ester in 10–11% yield. Solvent and nitrite ester were removed at reduced pressure, resulting in the isolation of 661 mg of red oil.

Analysis of the red oil using gc showed the presence of seven products, samples of which were isolated using preparative gc and characterized spectrally. A total of 79 mg (0.94 mmol, 10% yield) of 4-pentynol, characterized by comparison of its ir and nmr spectra with that of an authentic sample, was detected by this method. The following products, in order of their elution from the gc, were also detected.

4-Pentynal: ir ν_{max} (CCl_4) 3312 (s), 2820 (m), 2720 (m), 2120 (w), 1720 (s) cm^{-1}; nmr τ (ppm, TMS, CCl_4) 0.07 (1 H), 7.45 (3–4 H), 8.17 (2 H); 28 mg (0.34 mmol; 4% yield).

Component A: ir ν_{max} (CCl_4) 3320 (s), 3070 (w), 1720 (s), 1570 (m), 993 (s), 680 (s), 650 (s), 625 (s) cm^{-1}; nmr (ppm, TMS, CCl_4) 2.35 (d), 2.84 (t), 7.75, 8.20, 8.65; mass spectrum m/e 205, 204 (C_6H_4I + H), 128 (HI), 127 (I), 106, 105 (C_6H_4CO), 79–74 (phenyl ring), 66, 51, 50, 43, 39 ($CH{\equiv}CCH_2$); 0.43 mmol detected (*ca.* 5% yield).

Component B: ir ν_{max} (CCl_4) 3312, 3075, 2952, 1520, 1340, 848 cm^{-1}; mass spectrum m/e 204 ($CH{\equiv}C(CH_2)_3OC_6H_4NO_2$ − 1), 139 ($OC_6H_4NO_2$ + H), 123 ($C_6H_5NO_2$), 105, 93 (C_6H_5O), 84, 83 [$CH{\equiv}C(CH_2)_3O$], 78, 77, 66, 65, 55, 53, 51, 46 (NO_2), 39 ($CH{\equiv}CCH_2$), 30 (NO); 0.21 mmol detected (*ca.* 2–3% yield).

Component C: ir ν_{max} (CCl_4) 3312, 3235 (br), 3080 (w), 1610, 1586, 1527, 1470, 1450, 1320, 1245 cm^{-1}; mass spectrum m/e 139, 122, 109 (OC_6H_4OH), 93 (C_6H_5O), 81, 65, 64, 53, 39; 0.31 mmol detected (*ca.* 3–4% yield).

In a similar manner, 1.907 g (10.0 mmol) of nitrite, 1.907 g (7.5 mmol) of I_2, and 300 ml of benzene were photolyzed for 7.5 hr (77% completion; uv analysis). A total of 250 mg of insoluble polymer precipitated from the solution after 8 hr. Excess I_2 was not reduced with 10% thiosulfate solution. The solution was concentrated to 10 ml and analyzed using gc. No 4-pentyn-1-ol or 4-pentynal was detected.

Registry No. —III, 30428-24-1; IV, 5390-04-5; V, 30428-26-3.

Acknowledgment. —Financial support of this investigation by the University of North Carolina Research Center under Contract SD-100 with the Advanced Research Projects Agency and by a University of North Carolina Research Grant is gratefully acknowledged.

Heterocyclic Studies. 34. Toluenesulfonyl Derivatives of 2,3-Dihydro-5-methyl-6-phenyl-1,2-diazepin-4-one. Rearrangement to a 1,4-Dihydropyridazine[1]

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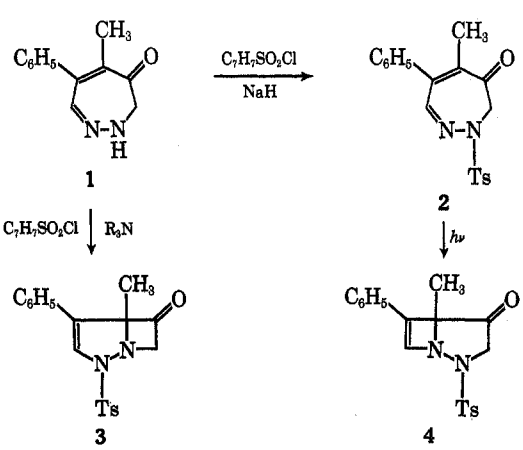
The 2-tosyldiazepinone **2** undergoes rearrangment in the presence of triethylamine to the 2-tosylamido-3-hydroxypyridine **5**. With sodium alkoxides, **2** rearranges with loss of $ArSO_2H$ to give the dihydropyridazine esters **11**; a bicyclo[4.1.0] intermediate is suggested. The 2-tosylbicyclo[3.2.0] ketone **3** undergoes ring opening in methanol and rearrangement to the 1-tosylamidopyridinium ylide **18** in strong acid. In base, **3** gives the 6-tosylamido-3-hydroxypyridine **17**.

In a continuation of work on the diazepinone **1**, sulfonyl derivatives were of interest for comparison of some reactions with those of acyl counterparts.[2] Acylation of the diazepinone **1** can be directed by choice of conditions to give either seven-membered or bicyclic derivatives.[3] Similarly, the reaction of **1** with tosyl chloride and tertiary amines gave the bicyclic sulfonamide **3**, whereas, in the presence of sodium hydride, attack of tosyl chloride on the N-2 anion of **1** led to **2**.



2-Tosyldiazepinone (2).—The yellow 2-tosyl ketone **2** showed an ir carbonyl band (1680 cm^{-1}) and uv spectrum typical of other 2,3-dihydrodiazepinones in this series. Irradiation (sunlight) converted **2** cleanly to the photoisomer **4**, also obtained by tosylation of the photoisomer of **1**.[1a]

Our principal interest in the chemistry of **2** lay in its reactions in base. Deuterium exchange of the C-3 methylene protons occurred rapidly in DMSO–D_2O containing triethylamine. On heating a solution of **2** in benzene containing triethylamine, a colorless isomer was obtained in 60% yield. This product was recognized from its properties as the 2-tosylamidopyridine **5**; the structure was confirmed by further tosylation to the *O,N*-ditosyl derivative **6** and comparison with a sample prepared by vigorous treatment of the aminopyridine **7** with toluenesulfonyl chloride. Unexpectedly, the initial monotosylation product of **7** was the *O*-tosylate **8** rather than the sulfonamide **5**. Parallel behavior was observed on tosylation of 2-amino-3-hydroxypyridine (**9a**) and also the 3-hydroxy-6-aminopyridine **19a**; the *O*-tosyl esters were obtained with excess tosyl chloride and triethylamine or pyridine at room temperature. Treatment of **9a** with 1 equiv of benzoyl chloride similarly gave the ester **9c** (Chart I).

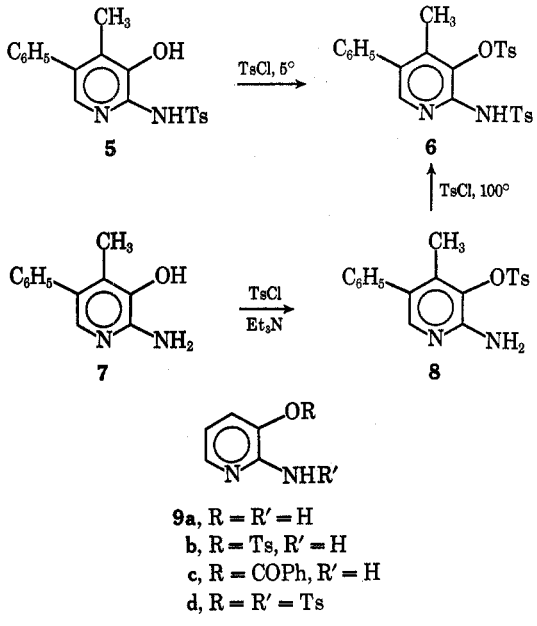
The transformation of **2** to the pyridine **5** presumably occurs by an enolization–valence isomerization sequence *via* the bicyclo[4.1.0] system **10**, as proposed

(1) (a) Part 33: E. J. Volker, M. G. Pleiss, and J. A. Moore, *J. Org. Chem.*, **35**, 3615 (1970). (b) Supported by Grant No. GP-9322 from the National Science Foundation.

(2) J. A. Moore, R. L. Wineholt, F. J. Marascia, R. W. Medeiros, and F. J. Creegan, *J. Org. Chem.*, **32**, 1353 (1967).

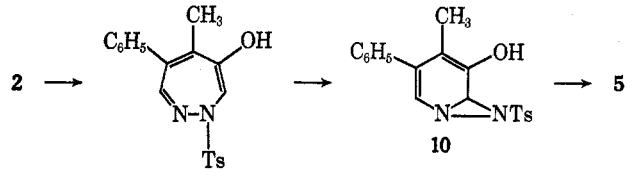
(3) W. J. Theuer and J. A. Moore, *ibid.*, **32**, 1602 (1967).

CHART I



9a, R = R′ = H
b, R = Ts, R′ = H
c, R = COPh, R′ = H
d, R = R′ = Ts

for the rearrangement of **1** to **7**.[4] Although tosyldiazepinone **2** undergoes deuterium exchange in the presence of triethylamine, the C-3 protons of the 2-methyl and the 2-acetyl counterparts do not exchange under these conditions. The latter compounds were recovered unchanged after heating in triethylamine.



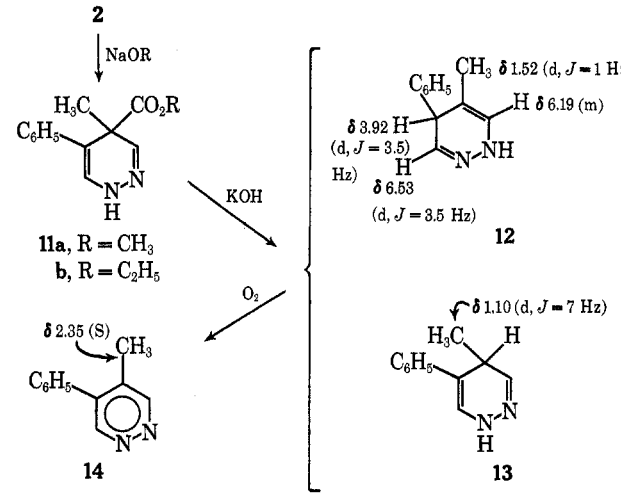
Treatment of the tosyldiazepinone **2** with alkoxides in ether or alcohol brought about an entirely different reaction, in which toluenesulfinic acid was eliminated and the elements of alcohol were added. The nmr spectra of the products indicated a quaternary methyl group [δ 1.40 ppm (s, 3)] and two $-N{=}CH-$ protons. The infrared spectra showed strong bands at 3200–3300 cm^{-1} (NH) and carbonyl bands at 1725 cm^{-1}, suggesting an ester. The 4-methyl-4-alkoxycarbonyldihydropyridazine structures **11** were established for these products by alkaline degradation to 4-methyl-5-phenylpyridazine (**14**).

After saponification of the methyl ester **11a** and neutralization, extraction gave a solution whose nmr spectrum showed three new methyl signals, at δ 1.10 (d, J = 7 Hz), 1.52 (d, J = 1.2 Hz), and 2.35 (s). The relative intensities of these three peaks varied in different runs and changed with time. After several days' standing, or rapidly on exposure to air, the two higher field doublets gave way completely to the 2.35 singlet, with simultaneous increase in intensity of two singlet peaks at δ 9.25 and 9.30. Isolation of the product at this point gave **14**, isolated in 75% yield as the picrate (Chart II).

The nmr data show the path of the degradation quite clearly; the high-field doublets in the initial spectra correspond to the two 1,4-dihydropyridazines **12** and

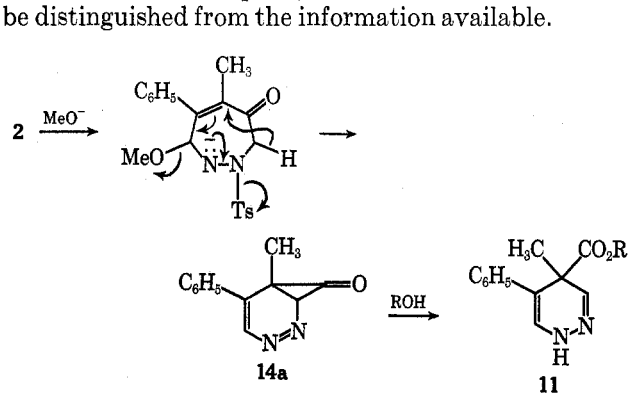
(4) M. G. Pleiss and J. A. Moore, *J. Amer. Chem. Soc.*, **90**, 1369 (1968).

CHART II



13. In another experiment, the tosyldiazepinone **2** was treated directly with aqueous methanolic KOH, and the solution was neutralized and extracted. The major methyl peak in the intermediate spectrum in this case was the δ 1.52 doublet due to **12**, and three additional peaks, δ 3.92 (d, J = 3.5 Hz), 6.19 (m), and 6.53 (d, J = 3.5 Hz), were present in an intensity ratio of 1:1:1 (with the δ 1.52 peak as 3). These signals can be assigned to the 3-methyl-4-phenyl isomer, as shown in **12**. Although **12** predominated in this instance it could not be isolated. The data do not permit conclusions about the relative stabilities or interconvertibility of **12** and **13** or the effect of pH, if any, on the tautomeric equilibrium.

The ester **11a** was also formed in the reaction of **2** with methanolic cyanide, suggesting that this rearrangement is initiated by nucleophilic attack of CN^- or OMe^-. The most likely site would be at C-7, as suggested for reactions of **1** with good nucleophiles.[5] The immediate precursor of the esters **11** must be the bicyclo[4.1.0] ketone **14a**, with the overall process comprising a "vinylogous" Favorskii-type rearrangement.[6,7] The bicyclic intermediate **14a** might also arise *via* the diazatropone, but these alternatives cannot be distinguished from the information available.



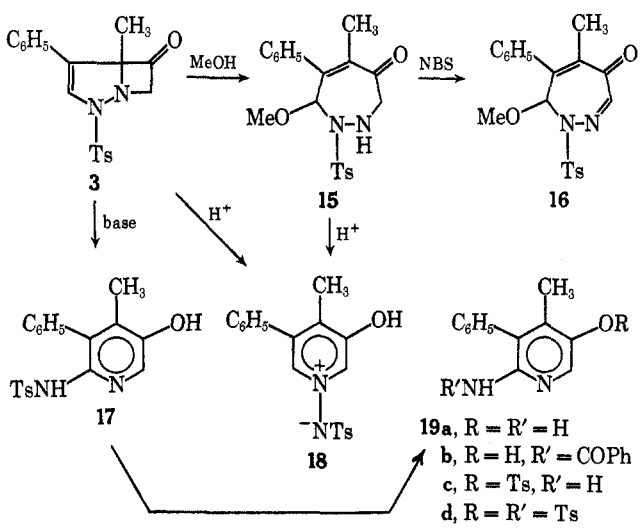
2-Tosyldiazabicyclo[3.2.0]heptanone (3).—The structure of this bicyclic ketone follows by analogy with the corresponding acyl derivatives.[8] The nmr spectrum was generally consistent for **3**, but a curious fea-

(5) J. A. Moore and J. Binkert, *ibid.*, **81**, 6029 (1959).
(6) A. W. Fort, *ibid.*, **84**, 2625 (1962).
(7) G. M. Iskander and F. Stansfield, *J. Chem. Soc., C*, 669 (1969).
(8) J. A. Moore, F. J. Marascia, R. W. Medeiros, and R. L. Wineholt, *J. Org. Chem.*, **31**, 34 (1966).

ture was the highly shielded position of the C-5 CH_3 singlet (δ 0.68 ppm), compared to that in the benzoyl analog (δ 1.60 ppm). Similar high-field CH_3 signals were seen in the spectra of other arenesulfonyl derivatives, but not the methanesulfonyl compound (δ 1.65 ppm). The abnormal shielding of the methyl group in **3** must be caused by the ring of the arenesulfonyl group lying at a more acute angle with respect to the five-membered ring than in the benzamide, so that the methyl group in **3** lies in the shielding cone of the toluenesulfonyl group.

The reactions of **3** are summarized in Chart III.

CHART III



Warming in methanol, or more rapidly in methanol containing a trace of a carboxylic acid, gave the 7-methoxy-1-tosyl-1,2,3,7-tetrahydrodiazepinone (**15**) which could be readily oxidized with NBS to the 1,7-dihydrodiazepine **16**. Both the bicyclic tosylamide and the diazepinone **15** were converted in hydrochloric acid to the 1-tosylamidopyridinium ylide **18**. All of these reactions except that of **3** in neutral methanol parallel those observed and previously discussed[2,3] with the analogous acetyl and benzoyl derivatives and require no further comment.

The reactions of the 2-tosyl[3.2.0] ketone **3** in base differ significantly, however, from those of the 2-acyl analogs (**3**, Ac or Bz instead of Ts). The latter compounds in aqueous base give complex mixtures of degradation products, the composition of which depend on the substituent, conditions, and solvent.[2] The 6-benzamidopyridine **19b** is the major product obtained on refluxing the 2-benzoyl[3.2.0] ketone with methanol or methanolic base, but this product is characteristic of the solvent rather than the presence of base.[2]

In contrast, treatment of the tosyl bicyclic ketone **3** with methanolic sodium methoxide or aqueous hydroxide or triethylamine gave in each case the 6-tosylamido-3-hydroxypyridine **17** in 50–60% yield. The characterization followed that used for the 2-tosylamide **5**, *i.e.*, correlation with the known 6-aminopyridine **19a** by conversion of both compounds to the ditosyl derivative **19d**. Tosylation of **19a** under mild conditions gave the ester **19c**; a tritosyl derivative was obtained from **17** with excess tosyl chloride.

The formation of **17** from **3** thus depends on the presence of base and appears to be independent of the medium. On the other hand, as noted above, **3** in methanol alone gives the methoxydiazepinone and no **17**. Although the formation of analogous 6-aminopyridine derivatives in the tosyl and benzoyl series suggests a common process, the two reactions may in fact be unrelated. We can offer no explanation at present for the differences in behavior of the tosyl and acyl compounds or for the formation of **17** from **3** in base.

Experimental Section[9]

5-Methyl-6-phenyl-2-tosyl-2,3-dihydro-4*H*-1,2-diazepin-4-one (2).—A solution of 3.0 g of diazepinone **1** in 150 ml of glyme (1,2-dimethoxyethane) was treated with 750 mg of sodium hydride suspension (52% in mineral oil), and the mixture was stirred vigorously until hydrogen evolution ceased (30 min). The yellow solution was chilled to −10° and a solution of 2.85 g of tosyl chloride in 50 ml of glyme was added dropwise with stirring; a transient green color appeared. Ether and water were then added and the red ether solution was washed, dried, and evaporated to an oil which was crystallized from ethanol to give 2.65 g of **2**, mp 118–119°, and 0.7 g, mp 112–115°. Recrystallization twice from ethanol gave yellow prisms: mp 120–121°; λ_{max}^{MeOH} 229 nm (ϵ 14,600), 313 (6400), 390 (sh); ν^{KBr} 1685, 1335, 1150 cm^{-1}; δ^{CDCl_3} 1.93 (s, 3), 2.48 (s, 3), 4.11 (s, 2), 7–8 ppm (m, 10).

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.95; H, 5.36; N, 8.18.

A solution of 600 mg of **2** in 600 ml of methanol in a Pyrex flask was exposed to direct sunlight for 1 hr. The uv spectrum showed nearly complete absence of **2**. After another hour of irradiation the solution was concentrated *in vacuo;* crystallization gave 500 mg of **4**,[1a] mp 153–154°, and 35 mg (total 90%), mp 150–151°.

3-Hydroxy-4-methyl-5-phenyl-2-tosylamidopyridine (5) (By W. J. Freeman).—A solution of 418 mg of diazepinone **2** and 0.34 ml of triethylamine in 1.2 ml of benzene was heated in a sealed tube at 85–90° for 18 hr; the nmr spectrum showed 85–90% conversion to one product. The solution was evaporated to a dark oil, which was extracted with water and was then decolorized in CH_2Cl_2 solution. The yellow solution was then concentrated and diluted with ether; crystallization (three crops) gave 277 mg (66%) of tan solid, mp 189–192°. Further decolorization and recrystallization from CH_2Cl_2–ether gave white crystals of **5**: mp 192–193°; pK_a' 8.5 (proton lost);[10] ν^{KBr} 3500, 1275, 1085 cm^{-1} (SO_2); δ^{CDCl_3} 2.10 (s, 3), 2.38 (s, 3), 7.0–7.9 ppm (m, 11).

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.39; H, 5.11; N, 7.90. Found: C, 64.58; H, 4.69; N, 7.51.

3-Hydroxy-4-methyl-5-phenyl-2-tosylamidopyridine *p*-Toluenesulfonate (6).—A solution of 354 mg of the above 2-toluenesulfonamido-3-hydroxypyridine, 150 mg of triethylamine, and 195 mg of tosyl chloride in 5 ml of methylene chloride was kept at 5° for 4 hr and was then washed, dried, and evaporated. Addition of ether and pentane caused crystallization of 450 mg of white solid, mp 194–195°. Recrystallization from methylene chloride–pentane and then ethanol–water gave an analytical sample of **6**: mp 194–195°; ν^{KBr} 1600, 1560, 1380, 1330 cm^{-1}; δ^{CDCl_3} 2.16 (s, 3), 2.42 (s, 3), 2.53 (s, 3), 7.1–8.2 ppm (m, 16); pK_a' = 7.6 (proton lost).[10]

(9) General procedures and instruments are described in ref 2.

(10) Apparent dissociation constants, pK_a', were determined by electrometric titration.[11] We are greatly indebted to Dr. John M. Vanderbelt and Mrs. Carola H. Spurlock, Parke, Davis and Co., for these measurements. All titrations were carried out in 66% dimethylformamide unless otherwise noted. The designations "proton gained" and "proton lost" correspond to the position of inflections below and above the electroneutrality baseline in the difference curve from titration.[11]

Values for pK_a' for protonation ("proton gained") of the 2-aminopyridines **8**, **9b**, **9c**, and **19c** were 3.0–4.0. For the 3-hydroxy-2- or -6-tosylamidopyridines and 3-tosyloxy-2- or -6-tosylamidopyridines, acidic pK_a values ("proton lost") ranged from 7.6 to 10.1. For the latter series (tosylates **6**, **9d**, and **19d**) this pK_a' evidently corresponds to loss of the –NHTs proton. For the hydroxysulfonamides **5** and **17**, it is not known whether –OH or –NHTs is responsible for the observed pK_a'.

(11) T. V. Parke and W. W. Davis, *Anal. Chem.*, **26**, 642 (1954).

Anal. Calcd for $C_{26}H_{24}N_2O_5S_2$: C, 61.41; H, 4.76; N, 5.51. Found: C, 61.21; H, 4.62; N, 5.47.

2-Amino-3-hydroxy-4-methyl-5-phenylpyridine 3-*p*-Toluenesulfonate (8).—2-Amino-3-hydroxy-4-methyl-5-phenylpyridine (7) was prepared as previously described[12] by refluxing a solution of 2 g of diazepinone 1 in 20 ml of 5% aqueous NaOH for 3 hr. After acidification, charcoal treatment, and adjustment of the pH with $NaHCO_3$, the resulting precipitate was extracted with chloroform. After washing and drying, the chloroform solution was evaporated to give a first crop of 300 mg (15%) of the 2-amino-3-hydroxypyridine 7, mp 218–220°. Subsequent crops of crystals (710 mg) contained predominately the 6-amino-3-hydroxy isomer. Chromatography on silicic acid gave little separation of these isomers; alumina caused decomposition.

A solution of 300 mg of the 2-amino-3-hydroxy isomer, 170 mg of triethylamine, and 290 mg of tosyl chloride in 5 ml of methylene chloride was allowed to stand for 4 hr at 20°. After washing, drying, and evaporation, addition of pentane gave 400 mg of solid, mp 129–130°. Recrystallization from ethanol–water and sublimation gave **8** as colorless crystals: mp 130°; ν^{KBr} 3400, 3200, 1640, 1480, 1360 cm^{-1}; δ^{CDCl_3} 2.04 (s, 3), 2.50 (s, 3), 4.72 (br, 2), 7.1–8.1 ppm (m, 10); pK_a' 3.1 (proton gained).[10]

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.35; H, 5.16; N, 7.76.

For conversion to the 2-tosylamido-3-tosylate **6**, 100 mg of tosylate **8** was refluxed with 200 mg of tosyl chloride in 3 ml of pyridine for 2 days. After evaporation, the black oil in chloroform solution was treated with charcoal and the solution was applied to a 5 × 20 cm plate with 1-mm silica gel G coating. After development with chloroform–methanol, the fluorescent zone was scraped off and eluted, and the resulting solution was evaporated to give 50 mg of tan solid, mp 188–190°. Further treatment with charcoal and recrystallization from CH_2Cl_2–pentane and then ethanol gave pale tan crystals, mp 194–195°; the ir spectrum matched (17 peaks) that of **6** prepared from **5**.

2-Amino-3-hydroxypyridine *p*-Toluenesulfonate (9b).—A solution of 1.1 g of 2-amino-3-hydroxypyridine (Aldrich Chemical Co.), 1.5 g of triethylamine, and 1.90 g of tosyl chloride in methylene chloride was kept at 0° for 2 hr and was then washed with water and acid, dried, and evaporated. Addition of ether caused crystallization of 1.97 g of white solid, mp 132–133°. After recrystallization from methylene chloride–pentane and sublimation (120°), the melting point was 135–136°; $pK_a' = 3.0$ (proton gained);[10] ν^{KBr} 3400, 3200, 1640, 1600, 1580, 1370 cm^{-1}; δ^{CDCl_3} 2.43 (s, 3), 4.70 (br, 2, exchanged in D_2O), 6.53 (m, 1), 7.0–8.0 ppm (m, 6).

Anal. Calcd for $C_{12}H_{12}N_2O_3S$: C, 54.54; H, 4.84; N, 10.60. Found: C, 54.68; H, 4.55; N, 10.41.

2-*p*-Toluenesulfonamido-3-hydroxypyridine *p*-Toluenesulfonate (9d).—A solution of 200 mg of the above 2-amino-3-toluenesulfonate **9b** and 400 mg of tosyl chloride in 5 ml of pyridine was warmed for 2 days and then evaporated. After preparative tlc as described above for **6**, the fluorescent zone was eluted and the solution was crystallized from CH_2Cl_2–pentane to give 90 mg (28%) of white solid, mp 127–129°. Recrystallization gave crystals: mp 129–130°; $pK_a' = 7.6$ (proton lost);[10] δ^{CDCl_3} 2.38 (s, 3), 2.47 (s, 3), 6.7–8.2 ppm (m, 12).

Anal. Calcd for $C_{19}H_{18}N_2O_5S_2$: C, 54.55; H, 4.34; N, 6.70. Found: C, 54.72; H, 4.38; N, 6.61.

2-Amino-3-benzoyloxypyridine (9c).—A solution of 220 mg of **9a**, 300 mg of pyridine, and 270 mg of benzoyl chloride in CH_2Cl_2 (1 ml) was kept for 1 hr at 0°. After addition of aqueous KOH, washing, drying, and evaporation, 210 mg (49%) of solid, mp 120–122°, was obtained. Recrystallization from ethanol–water and CH_2Cl_2–pentane and sublimation gave white crystals of **9c**: mp 123–124°; $pK_a' = 4.0$ (proton gained);[10] ν^{KBr} 3300, 3200, 1725, 1650, 1600, 1480 cm^{-1}.

Anal. Calcd for $C_{12}H_{10}N_2O_2$: C, 67.28; H, 4.71; N, 13.08. Found: C, 67.07; H, 4.59; N, 12.89.

Deuterium Exchange of 2.—A solution of 750 mg of the 2-tosyldiazepinone **2** in 3 ml of dimethyl sulfoxide containing 5 drops of triethylamine and 0.2 ml of D_2O was allowed to stand for 10 min at 0° and was then diluted with D_2O. The resulting yellow crystals were collected, washed with water, dried, and recrystallized from ether, mp 116–118°. Integration of the nmr spectrum gave 4 ± 1 mm for the δ 4.10 peak *vs.* 29–30 mm for each of the methyl singlets (20 ± 5% of CH_2); the δ 4.10 peak was an unsymmetrical doublet due to change of chemical shift in CHD.

(12) J. A. Moore and E. C. Zoll, *J. Org. Chem.*, **29**, 2124 (1964).

Under similar conditions, the 2-methyl- and 2-acetyldiazepinones showed <5% exchange of the C_3–CH_2 singlet.

4-Methoxycarbonyl-4-methyl-5-phenyl-1,4-dihydropyridazine (11a).—To a solution of 500 mg of **2** in 30 ml of ether was added 2.5 g of sodium methoxide. After the mixture was stirred at 25° for 1 hr, dilute HCl was added and the ether layer was washed, dried, and evaporated to give 360 mg of brown oil. Chromatography on 18 g of silicic acid (benzene) gave initially 32 mg of unreacted **2** and then a yellow oil which crystallized to give 142 mg (46%) of white solid, mp 76–77°, which was sublimed: ν^{KBr} 3400, 1725 cm^{-1}; δ^{CCl_4} 1.40 (s, 3), 3.58 (s, 3), 6.23 (s, 1), 6.45 (d, 1, J = 4 Hz, $\xrightarrow{D_2O}$ s), 7.18 (s, 5), 7.95 ppm (s, 1 $\xrightarrow{D_2O}$ 0).

Anal. Calcd for $C_{13}H_{14}N_2O_2$: C, 67.81; H, 6.13; N, 12.17. Found: C, 68.02; H, 6.02; N, 12.25.

The **ethyl ester 11b** was obtained by treatment of a solution of 3.0 g of **2** in 10 ml of glyme with 1 equiv of sodium ethoxide in 30 ml of ethanol. The resulting red solution stood for 30 min at 25° and was then diluted with ether and extracted with three 30-ml portions of water. After drying and evaporation the yellow oil (1.8 g) was chromatographed on silicic acid (chloroform). After elution of 200 mg of unreacted **2**, further fractions were combined and evaporated to give 1.40 g of solid, mp 52–55°. After repeated recrystallization from ether–hexane, **11b** was obtained as white crystals: mp 57–58°; ν^{KBr} 3250, 1725 cm^{-1}; λ_{max}^{MeOH} 229 nm (ε 7400), 311 (5500); δ^{CDCl_3} 1.06 (t, 3, J = 7 Hz), 1.46 (s, 3), 4.11 (q, 2, J = 7 Hz), 6.41 (s, 1), 6.58 (d, 1, J = 4 Hz, $\xrightarrow{D_2O}$ s), 7.30 ppm (s, 6).

Anal. Calcd for $C_{14}H_{16}N_2O_2$: C, 68.83; H, 6.60; N, 11.47. Found: C, 68.61; H, 6.83; N, 11.30.

Conversion of Dihydropyridazinecarboxylate 11 to 4-Methyl-5-phenylpyridazine.—The methyl ester **11a** (30 mg) was dissolved in a solution of 90 mg of KOH in 1 ml of water and 2 ml of methanol. After standing at 75° for 50 min, the solution was treated with dilute HCl until turbid and was then extracted with chloroform. An nmr spectrum of the solution showed peaks due to **12**, **13**, and **14** (see discussion). After standing in the presence of air until the spectrum showed only **14**, the solution was evaporated and the residue was treated with alcoholic picric acid; 39 mg (75%) of yellow crystals was obtained, mp 137–138°, ir identical with that of a previously characterized sample.[13]

2-Tosyl-5-methyl-4-phenyl-1,2-diazabicyclo[3.2.0]-3-hepten-6-one (3).—A solution of 3.0 g of the 2,3-dihydrodiazepinone **1** and 8.0 g of tosyl chloride in 60 ml of pyridine was kept at 25° for 13 hr. After diluting with CH_2Cl_2 the solution was washed with water, excess dilute HCl, and water again, dried, and evaporated. The residual yellow solid was washed with ether and recrystallized from methylene chloride–ether to give 3.1 g of white prisms: mp 148–150°; ν^{KBr} 1810, 1370, 1170 cm^{-1}; δ^{CDCl_3} 0.68 (s, 3), 2.37 (s, 3), 4.56, 4.87 (AB, dd, J = 17.6 Hz, additional splitting of both doublets, J = 1 Hz), 7.00 (s, 1, br, $W_{1/2}$ = 2 Hz), 7.2–8.0 ppm (m, 9).

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.55; H, 5.29; N, 8.11.

2-Methanesulfonyl-5-methyl-4-phenyl-1,2-diazabicyclo[3.2.0]-3-hepten-6-one.—To a solution of 400 mg of diazepinone **1** in 3 ml of pyridine was added 0.4 ml of methanesulfonyl chloride; the solution became warm and crystals separated. After CH_2Cl_2 was added, the mixture was washed with acid and water, dried, and evaporated to an oil which crystallized on adding ether to give 250 mg of colorless crystals: mp 148–149°; ν^{KBr} 1800, 1335, 1154 cm^{-1}; δ^{CDCl_3} 1.65 (s, 3), 2.99 (s, 3), 4.55 (dd, 1, $J_{7,7'}$ = 17.7 Hz, $J_{3,7}$ = 1.1 Hz), 4.92 (dd, 1, $J_{7,7'}$ = 17.7, $J_{3,7'}$ = 0.9 Hz), 6.93 (s, 1, br, $W_{1/2}$ = 2.1 Hz), 7.25–7.60 ppm (m, 5).

Anal. Calcd for $C_{13}H_{14}N_2O_3S$: C, 56.11; H, 5.07; N, 10.07. Found: C, 56.20; H, 5.11; N, 10.07.

The benzenesulfonyl (mp 134–135°, δ_{CH_3} 0.65 ppm) and *p*-cyanobenzenesulfonyl (mp 159–160° dec, δ_{CH_3} 0.73 ppm) derivatives were obtained by the same procedures; these compounds were not analyzed.

1-*p*-Tosyl-5-methyl-7-methoxy-6-phenyl-1,2,3,7-tetrahydro-4*H*-diazepin-4-one (15).—A solution of 380 mg of the tosyl[3.2.0] ketone **3** and 20 mg of benzoic acid in 15 ml of methanol was refluxed for 30 min and chilled. The resulting white crystals of **15** were collected and washed with cold methanol: yield 365 mg (80%); mp 140–142° dec; ν^{KBr} 3400, 1690 cm^{-1}; $\delta^{DMSO\text{-}d_6}$ 1.67 (s, 3), 2.33 (s, 3), 3.10–3.23 (m, 6, OCH_3 + CH_2 + NH), 5.68 (s, 1), 7.3–7.9 ppm (m, 9).

(13) R. K. Bly, E. C. Zoll, and J. A. Moore, *ibid.*, **29**, 2128 (1964).

Anal. Calcd for $C_{20}H_{22}N_2O_4S$: C, 62.16; H, 5.74; N, 7.25. Found: C, 62.33; H, 6.09; N, 7.31.

A suspension of 200 mg of **3** in 30 ml of methanol was refluxed for 1.5 hr; after chilling, 150 mg of **15**, mp 142–143°, was collected.

1-*p*-Tosyl-5-methyl-7-methoxy-6-phenyl-1,7-dihydro-4*H*-diazepin-4-one (16).—A solution of 190 mg of *N*-bromosuccinimide in 12 ml of pyridine was added slowly to a solution of 400 mg of the 7-methoxy-1-tosyldiazepinone **15** in 50 ml of CH_2Cl_2. After 18 hr at 20°, ice and 20 ml of concentrated HCl were added and the CH_2Cl_2 layer was washed, dried, and evaporated to an oil which crystallized on adding methanol to give 280 mg of pale yellow crystals. Recrystallization from methanol gave **16**: mp 142–144°; ν^{KBr} 1600, 1340, 1160 cm^{-1}; δ^{CDCl_3} 1.90 (s, 3), 2.46 (s, 3), 3.13 (s, 3), 6.21 (s, 1), 7.2–8.0 ppm (m, 9).

Anal. Calcd for $C_{20}H_{20}N_2O_4S$: C, 62.49; H, 5.24; N, 7.28. Found: C, 62.83; H, 5.55; N, 7.06.

1-Tosylamido-3-hydroxy-4-methyl-5-phenylpyridinium Betaine (18).—To a solution of 0.10 g of tosyl bicyclic ketone **3** in 2 ml of dimethyl sulfoxide was added 1 ml of concentrated HCl. After heating at 90° for 5 min, the deep red solution was poured into ice. The resulting tan precipitate (65 mg) was collected and recrystallized from methanol (charcoal treatment) to give colorless prisms of **18**: mp 253–254° dec; ν^{KBr} 3300, 1290, 1130 cm^{-1}; $pK_a' = 7.0$ (proton lost).[10]

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.36; H, 5.29; N, 7.62.

Similar treatment of the methoxytosyltetrahydrodiazepinone **15** (100 mg) in 3 ml of DMSO with 1 ml of concentrated HCl gave 56 mg of crude **18**, mp (after recrystallization from methanol) 253–254°.

A comparison sample of **18** was prepared by treatment of 500 mg of 1-amino-3-hydroxy-4-methyl-5-phenylpyridinium betaine in 5 ml of pyridine with 550 mg of tosyl chloride. The resulting burgundy solution was poured onto ice, and, after acidification with concentrated HCl, the hydrochloride of **18**, mp 159–161°, separated. Neutralization gave the base **18**, mp 245–258°; ir matched that of a sample prepared from **3**.

3-Hydroxy-4-methyl-5-phenyl-6-tosylamidopyridine (17).—A suspension of 500 mg of the tosyl bicyclic ketone **3** in 5 ml of methanol was treated with 1.2 ml of 1.29 *M* sodium methoxide in methanol. The resulting yellow solution stood for 10 min at 25° and was then evaporated to an oil. The oil was dissolved in CH_2Cl_2 and this solution was then extracted with 20 ml of 1 *N* aqueous KOH. Neutralization of the KOH extract gave 270 mg of precipitate, which was recrystallized from ethyl acetate–hexane to give 250 mg of **17**, mp 187–189°. Further recrystallization gave needles: mp 192–193°; ν^{KBr} 3300, 1320, 1150 cm^{-1}; λ_{max}^{MeOH} 237 (ϵ 13,600), 352 nm (1050); $\delta^{DMSO\text{-}d_6}$ 1.80 (s, 3), 2.33 (s, 3), 7.1–7.9 ppm (m, 12); $pK_a' = 10.1$ (proton lost).[10]

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.09; H, 5.24; N, 7.81.

6-Amino-3-hydroxy-4-methyl-5-phenylpyridine 3-*p*-Toluenesulfonate (19c).—A solution of 100 mg of the 6-aminopyridine **19a**[14] and 300 mg (3 equiv) of tosyl chloride in 3 ml of pyridine stood for 4 hr at 25° and then was poured onto ice. The resulting solid (80 mg) was collected and sublimed at 145° (0.1 mm). Recrystallization of the sublimate from $CHCl_3$–hexane gave **19c** as a powdery white solid: mp 151–153°; δ^{CDCl_3} 1.83 (s, 3), 2.46 (s, 3), 4.40 (br, 2, exchanges in D_2O), 7–7.9 ppm (m, 10); $pK_a' =$ (50% MeOH) 2.9 (proton gained).

Anal. Calcd for $C_{19}H_{18}N_2O_3S$: C, 64.40; H, 5.12; N, 7.91. Found: C, 64.29; H, 5.07; N, 7.70.

3-Hydroxy-4-methyl-5-phenyl-6-tosylamidopyridine 3-*p*-Toluenesulfonate (19d).—A solution of 290 mg of the 6-tosylamide **17**, 150 mg of triethylamine, and 160 mg of tosyl chloride in 5 ml of CH_2Cl_2 was allowed to stand for 2 hr at 25°. After washing, drying, and evaporation, dilution of the oil with ether gave 293 mg (70%) of colorless crystals of **19d**, mp 158–159°. Recrystallization from ethanol gave mp 158–159°; ν^{KBr} 1590, 1420, 1360, 1320 cm^{-1}; δ^{CDCl_3} 1.80 (s, 3), 2.42 (s, 3), 2.50 (s, 3), 6.72 (br s, 1), 7–8 ppm (m, 14); $pK_a' = 8.4$ (proton lost).[10]

Anal. Calcd for $C_{26}H_{24}N_2O_5S_2$: C, 61.41; H, 4.76; N, 5.51. Found: C, 61.25; H, 4.80; N, 5.34.

Conversion of **19c** to the 6-tosylamido-3-tosylate **19d** was accomplished by treatment of 250 mg of **19c** with 500 mg of tosyl chloride in 3 ml of pyridine at 115° for 3 days. After evaporation and treatment with charcoal the product was chromatographed on a 20 × 25 × 1 mm silica gel G plate. The fluorescent zone was collected and eluted and the material was recrystallized from CH_2Cl_2–pentane to give 110 mg of tan crystals, mp 145–150°. Further treatment with charcoal and recrystallization from CH_2Cl_2–pentane gave colorless crystals, mp 158–159°, identical (mixture melting point, infrared) with material prepared from the 6-tosylamide **17**.

Tosylation of 17 with Triethylamine.—A solution of 70 mg of the 6-tosylamidopyridine **17**, 80 mg (2 equiv) of tosyl chloride, and 1 ml of triethylamine in 2 ml of CH_2Cl_2 was allowed to stand at 25° for 1 hr and was then washed with water and acid, dried, and evaporated to a colorless oil which crystallized to give flocculent needles, mp 216–218°, ν^{KBr} 1170, 1370 cm^{-1}. The compound was too sparingly soluble in $CDCl_3$ or DMSO to permit nmr. Analysis indicated a tritosyl derivative.

Anal. Calcd for $C_{33}H_{30}N_2O_7S_3$: C, 59.80; H, 4.56; N, 4.23. Found: C, 59.80; H, 4.57; N, 4.08.

Registry No.—**2**, 30428-27-4; **3**, 30428-28-5; **4**, 26439-91-8; **5**, 30428-30-9; **6**, 30428-31-0; **8**, 30428-32-1; **9b**, 30378-30-4; **9c**, 30428-33-2; **9d**, 30428-34-3; **11a**, 30428-35-4; **11b**, 30428-36-5; **14**, 26439-97-4; **15**, 30428-38-7; **16**, 30428-39-8; **17**, 30428-40-1; **17** tritosyl derivative, 30378-31-5; **18**, 30428-41-2; **19c**, 30428-42-3; **19d**, 30428-43-4; 2-methanesulfonyl-5-methyl-4-phenyl-1,2-diazabicyclo[3.2.0]-3-hepten-6-one, 30428-44-5; benzenesulfonyl derivative, 30428-45-6; *p*-cyanobenzenesulfonyl derivative, 30428-46-7.

(14) Prepared by hydrolysis (60% H_2SO_4) of the 6-benzamidopyridine **19b**, which was obtained by rearrangment of 2-benzoyl-5-methyl-4-phenyl-1,2-diazabicyclo[3.2.0]-3-hepten-6-one in methanol.[2] This route is our preferred method for obtaining this pyridine; although it requires several steps from the 2,3-dihydrodiazepinone **1**, the reactions are simple and reproducible. The 6-aminopyridine is formed directly from **1**, in admixture with the 2 amino isomer, but the two amines do not have characteristically distinct properties, and a reliable procedure for isolation of pure 6-amine from this mixture has not been developed.