[Chem. Pharm. Bull. 24(3) 515—521 (1976)]

UDC 547.822.1.04 : 546.185-31.04

Studies on the Syntheses of Azabicyclo[3,3,1]non-6-enes by the Novel Cyclization Reaction of Tetrahydropyridines with Lewis Acid

Michio Kimura, Takeshi Nakajima, Shigeho Inaba, and Hisao Yamamoto

Institute for Biological Science, Sumitomo Chemical Co., Ltd.[1]

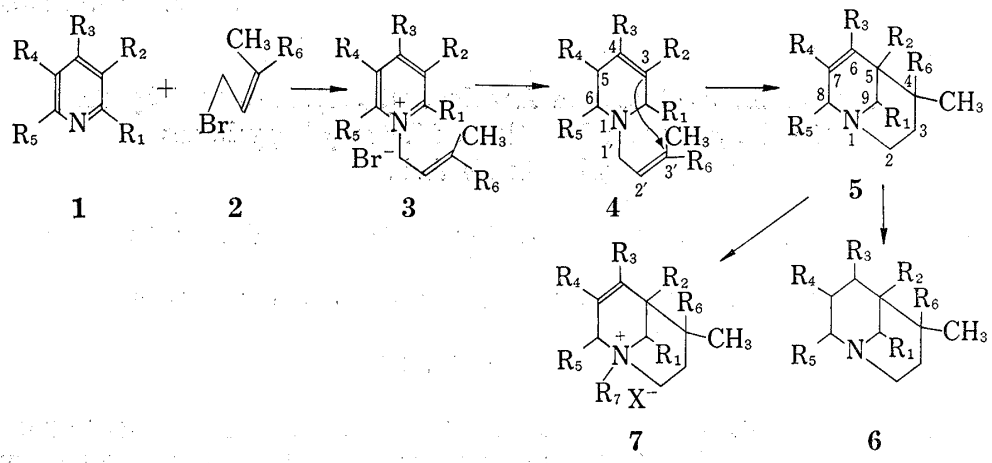
(Received July 14, 1975)

Previously the authors have reported that the cyclization reaction of 1-(substituted-allyl)-2-benzyl-3,4-dimethyl-1,2,5,6-tetrahydro-pyridines with Lewis acid gives the novel type benzazocines which have potent analgesic activity. By examining in more details the novel cyclization reaction, it was found that this reaction was one of the available methods for the synthesis of various 1-azabicyclo[3,3,1]non-6-enes. Some of them had analgesic activity in acetic acid Writhing test. Moreover, catalytic hydrogenation of the 1-azabicyclo[3,3,1]non-6-enes afforded the corresponding 1-azabicyclo[3,3,1]nonanes which are useful as agricultural chemicals and as additives or additive precursors for hydrocarbon compositions ranging from gasoline fractions through middle distillate fuels and lubricating oils.

Previously the authors have reported that the cyclization of 1-(substituted-allyl)-2-benzyl-3,4-dimethyl-1,2,5,6-tetrahydropyridines with Lewis acid (PPA and 47%-HBr) gave the novel type benzazocines which have potent analgesic activity with low toxicity and that the key intermediates of this reaction were 9-benzyl-4,4,5,6-tetramethyl-1-azabicyclo[3,3,1]-non-6-enes.[2,3] Thereafter, by examining in more details the novel cyclization reaction, we have found that this reaction is one of the available methods for the formation of various 1-azabicyclo[3,3,1]non-6-enes (**5**). The formation of the novel compounds (**5**) was carried out by using 1-allyl-1,2,5,6-tetrahydropyridine derivatives (**4**) as starting materials. Some of the resulting compounds (**5**) had analgesic activity in acetic acid Writhing test. The quaternary ammonium salts (**7**) can be easily obtained by reacting compounds (**5**) with alkylhalides. The present report is concerned with the syntheses of 1-azabicyclo[3,3,1]non-6-enes (**5**) by utilizing the novel cyclization reaction with Lewis acid (PPA and 47%-HBr). Moreover, the catalytically promoted reduction of **5** afforded the corresponding 1-azabicyclo[3,3,1]nonanes (**6**) which are useful as agricultural chemicals and as additives or additive precursors for hydrocarbon compositions ranging from gasoline fractions through middle distillate fuels and lubricating oils.[4] According to the previous reports,[5,6] the formation of the 1-azabicyclo[3,3,1]-nonanes has required complicated reaction processes and drastic reaction condition. Hence the present report may also give one of the most practical synthetic method of 1-azabicyclo-[3,3,1]nonanes.

A pathway to the formation of **5** and related compounds is postulated as shown in Chart 1. The quaternary pyridinum salts (**3**) synthesized from pyridines (**1**) and substituted allyl bromides (**2**) were hydrogenated with sodium borohydride in aqueous methanol to form the

1) Location: *Takatsukasa, Takarazuka, Hyogo, 665, Japan.*
2) M. Kimura, T. Nakajima, S. Inaba, and H. Yamamoto, *Bull. Chem. Soc. Japan*, **47**, 1404 (1974).
3) M. Kimura, T. Nakajima, T. Atsumi, Y. Koga, and H. Yamamoto, *Chem. Pharm. Bull.* (Tokyo), **23**, 3208 (1975).
4) Esso Research and Engineering Company, US. Patent 3661918 (1972) [*C.A.*, **80**, 27112*b* (1974)].
5) R.C. Elderfield, "Heterocyclic Compounds," Vol. 3, John Wiley and Sons, Inc., New York, 1952, pp. 374—383.
6) V. Prelog, S. Heimbach, and R. Seiwerth, *Chem. Ber.*, **72**, 1319 (1937).



1 2 3 4 5 7 6

	a	b	c	d	e	f	g	h	i	j	k	l	m
R_1=	H	H	H	H	H	H	H	Me	H	H	H	H	H
R_2=	Me	H	H	Et	H	Me	H	H	Me	Me	Me	H	H
R_3=	Me	H	Me	Me	Et	H	Me	Me	H	Me	Me	Ph	H
R_4=	H	H	H	H	H	H	H	H	H	H	H	H	H
R_5=	H	H	H	H	H	Me	H	H	H	H	H	H	Me
R_6=	Me	Me	Et	Me	Me	Me	Me	Me	Me	Pro	Et	Me	Me
R_7=	methyl or benzyl, X=Cl or I												

Chart 1

TABLE I. Tetrahydropyridine Derivatives (**4**)

Compound	bp °C (mmHg)	Yield[a] (%)	IR data ν_{max}^{neat} cm^{-1}:	NMR data in $CDCl_3$ (δ from TMS)
4a	79—81 (0.3—0.4)	71.1	3000—2700 1670	1.6 (3H, s, C3′–CH_3), 1.62 (6H, broad s, C3′–CH_3 and C3–CH_3), 1.75 (3H, broad s, C4–CH_3), 5.1—5.5 (1H, m, C2′–H)
4b	52—53 (0.48—0.55)	95	3000—2650 1660	1.63 and 1.73 (each 3H, each s, C3′–$(CH_3)_2$), 5.67 (2H, s, C3–H and C4–H), 5.06—5.5 (1H, m, C2′–H)
4c	73—76 (0.45—0.47)	50	3000—2650 1670	1.0 (3H, t, C3′–CH_2–CH_3, J=7.0 Hz), 1.54—1.77 (6H, broad s, C3′–CH_3, and C4–CH_3), 5.1—5.46 (2H, m, C2′–Hand C3–H)
4d	70—74 (0.32—0.33)	72.8	3000—2700 1670	1.0 (3H, t, C3–CH_3, J=8.0 Hz), 1.68 (6H, broad s, C3′–$(CH_3)_2$), 1.75 (3H, s, C4–CH_3)
4e	80—85 (0.24—0.28)	74.6	3100—2600 1670	1.0 (3H, t, C4–CH_3, J=7.0 Hz), 1.68 and 1.74 (each 3H, each s, C3′–$(CH_3)_2$), 5.03—5.42 (2H, m, C2′–H and C3–H)
4f	58—60 (0.15)	43.2	3000—2650 1650	0.98 (3H, d, C6–CH_3, J=6.0 Hz), 1.62 (6H, broad s, C3′–$(CH_3)_2$), 1.74 (3H, s, C3–CH_3), 5.0—5.49 (2H, m, C2′–H and C4–H)
4g	65—68 (0.28—0.3)	40	3000—2650 1640	1.62 (6H, broad s, C3′–$(CH_3)_2$), 1.7 (3H, s, C4–CH_3) 5.1—5.5 (2H, m, C2′–H and C3–H)
4h	70—74 (0.5—0.6)	45.3	3000—2700 1660	1.07 (3H, d—d, C2–CH_3, J=6.0 Hz and 3.4 Hz), 1.63 (9H, broad s, C3′–$(CH_3)_2$ and C4–CH_3), 5.05—5.44 (2H, m, C2′–H and C3–H)
4i	75—79 (0.2—0.22)	60.5	3000—2700 1640	1.62 (6H, broad s, C3′–CH_3), 1.73 (3H, s, C3–CH_3), 5.03—5.58 (2H, m, C2′–H and C4–H)
4j	85—88 (0.3—0.34)	71.7	3000—2700 1660	0.85 (3H, t, C3′–CH_3, J=6.0 Hz), 1.6 (9H, broad s, C3′–CH_3, C3–CH_3 and C4–CH_3), 5.02—5.5 (1H, m, C2′–H)
4k	73—76 (0.27—0.29)	58.1	3000—2700 1660	1.02 (3H, t, C3′–CH_2–CH_3, J=7.6 Hz), 1.43—1.8 (9H, m, C3′–CH_3, C3–CH_3 and C4–CH_3), 5.03—5.48 (1H, m, C2′–H)
4l	118—120 (0.12—0.15)	43.1	3100—2700 1640, 1600	1.64 and 1.74 (each 3H, each s, C3′–$(CH_3)_2$) 5.1—5.5 (1H, m, C2′–H), 5.88—6.1 (1H, m, C3–H), 7.05—7.6 (5H, m, aromatic H)
4m	53—55 (0.3—0.34)	83.3	3050—2750 1660	1.49 and 1.6 (each 3H, each s, C3′–$(CH_3)_2$), 0.98 (3H, d, C6–CH_3, J=6.0 Hz), 5.59 (2H, broad s, C3–H and C4–H), 5.0—5.45 (1H, m, C2′–H)

a) Yield based on pyridines (**1**).

tetrahydropyridines (**4**). Thereafter, the compounds (**4**) were cyclized to 1-azabicyclo[3,3,1]-non-6-enes (**5**) with Lewis acid (PPA and 47%-HBr). Optimal reaction condition of the cyclization are as follows; 130—140° and 5—15 hr in case of PPA, and 135—140° (refluxing), 10—15 hr in case of 47%-HBr. The overall yield of **5** based on pyridines (**1**) was 30—40% and that based on tetrahydropyridines (**4**) was 40—80%. The products (**5**) were purified by distillation under reduced pressure, and characterized as the quaternary ammonium salts (**7**) as in Table III. The ammonium salts (**7**) were formed by reaction of the compounds (**5**) with alkyl halides in organic solvent. Various organic halides, such as methyl iodide, benzyl chloride, and ethyl bromide *etc.*, can be employed in the synthesis of the quaternary ammonium salts.

Regarding the mechanism of the cyclization reaction, alkyl groups on the pyridine rings of **4** did not produce any particular influences for the formation of the desired compounds (**5**). However, if R_6 of **4** is hydrogen, the compounds (**5**) are not obtained. The bulky substituents of R_6, such as *iso*-propyl or propyl groups, decreased the yield of the formation of **5**. As summarized in Table II, the yield of **5** decreased according to the order of the bulkiness of R_6 as CH_3, C_2H_5 and C_3H_7. From the facts, it was concluded that protonation of **4** at C2′ were promoted by hyperconjugation of the two alkyl groups to give **5** as shown in Chart 1.

The structures of **5** were confirmed by infrared (IR) and nuclear magnetic resonance (NMR) spectra, considering the structures reported in the previous paper[2] of the compounds related to **5**. The data of IR and NMR spectra of **4** and **5** are shown in Table I and II respec-

Table II. 1-Azabicyclo[3,3,1]non-6-enes (**5**)

Compound	bp °C (mmHg)	Yield[a] (%)	IR data ν_{max}^{neat} cm^{-1}:	NMR data in $CDCl_3$ (δ from TMS)
5a	60—73 (0.3—0.36)	83.6	3000—2800 1650	0.82 (6H, s, C4-$(CH_3)_2$), 1.0 (3H, s, C5-CH_3), 1.68—1.84 (3H, m, C6-CH_3), 5.42—5.62 (1H, m, C7-H)
5b	48.5 (0.5)	59.7	3000—2750 1630	0.89 and 1.09 (each 3H, each s, C4-$(CH_3)_2$), 5.62—6.24 (2H, m, C6-H and C7-H)
5c	55—59 (0.1—0.2)	42.5	3000—2800 1660	0.8 (3H, s, C4-CH_3), 0.96 (3H, t, C4-CH_2-C$\underline{H}_3$, J=6.0 Hz), 1.68—1.83 (3H, m, C6-CH_3), 5.4—5.6 (1H, m, C7-H)
5d	67—71 (0.29—0.3)	74.7	3000—2800 1650	0.85 and 1.0 (each 3H, each s, C4-$(CH_3)_2$), 0.88 (3H, t, C5-CH_2-C$\underline{H}_3$, J=7.0 Hz), 1.65—1.93 (3H, m, C6-CH_3), 5.5—5.73 (1H, m, C7-CH_3)
5e	60—65 (0.26—0.27)	74.2	3000—2800 1650	0.83 and 1.06 (each 3H, each s, C4-$(CH_3)_2$), 0.95 (3H, t, C6-CH_2-C$\underline{H}_3$, J=7.6 Hz), 5.37—5.6 (1H, m, C7-H)
5f	37—40 (0.10)	78.8	3000—2800 1640	0.8 (6H, broad s, C4-$(CH_3)_2$), 1.02 (3H, d, C8-CH_3, J=6.0 Hz), 0.98 (3H, broad s, C5-CH_3), 5.4—5.74 (2H, m, C6-H and C7-H)
5g	61—62 (0.38—0.45)	55	3000—2700 1660	0.9 and 1.1 (each 3H, each s, C4-$(CH_3)_2$), 1.7—1.85 (3H, m, C6-CH_3), 5.43—5.64 (1H, m, C7-H)
5h	58—60.5 (0.4)	63	3000—2800 1650	0.98 (3H, d—d, C9-CH_3, J=8.0 and 4.0 Hz), 1.1 and 0.87 (each 3H, each s, C4-$(CH_3)_2$), 1.74 (3H, m, C6-CH_3), 5.3—5.58 (1H, m, C7-H)
5i	75—80 (0.15)	46.3	3000—2800 1640	0.82 (each 3H, each s, each s, C4-$(CH_3)_2$), 1.01 (3H, s, C5-CH_3), 5.4—5.98 (2H, m, C6-H and C7-H)
5j	80—83 (0.27—0.3)	43.2	2990—2800 1650	0.89 (3H, t, C4-CH_2-C$\underline{H}_3$, J=6.0 Hz), 0.92 (3H, s, C6-CH_3), 5.43—5.68 (1H, m, C7-H)
5k	67—71 (0.22—0.26)	42.6	3000—2800 1660	0.78 (3H, s, C4-CH_3), 0.94 (3H, t, C4-CH_2-C$\underline{H}_3$, J=5.4 Hz), 1.57 (3H, s, C5-CH_3), 1.63—1.8 (3H, m, C6-CH_3), 5.44—5.63 (1H, m, C7-H)
5l	113—114 (0.1—0.2)	77	1640, 1530	1.2 and 1.3 (each 3H, each s, C4-$(CH_3)_2$), 7.16 (5H, s, aromatic H), 7.0—7.6 (1H, m, C7-H)
5m	46—48 (0.1—0.12)	51.2	3000—2850 1640	0.83 and 1.1 (each 3H, each s, C4-$(CH_3)_2$), 1.12 (3H, d—d, C8-CH_3, J=8.0 and 4.0 Hz), 5.8 and 5.85 (each 1H, each broad s, C6-H and C7-H)

a) Yield based on tetrahydropyridines (**4**).

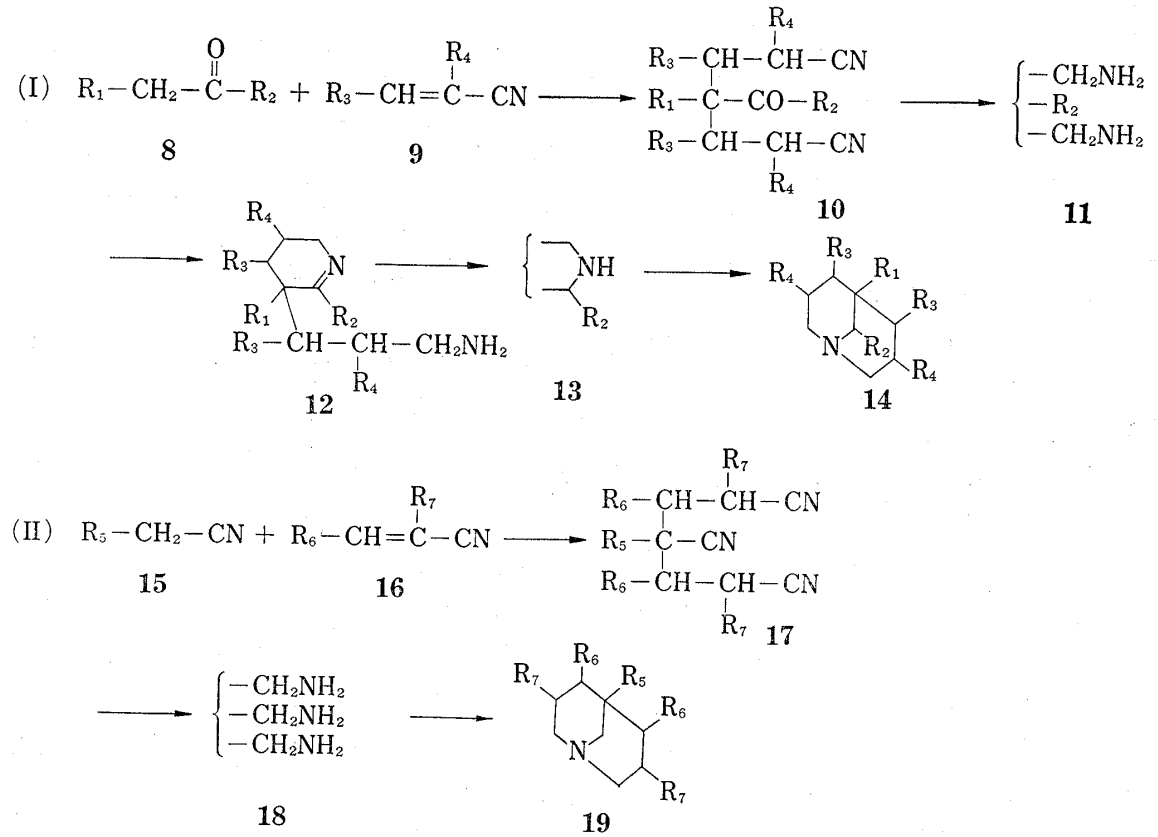
tively. In the NMR spectrum (in $CDCl_3$) of **5a**, the strong lines at 0.82, 0.89 and 1.0 ppm arise from the C4-, C5- and C6-methyl respectively, where the multi-splited lines at 1.68—1.84 ppm are attributed to the C6-methyl. The detailed interpretation of signals in region 1.7—3.6 ppm due to methylene of two piperidine rings is not feasible for unresolved complex signals. The IR spectra of **5** showed the absorption of the olefinic bond at 1600—1700 cm^{-1}.

The compounds (**5**) can be converted to the corresponding 1-azabicyclo[3,3,1]nonanes (**6**) by hydrogenation over Raney nickel or platinum oxide in ethanol. For example, 4,4-

Table III. Analytical Data of Quaternary Ammonium Salts (**7**)

Compound	mp (°C)	Formula	Analysis (%) Calcd. C	H	N	Found C	H	N
7a[a]	274—275	$C_{18}H_{26}NCl$	74.07	8.98	4.80	74.05	8.95	4.67
7b[a]	248—250	$C_{16}H_{22}NCl$	72.84	8.41	5.31	73.15	8.63	5.23
7c[a]	188—190	$C_{18}H_{26}NCl$	74.07	8.98	4.80	74.01	8.92	4.75
7d[a]	270—272	$C_{19}H_{28}NCl$	74.60	9.23	4.58	74.79	9.31	4.54
7e[b]	234—235	$C_{13}H_{24}NI$	48.60	7.53	4.36	48.38	7.44	4.48
7f[b]	300—301	$C_{13}H_{24}NI$	48.60	7.53	4.36	48.62	7.48	4.44
7h[b]	290—291	$C_{13}H_{24}NI$	48.60	7.53	4.36	48.64	7.48	4.43
7i[b]	>320	$C_{12}H_{22}NI$	46.91	7.22	4.56	47.11	7.14	4.59
7j[b]	semi-solid	$C_{15}H_{28}NI$	51.58	8.08	4.01	—	—	—
7k[b]	175—177	$C_{14}H_{26}NI$	50.15	7.82	4.18	50.02	7.61	4.03
7m[b]	300—301	$C_{12}H_{22}NI$	46.91	7.22	4.56	46.77	7.21	4.53

a) quaternary ammonium salts of benzyl chloride
b) quaternary ammonium salts of methyl iodide



(Substituents, R_1—R_7 are described in ref. 4))

Chart 2

dimethyl-1-azabicyclo[3,3,1]nonane (**6b**) was obtained by hydrogenation of 4,4-dimethyl-1-azabicyclo[3,3,1]non-6-ene (**5b**) over Raney nickel in ethanol (temperature; 80—90°, hydrogen pressure; 80—90 kg/cm²). The yield of the hydrogenation was very high and the resulting product (**6b**) was purified by distillation under reduced pressure. In the NMR spectrum of **6b**, two C4-methyl proton signals appeared in 0.98 and 1.02 ppm, while those of **5b** appeared in 0.89 and 1.09 ppm respectively.

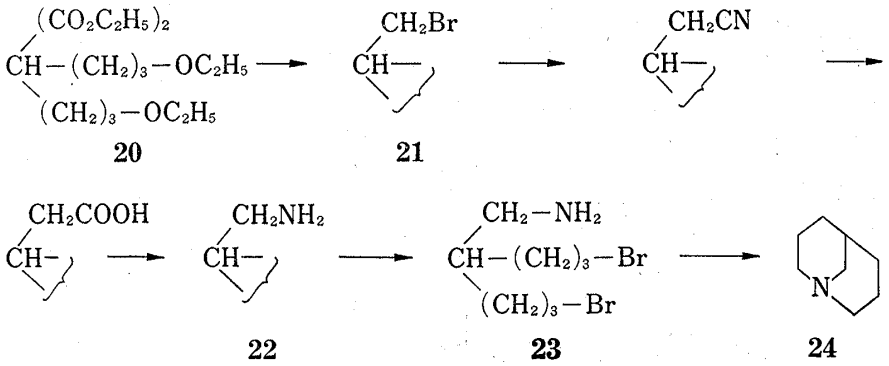


Chart 3

Synthetic methods in the previous papers[4–6] of 1-azabicyclo[3,3,1]nonanes (**14**, **19** and **24**) related to (**6**) are outlined as in Chart 2 and 3. That is, substituted 1-azabicyclo[3,3,1]nonanes (**14** and **19** in Chart 2) are formed through the catalytically promoted hydrogenation of ketodinitrile compounds (**10**), trinitrile compounds (**17**), ketodiamino compounds (**11**) and triamino compounds (**18**). Route I and II of Chart 2 show the reaction of keto-compounds (**8**) with acrylonitrile derivatives (**9**) to ketodinitriles (**10**) and the cyanoethylation of mononitriles (**15**) to trinitriles (**17**) respectively. The corresponding ketodiamino (**11**) and triamino compounds (**18**) are obtained by hydrogenation of the nitriles (**10** and **17**). As illustrated in route I intermediates to the formation of **14** are substituted alkylamino tetrahydropyridine compounds (**13**).

Prelog, *et al.*[5,6] have reported that 1-azabicyclo[3,3,1]nonanes (**24**) can be obtained from intramolecular alkylation of 2,2-bis(3-bromopropyl)ethylamine (**23**) as shown in Chart 3. The formation of **23** proceeded from 2,2-bis(3-ethoxypropyl)ethylamine (**22**) which was obtained from 2,2-bis(3-ethoxypropyl)ethyl bromide (**21**); the Br in **21** was substituted by –CN which was hydrolyzed to a carboxylic acid and the carboxyl group was converted into an amino group by means of the Curitius-Schmidt reaction.[6]

As described above, the formation of 1-azabicyclo[3,3,1]nonane derivatives reported in previous papers requires complicated reaction processes under drastic treatment (hydrogen pressure; 80—100 kg/cm² and reaction temperature; 120—250° with Raney nickel or Raney cobalt catalyst). On the contrary, in the present method shown in Chart 1, 1-azabicyclo[3,3,1]-nonanes were formed through shorter reaction processes and milder reaction condition than the precedents. Moreover, in the present synthetic way, commercially available starting materials can be used, such as pyridine and allylbromide derivatives. Accordingly, our present paper may give one of the most practical methods to obtain 1-azabicyclo[3,3,1]non-6-enes (**5**) and 1-azabicyclo[3,3,1]nonanes (**6**).

Experimental

Melting points were determined on a Thomas-Hoover Uni-Melt apparatus, and uncorrected. IR spectra were obtained on a Perkin-Elmer Model IR-21 spectrophotometer. NMR spectra were obtained on a Varian A-60 spectrometer. The starting materials, the various pyridine, allylbromide, and benzylchloride derivatives were obtained commercially or prepared routinely by literature procedures.

1-(3′,3′-Dimethylallyl)-4-phenyl-1,2,5,6-tetrahydropyridine (**41**)——To a solution of 30 g of 4-phenylpyridine in 70 ml of benzene and 15 ml of acetone was added a solution of 29 g of 3,3-dimethylallyl bromide

in 20 ml of benzene and 5 ml of acetone at 0—5° for 2 hrs and at room temperature for 2 hr. After cooling with ice-cold water, the resulting crystals were filtered and washed with benzene–acetone (2: 1) to give 55 g of 1-(3′,3′-dimethylallyl)-4-phenylpyridinium bromide (**31**). mp 180—183°. IR ν_{max}^{Nujol} cm^{-1}: 1630, 1160, 870, 780, 720. This product was used without purification for a next procedure. The pyridinium bromide (**31**) (55 g) obtained above was dissolved in 290 ml of methanol and 185 ml of 1N-sodium hydroxide and hydrogenated with 17 g of sodium borohydride by refluxing for 5 hr. The mixture was diluted with cold water and extracted three times with ether. The combined extracts were washed with water, and dried (sodium sulfate). After removal of ether, the residue was distilled under reduced pressure to obtain **4l**. bp 118—120° (0.12—0.15 mmHg). Yield 24 g (43.1%).

1-(3′,3′-Dimethylallyl)-4-methyl-1,2,5,6-tetrahydropyridine (4g)——To a solution of 40 g of 4-methylpyridine in 100 ml of benzene and 50 ml of acetone was added a solution of 64 ml of 3,3-dimethylallyl bromide in 40 ml of benzene and 10 ml of acetone at 0—5° with constant stirring. Stirring was continued at 0° for 2 hr and at room temperature for 2 hr. After cooling with ice-cold water, the resulting crystals were filtered and washed with benzene–acetone (2: 1) to give 88.4 g (85%) of 1-(3′,3′-dimethylallyl)-4-methylpyridinium bromide (3 g). mp 126—129°. IR ν_{max}^{Nujol} cm^{-1}: 1630, 1510, 1240, 1150, 820, 700. This product was used without purification for a next procedure. The pyridinium bromide (**3 g**) (87.9 g) obtained above was dissolved in 430 ml of methanol and 280 ml of 1N-sodium hydroxide and hydrogenated with 17.1 g of sodium borohydride by refluxing for 3 hr. The mixture was diluted with cold water and extracted three times with ether. The combined extracts were washed with water, and dried (sodium sulfate). After removal of ether, the residue was distilled under reduced pressure to obtain **4g**. bp 68—70° (0.3 mmHg). Yield 26.8 g (40%).

The IR and NMR spectra data of (**4l**) and (**4g**) are described in Table I. Other tetrahydropyridines (**4**) were similary obtained by the method described above and summarized in Table I.

4,4-Dimethyl-6-phenyl-1-azabicyclo[3,3,1]non-6-ene (5l)——Cyclization Method A (using PPA): A mixture of 20 g of the tetrahydropyridine (**4l**), 156 g of P_2O_5 and 196 g of 85%-H_3PO_4 was kept at 135—140° (oil-bath temperature 150—160°) for 10 hr under nitrogen atmosphere, cooled, poured into 500 ml of ice-water and basified with ammonium hydroxide. This liberated base was extracted three times with ether and dried over sodium sulfate. After removal of ether, the residue was distilled under reduced pressure to obtain **5l**. bp 113—114° (0.1—0.2 mmHg). Yield 15.4 g (77%). The hydrochloride was prepared by bubbling HCl-gas into the free base (**5l**) in ether. mp 260° (decomp.). *Anal.* Calcd. for $C_{16}H_{22}NCl$; C, 72.83; H, 8.41; N, 5.31; Cl, 13.44. Found: C, 72.41; H, 8.43; N, 5.48; Cl, 13.84.

4,4,6-Trimethyl-1-azabicyclo[3,3,1]non-6-ene (5g)——Cyclization Method B (using 47%-HBr): The tetrahydropyridine (**4g**) 10 g and 100 ml of 47%-HBr were kept at 135—140° (oil-bath temperature) for 6 hr, cooled, poured into 2 volumes of ice water and basified with ammonium hydroxide. The liberated base was extracted three times with ether, and dried over sodium sulfate. After removal of ether, the residue was distilled under reduced pressure to give 5.5 g (55%) of **5g**. bp 61—62° (0.38—0.45 mmHg).

The quaternary salts of benzyl chloride was prepared from 10 g of the free base (**5g**) and 7.6 g of the chloride in 40 ml of acetone and recrystallized from ethyl acetate–isopropyl alcohol (10: 1). mp 180—181°. *Anal.* Calcd. for $C_{17}H_{24}NCl$: C, 73.49; H, 8.71; N, 5.04; Cl, 12.76. Found: C, 73.56; H, 8.46; N, 4.85; Cl, 12.54.

The IR and NMR spectra data of **51** and **5 g** are described in Table II. Other azabicyclo[3,3,1]non-6-enes were similarly obtained by the methods described above. The results are summarized in Table II and III.

4,4,-Dimethyl-1-azabicyclo[3,3,1]nonane (6b)——Into a one-liter stainless steel rocking autoclave were placed 5 g of **5b** along with 100 ml of ethanol and 4 g of Raney nickel catalyst. The catalyst was washed with ethanol prior to introduction into the reactor. The air contained in the autoclave was then purged by introducing hydrogen and thereafter the reactor was pressurized with hydrogen to 85 kg/cm^2. The autoclave was stirred at room temperature for 35 hr. Hydrogen pressure throughout the reaction period ranged between 85 and 78 kg/cm^2. Thereafter, the contents of the autoclave were filtered to remove the catalyst. After removal of solvent, the residue was distilled under reduced pressure to give 3.8 g (75.6%) of **6b**. bp 40—43° (0.4—0.5 mmHg). IR ν_{max}^{Neat} cm^{-1}: 2900—2850, 1450, 1390, 1360, 1350, 1330, 1310, 1090, 1060, 850, 750. NMR ($CDCl_3$) δ: 0.97 and 1.0 (each 3H,each s, C4-$(CH_3)_2$).

The quaternary ammonium salt was prepared from 0.35 g of **6b** and 0.33 g of methyliodide in 10 ml of acetone, and recrystallized from iso-propylalcohol. mp>320°. *Anal.* Calcd. for $C_{11}H_{22}NI$: C, 44.75; H, 7.51; N, 4.73; I, 42.99. Found: C, 44.93; H, 7.48; N, 4.78; I, 43.04.

4,4,8-Trimethyl-1-azabicyclo[3,3,1]nonane (6m)——Into a one-liter stainless steel rocking autoclave were placed 3.3 g of **5m** along with 50 ml of ethanol and 4.5 g of Raney nickel catalyst. The catalyst was washed with ethanol to introduction into the reactor. The air contained in the autoclave was then purged by introducing hydrogen and thereafter the reactor was pressurized with hydrogen to 120 kg/cm^2. The temperature was raised from 25 to 100° and maintained at this level for 45 hr. Hydrogen pressure throughout the reaction period ranged between 100 and 150 kg/cm^2. Thereafter, the autoclave was permitted to cool to room temperarure, and the contents of the autoclave were filtered to remove the catalyst. After removal of solvent, the residue was distilled under reduced pressure to give 2.5 g (75.3%) of **6m**. bp 42—45° (0.07—0.09 mmHg). IR ν_{max}^{Neat} cm^{-1}: 3000—2850, 1450, 1390—1350, 1230, 1030, 790, 720. NMR ($CDCl_3$): δ 0.95 and 1.05 (each 3H, each s, C4-$(CH_3)_2$), 1.2 (3H, d, C8-CH_3).

The quaternary ammonium salt was prepared from 1.2 g of **6m** and 1.0 g of methyl iodide in 15 ml of acetone, and recrystallized from iso-propyl alcohol. mp 296—297°. *Anal.* Calcd. for $C_{12}H_{24}NI$: C, 46.61; H, 7.82; N, 4.53; I, 41.04. Found: C, 46.83; H, 7.60; N, 4.75; I, 41.03.

Acknowledgement The authors wish to express their thanks to Dr. T. Hirohashi and Dr. M. Sunagawa for valuable discussion and Mr. T. Inoue for technical assistance.