] in two cases,[5a,c] however, a ring carbon–phosphorus bond was cleaved even though this meant formation of the less stable carbanion. We have now found that reaction of the phosphine oxide **3** with fused sodium hydroxide obeyed the general rule and led to a 92% yield of **1**; 7% of the starting material **3** was also isolated from the reaction mixture.

The reaction of tertiary phosphines with lithium (or other alkali metal) results in the formation of a phosphide ion and a carbanion (eq 2).[4b,6] Hydrolysis,

$$R_3P + 2Li \rightarrow R_2PLi + RLi \quad (2)$$

oxidation, and acidification of the reaction mixture readily gives a phosphinic acid. The direction of cleavage for unsymmetrical phosphines has been shown to be thermodynamically controlled; *i.e.*, it is determined by the stability of the products.[6c,7] When a heterocyclic tertiary phosphine reacts with lithium, cleavage of the ring would result in the formation of a dianion. For a variety of phosphole derivatives, this pathway has proved to be of significantly higher energy than cleavage of the exocyclic carbon–phosphorus bond; in these cases, therefore, no cleavage of the heterocyclic ring was ob-

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