

Figure 1.

for a better understanding of the growing number of alkaloids which contain 2-acylindole chromophores.⁶

Burnamicine had m.p. 198–200°, $[\alpha]_D^{20}$ -281° , $\nu_{C=O}^{KBr}$ 1630 cm^{-1} ,⁷ pK_a 8.9 (50% aqueous methanol) [Found: mol. wt. (mass spectr.), 326; C, 73.23, 73.07; H, 8.04, 8.09; N, 8.74; OMe, 0.0; NMe, 4.81; active H, 0.61. Calcd. for $C_{20}H_{26}N_2O_2$: mol. wt., 326; C, 73.59; H, 8.03; N, 8.58; NMe, 4.64; active H, 0.64%]. Its ultraviolet absorption spectrum [λ_{max} 309–312 $m\mu$ ($\epsilon = 14,600$)] changed to that of a typical indole by either sodium borohydride reduction or solution in acid, and in the latter experiment the original chromophore was regenerated upon basification. In the p.m.r. spectrum⁹ the four aromatic protons, the ethylidene group and the N-methyl were identifiable. The alkaloid recovered from the p.m.r. measurement was acetylated, and its ultraviolet and infrared spectra were consistent with an N_a , O-diacetate, and the p.m.r. spectrum showed besides the singlet methyls that there was a triplet centered at 4.14 p.p.m., in agreement with $-CH_2-CH_2-OAc$.

The interpretation of the mass spectrum (Fig. 1) of burnamicine was completely consistent with structure I. The predicted fissions¹⁰ were observed and gave (with hydrogen transfer right to left) for *a*, m/e 130 (very strong) and 196; for *b*, 158 and 168 (very strong); and *c*, 172 and 154. Strong peaks at m/e 168, 130 and 144 (strongest peak in the spectrum) probably arose from the very facile extrusion of carbon monoxide ($m = 28$) from fragments m/e 196, 158 and 172. The

second strongest peak in the spectrum, m/e 143, could have arisen from a *c*-fission to yield m/e 171 then loss of carbon monoxide, or alternatively by fission of a parent ion-carbon monoxide (M-28) ring contracted ion. Other observed peaks result from the loss of the elements of water¹⁰ from various fragments. Thus, loss of water from the parent ion gave a medium strength peak at m/e 308 which by a *d*-type fragmentation and loss of a hydrogen yielded m/e 210. The double bond was important in all of these processes because the end products were stable allylic radicals or ions¹⁰ and peaks resulting from the loss of hydroxyethyl and/or CH_2-NCH_3 could also be picked out.

No burnamicine remained either for further study of the mass spectra of derivatives or for a trivial conversion into dihydrocorynantheol methochloride,¹¹ and preliminary experiments to realize the converse have not yet been successful.

(11) If the proposed structure of vobasine is correct (ref. 6), then lithium aluminum hydride reduction of either it or isovobasine followed by acid treatment should yield macusine B.

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RING INVERSION IN CYCLOOCTANE

Sir:

The single line in the n.m.r. spectrum of cyclooctane has been reported^{1,2} to broaden at temperatures below -85° . Harris and Sheppard estimated the coalescence temperature to be -153° , and the activation energy of ring inversion to be 2.6 kcal./mole. Meiboom suggested the existence of two different line-broadening processes, both with similar activation energies of about 8 kcal./mole.

Strong coupling among many protons of similar chemical shift complicates the low temperature spectrum of cyclooctane (Fig. 1). A simple proton magnetic resonance spectrum was obtained by preparation

(1) R. K. Harris and N. Sheppard, *Proc. Chem. Soc.*, 418 (1961).

(2) S. Meiboom, paper presented at the Symposium on High Resolution Nuclear Magnetic Resonance at Boulder, Colorado, July, 1962.

(6) Only in one other case, *viz.*, vobasine and its dihydro derivatives, dregamine and tabernaemontanine, have any detailed formulas been proposed: U. Renner and D. A. Prins, *Chimia*, **16**, 321 (1961).

(7) Correct for a 2-acylindole, J. A. Ballantine, C. B. Barrett, R. J. S. Beer, B. G. Boggiano, S. Eardley, B. E. Jennings and A. Robertson, *J. Chem. Soc.*, 2229 (1957); M. F. Bartlett, D. F. Dickel and W. I. Taylor, *J. Am. Chem. Soc.*, **80**, 126 (1958).

(8) Kindly run for us by Dr. R. Ryhage.

(9) The spectra were run in deuteriochloroform by Dr. A. Z. Zücher using a Varian HR60 with tetramethylsilane as internal standard.

(10) These are processes where the resulting ion or radical is stabilized by an adjacent π bond (aromatic system, double bond, carbonyl) or electron pair on N. Extrusion of carbon monoxide was also an important process. The observed loss of water was probably the result of ring closure and not of double bond formation. For detailed discussion of the application of mass spectrometry to alkaloid chemistry, see K. Biemann, "Mass Spectrometry," McGraw-Hill Book Co., Inc., New York, N. Y., 1962, Chapters 3 and 8.

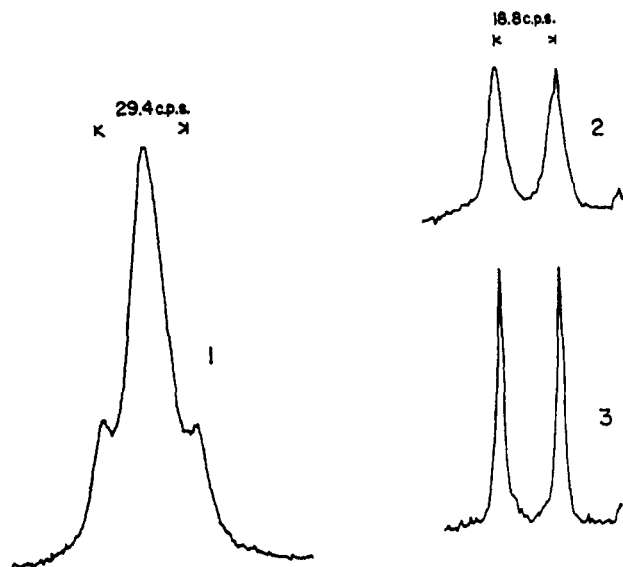


Fig. 1.—Cyclooctane at -135° : (1) C_8H_{16} ; (2) $C_8D_{16}H$; (3) $C_8D_{16}H$, D decoupled.

of the massively deuterated³ hydrocarbon. Hexa-deuterio-1,3-butadiene⁴ was photodimerized in the presence of acetophenone⁵ to give a 6:1 mixture of the *trans*- and *cis*-1,2-divinylcyclobutanes. The *cis* compound is readily converted to 1,5-cyclooctadiene.^{6,6} The *trans* compound isomerized on heating overnight at 190° to give a mixture of 1,5-cyclooctadiene and 4-vinylcyclohexene.⁷ The deuterated cyclooctadiene was chromatographically separated and reduced with deuterium gas in the presence of Adams' catalyst. Mass spectrographic analysis⁸ on the resulting cyclooctane yielded the following: C_8D_{16} , 39.9%; C_8HD_{16} , 36.1%; $C_8H_2D_{14}$, 16.1%; $C_8H_3D_{13}$, 5.29%; $C_8H_4D_{12}$, 2.21%.

The n.m.r. spectra were taken in vinyl chloride solution on a Varian Model V-4302 60 Mc./sec. spectrometer equipped with a "deuterium decoupler."⁹ The deuterated cyclooctane gave a broad line (8.56τ) at -50° ; this became quite sharp under double irradiation at the deuterium resonance frequency. As the temperature was lowered, the sharp line broadened and separated into two distinct lines, in the usual manner.¹⁰ The coalescence temperature, T_c , was $-111.5 \pm 0.5^{\circ}$. Below -135° , the chemical shift between the peaks remained constant at 18.8 ± 0.1 c.p.s. (Fig. 1).

From the changes in signal shape between -101° and -118° , the rates of ring inversion at various temperatures were calculated. The method of Gutowsky and Holm¹¹ was used below T_c ; above T_c , an equation of line-broadening derived from eq. 10-29, ref. 10, was applied and corrected for the effects of the transverse relaxation time by a calculation based on eq. 10-23, ref. 10. From the Arrhenius plot of the results (Fig. 2), the activation energy for the ring inversion process was

(3) J. L. Garnett, L. J. Henderson, W. A. Sollich and G. V. D. Tiers, *Tetrahedron Letters*, **15**, 516 (1961).

(4) D. Craig and R. B. Fowler, *J. Org. Chem.*, **26**, 713 (1961); A. T. Morse and L. C. Leitch, *ibid.*, **23**, 990 (1958).

(5) G. S. Hammond, N. J. Turro and A. Fischer, *J. Am. Chem. Soc.*, **83**, 4674 (1961).

(6) E. Vogel, *Ann.*, **615**, 1 (1958).

(7) The latter probably resulted from reversion to butadiene, followed by Diels-Alder dimerization.

(8) Kindly carried out by Dr. F. P. Lossing of the National Research Council of Canada.

(9) Manufactured by NMR Specialties.

(10) J. A. Pople, W. G. Schneider and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., New York, N.Y., 1959, Chapter 10.

(11) H. S. Gutowsky and C. H. Holm, *J. Chem. Phys.*, **25**, 1228 (1956).

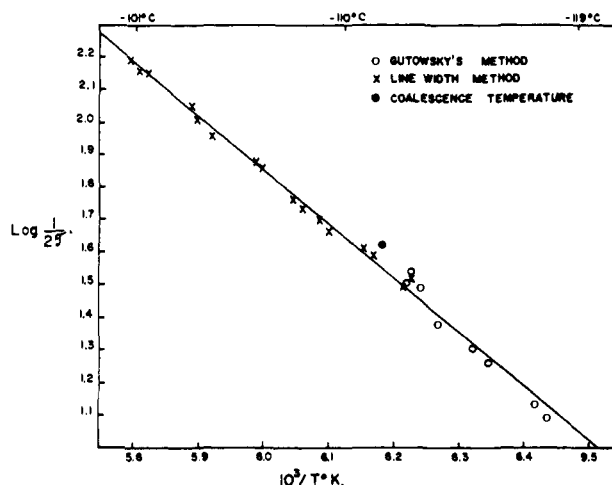


Fig. 2.—Temperature dependence of the inversion rate constant, $1/2\tau$; 2τ is the average lifetime in seconds of a proton on either site in the molecule.

calculated to be 7.7 ± 0.3 kcal./mole. Application of transition state theory showed that, at T_c , the free energy of activation was 8.1 kcal./mole and the entropy of activation was -4.4 e.u.

The presence of only two lines in the low temperature spectrum indicates that only one conformation, or one group of easily interconverted conformations, exists. This is in accord with fairly well established evidence of a skewed crown conformation in cyclooctane and its derivatives.¹² A further investigation supplied additional evidence for the crown model. Deuterated 1,5-cyclooctadiene was reduced with non-deuterated diimide.¹³ This reduction has been shown¹⁴ to give exclusively *cis* addition of hydrogen. The cyclooctane product must therefore contain two groups of *cis* vicinal protons at the 1,2 and 5,6 positions. The dihedral angle between *cis* protons in the crown conformation is expected to be close to 90° ; hence, according to the Karplus relationship,¹⁵ the vicinal coupling should be small. At -135° , the low field peak showed splitting of 2.85 ± 0.4 c.p.s.; this was obscured in the high field peak. This small splitting may be due to coupling of *cis* vicinal protons. It could also be due to the presence of two distinct species in which the two pairs of *cis* vicinal protons are *cis* or *trans* to each other. In either case, the absence of large *cis* vicinal coupling supports a crown or skewed crown conformation.

Acknowledgment.—This work was supported by the National Research Council of Canada.

(12) N. L. Allinger, S. P. Jindal and M. A. DaRooge, *J. Org. Chem.*, **27**, 4290 (1962), and papers cited therein.

(13) R. S. Dewey and E. E. van Tamelen, *J. Am. Chem. Soc.*, **83**, 3729 (1961).

(14) E. J. Corey, D. J. Pasto and W. L. Mock, *ibid.*, **83**, 2957 (1961); S. Hünig, H.-R. Müller and W. Thier, *Tetrahedron Letters*, **11**, 353 (1961).

(15) M. Karplus, *J. Chem. Phys.*, **30**, 11 (1959).

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STEREOCHEMISTRY OF THE MANGANESE(II)- PYRIDOXYLIDENEVALINE CHELATE¹

Sir:

Chelation of the Schiff bases derived from pyridoxal and amino acids to transition-period cations gives rise to

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