The examination of lobinaline and some degradation products by mass spectrometry

D. M. Clugston and D. B. MacLean
Department of Chemistry, McMaster University, Hamilton, Ontario

AND

R. H. F. Manske
Research Laboratories, Dominion Rubber Co. Ltd., Guelph, Ontario

Received August 30, 1966

Lobinaline, its derivatives, and its Hofmann degradation products have been examined by mass spectrometry and other spectral and chemical techniques. The results provide independent evidence for the structure of the alkaloid, but indicate that the free base may exist as a mixture of two or three tautomers.

Canadian Journal of Chemistry. Volume **45**, 39 (1967)

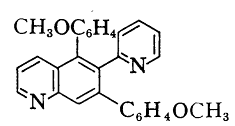
Lobinaline, the first binitrogenous alkaloid to be discovered in a *Lobelia* species, was isolated from *Lobelia cardinalis* L. in 1938 by Manske (1). Since that time, lobinaline has been detected in several other *Lobelia* species (2–4) by paper chromatography. Other binitrogenous bases have been isolated from *L. syphilitica* L.: lophiline, $C_{28}H_{38}N_2O_3$ or $C_{27}H_{36}N_2O_3$, by Steinegger and Egger (5) and syphilobine A (I) and syphilobine F (II) by Tschesche *et al.* (6).

With the exception of Manske's preliminary chemical studies, no work directed towards the elucidation of the structure of lobinaline was published until 1964. In that year, Robison *et al.* (7) proposed structure III for the compound on the basis of the dehydrogenation of desmethyllobinaline to the wholly aromatic compound IV and the synthesis of the latter for direct comparison.

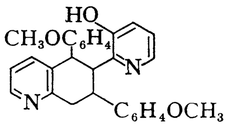
In this communication we report the results of a mass spectrometric investigation of lobinaline, its derivatives, and its Hofmann degradation products, which provide independent evidence that the alkaloid has structure III.

Lobinaline was isolated in the manner described by Manske (1) and purified by chromatography on alumina. Analyses of the free base and several derivatives agreed with the molecular formula $C_{27}H_{34}N_2$. The variable melting points of different batches of the alkaloid (7) appear to be caused by the presence of variable amounts of one or both of the tautomers V and VI as well as III. Thus, the infrared spectrum of the free base contains a low-intensity NH absorption band at 3 320 cm^{-1}. In addition, the nuclear magnetic resonance (n.m.r.) spectrum of a highly purified sample of the base in a degassed solution contains a broad peak at 4.6 δ. This peak integrates for approximately half a proton and shifts to 5.7 δ, with considerable broadening, upon addition of a trace of anhydrous hydrogen chloride, as expected for the absorption of a readily exchangeable amine hydrogen.

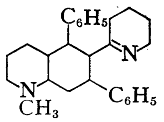
The mass spectrum of lobinaline is shown in Fig. 1*a*. In addition to the low-intensity molecular ion peak at *m/e* 386, the spectrum contains intense peaks at *m/e* 186, 200, and 201. In the mass spectrum of lobinaline-d_1 (Fig. 1*b*), the relative intensities of the peaks at *m/e* 387 and 187 are enhanced whereas the relative intensity of the peak at *m/e* 201 is unchanged. This observation led us to the conclusion that the fragments of *m/e* 186 and 200 from lobinaline differ in composition only by a *N*-methyl group, since deuterium exchange can only occur at the secondary nitrogen of tautomers V and VI. Scheme 1 outlines the fragmentation mechanism proposed to account for the major peaks in the mass spectrum of lobinaline. The molecular ion is drawn in two forms to depict the proposed mechanism. Thus, if the charge is localized on the piperideine nitrogen, hydrogen transfer from a benzylic carbon to the



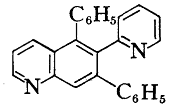
I



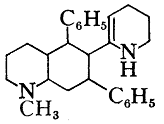
II



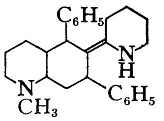
III



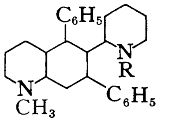
IV



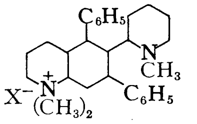
V



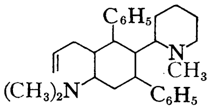
VI



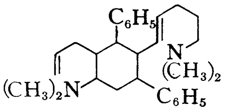
VII R=H
VIII R=CH_3



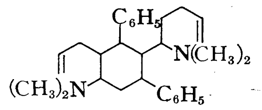
IX



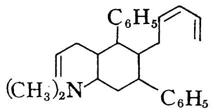
X



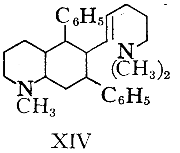
XI



XII



XIII



XIV

nitrogen followed by cleavage of the alicyclic ring yields the ion observed at *m/e* 186, with elimination of an *N*-methylpiperideine molecule and a styryl radical. If, on the other hand, the charge is localized on the decahydroquinoline nitrogen, cleavage of the alicyclic ring produces either the radical ion observed at *m/e* 97 or that observed at *m/e* 201 depending on the mode of ring cleavage. In either case, the radical ions readily lose a hydrogen atom to give the ions appearing at *m/e* 96 and 200, respectively. A fragmentation scheme, similar to Scheme 1, may be written for tautomer V to account for the spectrum of deuterated lobinaline.

Dihydrolobinaline (VII) is prepared by hydrogenation of lobinaline under unexpectedly severe conditions. The compound is an oil which shows no double-bond absorption but has intense NH absorption at 3 320 cm^{-1} in the infrared. The mass spectrum of VII is shown in Fig. 1*c*. The most striking feature of the spectrum is the very intense peak at *m/e* 84. Other significant peaks are found at *m/e* 56, 186, 200, 201, 305, 387, and 388 (molecular ion). The mechanism by which the major peaks in the mass spectrum are believed to arise is outlined in Scheme 2. The ion which appears at *m/e* 84 readily arises from the free piperidine ring. This fragmentation contrasts with that of lobinaline, where the double bond blocks cleavage of the type proposed in Scheme 2. Thus, the presence of a 2-substituted piperideine ring in lobinaline is indicated. The ion radical appearing at *m/e* 305 is apparently formed by loss of the free piperidine ring with hydrogen rearrangement, since a similar peak is found in the spectrum of the *N*-methyl derivative of dihydrolobinaline. The remaining fragmentations involve cleavage of the alicyclic ring in ways similar to those discussed above for lobinaline.

N-Methyldihydrolobinaline (VIII) is obtained by treatment of VII with formaldehyde and formic acid. The colorless oil shows no NH absorption in the infrared. It has peaks at 1.8 and 2.3 δ in its n.m.r.

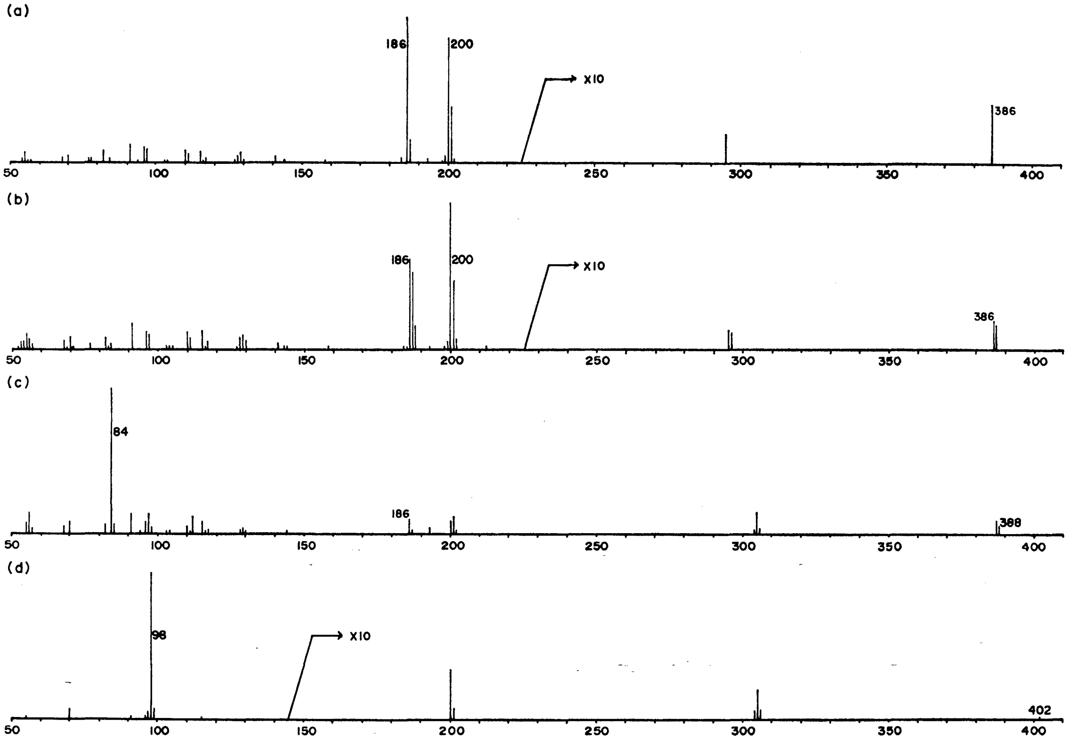
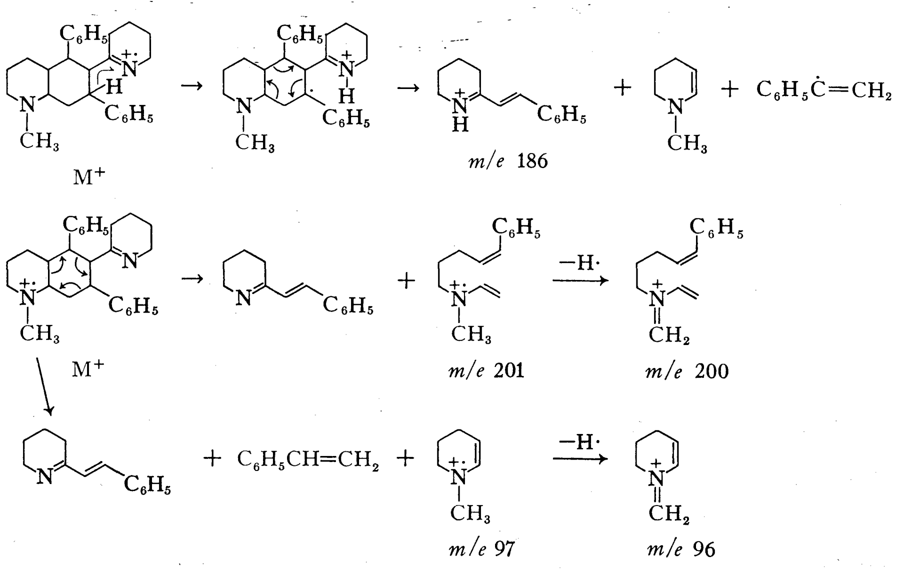
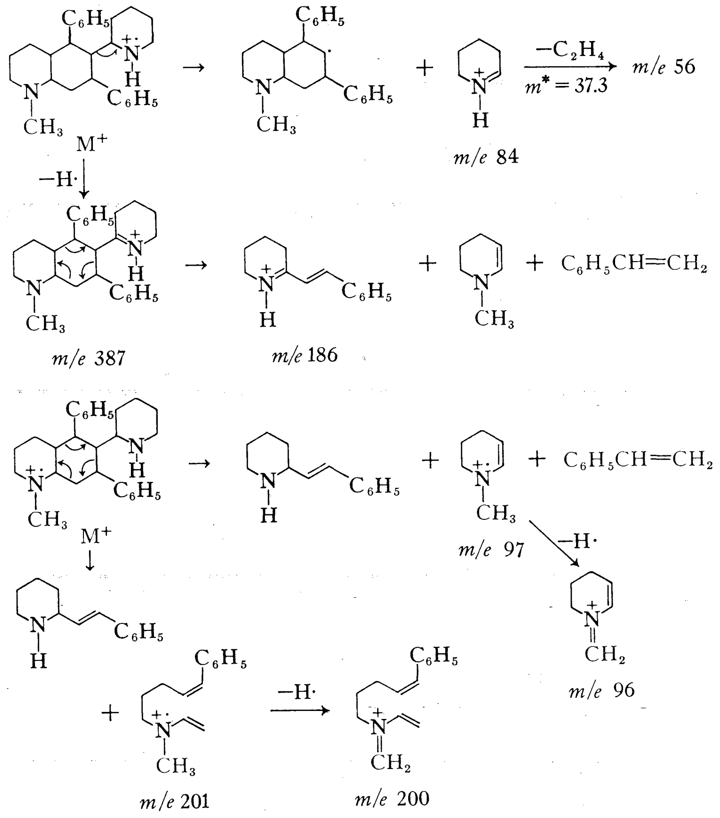


Fig. 1. Mass spectra of (*a*) lobinaline, (*b*) lobinaline-d_1, (*c*) dihydrolobinaline, and (*d*) *N*-methyldihydrolobinaline.



SCHEME 1.



SCHEME 2.

spectrum corresponding to three *N*-methyl protons each. The major peaks in the mass spectrum of VIII (Fig. 1*d*) can be accounted for in the manner outlined in Scheme 2 for dihydrolobinaline. Thus, the peaks at *m/e* 56, 84, 186, 387, and 388 in the spectrum of the dihydro compound are all shifted 14 mass units higher upon introduction of the second *N*-methyl group.

Although the alkaloid and its derivatives are remarkably resistant to most degradative approaches, it was found that the quaternary salts undergo Hofmann elimination reactions on long heating with potassium *t*-butoxide in *t*-butyl alcohol. *N*-Methyldihydrolobinaline monoquaternary salt (IX) proved to be the most useful starting material for degradation because of its ease of preparation from lobinaline dimethiodide by borohydride reduction.

Methine X is the only ring-opened product obtained from monoquaternary salt IX under the conditions described above. Compound X shows ethylenic absorption at 1 640 cm^{-1} and terminal methylene absorption at 912 and 1 000 cm^{-1} in the infrared. The n.m.r. spectrum contains a singlet at 2.2 δ corresponding to nine *N*-methyl protons, a multiplet at 5.0 δ corresponding to the two terminal methylene protons, and a very broad multiplet at 5.5 δ for the third ethylenic proton. The mass spectrum of X (Fig. 2*a*) is again dominated by a peak at *m/e* 98 corresponding to the *N*-methylpiperidinium ion arising from the monosubstituted *N*-methylpiperidine ring, which is therefore intact. Other peaks in the spectrum are of extremely low intensity, the only peak of much diagnostic value being that at *m/e* 160, which arises from the molecular ion by cleavage of the alicyclic ring (cf. Scheme 3).

The dimethiodide of X yields mainly XI under the Hofmann conditions. A small amount of a mixture of two compounds is also obtained from the reaction. The mass spectrum of the mixture indicates that it consists of compounds X and XII. The structure proposed for XII is based on the presence of a molecular ion peak at *m/e* 430 and an intense fragment ion peak at *m/e* 112. The latter peak arises from the $C_7H_{14}N$

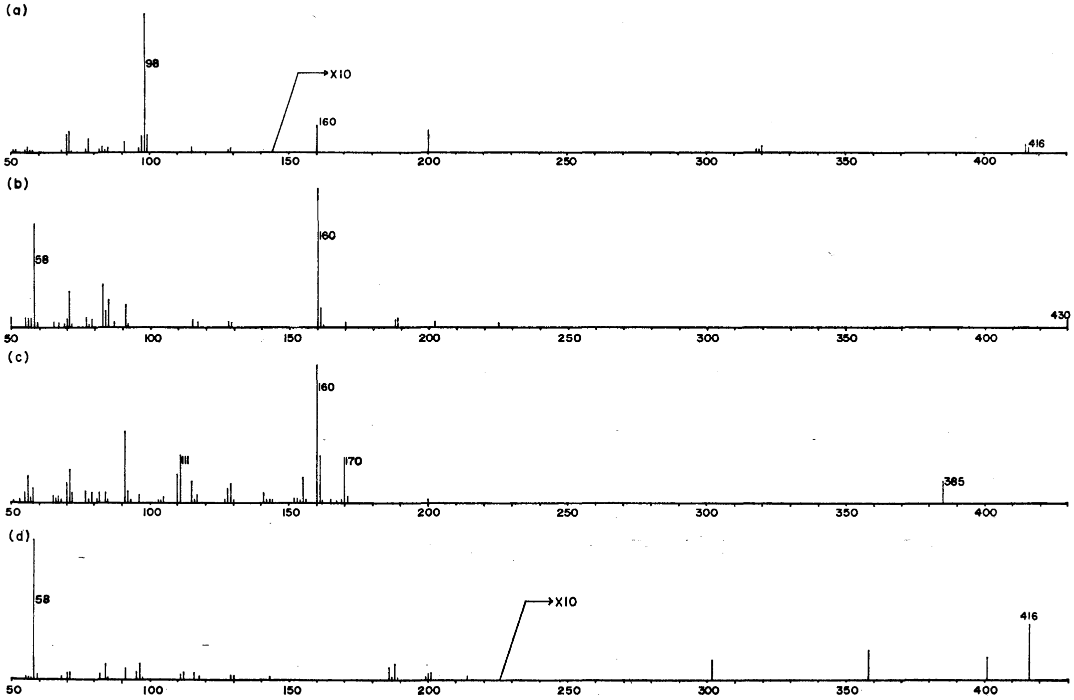
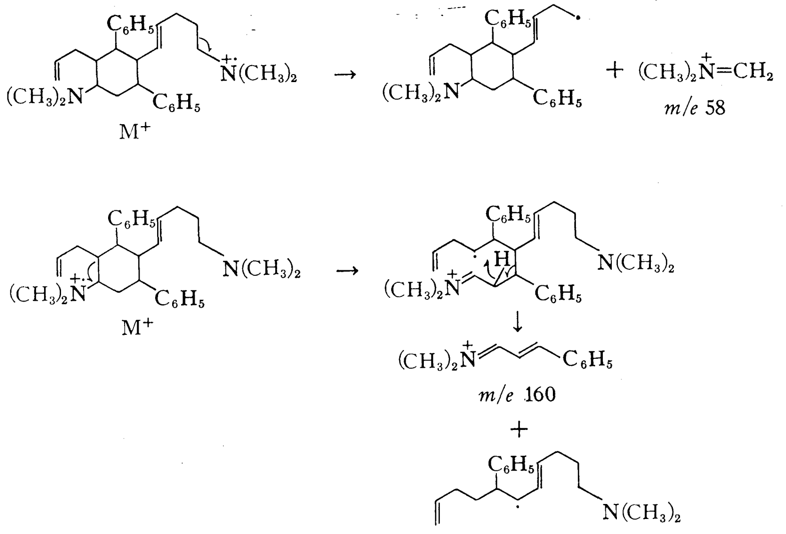


Fig. 2. Mass spectra of (*a*) X, (*b*) XI, (*c*) XIII, and (*d*) XIV.



SCHEME 3.

side chain of XII. The absence of a peak at *m/e* 58 indicates that the compound does not contain a terminal dimethylamino group.

Compound XI shows peaks at 2.0 and 2.2 δ corresponding to six *N*-methyl protons each and a multiplet between 4.5 and 6.0 δ corresponding to five ethylenic protons in its n.m.r. spectrum. The mass spectrum of XI (Fig. 2*b*) contains intense peaks at *m/e* 58 and 160 which arise as shown in Scheme 3. The ion appearing at *m/e* 58 is readily formed from the terminal dimethylamino group, and that at *m/e* 160 is a highly stabilized species formed by cleavage of the alicyclic ring, with hydrogen rearrangement, in a manner similar to that proposed for the fragmentation of cyclohexylamine and its derivatives (8). It is noteworthy that a peak is found at *m/e* 160 in the mass spectrum of every compound in which the disubstituted piperidine ring is open, indicating the presence of three carbon atoms between the dimethylamino group attached to the alicyclic ring and a phenyl group.

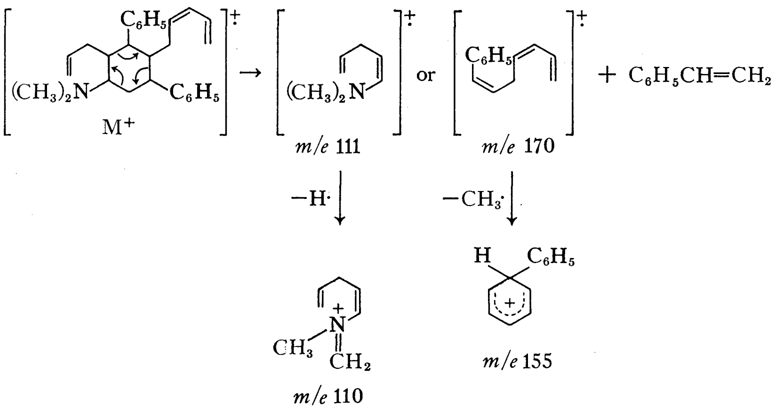
The fact that the dimethylamino group of compound X is not eliminated under the Hofmann conditions indicates that it occupies an equatorial position on the alicyclic ring, and that the ring is held sufficiently rigidly to prevent the nitrogen from becoming axial to the ring in the quaternary salt (9).

Zinc dust distillation of XI yields a mixture of compounds from which two high molecular weight fractions were isolated by vapor-phase chromatography. The more volatile fraction, fraction A, shows a broad maximum at 250 mμ in the ultraviolet corresponding to *m*-terphenyl as opposed to *o*- or *p*-terphenyl. The mass spectrum of fraction A contains peaks at *m/e* 230 and 244 in the high-mass region, which correspond in mass to terphenyl and methylterphenyl, respectively. The less-volatile fraction, fraction B, from vapor-phase chromatography shows peaks at *m/e* 272 and 243 in the high-mass region, which indicate that the compound may be propylterphenyl, which loses 29 mass units. The detection of *m*-terphenyl establishes the relationship of the two monosubstituted benzene rings in lobinaline.

The only product obtained by carrying out a Hofmann elimination on the dimethiodide of XI is basic and shows a molecular ion peak at *m/e* 385 in its mass spectrum. It has been assigned structure XIII. A broad maximum at 235 mμ in the ultraviolet suggests the presence of conjugated double bonds, whereas a terminal methyl group is ruled out by the absence of *C*-methyl absorption in its n.m.r. spectrum. The n.m.r. spectrum of XIII contains a peak at 2.3 δ corresponding to six *N*-methyl protons and a very broad multiplet between 4.8 and 6.2 δ corresponding to seven ethylenic protons. Structure XIII requires eight ethylenic protons; however, the integration error may be caused by the very broad nature of the multiplet. The mass spectrum of XIII is shown in Fig. 2*c*. The intense peak at *m/e* 160 is caused by the ion formed by cleavage of the alicyclic ring in the manner outlined in Scheme 3. Scheme 4 depicts the way in which ions appearing at *m/e* 110, 111, 155, and 170 may arise by cleavage of the alicyclic ring.

N-Methyldihydrolobinaline dimethiodide can be prepared by treatment of VIII with methyl iodide in a sealed tube. Treatment of this salt under the Hofmann conditions yields a mixture of XI and a new compound XIV. The n.m.r. spectrum of XIV contains a multiplet at 4.6 δ corresponding to two ethylenic protons, a singlet at 2.2 δ corresponding to three *N*-methyl hydrogens, and a singlet at 2.0 δ corresponding to six *N*-methyl hydrogens. The mass spectrum (Fig. 2*d*) is dominated by a peak at *m/e* 58, indicating the presence of a terminal dimethylamino group. The absence of a peak at *m/e* 160 in the mass spectrum supports the view that the decahydroquinoline system is intact, since fragmentation of the type depicted in Scheme 3 is not possible unless the disubstituted piperidine ring is open. Further support for this conclusion is provided by peaks at *m/e* 96, 97, 200, and 201, which arise by cleavage of the alicyclic ring in the manner depicted in Scheme 1.

The above results provide strong support for structure III for lobinaline (7). Thus, the presence in the molecule of a monosubstituted piperideine ring is indicated by



Scheme 4.

the dramatic difference between the mass spectra of lobinaline and its dihydro derivative. The absence of a peak at *m/e* 58 in the spectrum of X indicates that the dimethylamino group is attached directly to the alicyclic ring. The relationship of the two benzene rings to the disubstituted piperidine ring is established by the formation of ions appearing at *m/e* 200 and 201 in III, VII, VIII, and XIV and by the formation of an ion appearing at *m/e* 160 in X, XI, XII, and XIII. The 1,3 relationship of the benzene rings on the alicyclic ring is demonstrated by the formation of *m*-terphenyl on dehydrogenation of XI. The position of the piperideine ring on the alicyclic ring is established by the fact that no major fragment ion in any compound contains both nitrogen atoms. Moreover, only one ion, of *m/e* 186, containing the piperideine ring and a phenyl group is formed, which suggests that the phenyl groups are symmetrically located with respect to the piperideine ring.

NOTE ADDED IN PROOF: Robison *et al.* (J. Org. Chem., 30, 3206 (1966); 30, 3213 (1966); 30, 3220 (1966)) have recently reported further studies on the structure of lobinaline, and have synthesized and defined the stereochemistry of dehydrolobinaline (piperideine ring of V becomes aromatic).

EXPERIMENTAL

Infrared spectra were recorded with a Beckman model IR-5 spectrophotometer on liquid films unless otherwise stated. Ultraviolet spectra were measured in methanol solution on a Perkin–Elmer spectracord 4000. Nuclear magnetic resonance spectra were measured in concentrated $CDCl_3$ solution on a Varian V-4300B or a Varian A-60 spectrometer. Chemical shifts were determined in parts per million (δ) from tetramethylsilane used as an internal standard. Mass spectra were determined on a Hitachi Perkin–Elmer RMU-6A mass spectrometer equipped with an all-glass inlet system maintained at 200°. The instrument was operated at an ionizing potential of 80 eV and an ionizing current of approximately 50 μA. The spectra are plotted in terms of relative abundance, the most intense peak being taken as 100%. Except where otherwise noted, only peaks equal to or greater than 2% of the most intense peak are recorded. Vapor-phase chromatography was carried out on SE-30 silicone gum rubber on Celite or Chromosorb in glass columns. All compounds were purified by vapor-phase chromatography for mass spectrometric examination.

Lobinaline

Lobinaline was isolated from *Lobelia cardinalis* L., collected in Grey County, Ontario, according to the procedure described by Manske (1). The crude alkaloid was purified by chromatography on alumina with 5% chloroform in benzene as eluent. The base was converted into the monohydrochloride in the way described by Manske (1), and recrystallized from acetone–methanol to a constant melting point of 203–205°. After long drying at 80°, the salt analyzed for a sesquihydrate.

Anal. Calcd. for $C_{27}H_{34}N_2{\cdot}HCl{\cdot}1.5H_2O$: C, 72.1; H, 8.5; N, 6.2; Cl, 7.9. Found: C, 71.4; H, 8.6; N, 6.2; Cl, 7.8.

The free base obtained from the monohydrochloride still showed a minor impurity on thin-layer chromatography. Careful chromatography of the base on alumina with benzene as eluent followed by repeated recrystallizations from ether yielded crystalline material which melted at 116–118° after long drying at 60°.

Anal. Calcd. for $C_{27}H_{34}N_2$: C, 83.9; H, 8.8; N, 7.3; 1 N-CH_3, 3.9. Found: C, 83.6; H, 9.1; N, 7.7; N-CH_3, 3.9.

Lobinaline was converted into the dipicrate by mixing hot, concentrated solutions of the base and of picric acid in methanol. The product was recrystallized from 50% ethanol–water to a melting point of 230–233°.

Anal. Calcd. for $C_{39}H_{40}N_8O_{14}$: C, 55.5; H, 4.7; N, 13.3. Found: C, 55.5; H, 5.0; N, 13.2.

The distyphnate, prepared in a way similar to that by which the dipicrate was prepared, melted at 225° with decomposition.

Anal. Calcd. for $C_{39}H_{40}N_8O_{16}$: C, 53.4; H, 4.6; N, 12.8. Found: C, 53.6; H, 4.9; N, 12.6.

Lobinaline dimethiodide was prepared by treatment of the base with excess methyl iodide in dry acetone at room temperature for 1 h. The solvent and excess reagent were removed under vacuum, without warming, until crystallization ceased. The dimethiodide was recrystallized from dry acetone and dried under vacuum, whereupon it melted at 164–166° with decomposition.

Anal. Calcd. for $C_{29}H_{40}N_2I_2$: C, 52.0; H, 6.0; N, 4.2. Found: C, 51.8; H, 6.0; N, 4.0.

Dihydrolobinaline (VII)

Lobinaline monohydrochloride (1.1 g) dissolved in glacial acetic acid (40 ml) was shaken at 50° for 24 h with hydrogen gas at 200 p.s.i.g. in the presence of Adams' catalyst. The resulting mixture was filtered and the filtrate evaporated to dryness. The residue was dissolved in water, basified with concentrated ammonia, and extracted with chloroform. The chloroform extract yielded a yellow oil after the solution was dried and the solvent evaporated. The product was chromatographed on alumina with benzene as eluent to yield a colorless oil (1.0 g); ν_{max} 3 320 cm^{-1}; molecular ion at m/e 388.

The base was converted into *N*-methyldihydrolobinaline monomethiodide monohydriodide with methyl iodide in acetone. The crystals which separated when the reaction mixture was cooled melted at 223–224°.

Anal. Calcd. for $C_{29}H_{42}N_2I_2$: C, 51.8; H, 6.3; N, 4.2. Found: C, 51.8; H, 6.0; N, 4.0.

N-Methyldihydrolobinaline (VIII)

Dihydrolobinaline (0.5 g) was heated under reflux with a 40% formaldehyde (4 ml) and 90% formic acid (6 ml) mixture for 12 h. The resulting solution was poured into excess cold sodium carbonate solution and extracted with chloroform. The chloroform solution was dried over sodium sulfate and the solvent evaporated to yield a yellow oil, which was chromatographed on alumina with benzene as eluent to yield a colorless oil (0.45 g); molecular ion at m/e 402.

The base (0.04 g) was converted into the dimethiodide with methyl iodide (1 ml) in acetone (1 ml). The mixture was heated at 100° in a sealed tube for 5 h. The crystals (0.05 g) collected when the reaction mixture was cooled melted at 251–252° and analyzed for the dihydrate.

Anal. Calcd. for $C_{30}H_{44}N_2I_2 \cdot 2H_2O$: C, 49.8; H, 6.6; N, 3.9. Found: C, 49.5; H, 6.4; N, 4.0.

N-Methyldihydrolobinaline Monoquaternary Salt (IX)

Lobinaline dimethiodide (0.5 g) was dissolved in 95% ethanol (10 ml), and excess sodium borohydride was added in portions over ½ h. The reaction mixture was allowed to stand at room temperature for 1 h, the excess borohydride destroyed with acetic acid, and the solution evaporated to dryness. The residue was dissolved in water, made basic with concentrated ammonia, and extracted with chloroform. The chloroform solution was dried (Na_2SO_4) and evaporated to yield an oil, which turned to a powder on trituration with ether. In its n.m.r. it had a singlet at 2.6 δ (3H) and another at 3.2 δ (6H). The product obtained in this manner was used directly for further reactions.

Methine X

N-Methyldihydrolobinaline monoquaternary salt (IX) (1.7 g) was added to a solution of potassium (2 g) in *t*-butyl alcohol (100 ml) and the resulting solution heated under reflux for 16 h. A few milliliters of water was added to the reaction mixture and most of the *t*-butyl alcohol removed under vacuum. The residue was partitioned between chloroform and water. The chloroform solution was dried (Na_2SO_4) and evaporated to yield a yellow oil (1.3 g). Chromatography of the product on alumina with petroleum ether as eluent yielded a colorless oil (0.5 g); ν_{max} 912, 1 000, and 1 640 cm^{-1}; n.m.r.: singlet at 2.2 δ (9H) and multiplets at 5.0 δ (2H) and 5.5 δ (1H); molecular ion at m/e 416. A second band (0.2 g) eluted with benzene gave an infrared spectrum which was superimposable on that of *N*-methyldihydrolobinaline.

The methine was converted into its dipicrate with picric acid in methanol. The salt was recrystallized from 95% ethanol to a melting point of 188–190°.

Anal. Calcd. for $C_{41}H_{46}N_8O_{14}$: C, 56.3; H, 5.3; N, 12.8. Found: C, 56.0; H, 5.5; N, 12.6.

Methines XI and XII

Methine X (0.3 g) was converted into the dimethiodide (0.35 g) by heating X under reflux with methyl iodide (1 ml) in acetone (10 ml) for 2 h. The solvent was evaporated, the residue immediately added to a solution of potassium (2 g) in *t*-butyl alcohol (100 ml), and the solution heated under reflux for 24 h. The usual work-up was followed by chromatography of the product on alumina. Methine XI (0.2 g) was eluted with petroleum ether; ν_{max} 915, 965, and 1 640 cm^{-1}; n.m.r.: multiplet between 4.5 and 6.0 δ (5H); molecular ion peak at m/e 430. An analytical sample was obtained by careful chromatography on alumina followed by thorough drying, whereupon the compound crystallized, m.p. 96–98°.

Anal. Calcd. for $C_{30}H_{42}N_2$: C, 83.7; H, 9.8; N, 6.5. Found: C, 83.8; H, 9.5; N, 6.8.

A second fraction eluted with 1:1 benzene – petroleum ether was a mixture of X and XII; molecular ion peaks at m/e 416 and 430, fragment ion peaks at m/e 98 and 112.

Zinc Dust Distillation of XI

Compound XI (0.015 g) was heated with zinc powder (2 g) in a sealed tube at 320° for 1 h in the manner described by Biemann (10). The yellow liquid which collected in the cool part of the tube was subjected to vapor-phase chromatography on a 4 ft column of 2.5% SE-30 on Celite at 210°. Peaks of retention times 11 (fraction A) and 17 (fraction B) min were collected. Fraction A showed λ_{max} 250 mμ, molecular ion peaks at *m/e* 230 and 244. Fraction B showed peaks at *m/e* 243 and 272 in its mass spectrum.

Methine XIII

Methine XI was converted into its dimethiodide by treatment with neat methyl iodide at room temperature. The crystals which precipitated after 2 h melted at 188–192° with decomposition. This dimethiodide (0.2 g) was added to a solution of potassium (2 g) in *t*-butyl alcohol (100 ml) and the resulting solution heated under reflux for 60 h. The usual work-up, followed by chromatography of the product on alumina with 1:1 benzene – petroleum ether as eluent, yielded crystalline XIII (0.1 g); m.p. 98–100°; ν_{max} 910, 985, and 1 640 cm^{-1}; λ_{max} 235 mμ; n.m.r.: broad multiplet between 4.5 and 6.0 δ (7H) and singlet at 2.2 δ (6H); molecular ion peak at *m/e* 385.

Methine XIV

N-Methyldihydrolobinaline dimethiodide (0.7 g) was added to a solution of potassium (7 g) in *t*-butyl alcohol (500 ml) and the resulting solution heated under reflux for 48 h. The usual work-up was followed by chromatography of the product (0.5 g) on alumina. Elution with 1:20 benzene – petroleum ether yielded 0.15 g of a crystalline material, m.p. 96–98°, whose infrared spectrum was superimposable on that of methine XI. Elution with benzene yielded XIV, m.p. 118–120°. Recrystallization from ether raised the melting point to 125–126°; ν_{max} 1 680 cm^{-1}; n.m.r.: singlets at 2.0 δ (6H) and 2.3 δ (3H) and a multiplet at 4.6 δ (2H); molecular ion peak at *m/e* 416.

Compound XIV was converted into the dipicrate with picric acid in methanol. The salt melted at 248–250° after recrystallization from absolute ethanol.

Anal. Calcd. for $C_{41}H_{46}N_8O_{14}$: C, 55.3; H, 5.2; N, 12.6. Found: C, 55.5; H, 5.4; N, 12.4.

ACKNOWLEDGMENT

This work was supported at McMaster University through grants from the National Research Council of Canada.

REFERENCES

1. R. H. F. Manske. Can. J. Res., Ser. B, **16**, 445 (1938).
2. F. Kaczmarek and E. Steinegger. Pharm. Acta Helv. **34**, 330 (1959).
3. M. G. Chaubal, R. M. Baxter, and G. C. Walker. J. Pharm. Sci. **51**, 885 (1962).
4. F. Kaczmarek and E. Steinegger. Pharm. Acta Helv. **34**, 413 (1959).
5. E. Steinegger and F. Egger. Pharm. Acta Helv. **27**, 207 (1952).
6. R. Tschesche, D. Kloeden, and H. W. Fehlhaber. Tetrahedron, **20**, 2885 (1964).
7. M. M. Robison, W. G. Pierson, L. Dorfman, B. F. Lambert, and A. Lucas. Tetrahedron Letters, 1513 (1964).
8. Z. Pelah, M. A. Kielczewski, J. M. Wilson, M. Ohashi, H. Budzikiewicz, and C. Djerassi. J. Am. Chem. Soc. **85**, 2470 (1963).
9. J. McKenna and A. Tulley. J. Chem. Soc. 945 (1960).
10. K. Biemann. Mass spectrometry: organic chemical applications. McGraw-Hill Book Co., Inc., New York. 1962. p. 298.