Tetrahedron. Vol. 29, pp. 1063 to 1068. Pergamon Press 1973. Printed in Great Britain

N-AMINATION OF TERTIARY AMINES
A NOVEL METHOD FOR 1,1,1-TRISUBSTITUTED HYDRAZINIUM SALTS

Y. TAMURA,* J. MINAMIKAWA, Y. KITA, J. H. KIM, and M. IKEDA

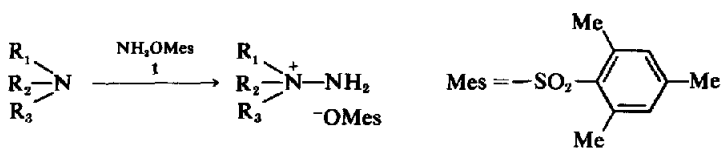
Faculty of Pharmaceutical Sciences, Osaka University, Toneyama, Toyonaka, Osaka, Japan

(*Received in Japan* 13 *November* 1972; *Received in the UK for publication* 23 *November* 1972)

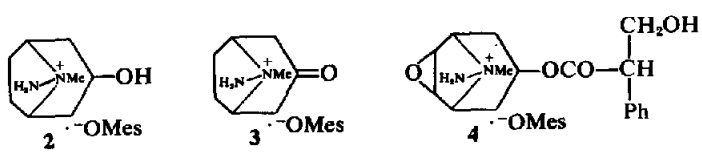
Abstract—A novel method for the preparation of 1,1,1-trisubstituted hydrazinium salts by the reaction with O-mesitylenesulfonylhydroxylamine (MSH) is described. The N-amine salts of some selected alkaloids were prepared. The stereochemistry of N-amination of securinine and allosecurinine with MSH was also investigated.

1,1,1-Trisubstituted hydrazinium salts have been prepared by several methods,[1-4] all of which have limitations. For examples, hydroxylamine-O-sulfonic acid[3] and chloramine[4] are known to react with tertiary amines to give the corresponding hydrazinium salts. The disadvantage of both methods is that the large excess of tertiary amines must be employed. As an extension of the synthetic application of O-mesitylenesulfonylhydroxylamine (1) (MSH),[5,6] it was found that MSH reacts readily with a variety of tertiary amines under extremely mild conditions to give the corresponding 1,1,1-trisubstituted hydrazinium salts in high yields (the yields are based upon amines) (Scheme 1). We applied this method to the preparation of the N-amine salts of some selected alkaloids, in the hope of pharmacological activities. The stereochemistry of N-amination of securinine (7) and allosecurinine (8) with MSH was also investigated.

Synthesis of 1,1,1-trisubstituted hydrazinium salts. In a typical experiment, tri-*n*-butylamine reacted with MSH to give 87% yield of 1,1,1-tri-*n*-butylhydrazinium mesitylenesulfonate, m.p. 136–137°. The results, summarized in Table 1, indicate that both aliphatic and aromatic tertiary amines react with equal ease. The structures of the products were assigned on the basis of the chemical and spectral data and elemental analyses, details of which are given in the Experimental. Of diagnostical importance is the fact that all the N-amine salts showed two NH_2 stretching bands in the IR spectra. The structures of **3**, **6**, **9** and **10** were further



SCHEME 1



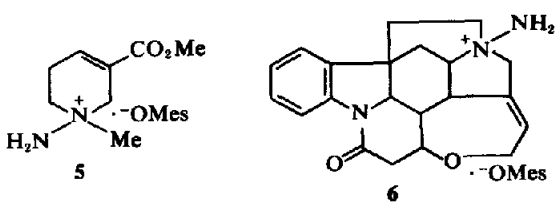
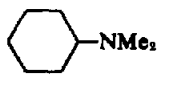
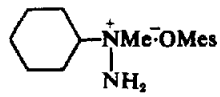
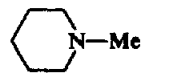
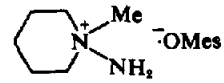
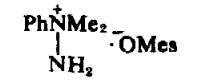


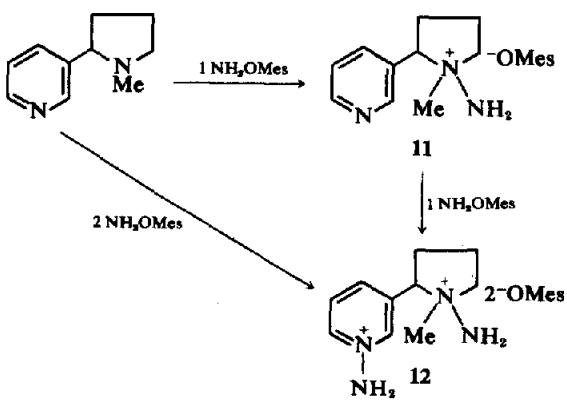
Table 1. Trisubstituted hydrazinium mesitylenesulfonates

Parent amines	Products	m.p.	Yield (%)
$(n\text{-Bu})_3N$	$(n\text{-Bu})_3\overset{+}{N}NH_2\cdot\bar{O}Mes$	136–137°	87
		201–202°	91
		173–174°	87
$PhNMe_2$		182–183°	89
Tropine	**2**	142–144°	86
Tropinone	**3**	182–183°	86
Scopolamine	**4**	240–242°	99
Arecoline	**5**	170–171°	77
Strychnine	**6**	279–281°	78
Securinine (**7**)	**9**	172–174°	97
Allosecurinine (**8**)	**10**	186–187°	93

confirmed by deamination with nitrous acid to the respective parent alkaloids.

It should be noted that tropinone, which has both a tertiary amine and a ketone group, gives rise to N-amine salt **3** only. Thus, it appears that N-amination proceeds faster than oxime formation.[7]

We have also investigated N-amination of nicotine, containing both a heteroaromatic and a tertiary amine N atom (Scheme 2). Thus, on the treatment with MSH, nicotine afforded a mono-N-amine salt (**11**) in 54% yield, whose structural assignment was based upon the following color test. Whereas the di-N-amine salt (**12**),* prepared either by the treatment of **11** with equimolar MSH or by the reaction of nicotine with two molar equivalents



SCHEME 2

of MSH, produced a reddish violet color on alkaline treatment, characteristic of pyridine N-imine,[8] the mono-N-amine salt (**11**) gave no color. The predominant formation of **11** parallels the results of N-oxide formation[9] and N-alkylation[10] of nicotine and may be ascribed to the difference in basicity between a pyridine and a tertiary amine N atom.

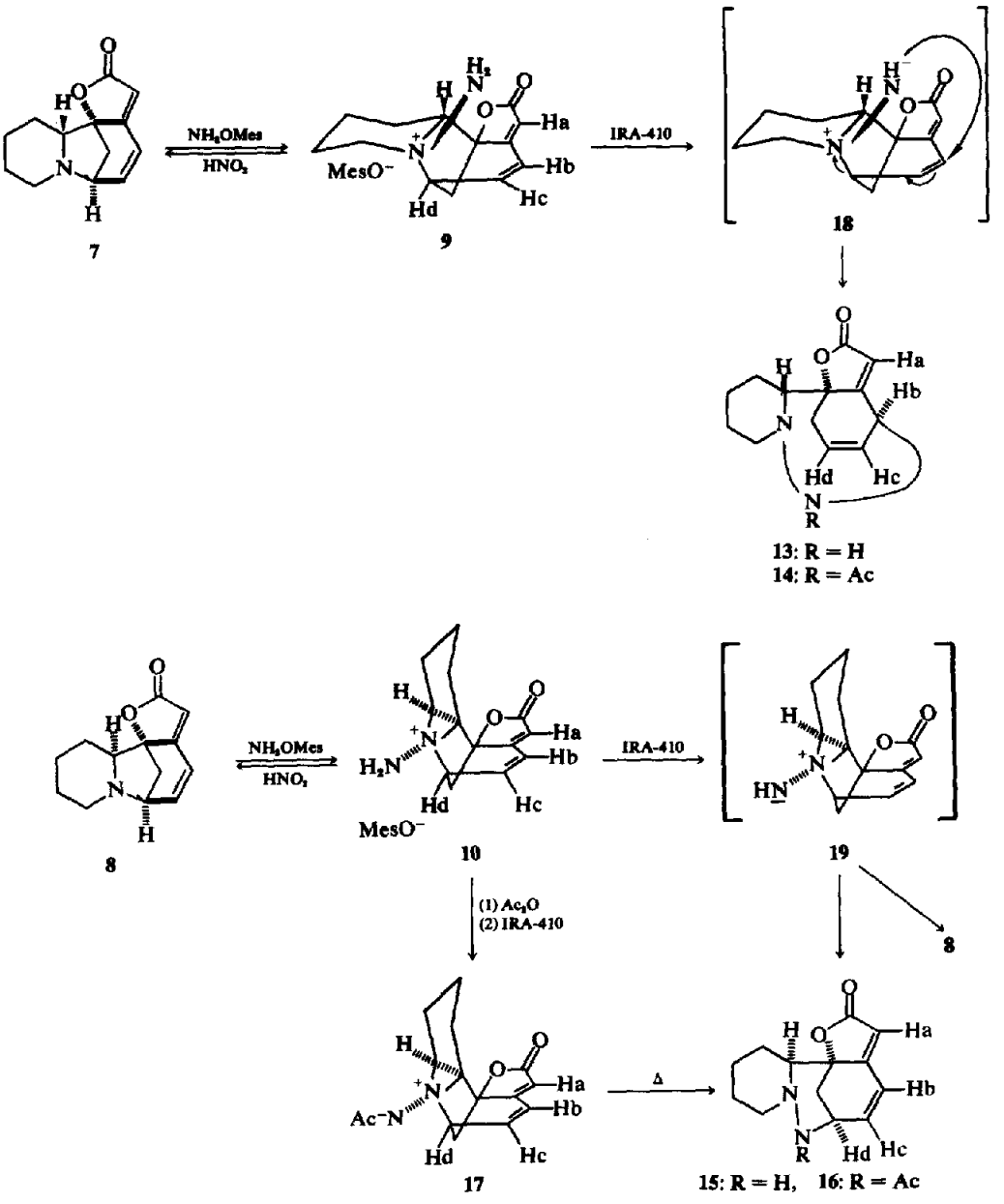
With primary and secondary amines the corresponding hydrazines were not obtained under reaction conditions described above.†

Stereochemistry of N-amination of securinine and allosecurinine. Whereas there has long been interest in the stereochemistry of quaternizations of cyclic tertiary amines,[11] no information has been available concerning the stereochemistry of N-amination. Development of a simple method for N-amination of tertiary amines enabled us to investigate the stereochemical course of the reaction. We chose securinine (**7**)[12] and its diastereomer allosecurinine (**8**)[13] as examples, because the stereochemical results of N-methylation of these alkaloids are now available and thus comparison of both the reactions is possible. The results described below indicate that N-amination of securinine (**7**) and allosecurinine (**8**) with MSH occurs by the same stereochemical pathway as quaternization with methyl iodide.

The stereochemical assignment of the NH_2 group in question was based on the following chemical behavior of **9** and **10** (Scheme 3). Thus, the treatment of **9** with Amberlite ion-exchange resin IRA-410 in methanol resulted in a clean rearrangement to a new compound $C_{13}H_{16}N_2O_2$, m.p. 170–172°, in quantitative yield. This compound was assigned the structure **13** on the basis of the following spectral evidence. The IR spectrum showed absorption bands at 3400 (NH), 1750 (C=O) and 1660

*For the reaction of MSH with pyridine see Ref. 5.

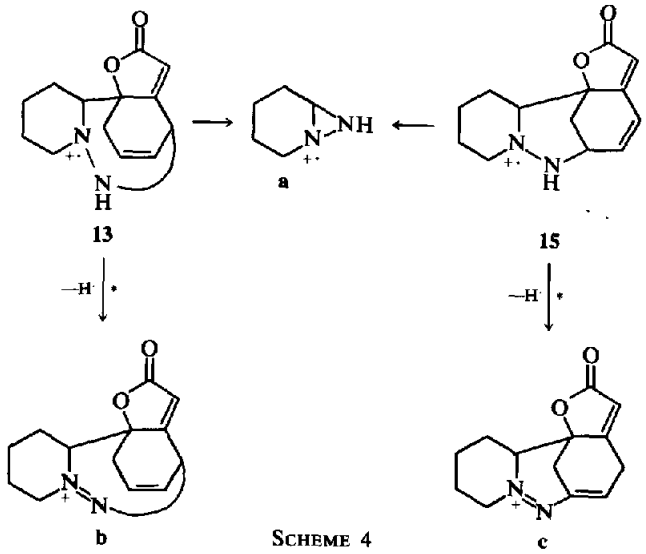
†The treatment of methylaniline with MSH in the presence of benzaldehyde, however, afforded benzaldehyde methylphenylhydrazone in 40% yield (Y. Tamura, J. Minamikawa, H. Matsushima, and M. Ikeda, *Synthesis* in press).



SCHEME 3

(C=C) cm^{-1}. The presence of an NH group was further confirmed by conversion of **13** to its N-acetate (**14**). In the UV spectrum of **13**, disappearance of the absorption maximum at the longer wave length and the appearance of a new maximum at 218 nm suggest the occurrence of the change of the chromophore from a doubly unsaturated γ-lactone moiety to an α,β-unsaturated γ-lactone system. In the NMR spectrum of **13**, two olefinic protons (Hc and Hd) at τ 4·12 and 3·88 give rise to a doublet of doublets and a doublet of triplets, respectively. The rest of the NMR spectrum consists of one olefinic proton (Ha) at τ 4·40, a hydrogen (Hb) geminal to nitrogen at τ 5·54 as a doublet and a broad N—H absorption at τ 7·25. The mass spectrum of this compound showed its base peak at *m/e* 98 (**a**) and a strong M-1 peak (**b**), whose formation is shown in Scheme 4.

In contrast with **9**, similar treatment of **10** gave **15**, $C_{13}H_{16}N_2O_2$, m.p. 185°, and allosecurinine (**8**) in 41 and 20% yields, respectively. The structure of the major component was readily assigned **15** by a comparison of its spectral data with those of allosecurinine (**8**).[13a] Thus, a UV absorption maximum



SCHEME 4

at 256 nm and strong IR absorption bands at 1740 and 1630 cm^{-1} suggest retaining of a doubly unsaturated γ-lactone moiety. The NMR spectrum of **15** is similar to that of **8** except for the appearance of a broad N—H signal at τ 7·43. The mass spectrum of **15**, however, is indistinguishable from that of **13** (Scheme 4). The compound **15** also gave the N-acetate (**16**), m.p. 186–188°, upon treatment with acetic anhydride and pyridine.

The simplest explanation for the above results is that N-imines (**18** and **19**) exist as intermediates (Scheme 3). The formation of **13** from **9** may then be pictured as occurring *via* a well-established concerted [2,3]-sigmatropic rearrangement.[14] On the other hand, the intermediate **19** in a geometrically unfavorable configuration of the amino group may undergo reaction *via* (a) a non-concerted radical-pair mechanism[5] to lead to Stevens rearrangement product **15*** and (b) a deamination process to allosecurinine (**8**).

The stereochemistry of allosecurinine methiodide has been established as **10** (Me and I^- instead of NH_2 and $OMes^-$) by X-ray analysis,[15] while that of securinine methiodide[16] (**9**, Me and I^- instead of NH_2 and $OMes^-$) was readily derived from a comparison of the NMR spectrum (in D_2O) of securinine methiodide with that of allosecurinine methiodide; the frequency of the N-Me singlet (τ 6·92) in the former is diamagnetically shifted by 0·3 ppm due to long-range shielding effect of a double bond than that of the N-Me singlet (τ 6·61) in the latter.

We have thus established that the stereochemical pathway of N-amination of securinine (**7**) and allosecurinine (**8**) with MSH parallels that of quarternization of these alkaloids with methyl iodide.

The striking difference in the stereochemical results of the N-amination reaction between **7** and **8** probably reflects a difference in the steric crowding around the N atoms of **7**[12b] and **8**.[13b]

EXPERIMENTAL

All m.ps are uncorrected. TLC was carried out using alumina GF_{258} (E. Merck). UV spectra were determined with a Hitachi EPS-3T spectrophotometer, IR spectra with a Hitachi EPI-G2 spectrometer, NMR spectra (unless noted otherwise, TMS as an internal standard) with a Hitachi R-20 instrument, and mass spectra with a Hitachi RMU-6D spectrometer at 70 ev.

General procedure for N-*amination.* A stirred soln of tertiary amine (1 mmole) in methylene chloride (2–3 ml), cooled in an ice bath, was added a soln of MSH (1 mmol) in methylene chloride (2–3 ml). The mixture was allowed to stand at room temp for 5 min and white ppt was filtered off. In some cases, it was necessary to add ether to precipitate the product. M.ps and yields are listed in Table 1.

N-*Amination of tri-*n*-butylamine.* From tri-*n*-butylamine, 1,1,1-tri-*n*-butylhydrazinium mesitylenesulfonate was obtained and recrystallized from methylene chloride-ether; ν_{max}^{KCl} 3250 and 3150 (NH_2) cm^{-1}. (Found: C, 62·80; H, 9·86; N, 7·05, $C_{21}H_{40}N_2O_3S$ requires: C, 62·97; H, 10·07; N, 6·99%.)

N-*Amination of dimethylcyclohexylamine.* From dimethylcyclohexylamine, 1,1,1-dimethylcyclohexylhydrazinium mesitylenesulfonate was obtained and recrystallized from methylene chloride-ether; ν_{max}^{KCl} 3260 and 3150 (NH_2) cm^{-1}. (Found: C, 59·67; H, 8·62; N, 8·07. $C_{17}H_{30}N_2O_3S$ requires: C, 59·62; H, 8·83; N, 8·18%.)

N-*Amination of* 1-*methylpiperidine.* From 1-methylpiperidine, 1-amino-1-methylpiperidinium mesitylenesulfonate was obtained and recrystallized from methylene

*N-Acetylimine (**17**), prepared in 70% yield [accompanied by **16** (20%)] by heating **10** in Ac_2O at 120° for 5 hr followed by the treatment with ion-exchange resin in MeOH, rearranged smoothly to **16** when a benzene solution was refluxed for several min. This result is also explained in terms of the nonconcerted radical-pair mechanism.[14]

chloride-ether; ν_{max}^{KCl} 3240 and 3130 (NH_2) cm^{-1}. (Found: C, 57·09; H, 8·20; N, 8·77. $C_{15}H_{26}N_2O_3S$ requires: C, 57·31; H, 8·34; N, 8·91%.)

N-*Amination of dimethylaniline.* From dimethylaniline, 1,1,1-dimethylphenylhydrazinium mesitylenesulfonate was obtained and recrystallized from methylene chloride-ether; ν_{max}^{KCl} 3250 and 3150 (NH_2) cm^{-1}. (Found: C, 60·65; H, 7·06; N, 8·46. $C_{17}H_{24}N_2O_3S$ requires: C, 60·70; H, 7·19; N, 8·33%.)

N-*Amination of tropine.* From tropine, compound **2** was obtained and recrystallized from ethanol-*n*-hexane; ν_{max}^{KCl} 3260 and 3150 (OH and NH_2) cm^{-1}. (Found: C, 57·20; H, 7·82; N, 7·95. $C_{17}H_{28}N_2O_4S$ requires: C, 57·29; H, 7·92; N, 7·86%.)

N-*Amination of tropinone.* From tropinone, compound **3** was obtained and recrystallized from acetone; ν_{max}^{KCl} 3250, 3150 (NH_2) and 1720 (C=O) cm^{-1}; NMR (D_2O, DSS as internal standard) τ 7·80 (s, 3H), 7·49 (s, 6H), 6·37 (s, 3H, N-Me), 3·04 (bs, 2H). (Found: C, 57·43; H, 7·76; N, 7·85. $C_{17}H_{26}N_2O_4S$ requires: C, 57·61; H, 7·40; N, 7·91%.)

N-*Amination of scopolamine.* From scopolamine, compound **4** was obtained and recrystallized from EtOAc; ν_{max}^{KCl} 3320 (OH), 3250, 3160 (NH_2) and 1715 (C=O) cm^{-1}. (Found: C, 60·19; H, 6·62; N, 5·32. $C_{26}H_{34}N_2O_7S$ requires: C, 60·22; H, 6·61; N, 5·40%.)

N-*Amination of arecoline.* From arecoline, compound **5** was obtained and recrystallized from methylene chloride-ether; ν_{max}^{KCl} 3230, 3120 (NH_2) and 1720 (C=O) cm^{-1}. (Found: C, 54·98; H, 7·26; N, 7·54. $C_{17}H_{28}N_2O_5S$ requires: C, 55·12; H, 7·08; N, 7·56%.)

N-*Amination of strychnine.* From strychnine, compound **6** was obtained and recrystallized from isopropanol; ν_{max}^{KCl} 3250, 3140 (NH_2), 1665 (C=O) and 1500 cm^{-1}. (Found: C, 65·36; H, 6·53; N, 7·59. $C_{30}H_{35}N_3O_5S$ requires: C, 65·55; H, 6·42; N, 7·64%.)

N-*Amination of securinine.* From securinine (**7**), **9** was obtained and recrystallized from MeOH-EtOAc; ν_{max}^{KCl} 3240, 3110 (NH_2), 1770 (C=O) and 1640 (C=C) cm^{-1}; λ_{max}^{EtOH} 224 (log ϵ 3·88) and 258 nm (3·93). (Found: C, 61·60; H, 6·37; N, 6·35. $C_{22}H_{26}N_2O_5S$ requires: C, 61·38; H, 6·09, N, 6·51%.)

N-*Amination of allosecurinine.* From allosecurinine (**8**), **10** was obtained and recrystallized from MeOH-EtOAc; ν_{max}^{KCl} 3250, 3130 (NH_2), 1770 (C=O) and 1640 (C=C) cm^{-1}; λ_{max}^{EtOH} 224 (log ϵ 3·69) and 256 nm (3·76). (Found: C, 61·17; H, 6·26; N, 6·53. $C_{22}H_{26}N_2O_5S$ requires: C, 61·38; H, 6·09; N, 6·51%.)

N-*Amination of nicotine*

(i) *Mono-N-amine salt* (**11**). To a soln of nicotine (0·49 g) in methylene chloride (3 ml) was added a soln of MSH (0·64 g) in methylene chloride (3 ml) at 0°. The mixture was concentrated and the residue was dissolved in EtOH (2 ml). Ether was added to the soln and a white ppt was filtered off and recrystallized from acetone to give colorless crystals of **11** (0·625 g, 54%), m.p. 184–185°; ν_{max}^{KCl} 3250 and 3150 cm^{-1}. (Found: C, 60·66; H, 7·35; N, 11·08. $C_{19}H_{27}N_3O_3S$ requires: C, 60·46; H, 7·21; N, 11·13%.)

(ii) *Di-N-amine salt* (**12**). (a) The mono-N-amine salt **11** (0·94 g) was treated with equimolar MSH and when ether was added to the mixture, a viscous oil separated. This oil crystallized from EtOH and ether to give white crystals of **12** (0·60 g, 40%), m.p. 188–190°; ν_{max}^{KCl} 3210 and 3150 cm^{-1}. (Found: C, 56·33; H, 7·11; N, 9·40. $C_{28}H_{40}N_4O_6S_2$ requires: C, 56·74; H, 6·80; N, 9·45%.) (b) Nicotine was treated with two molar equivs of MSH to give white crystals of **12** in 65% yield, identical with that obtained above.

Deamination of **3**, **6**, **9** *and* **10**. To a soln of **3** (177 mg) in 10% HCl (3 ml) was added a soln of $NaNO_2$ (100 mg) in water (3 ml) at 0°. After 5 min, the mixture was made alkaline with K_2CO_3, extracted with CH_2Cl_2 and the extract was dried over $MgSO_4$. Evaporation of the CH_2Cl_2 afforded 43 mg (62%) of white crystals, identical in all respects with tropinone. On a similar treatment, **6**, **9** and **10** regenerated the parent alkaloids in 59, 80 and 36% yields, respectively.

Rearrangement of **9** *to* **13**. A soln of **9** (0·300 g) in MeOH was passed through a column of Amberlite IRA-410 ion-exchange resin (7 ml) and the methanolic eluate was concentrated under reduced pressure below 50°. Sublimation of the residual solid at 125–130° (bath temp; 0·06 mmHg) gave colorless needles (0·143 g; 88%) of **13**, m.p. 170–172°; ν_{max} 3400 (NH), 1750 (C=O) and 1660 (C=C) cm^{-1}; λ_{max}^{EtOH} 218 nm (log ϵ 4·06); NMR ($CDCl_3$) τ 7·25 (bs, NH); 5·53 (d, J = 6 Hz, Hb), 4·12 (dd, J = 9 Hz, Hc), 4·40 (s, Ha), and 3·88 (t d, J = 9 and 2 Hz, Hd); *m/e* (rel. int.) 232 (M^+, 13), 231(35), 189(7), 124(15) and 98 (100). (Found: C, 67·36; H, 7·01; N, 11·95. $C_{13}H_{16}N_2O_2$ requires: C, 67·22; H, 6·94; N, 12·06%).

Rearrangement of **10** *to* **15**. A soln of **10** (0·612 g) in MeOH was treated with Amberlite IRA-410 ion exchange resin (15 ml) and evaporation of the MeOH gave 0·569 g of a crystalline substance (two major spots on TLC). The crystalline mixture (0·218 g) was separated by prep TLC using alumina and benzene-EtOAc as a solvent. The fraction with large R_f value gave 22 mg (20%) of allosecurinine as a yellow solid, m.p. 136–138°, identical in all respects with an authentic sample. From the fraction with small R_f value, 0·268 g (41%) of **15**, m.p. 181–184°, was obtained. A small sample was purified by sublimation at 140–145° (bath temp; 0·06 mmHg) to give yellow crystals of **15**, m.p. 185°; $\nu_{max}^{CHCl_3}$ 1740 (C=O), 1630 (C=C) cm^{-1}; λ_{max}^{EtOH} 256 nm (log ϵ 4·14); NMR ($CDCl_3$) τ 7·43 (bs, NH), 6·00 (m, Hc), 4·22 (s, Ha), 3·70 (d,d, J = 9 and 7 Hz, Hc), and 3·22 (d, J = 9 Hz, Hb); *m/e* (rel. int.) 232 (M^+, 34), 231 (32), 189 (5), 124 (11) and 98 (100). (Found: C, 67·11; H, 7·01; N, 11·99. $C_{13}H_{16}N_2O_2$ requires: C, 67·22; H, 6·94; N, 12·06%).

Acetylation of **13**. A mixture of **13** (50·1 mg), Ac_2O (1·5 ml) and anhyd pyridine (1·5 ml) was allowed to stand at room temp for 3 days and the soln was concentrated under reduced pressure. Recrystallization of the residual solid from benzene-light petroleum gave **14** (47·2 mg; 80%), m.p. 140–141·5°; $\nu_{max}^{CHCl_3}$ 1760 (C=O) and 1660 (C=C) cm^{-1}; λ_{max}^{EtOH} 222 nm (log ϵ 4·15); *m/e* (rel. int.) 274 (M^+, 5), 231(23), 189(3), 141(100), 112(8) and 99(15). (Found: C, 65·65; H, 6·65; N, 10·37. $C_{15}H_{18}N_2O_3$ requires: C, 65·67; H, 6·61; N, 10·21%).

Acetylation of **15**. Similar treatment of **15** (40 mg) with Ac_2O (0·5 ml) in anhyd pyridine (0·5 ml) gave colorless crystals of **16** (37 mg; 92%), m.p. 186–188°; $\nu_{max}^{CHCl_3}$ 1750 (C=O), 1650 (NHC=O) and 1640 (C=C) cm^{-1}; NMR ($CDCl_3$) τ 7·93 (s, $COCH_3$), 4·40 (m, Hd), 4·12 (s, Ha), 3·57 (d, d, J = 9 and 7 Hz, Hc), and 3·28 (d, J = 9 Hz, Hb); *m/e* (rel. int.) 274 (M^+, 15), 231(42), 189(9), 141(100), 112(11) and 99(15). (Found: C, 65·68; H, 6·60; N, 10·48. $C_{15}H_{18}N_2O_3$ requires: C, 65·67; H, 6·61; N, 10·21%).

Acetylation of **10**. A soln of **10** (0·388 g) in Ac_2O (3 ml) was heated at 120° for 5 hr and the mixture was concentrated under reduced pressure. The residual syrup was treated with Amberlite IRA-410 ion exchange resin in MeOH to give a crystalline substance (two spots on

TLC), which was separated by prep TLC using alumina and EtOAc. The fraction with large R_f value gave a yellow solid (80 mg; 20%), m.p. 186–188°, identical with **16** described above. The fraction with small R_f value yielded 0·238 g (70%) of **17**, m.p. 147–149°, after recrystallization from benzene-n-hexane. The structure of the betaine **17** was supported by its IR spectrum which showed a strong band at 1560 cm^{-1}, characteristic of the —N=C(—O—)—Me group; $\nu_{max}^{CHCl_3}$ 1790 sh, 1770 (γ-lactone), 1640 (C=C), and 1560 cm^{-1}; λ_{max}^{EtOH} 253 nm; NMR ($CHCl_3$) τ 8·20 (s, $COCH_3$), 4·07 (s, Ha), 3·85 (m, Hd), 3·40 (d, J = 9 Hz, Hc), and 3·10 (d, d, J = 9 and 1·5 Hz, Hb); *m/e* (rel. int.) 274 (M^+, 15), 231(42), 189(8), 141(100), 112(11) and 99(15). (Found: C, 66·05; H, 6·87; N, 9·85. $C_{15}H_{18}N_2O_3$ requires: C, 65·67; H, 6·61; N, 10·21%).

Rearrangement of **17** *to* **16**. A soln of **17** (50 mg) in benzene (2 ml) was refluxed for 5 min and concentrated under reduced pressure to give a quantitative yield of **16**, m.p. 186–188°.

REFERENCES

[1]E. Renouf, *Ber. Dtsch. Chem. Ges.* **13**, 2172 (1880).
[2]O. Westphal, *Ibid.* **74**, 772 (1941).
[3]H. H. Sisler, R. A. Bafford, G. M. Omietanski, B. Rudner, and R. J. Drago, *J. Org. Chem.* **24**, 859 (1959).
[4]G. M. Omietanski and H. H. Sisler, *J. Am. Chem. Soc.* **78**, 1211 (1956).
[5]Y. Tamura, J. Minamikawa, Y. Miki, S. Matsugashita, and M. Ikeda, *Tetrahedron Letters* 4133 (1972).
[6]Y. Tamura, K. Sumoto, J. Minamikawa, and M. Ikeda, *Ibid.* 4137 (1972).
[7]Y. Tamura, H. Fujiwara, K. Sumoto, M. Ikeda, and Y. Kita, *Synthesis* in press.
[8]T. Okamoto and M. Hirobe, *J. Syn. Org. Chem. Japan* **26**, 746 (1968).
[9]A. Pinner, *Ber. Dtsch. Chem. Ges.* **28**, 456 (1895); E. C. Taylor and N. E. Boyer, *J. Org. Chem.* **24**, 275 (1959).
[10]A. Pictet and P. Genequand, *Ber. Dtsch. Chem. Ges.* **30**, 2117 (1897).
[11]For examples, see [a]G. Fodor, R. V. Chastain, Jr., M. J. Cooper, N. Mandava, and E. L. Gooden, *J. Am. Chem. Soc.* **93**, 403 (1971); [b]U. O. de la Camp, A. T. Bottini, C. C. Thut, J. Gal, and A. G. Belettini, *J. Org. Chem.* **37**, 324 (1972); [c]R. A. Y. Jones, A. R. Katritzky, and P. G. Mente, *J. Chem. Soc.* **B**, 1210 (1970); [d]J. McKenna, *Top. Stereochem.* **5**, 275 (1970).
[12a]S. Saito, K. Kodera, A. Ide, K. Shigematsu, N. Sugimoto, Z. Horii, M. Hanaoka, Y. Yamawaki, and Y. Tamura, *Tetrahedron* **19**, 2085 (1963); [b]Z. Horii, M. Ikeda, Y. Yamawaki, Y. Tamura, S. Saito, and K. Kodera, *Ibid.* **19**, 2101 (1963).
[13a]I. Satoda, M. Murayama, J. Tsuji and E. Yoshii, *Tetrahedron Letters* 1199 (1962); [b]Z. Horii, M. Ikeda, Y. Tamura, S. Saito, M. Suzuki and K. Kodera, *Chem. Pharm. Bull. Tokyo* **12**, 1118 (1964).
[14]J. E. Baldwin, J. E. Brown and R. W. Cordwell, *Chem. Commun.*, 31 (1970).
[15]C. Pascard-Billy, *Bull. Soc. chim. Fr.*, 369 (1966).
[16]Z. Horii, T. Tanaka, Y. Tamura, S. Saito, C. Matsumura, N. Sugimoto, *J. Pharm. Soc. Japan* **83**, 602(1963).