Tetrahedron, 1965, Vol. 21, pp. 2561 to 2571. Pergamon Press Ltd. Printed in Northern Ireland

THE IDENTITY OF PIPTAMINE AND ORMOSANINE, AND THE STRUCTURES OF ORMOJANINE, ORMOSININE AND PANAMINE

E. M. WILSON
Department of Chemistry, Imperial College, London[1]

(*Received* 24 *March* 1965)

Abstract—Piptamine has been identified with ormosanine. The spectral and chemical properties of panamine and ormosinine, coupled with a study of molecular models, lead to the assignment of structures XVII and XXII, respectively, to these alkaloids. Ormojanine probably has structure XXX.

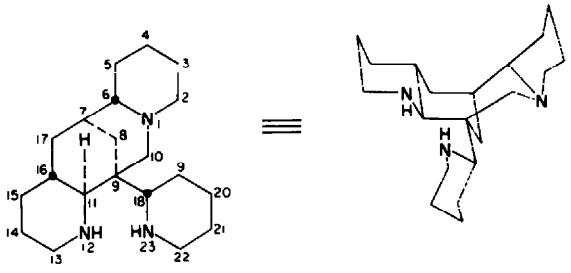
RECENT revision[2] of the properties of ormosanine from *Ormosia panamensis*[3] likens it to piptamine from *Piptanthus nanus*,[4] already identified with a $C_{20}H_{35}N_3$ alkaloid from *O. jamaicensis*.[5,6] By direct comparison we have shown that this latter base and ormosanine are identical.[7]

X-ray crystallography has shown that ormosanine has structure I,[8] and not II, suggested by the formation of the C_{20}-quinoline III on dehydrogenation.[9]

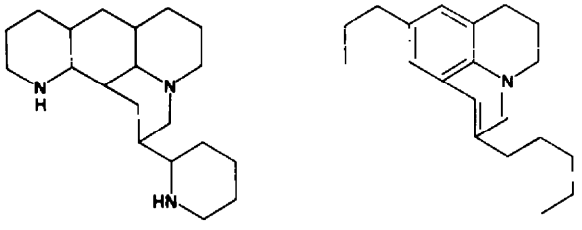
The properties of two $C_{20}H_{33}N_3$ alkaloids present in *O. panamensis*, ormosinine and panamine,[3] have been revised and extended.[2,10] Reduction of panamine with sodium borohydride gave ormosanine,[2] while mild dehydrogenation of ormosinine and ormosanine led to the same pyridine[10] IV,[11] the proton at C-6 being epimerised during the reaction,[11] and acid treatment converted ormosinine into panamine.[2] The PMR spectra of the bases were devoid of olefinic proton signals, and the mass spectra (these were identical) showed a strong piperidyl cation. On this evidence ormosinine and panamine were assigned structures V and VI, respectively.[2]

However, the assumed presence of an azomethine linkage in these bases is without adequate foundation. The spectral properties of the octahydroquinoline VII are quite different from those of the alkaloids. This octahydroquinoline, prepared by a modification of a known procedure,[12] shows an intense band at 1658 cm^{-1} in its IR

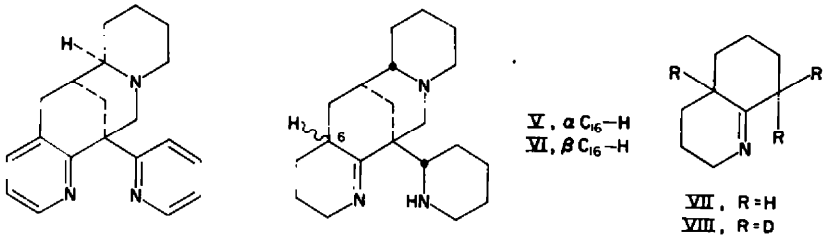
[1] Present address: Glaxo Research Ltd., Greenford, Middlesex, England.
[2] P. Naegeli, W. C. Wildman and H. A. Lloyd, *Tetrahedron Letters* 2069 (1963).
[3] H. A. Lloyd and E. C. Horning, *J. Amer. Chem. Soc.* **80**, 1506 (1958).
[4] R. A. Konovalova, B. S. Diskina and M. S. Rabinovich, *Zh. obshch. Khim.* **21**, 773 (1951).
[5] C. H. Hassall and E. M. Wilson, *Chem. & Ind.* 1358 (1961).
[6] C. H. Hassall and E. M. Wilson, *J. Chem. Soc.* 2657 (1964).
[7] A sample of ormosanine was kindly provided by Professor W. C. Wildman, Iowa State University, Ames, Iowa, U.S.A.
[8] I. L. Karle and J. Karle, *Tetrahedron Letters* 2065 (1963).
[9] Z. Valenta, P. Deslongchamps, M. H. Rashid, R. H. Wightman and J. S. Wilson, *Tetrahedron Letters* 1559 (1963).
[10] P. Naegeli, R. Naegeli, W. C. Wildman and R. J. Highet, *Tetrahedron Letters* 2075 (1963).
[11] P. Deslongchamps, J. S. Wilson and Z. Valenta, *Tetrahedron Letters* 3893 (1964).
[12] L. H. Cohen and B. Witkop, *J. Amer. Chem. Soc.* **77**, 6595 (1955).



I



II III



IV

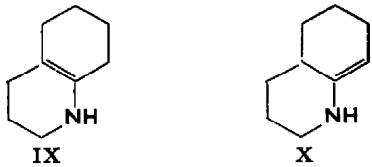
V, α C_{16}–H
VI, β C_{16}–H

VII, R=H
VIII, R=D

spectrum[13] due to the azomethine bond, in accordance with a previous observation.[14] The absence of appreciable absorption near 1650 cm^{-1} in the IR spectra of both ormosinine and panamine[15] is a clear indication that structures V and VI are inadequate.

The PMR spectrum of VII shows a 2-proton signal in the region 3·72–3·33 ppm and a complex 13-proton signal between 2·72 and 0·80 ppm. The PMR spectrum of the octahydroquinoline recovered after heating VII for several days in deuteriochloric

[13] This spectrum also showed a band of medium intensity at 3330 cm^{-1} indicating a small amount of the enamine IX, despite a report to the contrary.[14] The absence of olefinic proton signals in the PMR spectrum, *vide infra*, shows that the enamine X is not involved in the equilibrium.



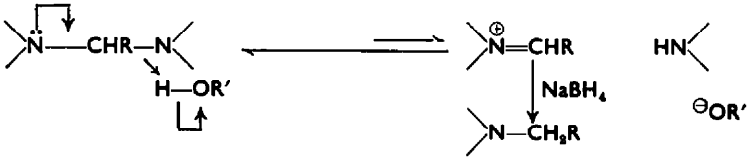
IX X

[14] B. Witkop, *J. Amer. Chem. Soc.* **78**, 2873 (1956).

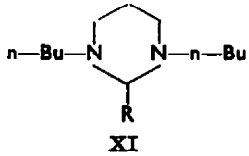
[15] Document No. 5425, ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D.C., U.S.A.

acid still showed the low field 2-proton signal, but the intensity of the high field signal was reduced by approximately 3 protons, suggesting that the product had structure VIII. The low field signal must be assigned to the methylene group adjacent to nitrogen, and the absence of a corresponding 2-proton signal in the PMR spectra of ormosinine and panamine again leads to the rejection of structures V and VI. The spectra of these bases do show a 1-proton signal near 3·5 ppm, which, on the basis of structures V and VI, was assigned to the proton on C-16.[2] However, the deuterium exchange reaction on VII indicates that a proton in this position would be expected to appear upfield of 2·7 ppm.

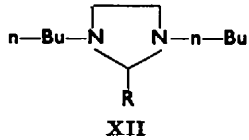
The 1-proton signal at 3·57 ppm in the PMR spectrum of panamine, and the reduction of the base by borohydride, despite the absence of an azomethine linkage, can be rationalized by assuming that panamine contains the structural unit N—CHR—N. The central proton in this unit, deshielded by two nitrogen atoms, would be expected to appear at a low field position in the PMR spectrum, and the reaction with borohydride is a cleavage to and a reduction of the iminium ion present in protic solvents,



To verify these assumptions the properties of a series of appropriate diamines were studied. Condensation of N,N'-di-n-butyl-trimethylenediamine with formaldehyde gave 1,3-di-n-butylhexahydropyrimidine XI (R = H), while condensation with acetaldehyde gave the homologue XI (R = Me). Similarly prepared were the 1,3-di-n-butylimidazolidines XII (R = H, Me).



XI



XII

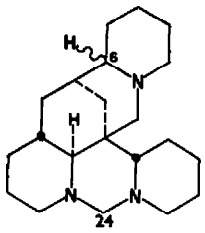
The positions and multiplicities of the PMR signals of the protons located on the carbon atom between the nitrogen atoms appear in Table 1.

TABLE 1

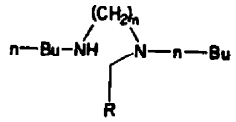
Diamine	Signals due to protons at C-2
XI, R = H	2-proton singlet at 3·08 ppm
XI, R = Me	1-proton quartet (J, 6·5 c/s) centred at 3·60 ppm
XII, R = H	2-proton singlet at 3·39 ppm
XII, R = Me	1-proton quartet (J, 5·0 c/s) centred at 3·20 ppm

In addition we have found that the PMR spectrum of jamine XIII[2,5,6,8,9] showed a double doublet (J, 8·0 c/s) centred at 3·40 and 3·21 ppm, i.e. an AB system due to the non-equivalent protons at C-24.

The hexahydropyrimidine XI (R = Me) and the imidazolidines XII (R = H,



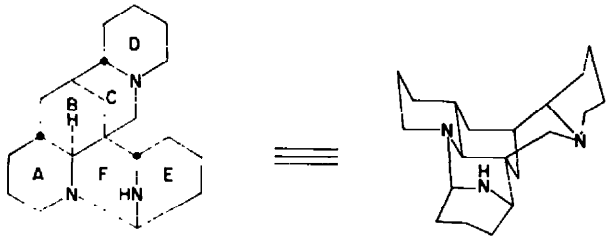
XIII, βC_6—H
XIV, αC_6—H



XV, n = 3
XVI, n = 2

Me) were readily cleaved and reduced to the corresponding N,N′-di-n-butyl-N-alkyldiamines XV (R = Me); XVI (R = H, Me) on exposure to sodium borohydride in boiling ethanol. The symmetrical hexahydropyrimidine XI (R = H) was not affected under the same conditions.

A study of Drieding models reveals that the only way that the N—CHR—N unit can be accommodated in the molecular framework of panamine is by forming a bond between N-12 and C-22, and to form this bond the configuration of the proton at C-18 must be the same as in ormosanine. The ease with which panamine is reduced to ormosanine suggests that bases have the same configuration at C-11 and C-16, and the same conformations in rings B, C and D. On this basis ring F can only assume a chair conformation, and rings A and E are likely to take up chair and boat conformations, respectively, to avoid unfavourable non-bonded interactions. The structure of panamine is therefore represented by XVII.

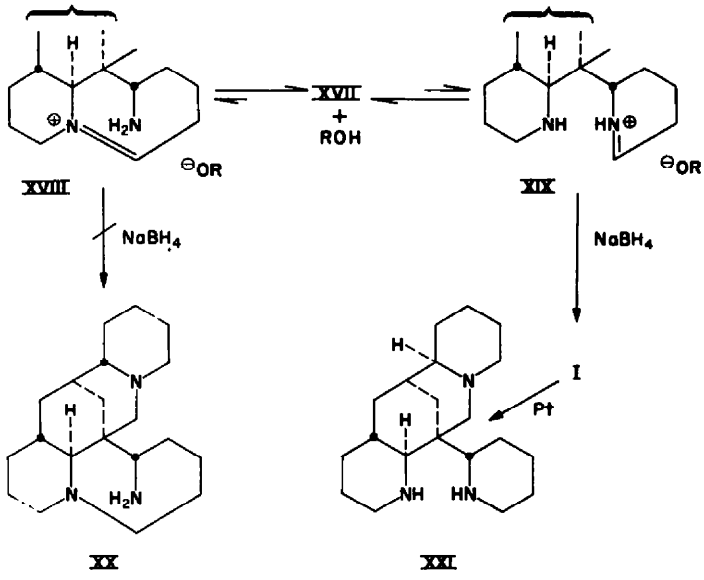


XVII

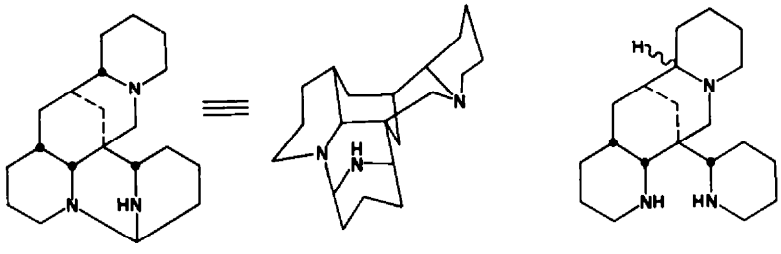
Reduction of panamine to ormosanine rather than the isomeric ditertiary primary amine XX is readily rationalized because the $C=\overset{\oplus}{N}$ bond in the intermediate XVIII is subject to appreciable steric hindrance, but the corresponding bond in XIX becomes approachable by rotation of ring E about the C-9–C-18 axis, and is consequently attacked by sodium borohydride.

The same considerations apply to the catalytic hydrogenation of panamine in dilute acid, which gives a mixture of ormosanine and piptanthine XXI, the catalyst causing partial isomerization at C-6.[11]

Ormosinine must have the same molecular skeleton as panamine, and as acid treatment converts ormosinine into panamine it is likely that the alkaloids differ in their configurations at C-11 and/or C-18 (*vide infra*). However, the configuration at C-18 in ormosinine has to be the same as that in panamine for the N—CHR—N bond to form, and consequently the bases must have opposite configurations at C-11. If it is assumed that the changes involved in the conversion of ormosinine to panamine



do not affect the conformations of rings B, C and D, then consideration of a molecular model shows that ring F of ormosinine must have a boat conformation, while rings A and E take up chair and boat conformations, respectively, to avoid unfavourable non-bonded interactions. The structure of ormosinine is consequently represented by XXII.



XXII

XXIII, α C_6—H
XXIV, β C_6—H

The catalytic reduction of ormosinine was reported to give two unidentified products;[3] by analogy with the reduction of panamine these products are likely to be XXIII and XXIV.

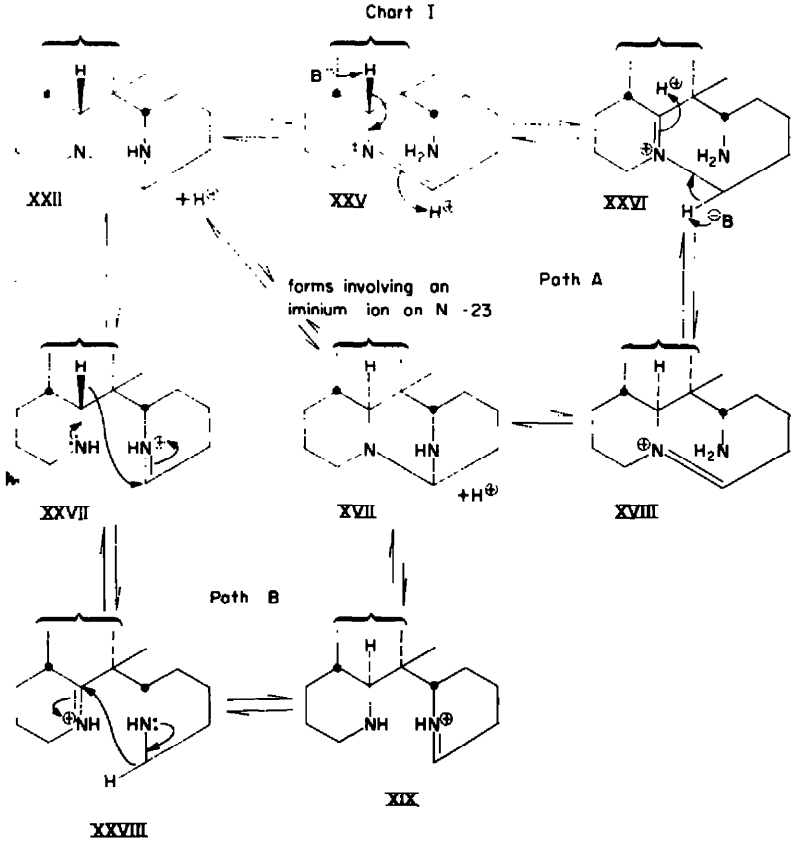
It is possible that the isomerization of ormosinine to panamine proceeds as indicated in path A, chart I, i.e. by simultaneous addition and elimination of protons in the intermediate states (XXV, XXVI and XVIII).[16] If this mechanism is correct

[16] cf. N. J. Leonard, K. Conrow and R. R. Sauers, *J. Amer. Chem. Soc.* **80**, 5185 (1958). The conversion of isoatisine to atisine by heating the base hydrochloride in dimethylsulphoxide[17] may proceed by a similar series of reactions.

[17] Unpublished work of S. W. Pelletier and K. Kawazu, mentioned by S. W. Pelletier, *Experientia* **20**, 1 (1964).

the isomerization should be suppressed in a strong acid medium. Of all the many contributing forms present in acid solution, that corresponding to panamine must be the most energetically favourable for the conversion from ormosinine to proceed. An alternative mechanism, path B, chart I, involving a reversible 1,5-hydride shift between the proton on C-11 and C-22 in the intermediate states (XXVII, XXVIII and XIX),[18] can be excluded because C-11 and C-22 cannot make a close approach.

Chart I

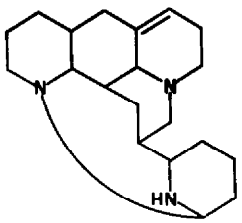


Ormojanine, a $C_{20}H_{31}N_3$ base from *O. jamaicensis*[5,6] has been assigned structure XXIX, largely because of the dehydrogenation of tetrahydro-ormojanine, which exactly parallelled that of its isomer ormosanine.[9] Since the latter dehydrogenation proved misleading it is probable that ormojanine has the same skeleton as the other *Ormosia* bases, especially as the pyridine IV is now known to result from mild dehydrogenation of ormojanine.[11] All the published spectral and chemical evidence[9,11] is successfully accommodated by the expression XXX which we regard as the most probable structure for ormojanine. Thus, a series of reactions established the presence

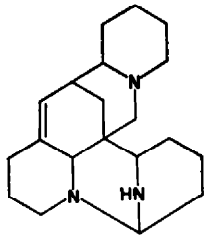
[18] R. B. Woodward, F. Sondheimer and Y. Mazur, *J. Amer. Chem. Soc.* **80**, 6693 (1958), have shown that the isomerization of sarsasapogenin in dilute acid[19] proceeds by a corresponding 1,5-hydride shift.

[19] R. E. Marker and E. Rohrmann, *J. Amer. Chem. Soc.* **61**, 846 (1939).

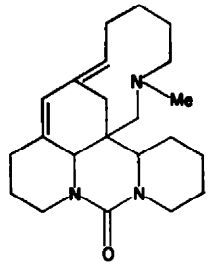
of a NH—CHR—N linkage, while the PMR spectrum showed a 1-proton signal at 3·3 ppm (proton on C-22, or possibly C-11). Controlled reduction of ormojanine led to the dihydrobase, containing two NH groups and still possessing the trisubstituted double bond, which condensed with phosgene forming a cyclic urea, Hofmann degradation of which gave a conjugated diene having two vinylic protons (singlet at 6·15 ppm, triplet at 5·21 ppm).[9] Compound XXXI is a satisfactory structure for this



XXIX



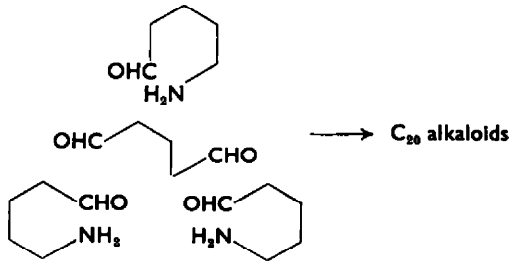
XXX



XXXI

diene. Although, formally, XXXI results from elimination in an anti-Bredt fashion, this is not a serious objection to its formulation.[20]

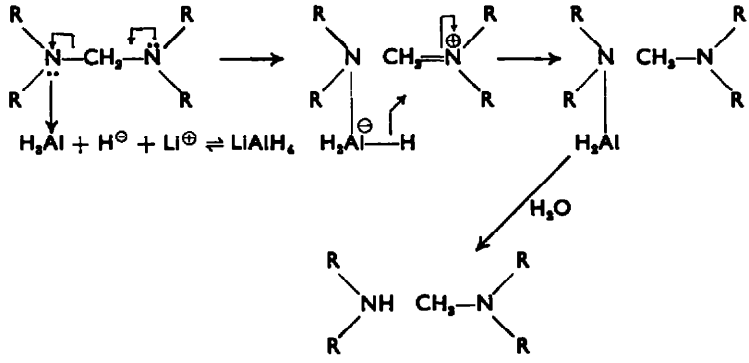
The C_{20} *Ormosia* alkaloids are found together with known lupin bases.[4–6,21–24] In the lupin series the bicyclic alkaloids are known to be formed from two lysine equivalents, and the tetracyclic bases from three lysine units.[25] A logical extension of this scheme to the penta- and hexa-cyclic *Ormosia* bases, involving the condensation of four lysine equivalents, is presented below.



The chemistry of the diamines prepared in this work was further explored. Exposure of the hexahydropyrimidines XI (R = H, Me) and the imidazolidines XII (R = H, Me) to excess lithium aluminium hydride (LAH) in dioxan at reflux afforded the same products as in the corresponding reactions with sodium borohydride. A

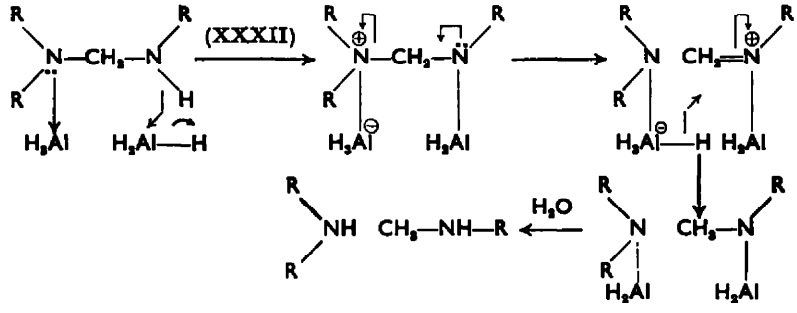
[20] A. C. Cope and E. R. Trumbull, *Org. Reactions* **11**, 317 (1960); see especially p. 347.
[21] H. A. Lloyd and E. C. Horning, *J. Org. Chem.* **23**, 1074 (1958).
[22] H. A. Lloyd and E. C. Horning, *J. Org. Chem.* **25**, 1959 (1960).
[23] H. A. Lloyd, *J. Org. Chem.* **26**, 2143 (1961).
[24] R. T. Clarke and M. F. Grundon, *J. Chem. Soc.* **41**, (1960).
[25] K. Mothes and H. R. Schutte, *Angew. Chem.* **75**, 265 (1963).

possible mechanism for the reductive cleavage, partly based on that proposed for the fission of the N—C—O unit,[26] is shown below.

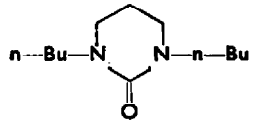


The remarkable stability to metal hydride reduction of the hexahydropyrimidines which are not substituted in the 2-position is also demonstrated by the resistance of homopiptanthine XIV to LAH.[27]

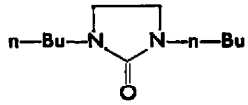
Although the action of LAH on panamine has not been reported, ormosanine would be the expected product, because a variety of secondary tertiary diamines of the general formula XXXII are cleaved by LAH between the central carbon atom and the tertiary nitrogen atom.[28] It is possible that these reductions proceed as indicated.



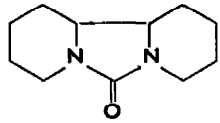
Condensation of N,N′-di-n-butyltrimethylenediamine and N,N′-di-n-butylethylenediamine with phosgene gave the cyclic ureas XXXIII and XXXIV, respectively. Several *Ormosia* alkaloids having the molecular formula $C_{20}H_{35}N_3$ undergo similar



XXXIII



XXXIV



XXXV

condensations with phosgene, and appearance of carbonyl absorption in the 1630–1642 cm^{-1} region of the IR spectra of the products was taken as indicating that 6- or

[26] N. L. Paddock, *Nature, Lond.* **167**, 1070 (1951).
[27] U. Eisner and F. Sorm, *Coll. Czech. Chem. Comm.* **24**, 2348 (1959).
[28] A. Larizza, G. Brancaccio and G. Lettieri, *J. Org. Chem.* **29**, 3697 (1964).

greater-membered rings had been formed.[9,27,29] We have found that the urea XXXIV absorbs at 1700 cm^{-1} and it is known that the imidazolidone XXXV absorbs at 1715 cm^{-1},[30] while the hexahydropyrimidone XXXIII absorbs at 1638 cm^{-1}.

The ureas XXXIII and XXXIV were treated with metal hydrides. Sodium borohydride does not reduce amides, and the expectation that it would not affect the ureas was fulfilled. Predictably, LAH reduced XXXIII to the corresponding amine XI (R = H), while XVI (R = H) was the sole product from the reduction of XXXIV. The LAH reduction of ureas has been discussed in a recent note.[28]

EXPERIMENTAL[31]

Ormosanine. Ormosanine[7] and the corresponding base (same R_f) from *O. jamaicensis* had identical IR spectra (Nujol mull and $CHCl_3$ solution), and had m.p. and mixed m.p. 178–179°.

Δ^1-Octahydroquinoline VII.[13] The pyrrolidine enamine of cyclohexanone (43 g) was added to a solution of freshly distilled acrylonitrile (20 g) in anhydrous dioxan (20 ml). The solution was refluxed for 2 hr, the excess acrylonitrile and dioxan evaporated under red. press., and the residue distilled, giving 1-[2-(2-cyanoethyl)-1-cyclohexenyl]-pyrrolidine as a colourless oil (50 g), b.p. 134–135°/0·8 mm (lit.[13] b.p. 170–172°/10 mm). This oil (50 g) in anhydrous ether (100 ml) was added over 75 min to a stirred suspension of LAH (10 g) in anhydrous ether (600 ml), and the mixture stirred for a further 60 min. Cautious addition of excess $Na_2SO_4.10H_2O$ destroyed the excess hydride and gave a basic medium in which the enamine amine was hydrolysed to the corresponding keto-amine which subsequently cyclized. The mixture was filtered and the material on the filter washed with ether. Evaporation of the ether from the combined filtrate and washings left a residue which was distilled in a N_2 atm., giving Δ^1-octahydroquinoline as a colourless oil (26·3 g), b.p. 65°/1·0 mm (lit.[13] b.p. 77–79°/10 mm).

Treatment of Δ^1-octahydroquinoline with deuteriochloric acid. Compound VII (0·41 g) was dissolved in a solution of DCl [prepared from $SOCl_2$ (1·00 g) and D_2O (3·00 g)] and the solution was sealed in a Carius tube under a N_2 atm. and heated at 100° for a week. The solution was cooled and poured into 2 N NaOH (10 ml) and the deuterated octahydroquinoline was extracted into $CHCl_3$ (3 × 10 ml). This $CHCl_3$-solution was washed with water and brine, dried, and the solvent was evaporated under red. press. leaving a residue which was distilled in a N_2 atm., giving deuterated octahydroquinoline as a colourless oil (0·31 g), b.p. 53°/0·4 mm, IR spectrum: 1654 (s) cm^{-1} (C=N), 3250 (m) cm^{-1} (ND).

N,N'-Di-n-butyltrimethylenediamine. Trimethylene dibromide (24·2 g, 0·12 mole) was added to a solution of n-butylamine (48·6 g, 0·60 mole) in benzene (200 ml), and the mixture was refluxed for 24 hr. The solution was cooled and washed with 40% NaOH (2 × 30 ml) and water (30 ml). The benzene and excess n-butylamine were evaporated under red. press. and the residue distilled, giving N,N'-di-n-butyltrimethylenediamine as a colourless oil (15·0 g, 67%), b.p. 77–78°/0·9 mm (lit.[32] b.p. 120–121°/14 mm), IR spectrum: 3331 cm^{-1} (NH). This oil rapidly formed a crystalline hydrate on exposure to atmospheric moisture.

N,N'-Di-n-butylethylenediamine. From 1,2-dichloroethane (11·8 g, 0·12 mole) and n-butylamine (48·6 g, 0·60 mole), by an analogous reaction, N,N'-di-n-butylethylenediamine was obtained as a colourless oil (17·8 g, 86%), b.p. 66°/0·9 mm (lit.[33] b.p. 110–111°/8 mm), IR spectrum: 3330 cm^{-1} (NH). The oil rapidly formed a crystalline hydrate on exposure to atmospheric moisture.

1,3-Di-n-butylhexahydropyrimidine XI (R = H).[28] Aqueous formaldehyde (40%; 2·5 ml, 0·033 mole) was added over 5 min to cold (5°) N,N'-di-n-butyltrimethylenediamine (5·6 g, 0·03 mole). At

[29] R. T. Clarke and M. F. Grundon, *J. Chem. Soc.* 535 (1963).

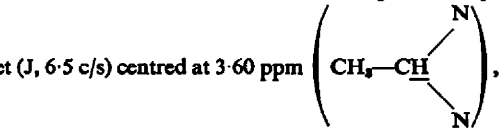
[30] T. P. Abbiss, A. H. Soloway and V. H. Mark, *J. Med. Chem.* 7, 644 (1964).

[31] M.ps are corrected. IR spectra were determined using a Unicam SP 200 spectrophotometer, and, unless otherwise stated, are for thin films. PMR spectra were recorded on a Varian A60 spectrometer and are for $CDCl_3$ solutions; TMS was used as the internal standard, O ppm. Microanalyses were performed by the Imperial College Microanalytical Laboratory, who also determined molecular weights using a vapour pressure technique.

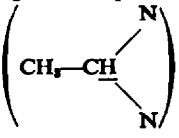
[32] F. B. Zienty, *J. Amer. Chem. Soc.* 68, 1388 (1946).

[33] Adaptation of the technique of R. A. Donia, J. A. Shotton, L. O. Bentz and G. E. P. Smith, Jr., *J. Org. Chem.* 14, 952 (1949).

first the mixture solidified due to the formation of the diamine hydrate, but at the completion of the addition there were two liquid phases. The mixture was kept at 5° for 1 hr, heated on the steam-bath for 2 min, and allowed to cool. NaCl was added to saturate the aqueous layer, and the organic layer was collected and distilled, giving 1,3-*di-n-butylhexahydropyrimidine* as a colourless oil (4·2 g, 71%), b.p. 87–88°/2·5 mm, PMR spectrum: 2-proton singlet at 3·08 ppm (N—CH$_2$—N) (Found: C, 72·4; H, 12·9; N, 14·4; M, 195. $C_{12}H_{26}N_2$ requires: C, 72·7; H, 13·2; N, 14·1%; M, 198).

1,3-*Di-n-butyl-2-methylhexahydropyrimidine* XI (R = Me). From acetaldehyde (1·47 g, 0·033 mole) in water (3 ml) and N,N′-di-n-butyltrimethylenediamine (5·6 g, 0·03 mole), by an analogous reaction, 1,3-*di-n-butyl-2-methylhexahydropyrimidine* was obtained as a colourless oil (4·8 g, 75%), b.p. 95–96°/3·5 mm, PMR spectrum: 1-proton quartet (J, 6·5 c/s) centred at 3·60 ppm  , 3-proton doublet (J, 6·5 c/s) centred at 1·10 ppm (CH$_3$—CH<) (Found: C, 73·8; H, 13·6; N, 13·0; M, 211. $C_{12}H_{26}N_2$ requires: C, 73·5; H, 13·3; N, 13·2%; M, 212).

1,3-*Di-n-butylimidazolidine* XII (R = H). From aqueous formaldehyde (40%; 2·5 ml, 0·033 mole) and N,N′-di-n-butylethylenediamine (5·2 g, 0·03 mole), by an analogous reaction, 1,3-di-n-butylimidazolidine was obtained as a colourless oil (4·1 g, 74%), b.p. 84°/2·5 mm (lit.[28] b.p. 105–106°/10 mm), PMR spectrum: 2-proton singlet at 3·39 ppm (N—CH$_2$—N), 4-proton singlet at 2·78 ppm [N—(CH$_2$)$_2$—N] (Found: C, 71·5; H, 12·8; N, 15·0; M, 188. Calc. for $C_{11}H_{24}N_2$: C, 71·7; H, 13·1; N, 15·2%; M, 184).

1,3-*Di-n-butyl-2-methylimidazolidine* XII (R = Me). From acetaldehyde (1·47 g, 0·033 mole) in water (3 ml) and N,N′-di-n-butylethylenediamine (5·2 g, 0·03 mole), by an analogous reaction, 1,3-*di-n-butyl-2-methylimidazolidine* was obtained as a colourless oil (4·6 g, 78%), b.p. 57–59°/0·2 mm, PMR spectrum: 1-proton quartet (J, 5 c/s) centred at 3·20 ppm  , 3-proton doublet (J, 5 c/s) centred at 1·14 ppm (CH$_3$—CH<) (Found: C, 72·9; H, 13·4; N, 14·0; M, 202. $C_{12}H_{26}N_2$ requires: C, 72·7; H, 13·2; N, 14·1%; M, 198).

Jamine XIII. Aqueous formaldehyde (40%; 0·15 ml) was added to a solution of ormosanine (14 mg)[7] in 30% aqueous acetic acid (0·08 ml). The solution was kept at room temp. for 2 days, heated on the steam-bath for 1 hr, and cooled. The solution was basified (2 N NaOH) and extracted with $CHCl_3$ (4 × 5 ml). This extract was washed with water and brine, dried (Na_2SO_4), and the solvent evaporated under red. press. leaving a residue which crystallized from ethyl acetate, giving jamine as colourless prisms (10 mg), m.p. 150–151° (lit.[8] m.p. 153–154°), PMR spectrum: 2-proton double doublet (J, 8 c/s) centred at 3·40 and 3·21 ppm.

1,3-*Di-n-butylhexahydropyrimid-2-one* XXXIII. A solution of phosgene (2·2 g, 0·022 mole) in toluene (17·6 ml) was added over 10 min to a cooled (ice-water bath) solution of N,N′-di-n-butyltrimethylenediamine (3·7 g, 0·02 mole) in benzene (40 ml) and triethylamine (20 ml), and the mixture was allowed to come to room temp. over 2·5 hr. The excess phosgene was blown out with a current of N_2, and the residue of solid and liquid was washed with 2 N HCl (3 × 80 ml), water and brine. The organic layer was dried (Na_2SO_4) and the solvent evaporated under red. press., leaving a residue which was distilled, giving 1,3-*di-n-butylhexahydropyrimid-2-one* as a colourless oil (1·7 g, 40%), b.p. 120°/1·2 mm, IR spectrum: 1638 (s) cm^{-1} (C=O), IR spectrum ($CHCl_3$ solution): 1617 (s) cm^{-1} (C=O) (Found: C, 68·0; H, 11·4; N, 12·9; M, 214. $C_{12}H_{24}N_2O$ requires: C, 67·9; H, 11·4; N, 13·2%; M, 212).

1,3-*Di-n-butylimidazolid-2-one* XXXIV. From phosgene (2·2 g, 0·022 mole and N,N′-di-n-butylethylenediamine (3·4 g, 0·02 mole), by an analogous reaction, 1,3-*di-n-butylimidazolid-2-one* was obtained as a colourless oil (1·9 g, 48%), b.p. 110–111°/1·5 mm, IR spectrum: 1700 (s) cm^{-1} (C=O), IR spectrum ($CHCl_3$ solution): 1677 (s) cm^{-1} (C=O) (Found: C, 66·7; H, 11·0; N, 14·0; M, 193. $C_{11}H_{22}N_2O$ requires: C, 66·6; H, 11·2; N, 14·1%; M, 198).

Reaction of XI (R = H) *with* $NaBH_4$. To a solution of XI (R = H; 1·98 g, 0·01 mole) in EtOH (20 ml) $NaBH_4$ (0·76 g, 0·02 mole) was added during 20 min. The solution was kept at room temp

for a further 40 min, then gently refluxed for 1 hr. The solvent was evaporated under red. press. and the residue was treated with 2 N NaOH (10 ml) giving two liquid phases. The organic layer was collected, washed with water and brine, and distilled, giving unchanged XI (R = H; 1·43 g).

Reaction of XI (R = Me) *with* $NaBH_4$. From XI (R = Me; 2·12 g, 0·01 mole) and $NaBH_4$ (0·76 g, 0·02 mole), by an analogous reaction, N,N'-*di-n-butyl*-N-*ethyltrimethylenediamine* XV (R = Me) was obtained as a colourless oil (1·50 g, 70%), b.p. 88°/1·5 mm, IR spectrum: 3360 (m) cm^{-1} (NH), PMR spectrum: 3-proton triplet (J, 7 c/s) centred at 1·01 ppm ($C\underline{H}_3$—CH_2—), 1-proton singlet at 1·39 ppm disappearing on deuteration (N$\underline{H}$) (Found: C, 72·8; H, 14·5; N, 12·8; M, 213. $C_{13}H_{30}N_2$ requires: C, 72·8; H, 14·1; N, 13·1%; M, 214).

Reaction of XII (R = H) *with* $NaBH_4$. From XII (R = H; 1·84 g, 0·01 mole) and $NaBH_4$ (0·76 g, 0·02 mole), by an analogous reaction, N,N'-*di-n-butyl*-N-*methylethylenediamine* XVI (R = H) was obtained as a colourless oil (1·36 g, 73%), b.p. 79°/2·0 mm, IR spectrum: 3335 (m) cm^{-1} (NH), PMR spectrum: 3-proton singlet at 2·21 ppm ($C\underline{H}_3N<$), 1-proton singlet at 1·58 ppm disappearing on deuteration (N$\underline{H}$) (Found: C, 71·2; H, 13·9; N, 15·1; M, 188. $C_{11}H_{26}N_2$ requires: C, 70·9; H, 14·1; N, 15·0%; M, 186).

Reaction of XII (R = Me) *with* $NaBH_4$. From XII (R = Me; 1·98 g, 0·01 mole) and $NaBH_4$ (0·76 g, 0·02 mole), by an analogous reaction, N,N'-*di-n-butyl*-N-*ethylethylenediamine* XVI (R = Me) was obtained as a colourless oil (1·57 g, 79%), b.p. 71–72°/0·9 mm, IR spectrum: 3343 (m) cm^{-1} (NH), PMR spectrum: 3-proton triplet (J, 7 c/s) centred at 1·01 ppm ($C\underline{H}_3$—CH_2—), 1-proton singlet at 1·65 ppm disappearing on deuteration (N$\underline{H}$) (Found: C, 71·9; H, 13·9; N, 13·7; M, 203. $C_{12}H_{28}N_2$ requires: C, 71·9; H, 14·1; N, 14·0%; M, 200).

Reaction of XXXIII *with* $NaBH_4$. From XXXIII (1·06 g, 0·005 mole) and $NaBH_4$ (1·14 g, 0·03 mole), by an analogous reaction, unchanged XXXIII (0·83 g) was recovered.

Reaction of XXXIV *with* $NaBH_4$. From XXXIV (0·99 g, 0·005 mole) and $NaBH_4$ (1·14 g, 0·03 mole), by an analogous reaction, unchanged XXXIV (0·74 g) was recovered.

Reaction of XI (R = H) *with* LAH. LAH (3·8 g, 0·1 mole) was added to a solution of XI (R = H; 1·98 g, 0·01 mole) in dry dioxan (200 ml) and the mixture was boiled under reflux for 16 hr. The cooled reaction mixture was cautiously treated with ethyl acetate (200 ml), water (100 ml), and 2 N NaOH (100 ml). The mixture was extracted with ether (3 × 200 ml), this extract washed with water and brine, then dried (Na_2SO_4), and the solvent eliminated. Distillation of the residue gave unchanged XI (R = H; 1·67 g).

Reaction of XI (R = Me) *with* LAH. From XI (R = Me; 2·12 g, 0·01 mole) and LAH (3·8 g, 0·1 mole), by an analogous reaction, XV (R = Me; 1·62 g) was obtained.

Reaction of XII (R = H) *with* LAH. From XII (R = H; 1·84 g, 0·01 mole) and LAH (3·8 g, 0·1 mole), by an analogous reaction, XVI (R = H; 1·43 g) was obtained.

Reaction of XII (R = Me) *with* LAH. From XII (R = Me; 1·98 g, 0·01 mole) and LAH (3·8 g, 0·1 mole), by an analogous reaction, XVI (R = Me; 1·49 g) was obtained.

Reaction of XXXIII *with* LAH. From XXXIII (1·06 g, 0·005 mole) and LAH (1·9 g, 0·05 mole), by an analogous reaction, XI (R = H; 0·61 g) was obtained.

Reaction of XXXIV *with* LAH. From XXXIV (0·99 g, 0·005 mole) and LAH (1·9 g, 0·05 mole), by an analogous reaction, XVI (R = H; 0·49 g) was obtained.

Acknowledgements—The author wishes to thank Professor D. H. R. Barton, F.R.S., for the provision of facilities, Dr. G. W. Kirby and Dr. A. G. Long for helpful discussions, and the Department of Scientific and Industrial Research for the award of a N.A.T.O. Fellowship.