then stirred with 5 g of sodium acetate, diluted with 30 ml of water, and extracted with chloroform. The extract was washed with saturated sodium bicarbonate solution, dried (Na_2SO_4), and evaporated to a syrup which was crystallized from ethyl acetate–heptane to give the acetyl derivative **8** (380 mg, 82%): mp 102–103°; ν_{max}^{Nujol} 3440 (NH), 1740 (OAc), and 1680 cm^{-1} (CONH); nmr ($CDCl_3$) τ 3.85 (s, due to H-1), 4.9 (d, H-2, $J_{2,3}$ = 5 Hz), 7.85, 7.90, 7.91, and 8.0 (due to 12 Ac protons); $[\alpha]^{25}D$ +44° (*c* 1.5, $CHCl_3$).

Anal. Calcd for $C_{13}H_{19}NO_8$: C, 49.18; H, 6.04; N, 4.41. Found: C, 49.39; H, 6.31; N, 4.42.

Registry No.—**3**, 35085-25-7; **4**, 35085-26-8; **5**, 35085-27-9; **6**, 14125-95-2; **7**, 29881-54-7; **8**, 35085-30-4.

4-Phenyl-1,2,3,6-tetrahydropyridines in the Prins Reaction. Examples of a Cis Steric Course

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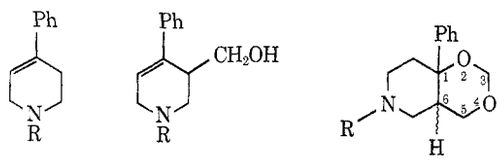
Schmidle and Mansfield[3] reported that the acid-catalyzed addition of formaldehyde to 1-substituted 4-phenyl-1,2,3,6-tetrahydropyridines (**1**) gave the corresponding 3-hydroxymethyltetrahydropyridines **2**. When this Prins reaction[4] is performed using a 10-fold or larger molar excess of formaldehyde, we find that the novel bicyclic 1,3-dioxanes **3** form in yields above 50%; they are isolated as crystalline hydrohalides. The 100-MHz pmr spectrum of **3a** in deuteriochloroform (Figure 1) shows a pair of doublets near δ 4.83 and 3.7, respectively each of two-proton intensity. The former is assigned to the 3-methylene group as the chemical shifts of the equatorial and axial protons are typical of protons flanked by oxygen atoms in 1,3-dioxanes[5] while the ^2J value is numerically low (~6 Hz), also characteristic of methylene in this environment.[6] The lower field half of the four-line signal near δ 3.7, assigned to the 5-methylene protons, shows clear evidence of vicinal coupling (^3J = 2.5 Hz) but the higher field doublet is merely broadened. The absence of a large



1 **2** **3**

a, R = Me; **b**, R = CH_2Ph; **c**, R = *t*-Bu

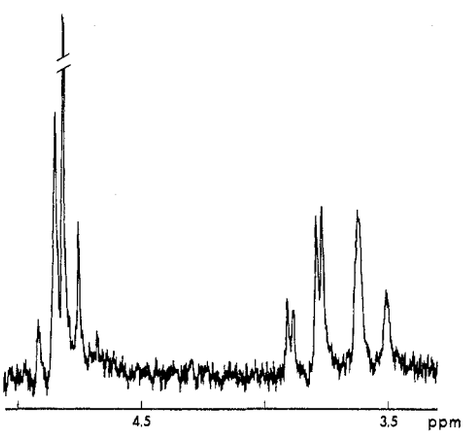
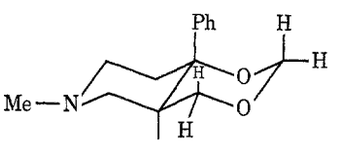


Figure 1.— Part of the 100-MHz pmr spectrum of the 1,3-dioxane **3a** in $CDCl_3$.

^3J value within this signal establishes that neither 5-methylene proton bears a 180° dihedral angle relationship to the 6-methine proton.[7] This conclusion excludes the trans isomer **4** and shows that **3a** is the cis



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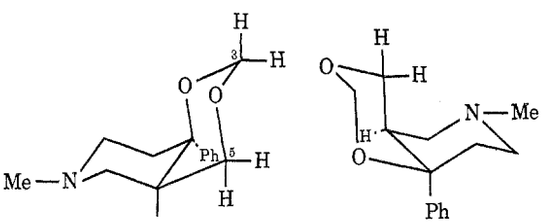

5 **6**

form with the "O inside" (**5**) (opposed to axial hydrogens) rather than "O outside" (**6**)[8] preferred conformation. In **5** the 3 and 5 equatorial protons are linked by a near planar W pathway and their pmr signals display the anticipated long range coupling which broadens the doublets,[7] in support of this stereochemical assignment. Similar evidence was derived from the pmr spectra of **3b** and **3c** (Experimental Section).

While both cis and trans products have been identified from the Prins reaction of acyclic alkenes,[9] the alicyclic derivatives cyclohexene[10] and *trans*-Δ^2-octalin[11] yield trans products exclusively in this procedure. Observation of a cis reaction pathway in the present alicyclic examples is probably a result of the steric demands of the bridgehead phenyl substituent; the same factor will similarly influence the conformation of the

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(2) A. B. S. and D. S.

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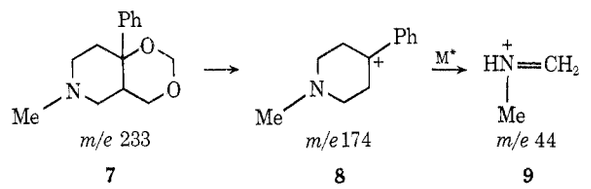
cis derivatives as will also that of the known preference for the "O inside" rather than "O outside" conformation in cis 1,3-dioxadecalanes.[8]

The mass spectral features of **3a** were consistent with the assigned structure; a molecular ion peak was present (*m/e* 233) and prominent lines at *m/e* 44 (base peak) and 174 plus a metastable peak at 11.1 showed the chief fragmentation pathway to be **7** → **8** → **9**.



Experimental Section[12]

Prins Reaction of 1-Methyl-4-phenyl-1,2,3,6-tetrahydropyridine and Analogs.—A mixture of the tetrahydropyridine **1a** (112 g),[13] aqueous formaldehyde (500 ml, 37%), concentrated sulfuric acid (250 ml), and water (to 1-l. total volume) was heated under reflux for 5 hr. The cooled product was made alkaline with aqueous ammonia and extracted with ether which was dried (Na_2SO_4) and evaporated. The residue with excess of ethanolic hydrogen chloride gave the **1,3-dioxane 3a hydrochloride** (81 g): mp 323° dec from ethanol; pmr (base in $CDCl_3$) δ 4.87, 4.80 (2 d, 3-CH_2, ^2J = 6.5 Hz), 3.94, 3.45 (d d, d, 5-CH_2, ^2J = 11.5, ^3J = 2.5 Hz for lower field signal), 2.39 (s, NMe).

Anal. Calcd for $C_{14}H_{20}ClNO_2$: C, 62.32 H, 7.47 N, 5.19. Found: C, 62.05 H, 7.52; N, 5.14.

Similar treatment of **1b**[13] gave the *N*-benzyl analog **3b hydrochloride**: mp 282° dec from ethanol; pmr (base in $CDCl_3$) δ 4.87, 4.71 (2 d, 3-CH_2, ^2J = 6.5 Hz), ~3.78 (d d, one 5-CH_2 proton, ^2J = 11.5, ^3J = 2.0 Hz, higher field signal not resolved), 3.6 (s, NCH_2).

Anal. Calcd for $C_{20}H_{24}ClNO_2$: C, 69.45; H, 7.0; N, 4.0. Found: C, 68.95; H, 7.27; N, 3.93.

Reaction of **1c** gave the ***N-tert*-butyl analog 3c hydrobromide**: mp 297° dec; pmr (base in $CDCl_3$) δ 4.66, 4.58 (2 d, 3-CH_2, ^2J = 6.5 Hz), 3.81, 3.55 (dd, d, 5-CH_2, ^2J = 11.6 Hz, ^3J = 2.5 Hz for lower field signal), 1.12 (s, *t*-Bu).

Anal. Calcd for $C_{17}H_{26}BrNO_2$: C, 57.31; H, 7.36; N, 3.93. Found: C, 57.50; H, 7.38; N, 3.78.

The tetrahydropyridine **1c** was made by treating 1-*tert*-butyl-4-phenyl-4-piperidinol (see below) with a hot mixture of acetic and hydrochloric acids;[14] it formed a **hydrogen oxalate**, mp 224° from acetone–ether.

Anal. Calcd for $C_{17}H_{23}NO_4$: C, 66.8; H, 7.46; N, 4.5. Found: C, 66.8; H, 7.59; N, 4.6.

The 4-piperidinol, prepared from 1-*tert*-butyl-4-piperidone[15] and phenyllithium in the usual manner,[14] melted at 112–113° (from ether–ligroin).

Anal. Calcd for $C_{15}H_{23}NO$: C, 77.2; H, 9.93; N, 6.0. Found: C, 77.59; H, 9.93; N, 6.1.

It formed a **hydrogen oxalate**, mp 201–203°.

Anal. Calcd for $C_{17}H_{25}NO_5$: C, 63.14; H, 7.79; N, 4.3. Found: C, 62.98; H, 7.65; N, 4.3.

Registry No.—**1c** hydrogen oxalate, 35116-80-4; **3a** hydrochloride, 35116-81-5; **3b** hydrochloride, 35116-82-6; **3c** hydrobromide, 35116-83-7; 1-*tert*-butyl-4-phenyl-4-piperidinol, 35116-84-8; 1-*tert*-butyl-4-phenyl-4-piperidinol hydrogen oxalate, 35116-85-9.

(12) Melting points were determined in sealed capillary tubes (Gallenkampf apparatus) and are uncorrected. Pmr spectra were recorded in deuteriochloroform with tetramethylsilane as internal standard on a Varian HA-100 instrument.

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Reactions of 6-Acyl-5*H*-1-pyrindine-5,7(6*H*)-diones with Diamines

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As a continuation of our work on the preparation of 6-acyl-5*H*-1-pyrindine-5,7(6*H*)-diones (**1**) and on their reactions with hydrazine,[1] we now report the results of the reactions of compounds **1** with a variety of other diamines, with emphasis on a new pyridocyclopentadiazepine system.

We found that condensation of 6-acetyl-5*H*-1-pyrindine-5,7(6*H*)-dione (**1a**) with ethylenediamine yielded two different types of products depending upon the reaction conditions. Addition of **1a** (1 mol) to a refluxing ethanolic solution of ethylenediamine (1.5 mol) in the presence of formic acid gave 6-[1-(2-aminoethylimino)ethyl]-5*H*-1-pyrindine-5,7(6*H*)-dione (**2**) in good yields. Structure **2** is based on the elemental analyses, on the spectral data, and on the method of preparation which is analogous to that used by Mosher and Piesch to prepare 2-[1-(2-aminoethylimino)alkyl]-1,3-indandiones.[2]

Reverse addition of the reactants, ethylenediamine to a refluxing ethanolic solution of **1a**, and change of their molar ratio yielded the 1:2 product, 6,6′-[ethylenebis(nitriloethylidyne)]di-5*H*-1-pyrindine-5,7(6*H*)-dione (**6**), in very good yields.

When compound **2** was heated for 12 hr in refluxing 1-propanol and in the presence of formic acid, the expected ring closure took place with the formation of only one of the two possible isomers, 2,3-dihydro-5-methylpyrido[2′,3′:4,3]cyclopenta[2,1-*e*][1,4]diazepin-6(1*H*)-one (isomer **4**) or 2,3-dihydro-5-methylpyrido-[2′,3′:3,4]cyclopenta[2,1-*e*][1,4]diazepin-6(1*H*)-one (**3**). Structure **4** was assigned to the isolated isomer on the basis of elemental analyses, spectral data, and its reaction with ferrous ammonium sulfate. A 2:1 complex of pyridocyclopentadiazepinone **4** with ferrous iron as an intense blue-violet product was obtained. The ferrous iron complexes with the nitrogen of pyridine and the oxygen (enol form) of the cyclopentadiazepine moiety. The structurally related 2,3-dihydro-5-methyl-6*H*-indeno[1,2-*e*][1,4]diazepin-6-one[2] did not form a chelate with ferrous ammonium sulfate, indicating that it is not the diazepine ring which complexes with ferrous iron.

The ring closure of compound **2** to diazepinone **4** is similar to those previously observed in the reactions of 2-acetyl-1,3-indandione with ethylenediamine[2] and of 6-benzoyl-5*H*-1-pyrindine-5,7(6*H*)-dione with hydrazine.[1] Treatment of compound **4** with an excess of hydrazine in ethanolic solution gave the known hydrazone of 3-methylpyrazolo[3′,4′:3,4]cyclopenta[1,2-*b*]pyridin-4(1*H*)-one (**5**).[1]

Addition of 6-benzoyl-5*H*-1-pyrindine-5,7(6*H*)-dione (**1b**) to a refluxing solution of *o*-phenylenediamine in

* Deceased July 23, 1972.

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