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Studies on Diazepines. XVI.[1] Synthesis of Monocyclic 1,3-Diazepines. (1). Thermolysis of 1,2-Diazepines formed from Methylpyridine N-Imides

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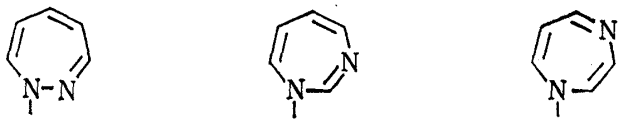
Thermolysis of various 4- and/or 6-methyl-1,2-diazepines (**12a, b** and **18a—e**), prepared from pyridine and lutidine N-imides (**11** and **17a—d**) having a methyl group in the 3-position, gave the corresponding 1,3-diazepines (**13** and **19**) and the 2-aminopyridine derivatives (**14** and **20**), whereas 1,2-diazepines (**9a—d**) having no methyl group in the 4- or 6-position gave only the parent N-imides (**8**) and no 1,3-diazepines. Heating of the 2,3-diazabicyclo[3.2.0]hepta-3,6-dienes (**21a, b**) formed from the corresponding 1,2-diazepines by irradiation also gave the 1,3-diazepines (**13a** and **19b**).

Keywords——thermolysis; photolysis; rearrangement; ring-conversion; pyridine N-imides; 1,2-diazepines; 1,3-diazepines; 2-aminopyridines

The synthesis of new conjugated seven-membered heterocyclic rings, heteroepines, has been the object of extensive study and there are several reviews concerning them.[2] As for diazepines, the fully unsaturated 1,2-,[3,4] 1,3,[5] and 2,3-benzodiazepines[6] have recently been synthesized, as well as related fused diazepines[7—9] condensed with aromatic heterocyclic rings such as pyridine, thiophene, furan, and pyrrole rings instead of the benzene ring. Of three theoretically possible monocyclic diazepines, the 1,2-diazepines (**1**) have been widely investigated,[2a] since Streith[10] first showed that pyridine N-acylimides undergo photo-induced rearrangement to give 1-acyl-1H-1,2-diazepines. However, the 1,3-diazepines (**2**) have not been reported except for two highly substituted examples,[11,12] and neither have the 1,4-diazepines (**3**). Therefore, we were interested in the preparation of simple monocyclic 1,3-diazepines and now report our results.[13]

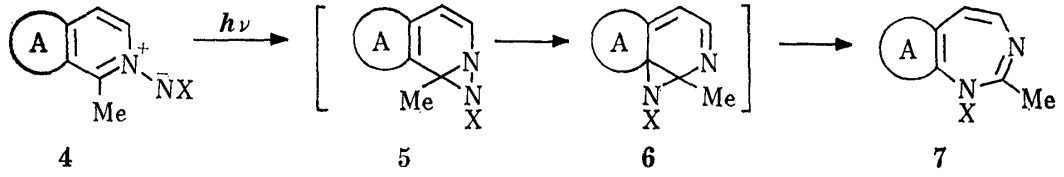


1 **2** **3**

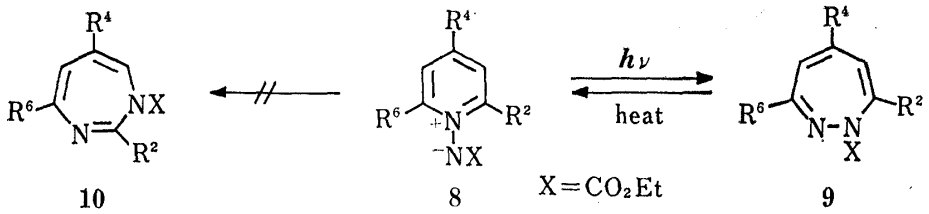
Chart 1

Very recently, we have showed that the 1-methylisoquinoline[5] and related fused pyridine[8] N-acylimides (**4**) undergo a photo-induced two-step rearrangement to give the corresponding novel fused 1,3-diazepines (**7**), presumably *via* the intermediates (**5**) and (**6**), whereas 1-unsubstituted isoquinoline N-acylimides give no 1,3-diazepines. Therefore, the photochemical behavior of the α-substituted pyridine N-imides (**8a, b**) was reexamined. However, irradiation of **8a, b** gave only the 1,2-diazepines (**9a, b**) in high yields, as already reported[14,15] and did not give the desired 1,3-diazepines (**10**).

On the other hand, one of the reported monocyclic 1,3-diazepines, 1-benzoyl-5-acetoxy-6-methyl-7-phenyl-1H-1,3-diazepine, was prepared by thermal rearrangement of 1,2-diazepine derivatives.[12] Prior to this work, the thermolysis of 1,2-diazepines had been investigated and had not been found to give the corresponding 1,3-diazepines.[16] These results prompted us to examine this thermolysis in more detail.



X=CO_2Et, Ac Ring A: benzene, thiophene, furan, pyrrole



a: $R^2=R^6=Me$, $R^4=H$ **c**: $R^2=R^4=R^6=H$
b: $R^2=R^4=H$, $R^6=Me$ **d**: $R^2=R^6=H$, $R^4=Me$

Chart 2

The 1,2-diazepines (**9a**—**d**), prepared from unsubstituted-, 2-methyl-, 4-methyl-, and 2,6-dimethyl-pyridine *via* the N-ethoxycarbonylimides (**8**) by the reported photochemical method,[10,14,15] were heated at 140—165°C in xylene or mesitylene to yield the corresponding parent N-imides (**8**) in 50—90% yields and no 1,3-diazepines (**10**), in the case of the unsubstituted pyridine N-imide (**9c**), 2-ethoxycarbonylaminopyridine was also obtained in 13% yield. In contrast, heating of the 4-methyl- (**12a**) and 6-methyl-1,2-diazepine (**12b**) formed from the 3-methylpyridine N-ethoxycarbonylimide (**11**) by irradiation resulted in the formation of the desired 1,3-diazepines (**13a**, **b**) along with the 2-aminopyridine derivatives (**14a**, **b**) in the yields shown in Chart 3.

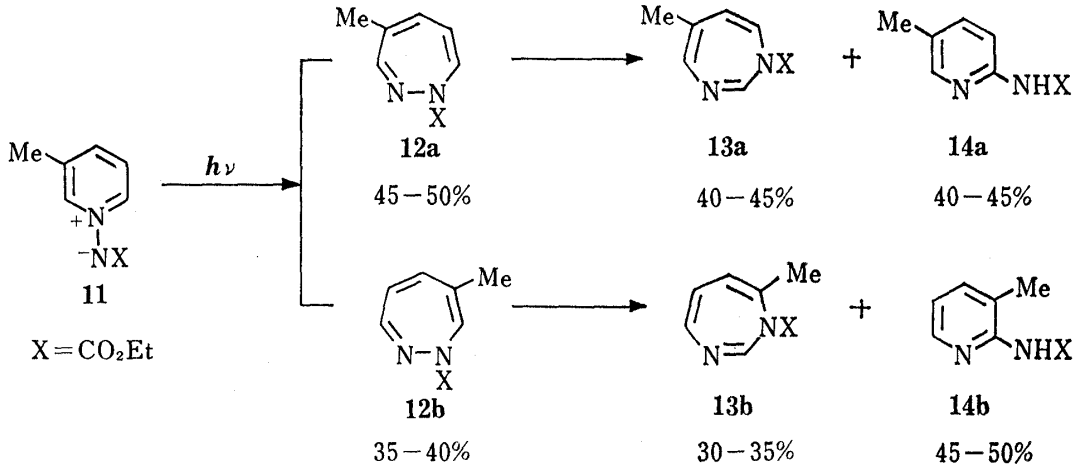


Chart 3

Next, the thermolyses of the dimethyl-1,2-diazepines (**18**) were examined. The lutidines (**15a**—**d**) having one of two methyl groups in the 3-position were aminated with O-mesitylenesulfonylhydroxylamine (H_2NOMes) according to the method of Tamura *et al.*[17] to give the corresponding N-aminolutidinium mesitylenesulfonates (**16**) in high yields. Treatment of the salts (**16**) with ethyl chloroformate in the presence of potassium carbonate gave the N-ethoxycarbonylimides (**17**) in 80—90% yields. Irradiation of the 2,3- (**17a**), 3,5- (**17b**), and 3,6-lutidine N-imide (**17c**) gave the corresponding 1,2-diazepines (**18a**—**c**) as the sole products

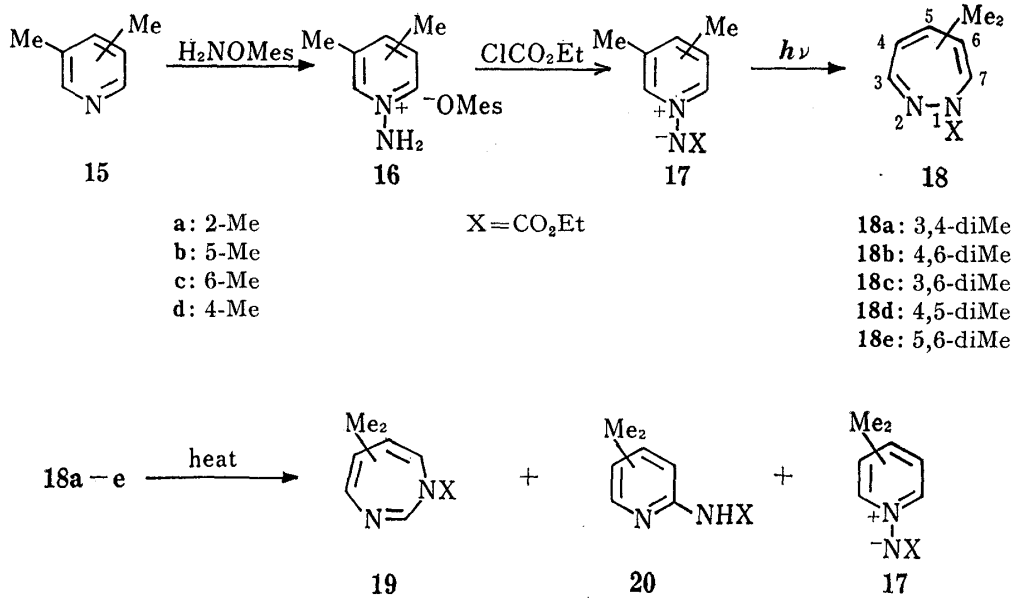


Chart 4

TABLE I. Thermolysis of the 1,2-Diazepines (**18**)

18	Solvent	Reaction time: h	Products (Yield %)		
			19	**20**	**17**
a	M[a]	3	4,5-diMe (25—30)	5,6-diMe (45—50)	**17a** (20—25)
b	X[b]	2	5,7-diMe (45—50)	3,5-diMe (45—50)	—
c	X	7	4,7-diMe (20—25)	3,6-diMe (50—60)	**17c** (10—15)
d	M	5	5,6-diMe (40—50)	4,5-diMe (10—15)	**17d** (30—40)
e	M	5	6,7-diMe (25—30)	3,4-diMe (24—30)	**17d** (35—40)

a) Heated in mesitylene at 165°C.
b) Heated in xylene at 140°C.

in 80—90% yields, but the 3,4-lutidine N-imide (**17d**) gave two kinds of 1,2-diazepines, **18d** and **18e**, in 60% and 35% yields, respectively.

Heating of the dimethyl-1,2-diazepines (**18a—e**) having a methyl group in the 4- and/or 6-position thus obtained also resulted in the formation of the corresponding 1,3-diazepines (**19**), 2-aminolutidines (**20**), and the parent lutidine N-imides (**17**) in the yields shown in Table I, in which the reaction conditions of the thermolysis are also shown.

1,2-Diazepines are known[16] to undergo photo-induced cyclization to give bicyclic compounds analogous to those observed for other various heteroepines.[2b] The 1,2-diazepines (**12a** and **18b**) were further irradiated to give the 2H-2,3-diazabicyclo[3.2.0]hepta-3,6-dienes (**21a, b**) in high yields, and these products were heated in refluxing mesitylene to give the 1,3-diazepines (**13a** and **19b**) and the 2-aminopyridines (**14a** and **20b**) in 45—50% and 40—45%

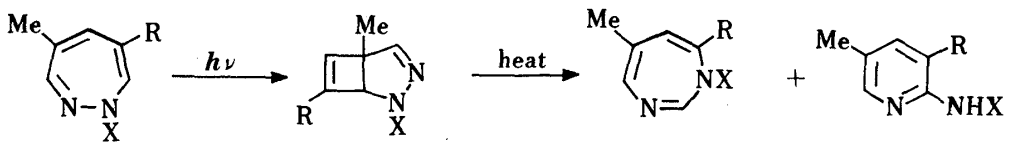


Chart 5

yields, respectively; these results are quite similar to those for the thermolysis of the 1,2-diazepines (**12a** and **18b**).

These novel 1,3-diazepines (**13** and **19**) are extremely susceptible to decomposition by water, acids, silica gel, and alumina, and thus can be isolated only by Sephadex chromatography. The analytical and some spectral (IR, UV, and mass) data for the 1,3-diazepines thus obtained are collected in Table II. The ^{1}H-NMR spectral data are summarized in Table III and the ^{13}C-NMR spectral data are given in the experimental section. These spectral data and the results of the following chemical studies are consistent with the proposed 1,3-diazepine structures.

TABLE II. 1-Ethoxycarbonyl-1H-1,3-diazepines (**13**) and (**19**)[a]

Compd. No.	IR $\nu_{max}^{CHCl_3}$ cm^{-1} (C=O)	UV λ_{max}^{EtOH} nm (ε)	MS m/e (M$^+$)	Formula	Analysis (%) Found (Calcd) C	H	N
13a	1720	245 (5800) 310 (1500)	180	$C_9H_{12}N_2O_2$	60.03 (59.99	6.72 6.71	15.61 15.55)
13b	1710	234 (4500) 293 (2200)	180	$C_9H_{12}N_2O_2$	59.87 (59.99	6.89 6.71	15.56 15.55)
19a	1720	250 (4400)	194	$C_{10}H_{14}N_2O_2$	61.90 (61.84	7.32 7.62	14.53 14.42)
19b	1710	245 (3300) 295 (1800)	194	$C_{10}H_{14}N_2O_2$	61.70 (61.84	7.31 7.26	14.53 14.42)
19c	1705	247 (6600) 305 (2400)	194	$C_{10}H_{14}N_2O_2$	61.93 (61.84	7.42 7.26	14.49 14.42)
19d	1710	240 (3700)	194	$C_{10}H_{14}N_2O_2$	61.82 (61.84	7.33 7.26	14.48 14.42)
19e	1705	240 (3600) 280 (3300)	194	$C_{10}H_{14}N_2O_2$	61.95 (61.84	7.31 7.26	14.40 14.42)

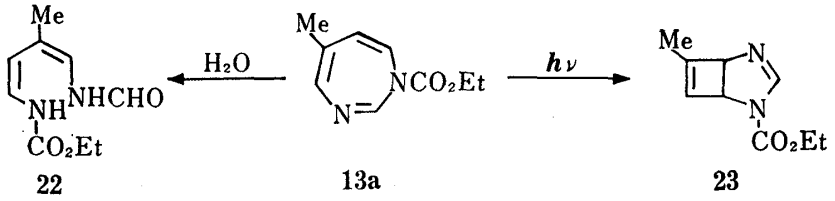
a) All compounds are pale yellow viscous oils.

TABLE III. ^{1}H-NMR Spectral Data for the 1H-1,3-Diazepines (**13**) and (**19**) δ ($CDCl_3$)

13a	1.81 (3H, br s, 5-Me), 5.41 (1H, dd, 6-H), 5.74 (1H, d, 7-H), 6.61 (1H, s, 2-H), 6.64 (1H, m, 4-H), $J_{6,7}$=7 Hz, 1.32 and 4.25 (3H, t, and 2H, q, CO_2Et)
13b	2.21 (3H, br s, 7-Me), 5.89 (1H, m, 6-H), 5.92 (1H, m, 5-H), 6.68 (1H, s, 2-H), 6.95 (1H, d, 4-H), $J_{4,5}$=8, $J_{5,6}$=6 Hz, 1.32 and 4.25 (3H, t, and 2H, q, CO_2Et)
19a	1.82 (3H, s, 5-Me), 1.99 (3H, s, 4-Me), 5.39 (1H, d, 6-H), 5.73 (1H, d, 7-H), 6.68 (1H, s, 2-H), $J_{6,7}$=7 Hz, 1.34 and 4.25 (3H, t, and 2H, q, CO_2Et)
19b	1.86 (3H, s, 5-Me), 2.10 (3H, s, 7-Me), 5.63 (1H, s, 6-H), 6.66 (1H, s, 2-H), 6.74 (1H, s, 4-H), 1.30 and 4.25 (3H, t, and 2H, q, CO_2Et)
19c	2.05 (3H, s, 4-Me), 2.09 (3H, s, 7-Me), 5.70 (2H, br s, 5- and 6-H), 6.69 (1H, s, 2-H), 1.34 and 4.25 (3H, t, and 2H, q, CO_2Et)
19d	1.80 and 1.84 (each 3H, s, 5- and 6-Me), 5.61 (1H, s, 4-H), 6.71 (1H, s, 7-H), 6.76 (1H, s, 2-H), 1.32 and 4.28 (3H, t, and 2H, q, CO_2Et)
19e	1.84 (3H, s, 6-Me), 2.04 (3H, s, 7-Me), 5.94 (1H, d, 5-H), 6.79 (1H, s, 2-H), 6.68 (1H, d, 4-H), $J_{4,5}$=9 Hz, 1.31 and 4.24 (3H, t, and 2H, q, CO_2Et)

Treatment of the 1,3-diazepine (**13a**) with water in tetrahydrofuran at 45—50°C resulted in the formation of the ring-opened product (**22**) in *ca.* 90% yield; this result is analogous to those for fused 1,3-diazepines[5,8,9] and 1,3-oxazepines.[18] Irradiation of the diazepine (**13a**) resulted in (2+2) intramolecular cyclization to give the 2H-2,4-diazabicyclo[3.2.0]hepta-3,6-diene (**23**) in *ca.* 70% yield.

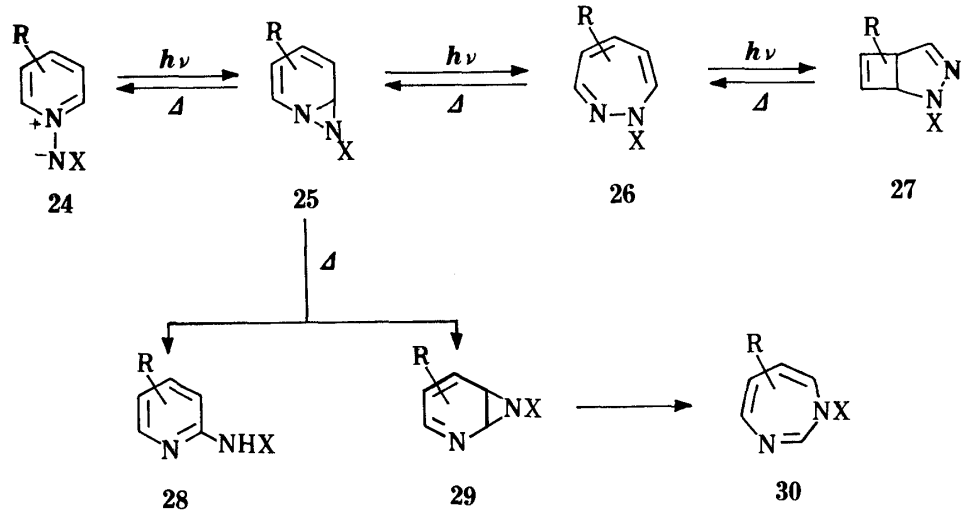
A possible mechanism for the present thermolysis is shown in Chart 7. The thermolysis of the 1,2-diazepines (**26**) may proceed by initial reversion to the diaziridines (**25**), which have



22 13a 23

Chart 6

been considered to be key intermediates for the photochemical formation of **26** from the pyridine N-imides (**24**). The diaziridines (**25**) may then undergo either thermal N–N bond fission or C–NX bond cleavage; the latter gives the parent N-imides (**24**) and the former generates the 2-aminopyridines (**28**) and the 1,3-diazepines (**30**) *via* the aziridine intermediates (**29**) by analogy with the formation of the condensed 1,3-diazepines.[5,8] The photochemical and thermal interconversions between the diazepines (**26**) and the bicyclic compounds (**27**) are analogous to those observed for various kinds of heteroepines.[2b]



24 25 26 27 28 29 30

Chart 7

The above-mentioned results show that the thermolysis of 4- and/or 6-methyl-1,2-diazepines formed from 3- and/or 5-methylpyridines gives 1,3-diazepines and 2-aminopyridine derivatives, whereas the 1,2-diazepines with no methyl group in the 4- or 6-position do not give 1,3-diazepines. These results clearly indicate that the presence of a methyl group in the 4- and/or 6-position is essential for the thermal ring-conversion of 1,2-diazepines into 1,3-diazepines. The methyl group, an electron-donating group, may provide assistance for breaking the N–N bond in the diaziridines (**25**) and for further cyclization into the aziridines (**29**), whereas a methyl group in the other positions would assist the C–NX bond fission into the imides (**24**). In order to confirm this assumption regarding the substituent effect on the present rearrangements, the thermolysis of 1,2-diazepines having various kinds of substituents has also been examined. These results will be reported separately in the following paper.

Experimental

Melting points were measured on a Yamato MP-21 apparatus and are uncorrected. Infrared (IR) spectra were determined with a JASCO IRA-2 spectrometer and mass spectra (MS) were recorded on a JEOL D-100 instrument. Proton nuclear magnetic resonance (^{1}H-NMR) spectra were recorded on a JEOL JNM-MH-100 spectrometer in $CDCl_3$ using tetramethylsilane as an internal standard unless otherwise stated; spectral assignments were confirmed by spin-decoupling experiments and, in the case of NH protons, by exchange with D_2O. ^{13}C-NMR spectra were recorded on a JEOL FX-100 spectrometer. Microanalyses

were performed in the Microanalytical Laboratory of this school by Mrs R. Igarashi. Photolyses were carried out under a nitrogen atmosphere in an immersion apparatus equipped with a 400 W high-pressure Hg lamp and a Pyrex filter, which was cooled internally with running water.

Materials——All starting pyridines were obtained from Tokyo Kasei Kogyo Co., Japan. Pyridine N-ethoxycarbonylimides (**8a—d**) and (**11**) were prepared from the corresponding parent pyridines by the reported procedures.[14,15] The 1H-1,2-diazepines (**9a—d**) and (**12a, b**) were also prepared from the corresponding pyridine N-imides (**8**) and (**11**) by irradiation according to the reported method.[14,15]

Thermolysis of the 1,2-Diazepines (9a—d)——General Procedure: A solution of **9** (0.5—2 mmol) in xylene or mesitylene (10—30 ml) was heated under reflux until the spot of the starting material disappeared on silica gel thin-layer chromatography. The reaction mixture was concentrated *in vacuo* and the residue was chromatographed on silica gel using CH_2Cl_2–*n*-hexane as an eluent to give the parent N-imides (**8**): **8a**, 88%; **8b**, 65%; **8c**, 50%; and **8d**, 76% yield. In the case of **9c**, 2-ethoxycarbonylaminopyridine: mp 101—102°C (lit.,[19] mp 102—103.5°C) was also obtained in 13% yield.

Thermolysis of the 1,2-Diazepines (12a, b)——A solution of **12** (2—5 mmol) in xylene (30—50 ml) was heated under reflux for *ca.* 40 h and then concentrated *in vacuo*. The resulting residue was chromatographed on Sephadex (LH-20) using $CHCl_3$–*n*-hexane (4: 1) as an eluent to give the 1,3-diazepines (**13a, b**) and 2-ethoxycarbonylaminopyridines (**14a, b**)[20] successively. The yields of these products are shown in Chart 3. Analytical and spectral (MS, IR, UV, and ^{1}H-NMR) data for the 1,3-diazepines (**13**) are summarized in Tables II and III. ^{13}C-NMR spectral data are given below.

13a: ^{13}C-NMR ppm: 14.423 (q), 20.905 (q), 62.716 (t), 120.703 (d), 125.724 (d), 129.038 (s), 137.420 (d), 137.755 (d), 153.013 (s).

13b: ^{13}C-NMR ppm: 14.423 (q), 19.881 (q), 62.082 (t), 119.728 (d), 119.924 (d), 135.026 (s and d), 139.704 (d), 151.891 (s).

N-Aminolutidinium Mesitylenesulfonates (16a—d)——General Procedure: A solution of O-mesitylenesulfonylhydroxylamine (1.1 mol eq) in CH_2Cl_2 (*ca.* 100 ml) was added dropwise to a solution of the lutidine (**15**: 0.1 mol) in CH_2Cl_2 (50 ml) with stirring in an ice bath. The reaction mixture was stirred for an additional 30 min. After addition of ether (300—500 ml) to the reaction mixture, the resulting crystalline precipitates were collected by filtration and recrystallized from ethanol to give the salts (**16**).

16a: 93% yield, mp 169—173°C. *Anal.* Calcd for $C_{16}H_{22}N_2O_3S$: C, 59.61; H, 6.88; N, 8.69. Found: C, 59.68; H, 6.85; N, 8.55.

16b: 92% yield, mp 105—106°C. *Anal.* Calcd for $C_{16}H_{22}N_2O_3S$: C, 59.61; H, 6.88; N, 8.69. Found: C, 59.60; H, 6.93; N, 8.61.

16c: 98% yield, mp 128—129.5°C. *Anal.* Calcd for $C_{16}H_{22}N_2O_3S$: C, 59.61; H, 6.88; N, 8.69. Found: C, 59.78; H, 6.81; N, 8.52.

16d: 94% yield, mp 104—106°C. *Anal.* Calcd for $C_{16}H_{22}N_2O_3S$: C, 59.61; H, 6.88; N, 8.69. Found: C, 59.53; H, 6.82; N, 8.67.

Lutidine N-Ethoxycarbonylimides (17a—d)——General Procedure: Solid potassium carbonate (2 mol eq) and ethyl chloroformate (1.5—2.0 mol eq) were added to a solution of the salt (**16**: *ca.* 0.1 mol) in ethanol (100—150 ml) with stirring in an ice bath. The mixture was stirred for an additional 7—8 h at room temperature and the resulting inorganic precipitate was filtered off. The filtrate was concentrated *in vacuo* and the residue was extracted with CH_2Cl_2. The extract was dried over $MgSO_4$ and evaporated to dryness *in vacuo*. The residue was chromatographed on silica gel using CH_2Cl_2–acetone as an eluent to give the imides (**17**), which were recrystallized from benzene.

2,3-Lutidine N-Imide (**17a**): 82% yield, mp 95—97°C. MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 1635 (C=O). ^{1}H-NMR δ: 2.40 (3H, s, 3-Me), 2.62 (3H, s, 2-Me), 7.10 (1H, t, 5-H), 7.62 (1H, d, 4-H), 8.35 (1H, d, 6-H), $J_{4,5}$=8, $J_{5,6}$=6 Hz, 1.33 and 4.12 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.93; H, 7.25; N, 14.26.

3,5-Lutidine N-Imide (**17b**): 91% yield, mp 140—141°C (lit.,[15] mp 138—140°C).

2,5-Lutidine N-Imide (**17c**): 88% yield, mp 76.5—78.5°C. MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 1635 (C=O). ^{1}H-NMR δ: 2.41 (3H, s, 5-Me), 2.61 (3H, s, 2-Me), 7.39 (1H, d, 3-H), 7.58 (1H, d, 4-H), 8.47 (1H, s, 6-H), $J_{3,4}$=9 Hz, 1.33 and 4.16 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.86; H, 7.15; N, 14.30.

3,4-Lutidine N-Imide (**17d**): 85% yield, mp 98—99°C. MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 1620 (C=O). ^{1}H-NMR δ: 2.32 (3H, s, 3-Me), 2.40 (3H, s, 4-Me), 7.10 (1H, d, 5-H), 8.42 (1H, d, 6-H), 8.47 (1H, s, 2-H), $J_{5,6}$=5 Hz, 1.32 and 4.13 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.96; H, 7.23; N, 14.42.

Dimethyl-1H-1,2-diazepines (18a—e)——A solution of the imide (**17**: 0.01—0.02 mol) in benzene (300—400 ml) was irradiated for 3—4 h. After removal of the solvent *in vacuo*, the residue was chromatographed on silica gel using *n*-hexane–ether as an eluent to give the 1,2-diazepines (**18**). The imides (**17a—c**) each gave the corresponding 1,2-diazepine (**18a—c**), respectively, whereas the imide (**17d**) gave two kinds of diazepines, **18d** (60%) and **18e** (35%). The diazepines (**18b**),[14,15] (**18c**),[14] and (**18d**)[14] are known and were characterized by comparison of the spectral data with the reported values.

3,4-Dimethyl-1-ethoxycarbonyl-1H-1,2-diazepine (**18a**): 87% yield, yellow oil. MS *m/e*: 194 (M^+).

IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1705 (C=O). ^{1}H-NMR δ: 1.98 (3H, s, 4-Me), 2.14 (3H, s, 3-Me), 5.67 (1H, t, 6-H), 6.27 (1H, d, 5-H), 6.31 (1H, d, 7-H), $J_{5,6}$=5, $J_{6,7}$=7 Hz, 1.34 and 4.30 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.91; H, 7.30; N, 14.41.

5,6-Dimethyl-1-ethoxycarbonyl-1H-1,2-diazepine (**18e**): 35% yield, yellow oil. MS *m/e*: 194 (M^+). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1705 (C=O). ^{1}H-NMR δ: 1.94 (3H, s, 5-Me), 6.01 (1H, d, 4-H), 6.06 (1H, s, 7-H), 7.25 (1H, d, 3-H), $J_{3,4}$=4 Hz, 1.35 and 4.29 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.80; H, 7.52; N, 14.49.

Thermolysis of the Dimethyl-1,2-diazepines (18a—e)——A solution of **18** (0.01—0.02 mol) in xylene or mesitylene (30—50 ml) was heated under reflux until the spot of the starting material had disappeared on silica gel thin-layer chromatography. The reaction mixture was concentrated *in vacuo* and the residue was extracted with *n*-hexane. The extract was concentrated *in vacuo* and the residue was chromatographed on Sephadex (LH-20) using $CHCl_3$–*n*-hexane (4: 1) as an eluent to give the 1,3-diazepines (**19**). The above *n*-hexane-insoluble fraction was chromatographed on silica gel using CH_2Cl_2–*n*-hexane as an eluent to give the 2-amino derivatives (**20**) and the parent N-imides (**17**) successively. Reaction conditions for thermolysis and the yields of products are shown in Table I. Physical, analytical, and spectral data of the 1,3-diazepines (**19a—e**) are collected in Tables II and III.

5,6-Dimethyl-2-ethoxycarbonylaminopyridine (**20a**): mp 106—108°C (from isopropyl ether–benzene). MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3180 (NH), 1725 (C=O). ^{1}H-NMR δ: 2.18 (3H, s, 5-Me), 2.36 (3H, s, 6-Me), 7.32 (1H, d, 3-H), 7.61 (1H, d, 4-H), $J_{3,4}$=8 Hz, 1.28 and 4.17 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.79; H, 7.26; N, 14.57.

3,5-Dimethyl-2-ethoxycarbonylaminopyridine (**20b**): mp 119—121°C (from benzene). IR ν_{max}^{KBr} cm^{-1}: 3175 (NH), 1730 (C=O). ^{1}H-NMR δ: 2.27 (6H, br s, 3- and 5-Me), 7.33 (1H, s, 4-H), 8.04 (1H, s, 6-H), 1.30 and 4.19 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.82; H, 7.21; N, 14.45.

3,6-Dimethyl-2-ethoxycarbonylaminopyridine (**20c**): mp 107—109°C (from isopropyl ether–*n*-hexane). MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3140 (NH), 1725 (C=O). ^{1}H-NMR δ: 2.24 (3H, s, 6-Me), 2.45 (3H, s, 3-Me), 6.90 (1H, d, 5-H), 7.39 (1H, d, 4-H), $J_{4,5}$=7 Hz, 1.29 and 4.20 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.78; H, 7.33; N, 14.58.

4,5-Dimethyl-2-ethoxycarbonylaminopyridine (**20d**): mp 179—180.5°C (from isopropyl ether–benzene). MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3185 (NH), 1725 (C=O). ^{1}H-NMR δ: 2.16 (3H, s, 5-Me), 2.26 (3H, s, 4-Me), 7.79 (1H, s, 3-H), 8.02 (1H, s, 6-H), 1.36 and 4.23 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.68; H, 7.14; N, 14.43.

3,4-Dimethyl-2-ethoxycarbonylaminopyridine (**20e**): mp 136—138°C (from isopropyl ether–benzene). MS *m/e*: 194 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3180 (NH), 1735 (C=O). ^{1}H-NMR δ: 2.16 (3H, s, 3-Me), 2.28 (3H, s, 4-Me), 6.10 (1H, d, 5-H), 8.01 (1H, d, 6-H), $J_{5,6}$=5 Hz, 1.29 and 4.17 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.78; H, 7.19; N, 14.53.

2H-2,3-Diazabicyclo[3.2.0]hepta-3,6-dienes (21a, b)——A solution of a 4-methyl-1,2-diazepine (**12a, 18b**: 5—10 mmol) in benzene (300—400 ml) was irradiated for 25—30 h and then concentrated *in vacuo*. The residue was chromatographed on silica gel using CH_2Cl_2–*n*-hexane as an eluent to give **21** in 85—90% yields.

21a: Pale yellow oil. MS *m/e*: 180 (M^+). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1695 (C=O). ^{1}H-NMR δ: 1.40 (3H, s, 5-Me), 4.58 (1H, br d, 1-H), 5.99 (1H, d, 7-H), 6.32 (1H, dd, 6-H), 6.75 (1H, s, 4-H), $J_{6,7}$=3, $J_{1,6}$=2 Hz, 1.32 and 4.26 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_9H_{12}N_2O_2$: C, 59.99; H, 6.71; N, 15.55. Found: C, 60.22; H, 6.65; N, 15.42.

21b: Pale yellow oil. MS *m/e*: 194 (M^+). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1690 (C=O). ^{1}H-NMR δ: 1.34 (3H, s, 5-Me), 1.75 (3H, br s, 7-Me), 4.46 (1H, d, 1-H), 6.04 (1H, br d, 6-H), 6.80 (1H, s, 4-H), $J_{1,6}$=1 Hz, 1.34 and 4.28 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_{10}H_{14}N_2O_2$: C, 61.84; H, 7.26; N, 14.42. Found: C, 61.83; H, 7.08; N, 14.35.

Thermolysis of the Bicyclo Compounds (21a, b)——A solution of **21** (*ca.* 1 mmol) in xylene (50 ml) was heated under reflux for 3—5 h and then worked up as described for **18** to give the 1,3-diazepines (**13a** and **19b**) and the 2-ethoxycarbonylaminopyridines (**14a** and **20b**) in 45—50% and 40—45% yields, respectively.

Hydrolysis of the 5-Methyl-1,3-diazepine (13a)——A mixture of **13a** (100 mg), tetrahydrofuran (2 ml) and water (1 ml) was heated at 45—50°C for 6 h and then concentrated *in vacuo*. The residue was extracted with CH_2Cl_2 and the extract was dried over $MgSO_4$, and then evaporated to dryness *in vacuo*. The resulting solid residue was recrystallized from benzene to give the ring-opened product (**22**): 102 mg, 93% yield, mp 110—112°C. MS *m/e*: 198 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3325 and 3235 (NH), 1725 and 1665 (C=O). ^{1}H-NMR δ: 1.98 (3H, br s, Me), 4.95 (1H, d, J=9 Hz, –CH=CH–NHCO$_2$Et), 6.60 (1H, dd, J=9 and 11 Hz, –CH=CH–NHCO$_2$Et), 6.76 (1H, d, J=10 Hz, =CH–NHCHO), 6.25 (1H, br d, J=11 Hz, –NH–CO$_2$Et), 7.04 (1H, br d, J=10 Hz, –NH–CHO), 8.12 (1H, s, CHO), 1.27 and 4.18 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_9H_{14}N_2O_3$: C, 54.53; H, 7.12; N, 14.13. Found: C, 54.65; H, 7.24; N, 14.15.

2-Ethoxycarbonyl-6-methyl-2H-2,4-diazabicyclo[3.2.0]hepta-3,6-diene (23)——A solution of the 1,3-diazepine (**13a**: 100 mg) in benzene (100 ml) was irradiated for 10 h and then concentrated *in vacuo*. The residue was chromatographed on silica gel using CH_2Cl_2–*n*-hexane as an eluent to give **23**: 71 mg, 71% yield, pale yellow oil. MS *m/e*: 180 (M^+). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1710 (C=O). ^{1}H-NMR δ: 1.82 (3H, br s, 6-Me), 4.57

(1H, m, 5-H), 4.90 (1H, m, 1-H), 5.96 (1H, m, 7-H), 7.48 (1H, s, 3-H), 1.32 and 4.22 (3H, t, and 2H, q, CO_2Et). *Anal.* Calcd for $C_9H_{12}N_2O_2$: C, 59.99; H, 6.71; N, 15.55. Found: C, 60.13; H, 6.55; N, 15.48.

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