gel column (20 g, 2.3 × 13 cm) with methanol–chloroform (1:100) as a developing solvent. The component of R_f 0.93 was obtained as colorless needles, mp 248–250°, after recrystallization from methanol. This material, showing an infrared absorption at 1715 cm^{-1}, was obtained in such a small amount (3 mg) that it could not be further investigated. The other component (R_f 0.83) was *d*-corydaline, mp 132–134°, identical (tlc behavior, infrared spectrum, and mixture melting point determination) with an authentic sample. Fraction 1-2 showed three spots (R_f 0.66, 0.55, and 0.43) on tlc. Repeated crystallization of this fraction from chloroform–methanol yielded a material showing R_f 0.55, which proved to be identical with *l*-tetrahydrocolumbamine by direct comparison. The mixture consisted of *l*-tetrahydrocolumbamine, and a material showing R_f 0.66 was deposited from the mother liquor. These two components were separated by means of silica gel column chromatography with methanol–chloroform (3:100) as a developing solvent. The component (R_f 0.66) was obtained from the first elute in pure form, which was designated as base A described below. The last elute gave *l*-tetrahydrocolumbamine. The mother liquors of these two bases were combined and concentrated to yield the residue (2.0 g) which was rechromatographed on silica gel column (60 g, 2.8 × 20 cm) and eluted in four fractions as shown in Table III.

TABLE III

COLUMN CHROMATOGRAPHY OF PHENOLIC ALKALOID (2)

Fraction	Eluent	Volume, ml	Yield, mg	R_f values on tlc, solvent a
2-1	4% MeOH–$CHCl_3$	50	150	0.83, 0.66
2-2	4% MeOH–$CHCl_3$	100	804	0.66, 0.55, 0.43
2-3	4% MeOH–$CHCl_3$	40	494	0.43, 0.33
2-4	4% MeOH–$CHCl_3$	40	285	0.33, 0.24

Additional amounts of *l*-tetrahydrocolumbamine (200 mg) and base A (500 mg) were obtained by recrystallization of fraction 2-2 from chloroform–methanol. The mother liquors were combined with the fraction 2-3 and recrystallized from the same solvent to give base B (R_f 0.43) (341 mg). Fraction 2-4 was converted to the hydrochloride and crystallized from ethanol–ether to yield pale yellow crystals of *l*-scoulerine hydrochloride (74 mg). Identity was established by comparison of the infrared spectrum of its base (mp 194–196°, R_f 0.24) with that of an authentic sample, and by mixture melting point determination.

Fraction 1-3 was recrystallized from chloroform–methanol to give *l*-tetrahydrocolumbamine (351 mg). This mother liquor was concentrated to give the residue (1.4 g), which was rechromatographed on silica gel column (70 g, 3.2 × 20 cm) and eluted in three fractions as shown in Table IV.

TABLE IV

COLUMN CHROMATOGRAPHY OF PHENOLIC ALKALOID (3)

Fraction	Eluent	Volume, ml	Yield, mg	R_f values on tlc, solvent a
3-1	4% MeOH–$CHCl_3$	20	198	0.55, 0.43
3-2	4% MeOH–$CHCl_3$	60	1250	0.33, 0.24
3-3	4% MeOH–$CHCl_3$	60	68	0.33, 0.24

Fraction 3-1 was treated as in the case of fraction 2-2 to give *l*-tetrahydrocolumbamine (51 mg) and base B (108 mg). Fraction 3-2 was converted to the hydrochloride and treated as in the case of fraction 2-4 to give *l*-scoulerine hydrochloride (451 mg). The mother liquor of the hydrochloride was reconverted to the base. This basic fraction (714 mg) showed the presence of a component of R_f 0.33 which was isolated by means of silica gel column chromatography (24 g, 2.1 × 16.5 cm) using chloroform–methanol (25:1) as a developing solvent. The compound, isolated as pale yellow needles (R_f 0.33), mp 189–190°, was identical with an authentic sample of noroxyhydrastinine.

Fraction 1-4 was converted to the hydrochloride and allowed to stand for 4 days. Pale yellow crystals of protopine hydrochloride separated, which, after recrystallization from ethanol, were converted to the base. This base was identified with an authentic sample of protopine by comparison of the infrared spectrum and by mixture melting point determination. The mother liquor of fraction 1-4 and fraction 1-5 contained more than two components (R_f 0.15 and 0.11), none of which could be isolated in pure form.

Crystallization of fraction 1-6 from ethanol yielded a small amount (120 mg) of the material showing R_f 0.02, mp 163–164°, which proved to be identical with α-allocryptopine. Identity was established by comparison of the infrared spectrum with that of an authentic sample, by tlc behavior, and by mixture melting point determination. The remainder of the fraction could not be separated into pure components.

Base A (*d*-**Corybulbine** = *d*-**Corydalmine**) (**III**).—Base A, mp 220–222° dec, $[\alpha]_D$ 307° (*c* 0.38, chloroform), was identical with *d*-corybulbine [nmr (described in the text) and infrared spectra, tlc behavior, and mixture melting point determination].

Anal. Calcd for $C_{21}H_{25}O_4N$: C, 70.96; H, 7.09; N, 3.94. Found: C, 71.30; H, 6.96; N, 3.84.

A solution of 5 mg of base A in 10 ml of methanol was added to a solution of an excess of diazomethane in ether, and the mixture was allowed to stand for 3 hr. The solution was concentrated under reduced pressure and the residue was recrystallized from ethanol to give pale yellow prisms of mp 134–136°. This compound was identified with *d*-corydaline by comparison of its infrared spectrum and by mixture melting point determination.

Base B (*d*-**Tetrahydrojatrorrhizine**).—Base B had mp 214–215°, $[\alpha]_D$ 302.2° (*c* 0.65, chloroform).

Anal. Calcd for $C_{20}H_{23}O_4N$: C, 70.36; H, 6.79; N, 4.10. Found: C, 70.57; H, 7.09; N, 4.04. Infrared (in chloroform solution) and nmr spectra and tlc behavior of this compound were identical with those of synthetic *dl*-tetrahydrojatrorrhizine.[13] Base B was methylated as in the case of base A by diazomethane to give pale yellow prisms, mp 143–145°. Tlc behavior and infrared spectrum of this methylated compound were identical with those of *dl*-tetrahydropalmatine.

Registry No.—*l*-Tetrahydrocolumbamine, 20504-94-3; *d*-corybulbine, 518774; *l*-scoulerine, 6451-73-6; *d*-tetrahydrojatrorrhizine, 6018-39-9; *d*-corydaline, 3907-48-0; *d*-glaucine, 475-81-0; *dl*-tetrahydropalmatine, 2934-97-6; protopine, 130-86-9; *l*-tetrahydrocoptisine, 20504-98-7; α-allocryptopine, 485-91-6.

Acknowledgment.—The authors are very grateful to Dr. S. Ose, Director of this laboratory, for his encouragement and also to Professor Sheng-Teh Lu, Kaohsiung Medical College, for the kind supply of the authentic sample of *d*-glaucine hydrobromide. Thanks are also due to the members of Analytical Center of this laboratory for microanalyses and nmr measurements.

A Novel Method of Converting Aldehydes into Nitriles under Mild Conditions. The Reaction of Dialkyl Hydrogen Phosphonates with Oximes

PATRICK J. FOLEY, JR.[1]

Department of the Army, Harry Diamond Laboratories, Washington, D. C. 20438

March 10, 1969

Present methods of converting aldehydes into nitriles generally require rather vigorous conditions.[2] We wish to report a very mild method of effecting this conversion in two simple steps.

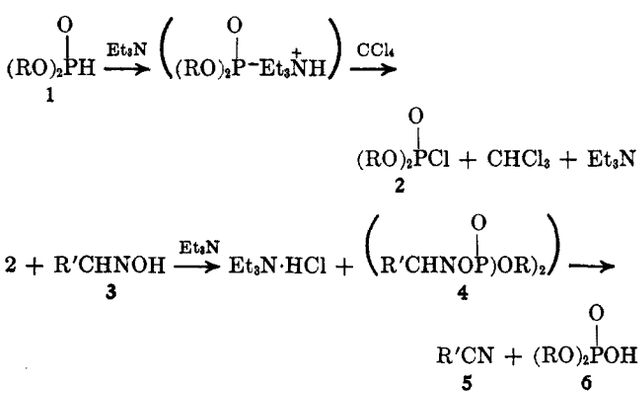
(1) Plastics Department, E. I. du Pont de Nemours and Co., Experimental Station Laboratory, Wilmington, Del. 19898.

(2) See, for example, W. Theilheimer ["Synthetic Methods of Organic Chemistry," Vol. 1–22, S. Karger, A G., Basel, Switzerland, 1946–1968] for representative techniques. For a mild method, see J. H. Pomeroy and C. A. Craig, *J. Amer. Chem. Soc.*, **81**, 6340 (1959).

Treatment of various aldoximes (**3**), readily available from the aldehydes, with dialkyl hydrogen phosphonates (**1**, R = phenyl, methyl, *n*-butyl) at room temperature in the presence of carbon tetrachloride and a tertiary amine (triethylamine) produced a high yield of the corresponding nitrile. Aliphatic, aromatic, and olefinic oximes all reacted cleanly to give good yields of the nitriles, but it was found that diphenyl hydrogen phosphonate gave higher yields than either the dimethyl or di-*n*-butyl compounds. The stereochemistry of the aldoxime (*syn* or *anti*) had little effect on the reaction, although it is possible that the oximes are isomerized under the reaction conditions.[3]

The oximes used and the yields of the purified nitriles produced in the reactions with diphenyl hydrogen phosphonate are *syn*-benzaldoxime, 88%; *syn*-anisaldoxime, 85%; *syn*-*p*-nitrobenzaldoxime, 85%; *syn*-cinnamaldoxime, 95%; butyraldoxime (stereochemistry unknown), 40%; and *anti*-furaldoxime, 60%.

The mechanism of this reaction is undoubtedly reaction of the phosphonate (**1**) with carbon tetrachloride and triethylamine to produce the dialkyl phosphorochloridate (**2**) and chloroform,[4] followed by esterification of the aldoxime (**3**) and Beckmann fragmentation[5] of this ester (**4**) to the nitrile (**5**) and the dialkylphosphoric acid (**6**).



Although the intermediate ester (**4**) could not be isolated, the likelihood of the correctness of this mechanism was shown by treating *syn*-benzaldoxime with diphenylphosphorochloridate (**2**, R = Ph) under the same conditions used in the phosphonate reactions. An 85% yield of benzonitrile was obtained directly, in support of the intermediacy of the dialkyl phosphorochloridate (**2**) in the dialkyl hydrogen phosphonate reactions.

Experimental Section

The oximes were either purchased or prepared by standard routes. The nitriles were identified by comparison of their ir spectra and gc retention times with those of authentic material, and by their melting points, in the case of solids.

A solution of 0.1 mol of the oxime and 0.1 mol of triethylamine in 250 ml of carbon tetrachloride was treated over 30 min with 0.1 mol of diphenyl hydrogen phosphonate and the solution was stirred for 4 hr at ambient temperature. The triethylamine hydrochloride was removed by filtration and the filtrate was poured into water. The organic layer was separated, washed twice with dilute aqueous sodium hydroxide, and dried (Na_2SO_4), and the solvent was removed at reduced pressure. The resulting nitrile was purified by distillation or recrystallization.

Registry No.—**1** (R = Ph), 4712-55-4; **1** (R = Me), 868-85-9; **1** (R = Bu), 1809-19-4; *syn*-benzaldoxime, 13830-84-7; *syn*-anisaldoxime, 20707-68-0; *syn*-*p*-nitrobenzaldoxime, 20707-69-1; *syn*-cinnamaldoxime, 20707-70-4; butyraldoxime, 110-69-0; *anti*-furaldoxime, 20728-36-3.

(3) P. A. S. Smith, "Open Chain Nitrogen Compounds," Vol. 2, W. A. Benjamin, Inc., New York, N. Y., 1966, p 34.

(4) G. M. Steinberg, *J. Org. Chem.*, **15**, 637 (1950); G. W. Kenner and N. R. Williams, *J. Chem. Soc.*, 522 (1955).

(5) P. A. S. Smith, in "Molecular Rearrangements," Vol. 1, P. de Mayo Ed., Interscience Publishers, New York, N. Y., 1963, p 504.