Lythraceae Alkaloids. X. Assignment of Absolute Stereochemistries on the Basis of Chiraloptical Effects[1,2]

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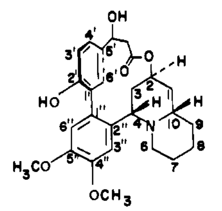
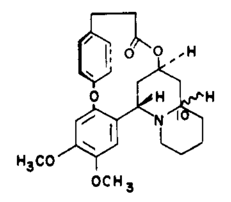
Abstract: The CD curves of methyldecinine (VIIa) and methyldecamine (VIIb) agree in both sign and wavelength between 200 and 250 nm with those of α-methyldihydrothebaine (III, R = CH_3) and neodihydrothebaine (III, R = H), thereby establishing that the chirality of the biphenyl chromophore in the Lythraceae alkaloids is as shown in VII. The entire CD spectrum between 200 and 250 nm was used to assign the chirality at the biphenyl link and not merely the sign of the CD curve in the region of the conjugation band at 250 nm. The absolute configuration of the asymmetric centers in the quinolizidine ring was established by the observation that the ORD curve of the decinine degradation product VIa had the same sign as that of L-(−)-2-methylpiperidine, and that the sign of the ORD curve of the decamine derivative VIb was the same as that of D-(+)-2-methylpiperidine. The absolute stereochemistry of decaline was established as IIa by the close similarity of its CD curve with that of vertaline (IIb), a compound of known chirality. The absolute stereochemistry of methyllagerine has been tentatively assigned to be the same as that of vertaline because of the similarity of the CD spectra of the two bases between 200 and 250 nm.

The assignments of the structures and relative configurations of the alkaloids of the Lythraceae family were outlined in the previous papers in this series.[2] The absolute stereochemistry of these bases remains to be established. Initially, this goal was achieved in the biphenyl series of alkaloids as a whole by optical rotatory dispersion (ORD) measurements,[3b,4] and for the biphenyl alkaloid lythridine (I) by X-ray techniques.[5] More recently, the absolute stereochemistry of the biphenyl ether alkaloid vertaline (IIb) was assigned by X-ray crystallography.[6] In the present study, we undertook the measurement of the circular dichroism (CD) and ORD spectra of these alkaloids with the aim of confirming and extending the previous assignments of absolute configuration.

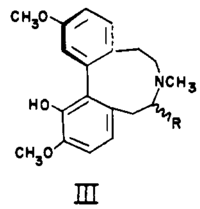
The relative configurations of all the asymmetric carbon atoms in the alkaloids from Lythraceae are known.[2,7] Establishing the absolute configuration at any one center of asymmetry should solve the entire problem of the absolute configuration of the quinolizidine moieties of these compounds.



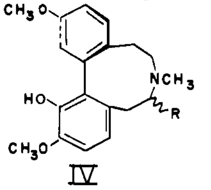
I



II a. C_{10}—H
b. C_{10}---H



III



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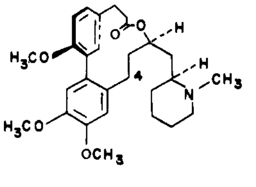
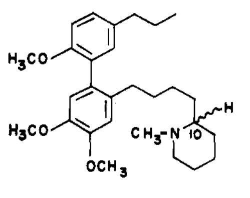
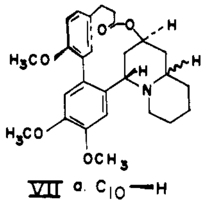


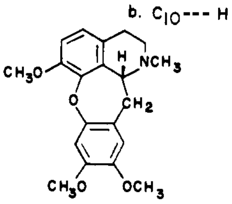
V



VI a. C_{10}—H
b. C_{10}--- H



VII a. C_{10}—H
b. C_{10}---H



VIII

To clarify the discussion, the Lythraceae alkaloids and their derivatives referred to in this paper have been divided into four main groupings which differ in the substitution patterns of the aromatic nuclei (Table I). The four groups are each divided into two subgroups on the basis of the two possible configurations at C-10.

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[1] Supported by grants from Smith, Kline and French Laboratories and the U. S. Public Health Service (MY-4748).

[2] Previous paper in the series: J. P. Ferris, R. C. Briner, and C. B. Boyce, *J. Amer. Chem. Soc.*, 93, 2958 (1971).

[3] (a) Rensselaer Polytechnic Institute, USPHS Career Development Awardee (GM 6380) of the National Institute of General Medical Sciences; (b) Florida State University, abstracted from the doctoral dissertations of C. B. Boyce [*Diss. Abstr. B*, 27 (12), 4361 (1967); *Chem. Abstr.*, 67, 117015 (1967)] and R. C. Briner [*Diss. Abstr. B*, 27 (11), 3845 (1967); *Chem. Abstr.*, 67, 100290 (1967)], submitted to Florida State University, Dec 1966. R. C. B. was a NSF Summer Fellow (1962) and a USPHS Predoctoral Fellow (1962–1965); (c) National Institute of Arthritis and Metabolic Diseases.

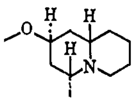
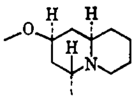
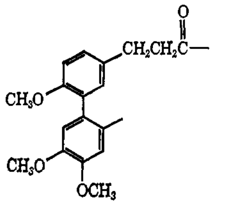
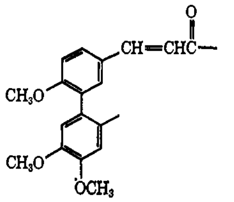
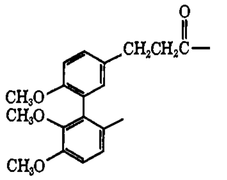
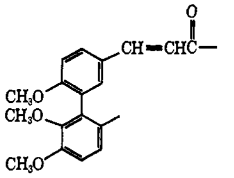
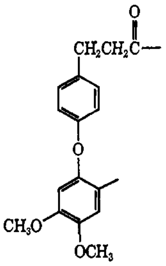
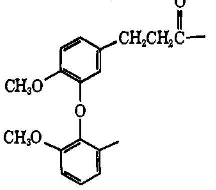
[4] J. P. Ferris, C. B. Boyce, and R. C. Briner, *Tetrahedron Lett.*, 3641 (1966).

[5] S. C. Chu, G. A. Jeffrey, B. Douglas, J. L. Kirkpatrick, and J. A. Weisbach, *Chem. Ind.* (*London*), 1795 (1966).

[6] J. A. Hamilton and L. K. Steinrauf, *J. Amer. Chem. Soc.*, **93**, 2939 (1971).

[7] J. P. Ferris, C. B. Boyce, and R. C. Briner, *ibid.*, 93, 2942 (1971); J. P. Ferris, R. C. Briner, and C. B. Boyce, *ibid.*, 93, 2953 (1971).

Table I. Classification of Lythraceae Alkaloids

Group	Aromatic nucleus		
1a		Methyldecinine	Methyldecamine
1b		Methyllythrine	Methylvertine
2a		Dimethyldecodine	Dimethyldihydro-verticillatine
2b		Methylnesodine[a]	Dimethylverticillatine
3		Decaline	Vertaline
4		[b]	Methyllagerine

[a] This compound was not available for CD measurements. [b] At present there is no Lythraceae alkaloid known with this structure.

Further subdivision of groups 1 and 2 is necessary (*e.g.*, 1a and 1b in Table I), based on the presence of a dihydrocinnamoyl or cinnamoyl grouping in the alkaloid.

Biphenyl Alkaloids (Groups 1 and 2). For an approach utilizing the chiraloptical[8] effects, the biphenyl system is by far the most favorable element of asymmetry, being the only chromophore with absorption in the accessible ultraviolet (uv). Dreiding models show it to be nonplanar in any conformation which can be built; it is thus an inherently dissymmetric chromophore[9] and hence should cause chiraloptical effects which are stronger by about one order of magnitude than those imposed upon a symmetrical chromophore by an adjacent asymmetric carbon atom. Inspection of Dreiding models shows that the biphenyl system is flexible; several conformations with opposite chiralities are possible from one absolute configuration of the quinolizidine system. Therefore, establishing the chirality of the biphenyl system would not, by itself, solve the problem of the chirality of the asymmetric atoms of the quinolizidine ring. However, Dreiding models also reveal that transitions from conformations with one chirality of the chromophore to those of the opposite chirality are not likely since this transformation brings certain hydrogen atoms into impossibly close juxtaposition. These conformers should thus exist as separate chemical individuals, just as is the case of the

[8] U. Weiss, *Experientia*, **24**, 1088 (1968).

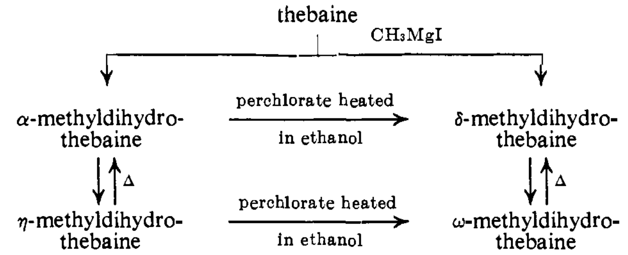
[9] A. Moscowitz, *Tetrahedron*, **13**, 48 (1961).

alkyl and aryl dihydrothebaines (see below). Therefore, additional information is needed on the absolute configuration of the saturated part of the molecule.

The chirality of the biphenyl system can be established by ORD or CD, if suitable model compounds are available for comparison, *i.e.*, compounds of unequivocally known relative and absolute stereochemistry and conformation, and with a chromophore identical with, or at least very closely similar to, the one to be investigated.[10]

No compounds of established chirality and with identically substituted nonplanar biphenyl system seem to be available for use as model compounds. Suitable reference compounds are, however, furnished by the stereoisomeric methyl-[13] and phenyl-[14,15] dihydrothebaines[16] (III, IV, R = Me and Ph, respectively), and by their recently discovered parent compound neodihydrothebaine (III, R = H).[17] The substitution pattern of the biphenyl system of all these bases is sufficiently similar to that of the biphenyl-type alkaloids from Lythraceae, especially those of group 1a, to permit valid comparisons, and the chirality of this chromophore in the epimeric α- and δ-phenyldihydrothebaines (III, R = Ph) has been convincingly established by Berson.[18] The relationship of the four mutually interconvertible methyldihydrothebaines is indicated in Scheme I; that of the phenyldihydrothebaines is analogous.

Scheme I



Study of Dreiding models reveals a situation very similar to that in the Lythraceae alkaloids: conformations of opposite chirality, interconvertible only through intermediate stages with very close approach of certain hydrogen atoms. The α and ω isomers are optical antipodes, as are the δ and η compounds. The nature of the stereoisomerism in the methyldihydrothebaines follows directly from that of their phenyl analogs, where Berson[18] has shown that the α and δ isomers, the initial products of the reaction of thebaine with phenylmagnesium halides, have the same chirality of the biphenyl system and differ only in the configuration of the single asymmetric carbon atom bearing the phenyl group. (This configuration is still unknown but is not pertinent to our problem.) The α and δ compounds are thus represented by III (R = Ph), and their thermal conversion to the η and ω isomers (IV, R = Me) must proceed with inversion of the biphenyl system. This interpretation is fully confirmed by our findings: the CD curves of α and δ III (R = Me) are almost identical, those of α and η (III and IV, R = Me, respectively) (Figure 1) almost mirror images.[19]

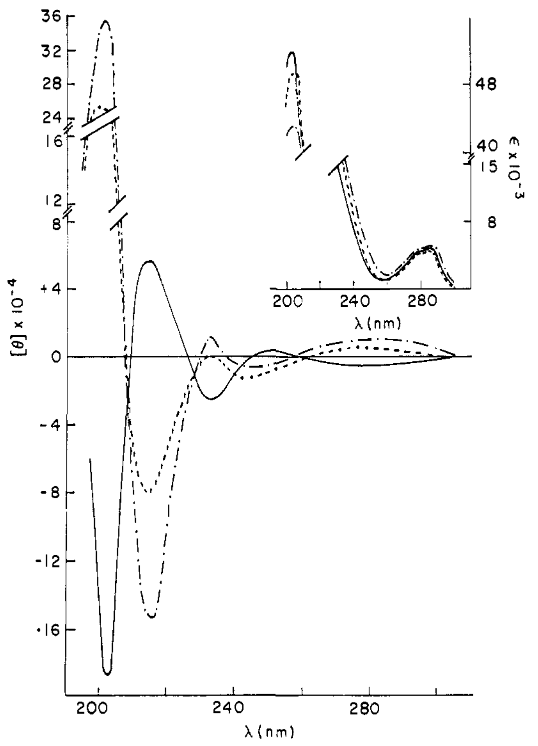


Figure 1. Uv and CD spectra of (– – – –) neodihydrothebaine, (·—·—·) α-methyldihydrothebaine perchlorate, and (———) η-methyldihydrothebaine perchlorate.

In neodihydrothebaine (III, R = H)[17] the nonplanar biphenyl system is the only element of asymmetry and also the only chromophore. In this compound all the CD bands (Figure 1) must necessarily reflect the chirality of the biphenyl system. *The similarity of its CD curve with that of α-methyldihydrothebaine shows that the entire CD spectrum of these compounds is available for stereochemical interpretation and not merely the conjugation band*[10] *at ~250 nm.*

Group 1a Alkaloids. The CD curves of lythridine (I) and the *O*-methyl derivatives of the group 1a alkaloids decinine and decamine have maxima (Figure 2) which agree in both sign and wavelength with those of α-methyldihydrothebaine (III, R = CH_3) and neodihydrothebaine (III, R = H) (Figure 1) between 200 and 250 nm. From this it can be concluded that the

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(10) Mislow and coworkers[11] have shown that the absolute configuration of biphenyls may be established by the sign of the conjugation band, an optically active transition at ~250 nm.[12] The conjugation band is sometimes difficult to detect, since its intensity depends upon the extent of the conjugation, and hence decreases as the torsional angle between the phenyl rings increases. However, as will be shown below, it is not necessary to restrict the analysis to the interpretation of the sign of this one band.

(11) K. Mislow, S. Hyden, and H. Schaefer, *J. Amer. Chem. Soc.*, **84**, 1449 (1962); K. Mislow, M. A. W. Glass, R. E. O'Brien, P. Rutin, D. H. Steinberg, J. Weiss, and C. Djerassi, *ibid.*, **84**, 1455 (1962); K. Mislow, M. A. W. Glass, H. B. Hopps, E. Simon, and G. H. Wahl, Jr., *ibid.*, **86**, 1710 (1964).

(12) H. H. Jaffé and M. Orchin, "Theory and Application of Ultraviolet Spectroscopy," Wiley, New York, N. Y., 1962, pp 397–407.

(13) L. Small and E. M. Fry, *J. Org. Chem.*, 3, 509 (1938).

(14) L. Small, L. J. Sargent, and J. A. Bralley, *ibid.*, 12, 839 (1947).

(15) K. W. Bentley and R. Robinson, *J. Chem. Soc.*, 947 (1952).

(16) The conversion of thebaine to the alkyl and aryl dihydrothebaines is reviewed by H. L. Holmes and G. Stork in "The Alkaloids, Chemistry and Physiology," Vol. II, R. H. F. Manske and H. L. Holmes, Ed., Academic Press, New York, N. Y., 1962, p 167.

(17) K. W. Bentley, *J. Amer. Chem. Soc.*, **89**, 2464 (1967); D. M. Hall and W. T. Manser, *Chem. Commun.*, 112 (1967).

(18) J. A. Berson, *J. Amer. Chem. Soc.*, **78**, 4170 (1956).

(19) We chose to investigate the methyl rather than the phenyl compounds, since in the latter the chromophoric phenyl group attached to the asymmetric carbon atom might produce CD bands of its own; however, these bands would be expected[9] to be weak compared with those due to the skewed biphenyl system.

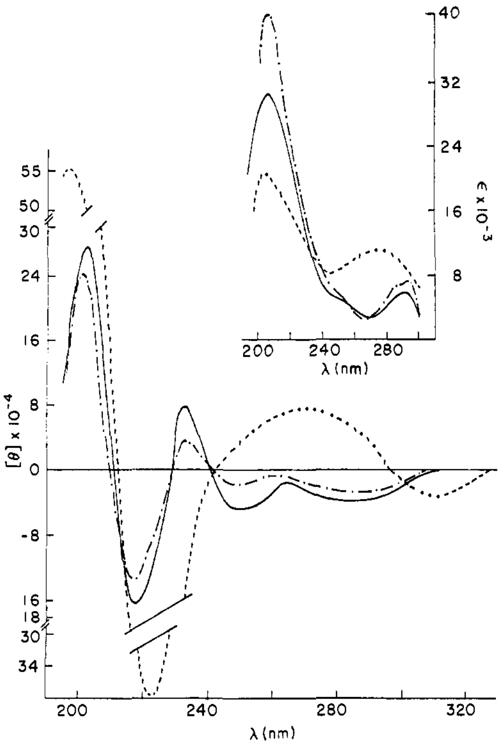

Figure 2. Uv and CD spectra of (----) methyllythrine, (——) methyldecinine, and (·—·—·) lythridine.

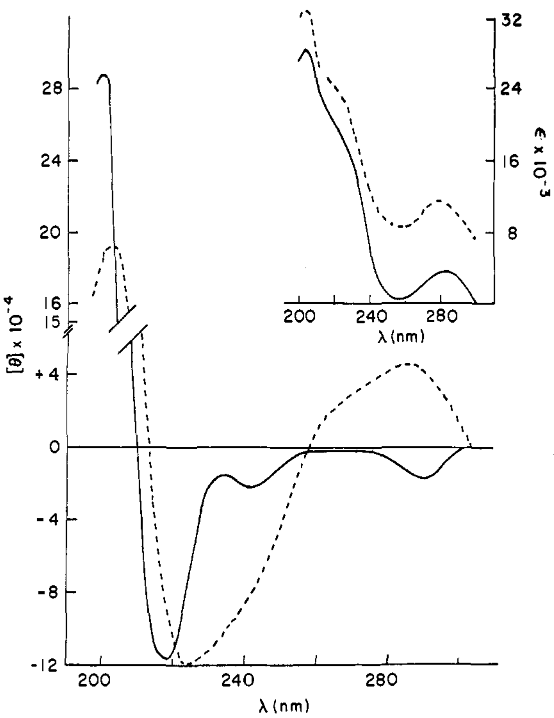

Figure 3. Uv and CD spectra of (---) dimethylverticillatine and (———) dimethyldihydroverticillatine.

chirality of the biphenyl system of the group 1a alkaloids is the same as that of α-methyldihydrothebaine. It is important to note that the CD spectra are not only comparable at 250 nm, the wavelength used by Mislow, *et al.*,[11] for assignment of the chirality of biphenyls, but also at shorter wavelengths.

The chirality of the biphenyl link in lythridine had been assigned previously by X-ray measurements.[5] Our conclusions are in agreement with this result. Furthermore, our CD measurements correlate the Lythraceae and morphine alkaloids and provide the first direct experimental verification of the chiralities which were assigned to the phenyldihydrothebaines on the basis of theoretical considerations.[18]

Since the biphenyl system in the Lythraceae alkaloids is an inherently dissymmetric chromophore, it was expected that the CD curves would reflect the chirality at this center only. However, there did exist the remote possibility that the CD curves might be influenced by the chirality of the asymmetric carbon atom at C-4, which is directly attached to the biphenyl nucleus. This possibility was eliminated by the observation that the maxima given by the parent base are also present in the CD spectrum of the Emde degradation product[7] of methyldecinine (V), in which the asymmetry at C-4 has been removed.

As expected, the difference in stereochemistry at C-10 between the decinine and decamine derivatives had little effect on the CD curves of these compounds.

Group 2a Alkaloids. The transition at 250 nm which is present in the CD curves of the alkaloids of group 1a is not as clearly defined in the CD curves of group 2a (Figure 3). This difference may reflect the different biphenyl substitution patterns or alternatively an increased biphenyl torsional angle in the 2a alkaloids due to the steric repulsions of the 2′,6′′-methoxyl groups. However, the CD spectra of the group 2a alkaloids exhibit the same maxima in the 200–240-nm region as do the dihydrothebaines, a result which demonstrates that the chiralities of the biphenyl nuclei are the same in each alkaloid.

Group 1b and 2b Alkaloids. Since the CD spectra of the cinnamoyl derivatives 1b and 2b (Figures 1, 2) exhibit the same maxima, the biphenyl systems should have the same chirality. Furthermore, it can be concluded that the chirality of the biphenyl system is the same as that of the corresponding saturated derivatives (1a and 2a), since the cinnamoyl derivatives can be readily hydrogenated to the alkaloids of the 1a and 2a series. Reversal of chirality is extremely unlikely under the mild conditions of catalytic hydrogenation.

From these studies it can be concluded that the chirality of the biphenyl chromophore of the group 1 and 2 alkaloids is the same as that of α-methyldihydrothebaine.

The CD measurements established the chirality of the biphenyl system. However, as discussed above, proof of the absolute configuration of the biphenyl system does not uniquely establish the absolute stereochemistry of the other asymmetric centers in the molecule. It became necessary, therefore, to assign the absolute configuration at one of the asymmetric carbon atoms of the quinolizidine ring.

Direct evidence for the absolute configuration at C-10 was obtained by ORD measurements of compounds VIa and VIb, which were prepared from decinine and decamine, respectively.[7] It was expected that compounds VIa and VIb would be enantiomers, since the asymmetry of the biphenyl system is no longer present. This enantiomeric relationship was proven by the ORD spectra, which are plain dispersion curves of equal amplitude but opposite sign.

The absolute configuration of an asymmetric center next to an amine function may be assigned on the basis of the sign of the end absorption in the 200–250-nm region of the ORD spectrum.[20] The plain positive ORD curve of VIb corresponds with those of D-(+)-coniine and D-(+)-2-methylpiperidine, while the negative plain curve of VIa corresponds with those of L-(−)-2-methylpiperidine and L-alaninol. These correlations allow the assignment of the absolute configurations at C-10 shown in VIa and VIb to decinine and decamine, respectively. Therefore, the absolute configurations of the asymmetric centers of the quinolizidine rings in decinine and decamine must be those depicted by VIIa and VIIb, respectively.

Combination of the chiralities assigned individually to the biphenyl system and the quinolizidine ring gives the absolute stereochemistries VIIa and VIIb for methyldecinine and methyldecamine, respectively. The same absolute stereochemistry can be assigned to the group 2 alkaloid derivatives dimethyldecodine and dimethyldihydroverticillatine.[21] These conclusions are in agreement with the absolute configuration assigned to the quinolizidine ring of lythridine (I) on the basis of X-ray techniques.[5]

Group 3 Alkaloids. The structures of the biphenyl ether alkaloids decaline and vertaline have been assigned on the basis of X-ray crystallographic and chemical studies.[7,22] More recently, the absolute configuration of vertaline (IIb) was established by X-ray measurements.[6] Inspection of molecular models suggests that there is restricted rotation about the biphenyl ether link in vertaline; CD measurements were therefore made on the group 3 bases with the expectation that these spectra would reflect the asymmetry of the biphenyl ether system.

The assignment of an absolute stereochemistry to decaline was a relatively simple matter. The CD spectrum of decaline is identical with that of vertaline (Figure 4); consequently, the absolute configuration of decaline is as shown in IIa.

The absolute stereochemistry of the biphenyl ether alkaloid cularine (VIII) has been assigned by use of chiraloptical methods.[23] If the substituted benzylamine unit is used as a point of reference, then the chirality of vertaline and decaline is opposite to that of cularine. Originally we attempted to assign the absolute stereochemistries of vertaline and decaline by comparison of the ORD curves of these alkaloids with that of cularine. However, the curves are quite different, so that is was not possible to reach any conclusion. The differences in the spectra probably reflect the differences in the substitution pattern and in the flexibility of the biphenyl ether system.

Group 4 Alkaloids. The structure of lagerine has been assigned on the basis of chemical degradation studies.[7] The CD spectrum of methyllagerine is shown in Figure 4. There are differences between the CD spectra of methyllagerine and the decaline–vertaline alkaloids because of differences in the aromatic substitution pattern. However, it is of interest that the CD curves of all of these alkaloids are comparable in the 200–250-nm region. This result suggests strongly that the asymmetric biphenyl ether link in lagerine has the same chirality as the ones in decaline and vertaline.

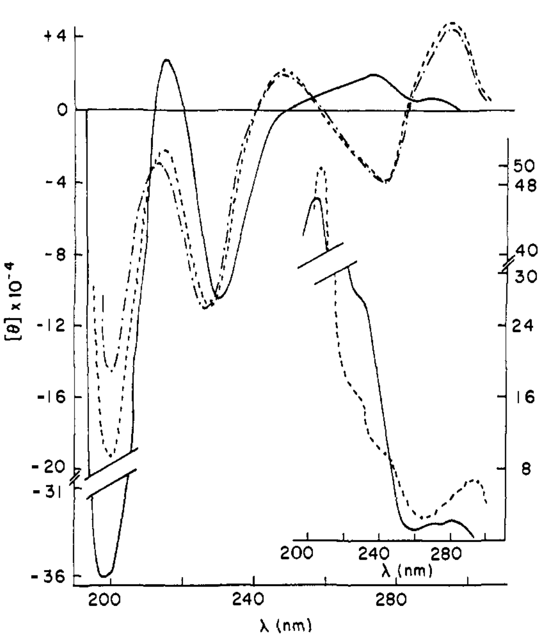

Figure 4. Uv and CD spectra of (----) decaline, (——) methyllagerine, and (·–·–·) vertaline.

Biosynthesis. In conclusion, it should be noted that the biosynthesis of these alkaloids proceeds in such a way as to give compounds with the same absolute configuration at C-2 and C-4. Furthermore, the coupling of the phenyl rings produces stereospecifically the same chirality at the biphenyl or biphenyl ether link, even though Dreiding models suggest that alternative conformations are possible. Any biosynthetic proposals for these alkaloids must be consistent with these observations.[24]

Experimental Section

Circular Dichroism Measurements. The CD measurements were made at 20° in methanol solution using a Cary Model 60 spectropolarimeter with a 6001 CD accessory. The concentration is in milligrams per milliliter of methanol.

Methyllythrine showed (*c* 0.018) $[\theta]_{3275}$ 0, $[\theta]_{3125}$ −31,200, $[\theta]_{2950}$ 0, $[\theta]_{2725}$ +74,880, $[\theta]_{2425}$ 0, $[\theta]_{2250}$ −374,400, $[\theta]_{2125}$ 0; (*c* 0.009) $[\theta]_{2000}$ +549,120.

Lythrine showed (*c* 0.092) $[\theta]_{3300}$ 0, $[\theta]_{3100}$ −13,251, $[\theta]_{2975}$ 0, $[\theta]_{2775}$ +26,502, $[\theta]_{2500}$ +1893, $[\theta]_{2450}$ +3786, $[\theta]_{2400}$ 0, $[\theta]_{2225}$ −141,-990, $[\theta]_{2135}$ 0, $[\theta]_{2000}$ +179,854, $[\theta]_{1975}$ +160,922.

Methyldecinine showed (*c* 0.172) $[\theta]_{3125}$ 0, $[\theta]_{2900}$ −36,750, $[\theta]_{2625}$ −18,375, $[\theta]_{2475}$ −39,375, $[\theta]_{2400}$ 0, $[\theta]_{2325}$ +73,500, $[\theta]_{2290}$ 0, $[\theta]_{2200}$ −157,500, $[\theta]_{2115}$ 0, $[\theta]_{2025}$ +273,000, $[\theta]_{1950}$ +105,000.

Methyldecamine showed (*c* 0.228) $[\theta]_{3075}$ 0, $[\theta]_{2850}$ −35,649, $[\theta]_{2675}$ −15,844, $[\theta]_{2500}$ −39,610, $[\theta]_{2410}$ 0, $[\theta]_{2325}$ +87,142, $[\theta]_{2265}$ 0, $[\theta]_{2175}$ −154,479, $[\theta]_{2100}$ 0, $[\theta]_{2025}$+269,348, $[\theta]_{1950}$ +83,181.

Dimethylverticillatine showed (*c* 0.126) $[\theta]_{3025}$ 0, $[\theta]_{2875}$ +46,390, $[\theta]_{2575}$ 0, $[\theta]_{2225}$ −117,760, $[\theta]_{2135}$ 0, $[\theta]_{2025}$ +192,699, $[\theta]_{1975}$ +164,151.

Dimethyldihydroverticillatine showed (*c* 0.114) $[\theta]_{3025}$ 0, $[\theta]_{2900}$ −17,829, $[\theta]_{2775-2550}$ −1981, $[\theta]_{2425}$ −21,791, $[\theta]_{2350}$ −15,848, $[\theta]_{2175}$ −116,879, $[\theta]_{2100}$ 0; (*c* 0.0285) $[\theta]_{2000}$ +285,264.

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(20) J. C. Craig and S. K. Roy, *Tetrahedron*, 21, 406 (1965).

(21) It would be of interest to attempt to correlate the chirality of the biphenyl links present in protostephanine [H. Kondo and K. Takeda, *Itsuu Kenkyusho Nempo*, 9, 78 (1958); *Chem. Abstr.*, 54, 1580 (1960)], tiliacorine, and tiliarine [B. Anjaneyula, K. W. Gopinath, T. R. Govindachari, and B. R. Pai, *J. Sci. Ind. Res.* (*India*), 21B, 602 (1962)] with that of the Lythraceae alkaloids.

(22) J. A. Hamilton and L. K. Steinrauff, *Tetrahedron Lett.*, 5123 (1966).

(23) N. H. Bhacca, J. C. Craig, R. H. F. Manske, S. K. Roy, M. Shamma, and W. A. Slusarchyk, *Tetrahedron*, 22, 1467 (1966).

(24) References to biosynthetic postulates and experimental tests of these postulates may be found in S. H. Koo, R. N. Gupta, I. D. Spenser, and J. T. Wrobel, *Chem. Commun.*, 1411 (1969).

Dimethyldecodine showed (*c* 0.186) $[\theta]_{3025}$ 0, $[\theta]_{2900}$ −15,568, $[\theta]_{2650}$ −486, $[\theta]_{2400}$ −20,246, $[\theta]_{2200}$ −97,300, $[\theta]_{2100}$ 0, $[\theta]_{2000}$ +238,-385, $[\theta]_{1925}$ +116,760.

Vertine showed (*c* 0.072) $[\theta]_{3225}$ 0, $[\theta]_{3100}$ −60,480, $[\theta]_{3025}$ 0, $[\theta]_{2825}$ +287,280, $[\theta]_{2400}$ 0, $[\theta]_{2225}$ −1,285,200, $[\theta]_{2125}$ 0, $[\theta]_{2025}$ +145,200, $[\theta]_{1925}$ +48,400.

Emde methyldecinine showed (*c* 0.2) $[\theta]_{3075}$ 0, $[\theta]_{2873}$ −18,704, $[\theta]_{2650}$ −7949, $[\theta]_{2475}$ −21,509, $[\theta]_{2400}$ 0, $[\theta]_{2300}$ +88,844, $[\theta]_{2238}$ 0, $[\theta]_{2150}$ −112,224, $[\theta]_{2075}$ 0, $[\theta]_{2025}$ +149,632, $[\theta]_{1950}$ +74,816.

Emde methyldecamine showed (*c* 0.41) $[\theta]_{3050}$ 0, $[\theta]_{2875}$, −22,810, $[\theta]_{2650}$ −6843, $[\theta]_{2475}$ −27,372, $[\theta]_{2400}$ 0; (*c* 0.205) $[\theta]_{2300}$ +86,678, $[\theta]_{2238}$ 0, $[\theta]_{2150}$ −123,174, $[\theta]_{2075}$ 0, $[\theta]_{2000}$ +187,042, $[\theta]_{1950}$ +68,430.

Lythridine showed (*c* 0.136) $[\theta]_{3075}$ 0, $[\theta]_{2800}$ −30,015, $[\theta]_{2600}$ −10,005, $[\theta]_{2475}$ −20,010, $[\theta]_{2400}$ 0, $[\theta]_{2323}$ +33,350, $[\theta]_{2285}$ 0, $[\theta]_{2175}$ −133,400, $[\theta]_{2100}$ 0, $[\theta]_{2000}$ + 240,120, $[\theta]_{1950}$ +106,720.

Methyllagerine showed (*c* 0.126) $[\theta]_{2975}$ 0, $[\theta]_{2900}$ +6994, $[\theta]_{2850}$ +5208, $[\theta]_{2725}$ +20,832, $[\theta]_{2475}$ 0, $[\theta]_{2300}$ −105,896, $[\theta]_{2200}$ 0, $[\theta]_{2150}$ +27,776, $[\theta]_{2125}$ 0, $[\theta]_{2000}$ −361,140, $[\theta]_{1925}$ 0.

Decaline showed (*c* 0.108) $[\theta]_{3100}$ 0, $[\theta]_{2950}$ +48,600, $[\theta]_{2815}$ 0, $[\theta]_{2750}$ −38,475, $[\theta]_{2575}$ 0, $[\theta]_{2475}$ +22,275, $[\theta]_{2400}$ 0, $[\theta]_{2275}$ −109,350, $[\theta]_{2150}$ −22,275, $[\theta]_{2000}$ −194,400, $[\theta]_{1950}$ −97,200.

Vertaline showed (*c* 0.036) $[\theta]_{3075}$ 0, $[\theta]_{2950}$ +43,758, $[\theta]_{2820}$ 0, $[\theta]_{2750}$ −38,896, $[\theta]_{2575}$ 0, $[\theta]_{2475}$ +19,448, $[\theta]_{2400}$ 0, $[\theta]_{2250}$ −109,395, $[\theta]_{2125}$ −29,172, $[\theta]_{2000}$ −145,848, $[\theta]_{1975}$ −103,309.

Neodihydrothebaine showed (*c* 0.157) $[\theta]_{2975}$ 0, $[\theta]_{2750}$ +4991, $[\theta]_{2625}$ 0, $[\theta]_{2450}$ −11,978, $[\theta]_{2325}$ 0, $[\theta]_{2150}$ −79,840, $[\theta]_{2080}$ 0, $[\theta]_{2000}$ +263,472, $[\theta]_{1950}$ +139,720.

α-Methyldihydrothebaine perchlorate showed (*c* 0.076) $[\theta]_{3050}$ 0, $[\theta]_{2800}$ +10,130, $[\theta]_{2575}$ 0, $[\theta]_{2450}$ −6753, $[\theta]_{2375}$ 0, $[\theta]_{2325}$ +11,260, $[\theta]_{2300}$ 0; (*c* 0.25) $[\theta]_{2150}$ −153,990, $[\theta]_{2075}$ 0, $[\theta]_{2000}$ +359,310, $[\theta]_{1950}$ +136,880.

η-Methyldihydrothebaine perchlorate showed (*c* 0.17) $[\theta]_{3025}$ 0, $[\theta]_{2775}$ −5031, $[\theta]_{2575}$ 0, $[\theta]_{2525}$ +1509, $[\theta]_{2450}$ 0, $[\theta]_{2325}$ −25,155, $[\theta]_{2265}$ 0, $[\theta]_{2150}$ +55,341, $[\theta]_{2090}$ 0, $[\theta]_{2025}$ −186,147, $[\theta]_{1975}$ −60,372.

Optical Rotatory Dispersion Measurements. The ORD measurements were carried out in methanol solution using a Cary Model 60 spectropolarimeter and are recorded in units of molecular rotation.

Compound VIa[25] showed $[\alpha]_{350}$ −260°, $[\alpha]_{330}$ −360°, $[\alpha]_{300}$ −480°, $[\alpha]_{280}$ −720°, $[\alpha]_{250}$ −1020°, $[\alpha]_{240}$ −1350°.

Compound VIb[25] showed $[\alpha]_{350}$ +160°, $[\alpha]_{330}$ +220°, $[\alpha]_{300}$ +410°, $[\alpha]_{260}$ +410°, $[\alpha]_{250}$ +730°, $[\alpha]_{240}$ +1240°.

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[25] The molecular rotations reported for VIa and VIb are of limited accuracy due to the intense uv absorption, the low molecular rotation, and the small amounts of these compounds. However, it is clear that the curves are of opposite sign. There may be a weak Cotton effect at 285 nm; however, this is not certain for the above-mentioned reasons.

Optical Properties of Some Heterohelicenes. The Absolute Configuration

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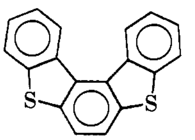
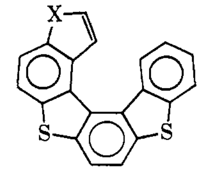
Abstract: The electronic spectra of a number of heterohelicenes are discussed. The optical rotatory dispersion and circular dichroism spectra of the resolved ones were measured. Calculations on a model compound were performed to establish the absolute configuration. The right-handed chirality was assigned to the (+)-heterohelicenes.

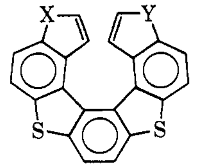
In previous papers we described the synthesis and resolution of a number of heterohelicenes[1] (I–VII). With the exception of I, IV, and VI these compounds were obtained in an optically active form, mainly by crystal picking, and they were found to show very high optical rotations due to the presence of an inherently dissymmetric chromophore.[2] In order to study this phenomenon in more detail we measured the optical rotatory dispersion (ORD) and circular dichroism (CD) spectra of the resolved heterohelicenes. Since these spectra cannot be interpreted well without knowledge of the uv spectra,[3] attention will be paid first to these spectra. Further objectives were (a) to assign the absolute configurations with the aid of the ORD and CD spectra and (b) to evaluate the effect of overcrowding on the uv spectra of the heterohelicenes. This work was



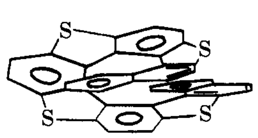
I



II, X = CH=CH
III, X = S



IV, X = Y = CH=CH
V, X = CH=CH; Y = S
VI, X = Y = S



VII

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[1] (a) H. Wynberg and M. B. Groen, *J. Amer. Chem. Soc.*, **90**, 5339 (1968); (b) H. Wynberg and M. B. Groen *ibid.*, **92**, 6664 (1970); (c) M. B. Groen, G. Stulen, G. J. Visser, and H. Wynberg, *ibid.*, **92**, 7218 (1970).

[2] A. Moscowitz, *Tetrahedron*, **13**, 48 (1961); Ph.D. Thesis, Harvard University, Cambridge, Mass., 1957.

[3] In some cases including the visible region.