pletely analogous in behavior to yohimbine oxindoles B and A, and may be assigned structures of the type IX and VII, respectively.

CHEMICAL RESEARCH DEPARTMENT
CIBA PHARMACEUTICAL COMPANY
DIVISION OF CIBA CORPORATION
SUMMIT, NEW JERSEY

NEVILLE FINCH
W. I. TAYLOR

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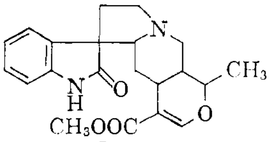
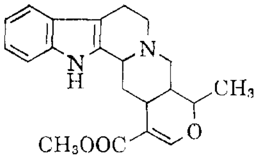
OXINDOLE ALKALOIDS. I. OXIDATIVE-REARRANGEMENT OF INDOLE ALKALOIDS TO THEIR OXINDOLE ANALOGS

Sir:

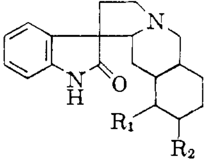
Mitraphylline, an alkaloid occurring in *Mitragyna* species, has been assigned the structure I[1] without stereochemical assignments. It is an oxindole analog of ajmalicine[2] (II) whose stereochemistry[3,4] has been well established except for the configuration of the C-19 methyl group. Recently the total synthesis of *dl*-ajmalicine[5] has been reported by a method which the authors claim will permit the establishment of the complete stereochemistry of ajmalicine and other hetero-ring E indole alkaloids.



I



II



III, R_1 = COOMe, R_2 = OH
IV, $R_1 = R_2$ = H

We wish to report the facile preparative conversion of ajmalicine to mitraphylline and isomitraphylline[6] (I) by an oxidative-rearrangement procedure of general utility for the conversion of indole alkaloids to their oxindole analogs.[7] Thus our results confirm the structural assignment of mitraphylline and, in addition, show that mitraphylline and ajmalicine have the same stereochemistry in rings D and E. This represents the first experimental proof that the universality of the C-15 α-hydrogen configuration[8] extends to the oxindole alkaloids since this configuration has been shown to be present in ajmalicine.[8]

Ajmalicine, when oxidized by *tert*-butyl hypochlorite,[9] gave a residue which when refluxed in aqueous methanolic solution adjusted to pH 6 gave a mixture of mitraphylline and isomitraphylline. Recrystallization from methanol gave mitraphylline (I), m.p. 265–266°, [α]D −38° (0.1 *N* HCl). Calcd. for $C_{21}H_{24}N_2O_4$: C, 68.46; H, 6.56; N, 7.60. Found: C, 68.20; H, 6.72; N, 7.63. Comparison of our material with authentic mitraphylline[10] revealed that the two compounds gave no mixed melting point depression, behaved identically on paper chromatography, and had superimposable ultraviolet and infrared spectra. The methanol filtrate afforded isomitraphylline (I) which was isolated as the picrate, m.p. 207–209°.[11] Calcd. for $C_{27}H_{27}N_5O_{11}$: C, 54.27; H, 4.56; N, 11.72. Found: C, 54.54; H, 4.58; N, 11.48. Examination by mixture melting point, paper chromatography, and infrared spectra with authentic isomitraphylline picrate[11] showed them to be identical. We have also obtained isomitraphylline picrate from our "synthetic" mitraphylline by equilibration in refluxing pyridine.[6]

Yohimbine, similarly rearranged, gave its epimeric oxindole analogs. The slower moving epimer (III) (R_f = 0.16) had m.p. 214–216° dec., [α]D + 17 (95% EtOH), $\lambda_{\max}^{95\%\ \text{EtOH}}$ 251 mμ (ε 7220). Calcd. for $C_{21}H_{26}N_2O_4$: C, 68.08; H, 7.08; N, 7.56. Found: C, 68.02; H, 7.21; N, 7.43. The hydrochloride had m.p. 231–235° dec., [α]D + 25 (H_2O). Calcd. for $C_{21}H_{27}N_2O_4Cl$: C, 61.98; H, 6.69; N, 6.89; Cl, 8.71. Found: C, 61.92; H, 6.86; N, 7.05; Cl, 8.91. The faster moving epimer (III) (R_f = 0.41) was isolated as the hydrochloride, m.p. 231–235° dec., [α]D +101 (H_2O), $\lambda_{\max}^{95\%\ \text{EtOH}}$ 251 mμ (ε 6800). Found: C, 61.80; H, 6.88; N, 6.64; Cl, 8.86.

Yohimbane on treatment with *tert*-butyl hypochlorite gave two epimeric chloro derivatives. The negatively rotating epimer had m.p. 256–268° dec., [α]D −72 (CH_2Cl_2), $\lambda_{\max}^{\text{EtOH}}$ 226 mμ (ε 21,400), 266 mμ (ε 2200 sh), 292–296 mμ (ε 2800). Calcd. for $C_{19}H_{23}N_2Cl$: C, 72.48; H, 7.36; N, 8.90; Cl, 11.26. Found: C, 72.69; H, 7.42; N, 8.96; Cl, 11.37. The positively rotating epimer had m.p. 256–268° dec., [α]D + 84 (CH_2Cl_2), $\lambda_{\max}^{\text{EtOH}}$ 224 mμ (ε 21,800), 266 mμ (ε 2400), 285–293 mμ (ε 2600). Found: C, 72.52; H, 7.14; N, 9.00; Cl, 11.53.

Subjecting the crystalline unfractionated mixture of chloroyohimbanes to the hydrolytic procedure gave the mixture of epimeric oxindole analogs.

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[1] For references see J. C. Seaton, R. Tondeur, and L. Marion, *Can. J. Chem.*, **36**, 1031 (1958).

[2] R. E. Woodson, Jr., H. W. Youngken, E. Schlittler, and J. A. Schneider, "Rauwolfia," Little, Brown, and Co., Boston, Mass., 1957, Chapter 3, and references contained therein.

[3] N. Neuss and H. E. Boaz, *J. Org. Chem.*, **22**, 1001 (1957).

[4] E. Wenkert and D. K. Roychaudhuri, *J. Am. Chem. Soc.* 1613 (1958).

[5] E. E. van Tamelen and C. Placeway, *J. Am. Chem. Soc.*, **82**, 2594 (1961).

[6] J. C. Seaton, M. D. Nair, O. E. Edwards and L. Marion, *Can. J. Chem.*, **38**, 1035 (1960), prepared this C_4 epimer of mitraphylline by refluxing the latter in pyridine. According to the numbering system of these authors the C_4 position of the oxindole alkaloids would correspond to the C_3 position of the indole alkaloids.

[7] Other related rearrangements of indoles to give oxindoles have been reported: W. H. Perkin, Jr., and S. G. P. Plant, *J. Chem. Soc.*, **123**, 676 (1923); S. G. P. Plant and R. Robinson, *Nature*, **165**, 36; (1950); E. E. van Tamelen, K. V. Siebrasse, and J. B. Hester, *Chem. Ind.*, 1145 (1956); A. Patchornik, W. B. Lawson, and B. Witkop, *J. Am. Chem. Soc.*, **80**, 4748 (1958); W. B. Lawson, A. Patchornik, and B. Witkop, *ibid.*, **82**, 5918 (1960); W. B. Lawson and B. Witkop, *J. Org. Chem.*, **26**, 263 (1961).

[8] E. Wenkert and N. V. Bringi, *J. Am. Chem. Soc.*, **81**, 1474 (1959).

[9] This differs from the method of W. O. Godftredsen and S. Vangedal, *Acta Chem. Scand.*, **10**, 1414 (1959), in that the hydrogen chloride treatment of the residue is omitted.

[10] Ref. 1 reports constants for naturally occurring mitraphylline: m.p. 275–276°, $[\alpha]^{24}$D −39° (0.1 *N* HCl). A sample of this mitraphylline, graciously supplied to us by Dr. Leo Marion, was found to melt at 265–266° in our apparatus. All our melting points are uncorrected.

[11] Ref. 6 reports m.p. 223° dec. for isomitraphylline picrate. The sample of this substance supplied to us by Dr. Marion had m.p. 209–211° in our apparatus.

The slower moving epimer (IV) (R_f = 0.55) had m.p. 189–192° dec., $[\alpha]_D$ −3 (pyridine), $\lambda_{max}^{95\%\ EtOH}$ 251 mμ (ε 7350). Calcd. for $C_{19}H_{24}N_2O$: C, 76.99; H, 8.16; N, 9.45. Found: C, 77.13; H, 8.21; N, 9.23. The faster moving epimer (IV) (R_f = 0.71) had m.p. 199–202° dec., $[\alpha]_D$ −60 (pyridine), $\lambda_{max}^{95\%\ EtOH}$ 251 mμ (ε 7000). Found: C, 77.20; H, 8.35; N, 9.31.

The isolation of the chloroyohimbanes[12] and their subsequent conversion to their oxindole analogs by a hydrolytic procedure suggests their role as intermediates in the rearrangement. The details of these and other experiments will be discussed in a forthcoming publication.

[12] Ref. 9 reports the preparation of one chloro derivative of deserpidine by the same method.

WARNER-LAMBERT RESEARCH INSTITUTE
DEPARTMENT OF ORGANIC CHEMISTRY JOHN SHAVEL, JR.
MORRIS PLAINS, NEW JERSEY HAROLD ZINNES

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VIBRATIONAL FREQUENCIES OF TRIMETHYLAMINE GALLANE AND TRIMETHYLAMINE GALLANE-d$_3$[1]

Sir:

Although numerous chemical investigations of the boron hydrides have been reported together with a modest number for aluminum hydride, relatively little work has appeared in the literature dealing with hydrides of the next element in the group, gallium. Spectroscopic studies have reflected chemical interest but to a diminished degree such that in the case of gallium only results for the simple diatomic hydride, GaH, have been reported. Recent work in this laboratory has resulted in the stabilization of gallane, GaH_3, in the form of a Lewis acid–base complex with trimethylamine. In view of the lack of data on gallium–hydrogen compounds, it was felt that a preliminary report listing characteristic frequencies of this compound, and of the Ga–H bond in particular, would be of some interest.

The preparation and properties of the normal and deuterated compound will be described in greater detail elsewhere.[2] Raman spectra of the two compounds were obtained from a few milligrams of the substances which had been sublimed into 4-mm. o.d. Pyrex tubes and sealed off under vacuum. Frequencies were recorded photographically using the Brandmuller technique[3] with multilayer interference filters to reduce the excess amount of exciting radiation. Exposure times varied from ten to thirty hours using heat senzitized Eastman IIa-0 plates. The spectra obtained were of quite satisfactory quality, particularly so considering the rather small amount of substance available in each case. Infrared measurements of the compounds in solution and also as mulls were attempted, but the reactive nature of the compound prevented generally satisfactory results from being obtained. Frequencies associated with the gallium–hydrogen bond were observed, however, and these results were in good agreement with the Raman data.

The observed frequency values and the preliminary assignments are given in the table. Identification of the bands associated with the trimethylamine part of the molecule were made by comparison with the spectra and assignments for trimethylamine borane[4] and free trimethylamine.[5] The gallium–hydrogen stretching frequencies were by far the most intense in the spectrum and occurred at about 1850 cm.$^{-1}$ in the hydrogen compound and 1330 cm.$^{-1}$ in the deuteriated. The symmetric and asymmetric frequencies were almost superimposed, the asymmetric appearing as a shoulder on the low frequency side of the intense symmetric band in the Raman spectrum of the hydrogen compound with the relative positions being reversed in the deuteriated case. Confirmation of the assignments was obtained from the infrared measurements, both bands being observed at the same frequencies as in the Raman spectra but with the intensity of the asymmetric mode appreciably greater than the symmetric. The ratios of hydrogen to deuterium stretching frequencies were 1.40 and 1.35, respectively, for the symmetric and asymmetric modes.

VIBRATIONAL FREQUENCIES AND ASSIGNMENTS FOR $(CH_3)_3NGaH_3$ AND $(CH_3)_3NGaD_3$ (IN CM.$^{-1}$)

δ = est. probable error; s = strong, m = medium, w = weak, br = broad.

$(CH_3)_3NGaH_3$			$(CH_3)_3NGaD_3$			
Infrared	Raman	δ	Raman	δ	I	Assignment
	3123	±3	3134	±4	m	C–H stretching
	3044	4	3052	5	m	C–H stretching
	2999	3	3006	5	m	C–H stretching
	2977	2	2985	5	m	C–H stretching
	2934	3	2938	5	m	C–H stretching
	2912	3	2915	4	m	C–H stretching
	2858	2	2863	4	ms	C–H stretching
	2476	3			vw, br	?
	2361	3			vw, br	?
1852	1852	2	1325	1	vs	*sym.* Ga–H stretch
1832	1823	8	1356	5	m	*asym.* Ga–H stretch
	1458	3	1454	3	m	CH_3 deformation
	1407	3	..		w	CH_3 deformation
	1262	5	1270	3	w	CH_3 rock ?
	1229	2	1231	3	w	CH_3 rock ?
	1106	2	..		w	CH_3 rock ?
	1044	1	1037	4	vw	
	1003	2	1002	3	wm	*asym.* C–N stretch
	834	2	829	3	m	*sym.* C–N stretch
745	..		..			*asym.* H–Ga–H deform.
726	730	4	536	3	wm	*sym.* H–Ga–H deform.
	581	?	..		vw, br	?
	521	?	..		vw, br	?
	..		370	2	wm	Ga–N stretch ?

The symmetric deformation frequency of the GaH_3 group is assigned to a band at 730 cm.$^{-1}$ in the Raman spectrum also by comparison with the spectrum of the free base. It shifts to 536 cm.$^{-1}$ upon deuteration, the ratio of the two frequencies being 1.35. No indication of the asymmetric frequency was obtained from the Raman spectrum but

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[2] D. Shriver and R. W. Parry, to be submitted.

[3] Brandmuller, *Z. Angew. Phys.*, **5**, 95 (1953); see also M. C. Tobin, *J. Opt. Soc. Am.*, **49**, 850 (1959).

[4] C. L. Cluff, Thesis, The University of Michigan, 1961; B. Rice, R. J. Galiano and W. J. Lehmann, *J. Phys. Chem.*, **61**, 1222 (1957).

[5] J. R. Barcelo and J. Bellanato, *Spectrochim. Acta*, **8**, 27 (1956); E. J. Rosenbaum, D. J. Rubin and C. R. Sandberg, *J. Chem. Phys.*, **8**, 366 (1940).