wards, *J. Chem. Soc.*, 1214 (1960). Correspondingly, (+)-1 gave the *R*-(+) isomer of carnegine.

(10) The optical properties of the enantiomers of D (R = CH$_3$) and the chemistry of their formation has been discussed in ref 7 and structures have been proposed (i.e., **5** from (*S*)-**1**, Scheme II). It is probably derived from the further oxidation of **3** by a mechanism not understood as yet.[2]

(11) (a) A. S. Steinfeld, Ph.D. Dissertation, University of Connecticut, 1968; (b) J. F. Colaruotolo, Ph.D. Dissertation, University of Connecticut, 1974; (c) J. M. Bobbitt, J. F. Colaruotolo, and S. J. Huang, *J. Electrochem. Soc.*, **120**, 773 (1973).

(12) A. J. Fry, *Fortschr. Chem. Forsch.*, **34**, 1 (1972).

(13) L. Eberson and K. Nyberg, *Acc. Chem. Res.*, **6**, 106 (1973).

(14) (a) E. Kariv, H. A. Terni, and E. Gileadi, *J. Electrochem. Soc.*, **120**, 639 (1973); (b) L. Horner, D. Degner, and D. Skaletz, *Chem.-Ing.-Tech.*, **44**, 209 (1972); (c) R. N. Gourley, J. Grimshaw, and P. G. Millar, *J. Chem. Soc. C*, 2318 (1970).

(15) J. O'M. Bockris and A. K. N. Reddy, "Modern Electrochemistry", Vol. 2, Plenum Press, New York, N.Y., 1970.

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(17) G. E. Hawkes, J. H. P. Utley, and G. B. Yates, *J. Chem. Soc., Chem. Commun.*, 305 (1973).

(18) N. L. Weinberg and E. A. Brown, *J. Org. Chem.*, **31**, 4058 (1966).

(19) W. I. Taylor and A. R. Battersby, "Oxidative Coupling of Phenols", Marcel Dekker, New York, N.Y., 1967.

(20) R. C. Hallcher, Ph.D. Dissertation, University of Connecticut, 1972. In this case also only one carbon-carbon dimer was formed, presumably corresponding to **3**. Since samples of dimer corresponding to **2** and **4** were not available for reference, we cannot claim another stereoselective reaction. However, the single carbon-carbon dimer was formed in good yield and was crystalline.

(21) F. R. Hewgill, *MTP Int. Rev. Sci.: Org. Chem., Ser. One, 1973*, **10**, 167 (1973).

(22) P. A. McDonald and G. A. Hamilton in "Oxidation in Organic Chemistry", W. S. Trahanovsky, Ed., Academic Press, New York, N.Y., 1973, p 97.

(23) (a) A. Ronlán, *Chem. Commun.*, 1643 (1971); (b) A. Nilsson, A. Ronlán, and V. D. Pakker, *J. Chem. Soc. C*, 2337 (1973).

(24) Melting points were taken on a Kofler hot-stage apparatus and are corrected. The NMR spectra were taken on a Varian A-60 instrument in CDCl$_3$ using tetramethylsilane as an internal standard unless noted. Mass spectra were measured on an AEI MS-12 instrument. Microanalyses were carried out by Baron Consulting Co., Orange, Conn. TLC was carried out on silica gel GF$_{254}$ layers and visualized with Dragendorff's reagent. All of the potentials were measured against a standard calomel electrode and controlled with a Wenking potentiostat No. 61TR. Tetraethylammonium perchlorate, the toluoyl tartaric acid, and CH$_3$CN were commercial materials used without purification. The solvent evaporations were carried out on a rotary vacuum evaporator. The ORD curves were measured through the courtesy of Professor T. Kametani, Tohoku University, Sendai, Japan.

(25) T. Kametani, "The Isoquinoline Alkaloids", Hirokawa Publishing Co., Tokyo, 1968, p 26.

(26) This experiment will be described in detail since it was found to give the best yields.

(27) WDF graphite felt, Carbon Products Division, Union Carbide Corp., New York, N.Y.

(28) For general cell design see ref 2 and G. F. Kirkbright, J. T. Stock, R. D. Pugliese, and J. M. Bobbitt, *J. Electrochem. Soc.*, **116**, 219 (1969).

(29) This is generally done by shredding the electrode in a Waring Blendor with methanol followed by suction filtration.

(30) The ORD curves for these compounds and for the enantiomers of **1** were not corrected for zero lines and are therefore not exactly equal and opposite. A better criterion for purity is probably the more accurately measured rotations at the D line of sodium.

(31) R. L. Augustine, "Catalytic Hydrogenation", Marcel Dekker, New York, N.Y., 1965, p 151.

The Chiroptical Properties of Bistetrahydroisoquinoline and Polycyclic Biaryl Derivatives[1]

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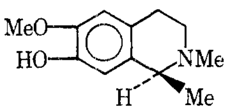
The ORD and CD spectra are described for the atropisomers of 8,8′-bis-1,2-dimethyl-7-hydroxy-6-methoxy-1,2,3,4-tetrahydroisoquinoline (**2**), which were prepared by the electrochemical and chemical oxidation of (*S*)-(−)-1,2-dimethyl-7-hydroxy-6-methoxy-1,2,3,4-tetrahydroisoquinoline (**1**). The anticlinal isomer **2a**, mp 164–165°, probably has the (1*S*,1′*S*,biphenyl-*S*) configuration and gives CD curves with moderate Cotton effects while the curves of the synclinal isomer **2b**, mp 176–178°, of (1*S*,1′*S*,biphenyl-*R*) configuration vary more significantly with pH. A third product, which may result from cyclization of one of the atropisomers, probably has hexacyclic structure **3b** and is assigned the *S* configuration at both chiral centers and the *R* configuration (*P* helicity) of the biaryl chromophore based on the signs of the high-intensity Cotton effects.

The helicity of ortho-substituted biphenyls has been correlated with chiroptical properties [circular dichroism (CD) and optical rotatory dispersion (ORD)] by Mislow and his collaborators.[2–4] These workers observed that the nature of the substituents had profound effects on the chiral properties, but the inherently dissymmetric chromophore dominated the ORD and CD curves. The ortho,ortho′ substituents were then cyclized to yield bridged biphenyls of known[4a] absolute configuration and helical sense. The size of the ring and nature of the bridge determined the angle from coplanarity (angle of torsion) of the benzene rings. When the bridge stabilized the helicity and lacked additional elements of dissymmetry, the sign of the strongest Cotton effect could be related to the absolute configuration or sense of twist of the molecule.[4b] Since these first observations were made, a number of investigators have discussed the correlation of the ORD and CD spectra in a variety of systems with the helicity of the chromophore.[5,6]

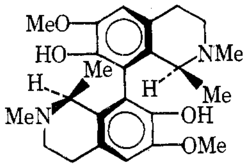
The study of the chiroptical properties of biaryl derivatives produced by coupling of phenolic tetrahydroisoquinolines was undertaken to ascertain the stereochemical consequences of inducing helicity in the biaryl moiety. Since the starting monomeric species possessed a single chiral center at C-1, the dimeric products contain an additional center of dissymmetry, the biaryl, whose helical sense may be predicted from the signs of the circular dichroism Cotton effects. A doubly bridged biaryl also resulted from the electrochemical oxidation, and its helicity may be deduced from ORD and CD measurements which would suggest some steps in the mechanism for its formation.

Bobbitt and co-workers have synthesized chiral biaryl derivatives by the methods described in the accompanying paper.[7] The configurations were assigned from NMR evidence, and confirmation of the assignments was sought by the chiroptical methods described below.

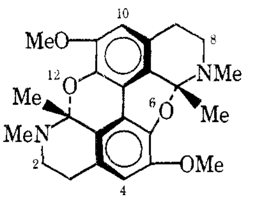
The compounds were prepared by the electrochemical and chemical dimerization of 1,2-dimethyl-7-hydroxy-6-methoxy-1,2,3,4-tetrahydroisoquinoline [(±)-**1**], and its enantiomers.[7,8] Bobbitt and co-workers[9] have shown that a bond is formed at the 8 positions, ortho to the hydroxyl group. Rearomatization produces the biaryl **2**. The presence of the substituents at the chiral center at the ortho,ortho′ positions creates steric interference to rotation about the biphenyl bond and adds a new element of dissymmetry. As a result two biaryls, **2a** and **2b**, result from the coupling of a single enantiomer [(*S*)-(−)-**1**], but the product has a new element of dissymmetry (the helicity of the biaryls) which results in the formation of two diastereomers which are atropisomers[10a] and have been called *rotamers*.[8] A second pair of diastereomers would arise from the (*R*)-(+)-**1** enantiomer.[10b] A recent report cited evidence for the existence of diastereomeric conformations in solution for an enantiomer of a chiral biphenyl.[10c]



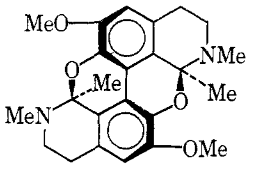
(−)-**1**



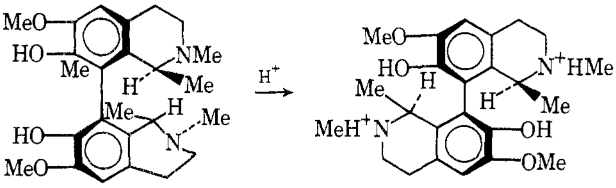
2a



3a



3b



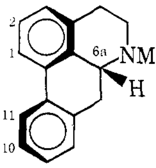
2b

If rotation about the bond joining the aromatic rings permits the ortho substituents to pass each other, the rotamers will be interconverted. This energy barrier is probably high because of the size of the chiral ortho substituents. A number of conformations are possible, but those derived from (*S*)-(−)-**1** which have the probable minimal nonbonded interactions have the left-handed helical sense of the biphenyl as shown in **2a** and **2b.** Both enantiomers were studied for all compounds, but the discussion will concern the products from the (*S*)-(−)-**1** series. Data from the enantiomeric series derived from (*R*)-(+)-**1** will be used in some examples with appropriate sign changes.

The third biaryl compound isolated from the oxidative coupling reactions resulted most likely from cyclization of the rotamers. The phenolic oxygen formed a bridge to the 1 position of **2** which created an aminoketal type of functional group. Since both hydroxyl groups produced the ethereal bonds, the doubly bridged biphenyl 5,11-dimethoxy-6a,12a-dimethyl-1,2,3,6,6a,7,8,9,12,12a-decahydro-6,12-dioxa-1,7-diazadibenzo[*def,mno*]chrysene (**3**) was formed.[7]

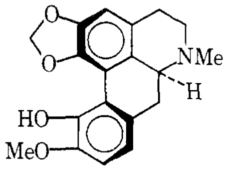
The configurations of the products of the phenolic coupling can be derived from that of the starting material whose rotation, (+) or (−), is specified by the observed rotation at 589 nm in chloroform solution. When (*S*)-(−)-**1** is coupled with itself by a phenolic oxidation process, the products **2** retain the *S* configuration at the asymmetric carbon atoms, but the configuration of the biphenyl will be *R* in one isomer and *S* in the other.[11] The assignment of configuration to the two products isolated in this reaction is complicated by the fact that each isomer has syn and anti conformations. Because of the dissymmetry produced by the chiral carbon centers at C-1 and C-1′ of the tetrahydroisoquinoline moieties, the nonbonded interactions destabilize one conformer appreciably leading to the predominant structures **2a** and **2b.** The anticlinal[11b] isomer **2a** has thg (1*S*,1′*S*,biphenyl *S*) absolute configuration, while the synclinal[11b] isomer **2b** has the (1*S*,1′*S*,biphenyl *R*) configuration. On the basis of NMR data the racemate melting at 226–227° was assigned the anticlinal structure **2a** and its enantiomer.[8] The CD data discussed below will support this assignment.

The helical sense of **3** is determined by the absolute configuration at the asymmetric carbons, 6a and 12a. A similar observation was made by Shamma[12] in the case of the aporphine alkaloids **4** and **5.** When the bridge between the biphenyl carried the *R* configuration (C-6a in aporphine **4**), the biphenyl moiety could only achieve a left-handed twist. The absolute configuration of the biphenyl moiety of **4** is also *R* by the Cahn–Ingold–Prelog nomenclature system[11] when no other substituents are present at C-1 or C-11, while that of **5** would be *S*. A more satisfactory terminology which is not dependent on substituents but only on the sense of twist is to describe **4a,b** as having *M* helicity and **5** with *P* helicity.[10]



4a, nuciferine, OCH_3 at C-1, C-2

4b, apomorphine dimethyl ether, OCH_3 at C-10, C-11



5, bulbocapnine

The stereochemistry of the cyclized product **3** cannot be assigned unless the mechanism by which cyclization occurs is known or the configuration at the asymmetric carbons can be determined by other methods. The cyclization of **2a** would yield **3a** by retention of configuration where oxygen replaces hydrogen but would yield **3b** only by inversion at all chiral centers. Hence, **2b** or its precursor must lead to **3b.** As long as the pathway yields an optically active product, the configurations at both carbons must be the same and will determine the helical sense of the molecule. This results from the same strains Shamma found for the aporphine alkaloids.[12b] In **3a** this is a left-handed screw sense, *M* helicity, and **3b** has the right-handed or *P* sense.[10] A correlation of the helical sense with the signs of the Cotton effects of chiral molecules has been discussed from several theoretical approaches by Brewster[13] and, more recently, by Hug and Wagnière.[6] Mason et al. have assigned absolute configurations to open biphenyls,[5b] binaphthyls,[5b] and bianthryls[5c,14] on the theoretical treatment of CD results. Utilization of the rules formulated for biphenyls by Hug and Wagnière[6] leads to the proposition that the helical sense of the product **3** obtained from (*S*)-(−)-**1** is probably *P*. This helicity must result from inversion of configuration at the asymmetric carbons and produce the 6a*S*,12a*S* absolute configuration shown in **3b.**

Experimental Section

Absorption spectra were recorded on the Cary 15 or a Beckman DK-2A with 95% ethanol as solvent. Measurement at 27° of the ORD and CD spectra was accomplished with the Cary 60 equipped with a 6001 circular dichroism attachment. The CD spectra were recorded in 95% ethanol and concentration and path length were varied by diluting the concentrations given in the figures or by using cells of light path 1.0, 0.1, or 0.05 cm. The solutions showed pH about 5. After the spectrum was recorded, a drop of concen-

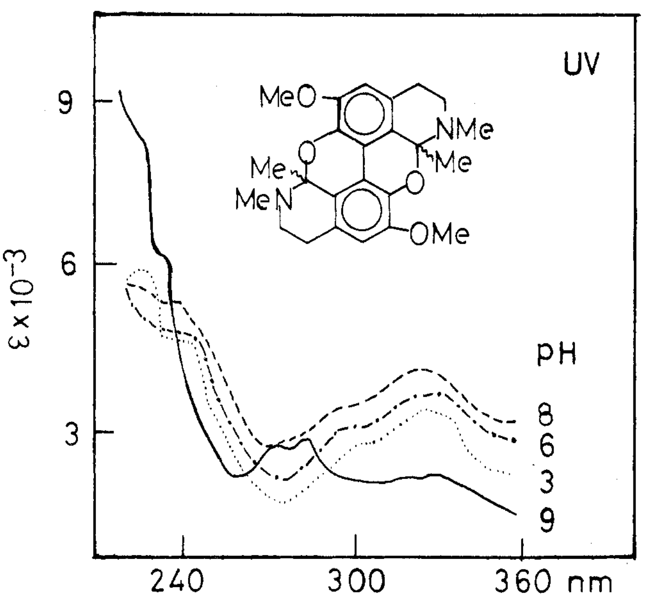


Figure 1. Uv spectra of 3 in 95% ethanol: —, fresh solution and pH 9; ····, pH 3; –·–, pH 6; - - -, pH 8. The pH may be changed in either direction with duplication of curves.

trated HCl was added to pH 2, and the spectrum was remeasured. Neutralization with solid KOH gave solutions whose spectra appeared essentially identical with the original curves (pH 8). Additional KOH was added to obtain strongly basic solutions (pH 10). Reported spectra were recorded at least twice and by different analysts with agreement in wavelength and sign and 10% maximum variation in amplitude. The CD spectra and some ORD curves of both enantiomers were obtained, and the figures show curves for only the enantiomer comparable to or derived from (*S*)-(−)-1.

The compounds were obtained as previously described[7] by the electrochemical or chemical dimerization of 1,2-dimethyl-7-hydroxy-6-methoxy-1,2,3,4-tetrahydroisoquinoline [(±)-1] and each enantiomer of 1. Purity of the products was confirmed by measuring spectra of both enantiomers of each structure. The absolute configuration *S* was assigned to (−)-1 on the basis of chemical correlation.[8]

Results and Discussion

Uv Spectra. The electronic spectra of biphenyl derivatives[15] usually show a large band at about 250 nm which has been called the conjugation band, one or more weak bands at longer wavelength characterized as the ^1L_b band in Platt's notation,[16] a band at ca. 230 nm which may be the ^1L_a band, and the bands at 220 nm and below corresponding to the ^1B bands of benzene. The ^1L_b and ^1L_a bands of biphenyl apparently overlap in a broad 250 nm conjugation band.[15] The substitution of hydroxyl or ether groups on the aromatic ring causes red shifts.[17] The combination of two tetrahydroisoquinoline moieties into the biphenyl structure was expected to give spectra similar to that of 1 plus the intensive biphenyl conjugation band. The hexacyclic product 3, which is formally a doubly bridged biphenyl, should also absorb at 250 nm as well as show phenolic bands.

The complex spectra of the cyclized product 3 shown in the study of pH variation (Figure 1) contrasted with the relatively featureless spectra of the monomer 1 and dimers 2 (Figures 2–4). The spectra of 1 and 2 showed the ^1L_b band of monomethylated catechol at 288 nm, which is the only significant peak at long wavelength in neutral or acid media. A shoulder at 255–260 nm which is not present in the spectra of 1 appeared on acidification, indicating further biphenyl interaction.

In contrast to these very simple spectra, 3 on dissolution in alcohol (pH 8.5–9) absorbed (ϵ ~10^4) at 330, 283, 273, and 240 nm with a shoulder at 317 nm (Figure 1). The bands changed in intensity and structure on addition of acid and showed variation in extinction coefficient with pH 1–8 which precluded equilibria studies.[18] At pH 9 the spectrum changed, resembling that of the original solution. Acidification of this solution restored the curve at pH 3 with only a 5% loss of intensity in the 330-nm band and no other change.

The absorption of the biphenyl chromophore at 240–245 nm was constant from pH 1 to 6, increased from pH 6 to 8, and was lost or hidden under the strong 230-nm band at pH 9. Since the conjugation band is expected to be inde-

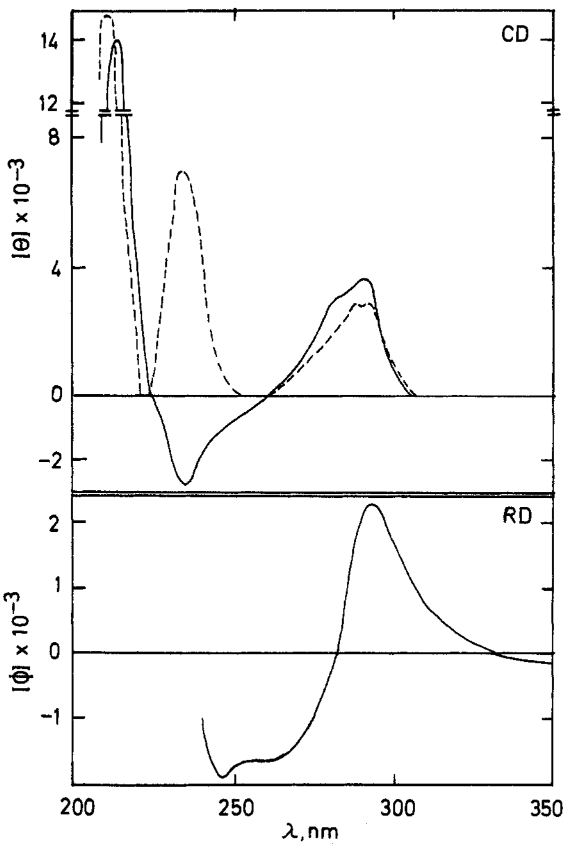


Figure 2. CD and ORD of (*S*)-(−)-1, *c* 0.417 mg/ml, 95% ethanol (—) and CD (- - -) in acidified ethanol.

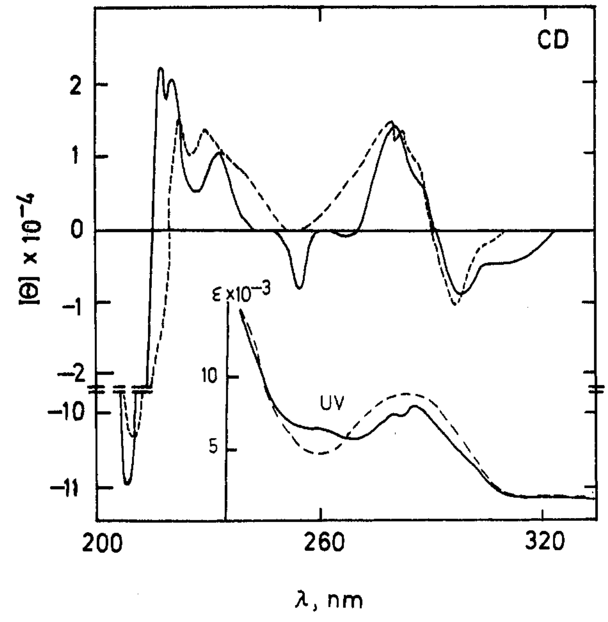
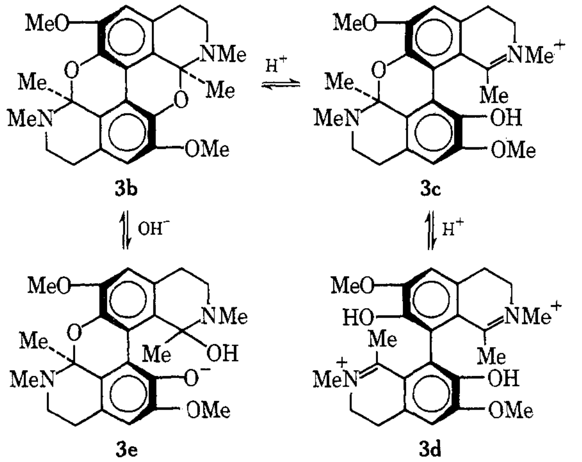


Figure 3. CD and uv of *SS* rotamer A (2a), *c* 0.162 mg/ml, 95% ethanol (- - -) and in acidified ethanol, pH 2 (—).

pendent of pH, it was sought and found to be strong in the CD spectra (vide infra), and the wavelength did not change with pH. The presence of two bands, 330 and 300 nm, may indicate exciton splitting of the ^1L_b band.

The curve of **3** obtained initially in alcohol very likely indicates only the molecular species which undergoes ring opening in both acid and base. An equilibrium shown in Scheme I is consistent with the uv spectra. In acid, the ring-opened structures **3c** and **3d** have decreased conjugation of the biphenyl because the methyl group at C-1 is coplanar with the benzene ring. Thus the absorption decreases at 240, 300, and 330 nm with decreasing pH. Chirality is retained, however, because of the interference to free rotation. Basification leads to **3e** and comparison of the spectrum at pH 9 with that of the original solution showed a similar curve which has a broadened band in the 300–340-nm region, possibly due to phenoxide absorption.

Scheme I



The small but possibly significant differences in the uv curves of the atropisomers **2** and the variation with pH shown by **3** suggested that the removal of some overlapping absorptions and presentation of signed maxima in the CD spectra should permit clarification of the uv spectra. In addition, the signs of the bands should test the validity of the conformational arguments and suggest the helicity of the twisted biphenyls in **2a**, **2b**, and **3**.

CD Spectra. The starting material (*S*)-(−)-**1** has positive ^1L_b Cotton effects at 290 and 280 nm (Figure 2). Snatzke and Ho[19] assigned *M* helicity to the heterocyclic ring in a tetrahydroisoquinoline having oxygen substituents at C-6,7 if the compound gave a positive ^1L_b Cotton effect. This assignment requires the 1-methyl substituent to assume an axial conformation which is plausible from examination of molecular models. A negative Cotton effect at 236 nm resulted from the ^1L_a transition, and the ^1B Cotton effect at 212 nm was positive. The acidified spectrum showed similar ^1L_b and ^1B bands, but the ^1L_a band inverted to a positive ellipticity at 233 nm.

Dimerization should add the biphenyl bands to the spectra and produce a red shift of other bands. The anticlinal conformation of **2a** is consistent with the isomer, mp 226–227°, which showed very similar spectra in neutral and acidic solutions. Suzuki[15] found that the dihedral angle of biphenyl (23°) was enlarged to 70° with ortho,ortho′ disubstitution, and the angle in **2a** may be even larger. Protonation of the diamine should not appreciably change the conformation or the CD spectra. The CD curves of **2a** in both neutral and acidic media (Figure 3) gave one band with a negative sign at 300 nm and a positive maximum at 284 nm which may result from exciton splitting of the ^1L_b band. An overlapping band at 279 nm increased the breadth of the positive half of the bisignate band. The second atropisomer **2b** showed a negative, single Cotton effect at 284 nm (Figure 4) with no splitting. Acidification of the solution, however, gave a striking increase in ellipticity and the appearance of a long wavelength bisignate Cotton effect. The band was shifted to the red with maxima at 330 and 300 nm, the former being positive.

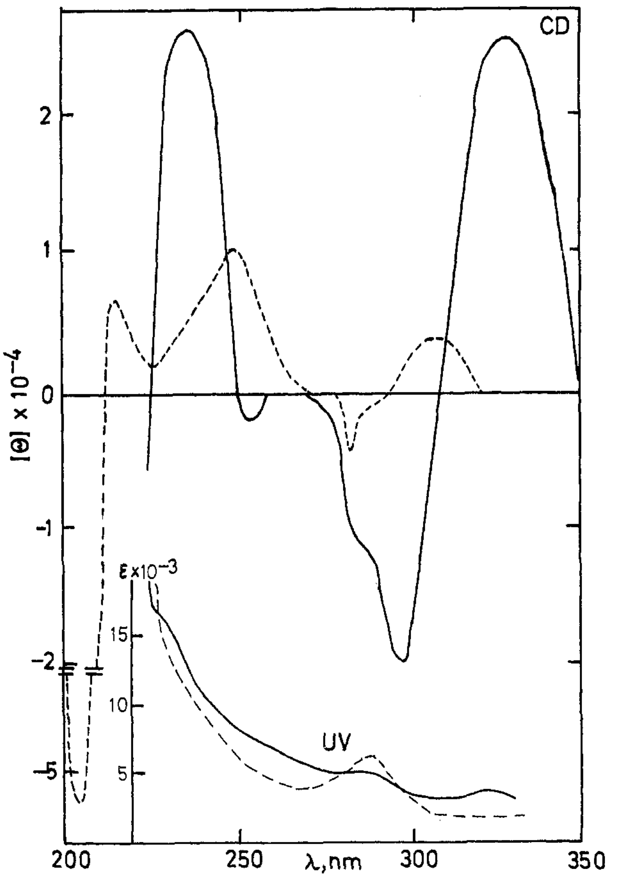


Figure 4. CD and uv of *SS* rotamer B (**2b**), *c* 0.042 mg/ml, 95% ethanol (- - -) and in acidified ethanol, pH 2 (—).

Use of the ^1L_b traniition for assigning absolute configuration and helical sense to twisted biaryls has been calculated for a variety of systems since Kuhn[20] first attempted to determine the absolute configuration of 2,2′-diamino-6,6′-dimethylbiphenyl. The data were recently reexamined by Mason et al.[5b,14] along with the studies of binaphthyls and bianthryls. The results of the theoretical treatment were consistent with the known configurations. Hug and Wagnière proposed[6] that the helicity of a biaryl which shows an exciton split of the ^1L_b Cotton effect can be correlated with the sign of the CD band. According to their rules, a bisignate Cotton effect with a positive long-wavelength maximum resulting from B-type symmetry of the electronic transition correlates with a biphenyl of *P* helicity. Exact identification of this transition, its symmetry type, and characterization as exciton splitting are essential. Assuming that these criteria are applicable to the spectra of **2a** (Figure 3), the negative 300 nm and positive 280 nm exciton split Cotton effect indicates *M* helicity which was also predicted by Bobbitt et al.[8] from the NMR data and absolute configuration at C-1 and C-1′. If the acidified spectrum of **2b** (Figure 4) also meets the criteria, the long-wavelength positive maximum of the exciton split ^1L_b band shows that **2b** has *P* helicity in acid. Since **2b** probably has the syn relationship of the amino groups in neutral solution, diprotonation should cause repulsion of the ammo-

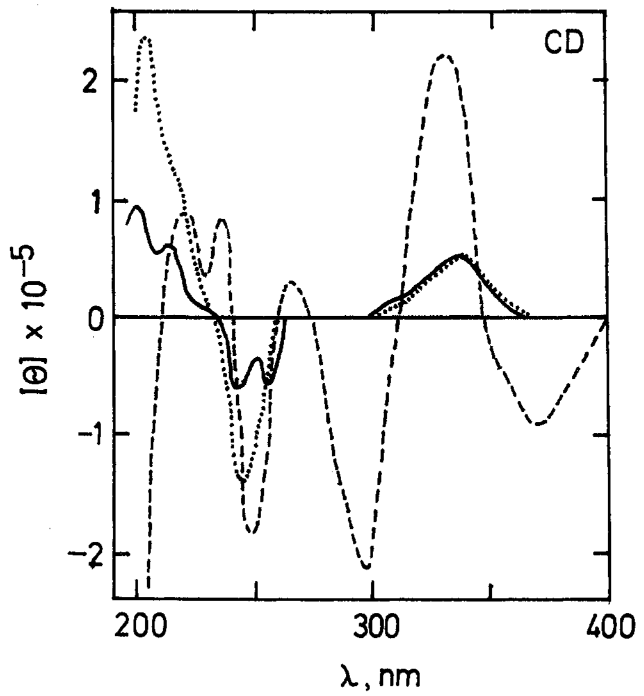


Figure 5. CD of 3 prepared from (*S*)-(−)-1 at pH 2 (- - -), pH 5–8 (—), and pH 10 (• • • •), *c* 0.076 mg/ml 95% ethanol.

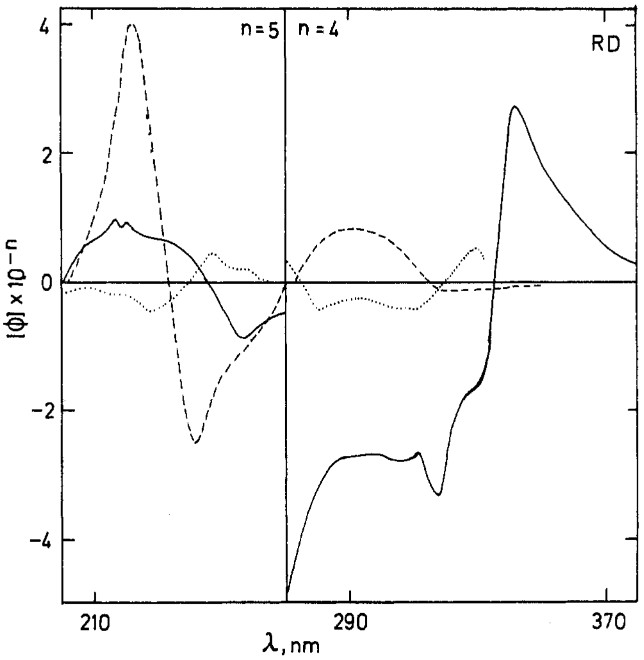


Figure 6. RD in 95% ethanol of 3 prepared from (*S*)-(−)-1, *c* 0.0676 mg/ml (—), (*S*)-(+)-bulbocapnine (5), *c* 0.159 mg/ml and adapted from ref 23 (• • • •), and (*R*)-(−)-apomorphine dimethyl ether hydriodide (4b), *c* 0.247 mg/ml (- - -).

nium ions and open the biphenyl to the anticlinal conformation. This is consistent with the *P* helicity of the salt which would be predicted from the knowledge of the absolute configuration and NMR data.[8]

The identification of the biaryl ^1L_a band is not certain. Verbit[21] proposed a CD bandwidth criterion for characterizing this band in benzene derivatives. Resolution of these curves on a Du Pont Model 310 instrument eliminated some bands on this basis but did not clearly identify the ^1L_a band in either compound.

The very strong bands at 200–210 nm in the spectra of **2** which may be the result of the ^1B_b transition were proposed by Ferris et al.[22] as diagnostic for helicity of some bridged biphenyls. Theory suggested[5c] that they should have the same sign as the ^1L_b Cotton effect. In this case, both **2a** and **2b** have negative Cotton effects at about 210 nm in alcohol, but the acidic solution of **2b** was not readable in this region. Use of this band may become possible with further developments in instrumentation.

The CD spectra of **3** prepared from (*S*)-(−)-**1** are quite complex (Figure 5), but the ^1L_b transition gave a positive, unsplit Cotton effect at 318 nm with a shoulder at 310 nm. Acidification produced a very strong, bisignate Cotton effect with the positive maximum at 330 nm and the negative maximum at 298 nm. A longer wavelength negative Cotton effect appeared at 370 nm which may be a charge transfer band. The positive sign of the exciton split band at 330 nm requires assignment of *P* helicity to **3** according to the rules of Hug and Wagnière.[6] The biphenyl conjugation band at 244 nm was almost constant with pH change but became stronger and shifted to 250 nm in base. It remained negative at all pH values. The similarity of the spectra in acid medium of **2b** and **3** prepared from (*S*)-(−)-**1** is striking, especially in the long-wavelength region (Figures 4 and 5). The rules of Hug and Wagnière[6] thus demand the assignment of *P* helicity to both compounds in acid solution. With *P* helicity, **3** must have the absolute configuration shown in **3b**, i.e., 6a*S*,12a*S*.

The aporphine structures **4** and **5** were expected to be models for **3**, but there were critical differences. The aporphines have a two-carbon bridge between the benzene rings while **3** has an oxygen–carbon bridge. The helicity is governed in both systems, however, by the absolute configuration of the C-6a (and C-12a in **3**) atom and its substituents. Thus knowledge of one leads to assignment to the other center. The oxygen substituents of the aromatic rings are on opposite sides of the rings (i.e., anti) and thus opposite to the syn arrangement in the aporphines which probably prevents the aporphines from being satisfactory models for **3**. The similarity of the RD curves (Figure 6) of **3** prepared from (*S*)-(−)-**1** and the alkaloid nuciferine[23] (**4a**) led to the initial assignment of configuration based on *M* helicity.[1b] The conjugation bands are strong and negative, that of **3** being at slightly longer wavelength than that of **4a**. The ^1L_b bands in the aporphines have relatively low amplitudes and are of questionable value in assignment of configuration.[23] Since **3** gave opposite signs of the ^1L_b (positive, 320 nm) and conjugation (negative, 245 nm) bands, no assignment was possible based only on model aporphine compounds in which these bands have the same sign [e.g., bulbocapnine (**5**), positive, 320 and 240 nm]. Application to **3** of the method Mason used[24] for boldine was also inapplicable because of the structural differences. In view of the strength of the ^1L_b exciton split transition, the assignment of *P* helicity to **3** based on the rules of Hug and Wagnière[6] seems plausible. It is certain that the aporphines are not satisfactory models for this compound, and an analysis of **3** would be desirable on a theoretical basis since it is a rare example of an anti oonfiguration of the oxygen in a bridged bicyclic analogous to the aporphine structure.

The mechanism by which (*S*)-(−)-**1** is converted to **3b** is not established, but the hydrogen at C-1 must be removed initially as the atom or ion causing loss of chirality at the carbon center. The chirality of **3** would, therefore, be determined by the twist of the biphenyl system in the intermediate. If **2a** is the precursor to **3b**, this requires both a change in the twist of the biphenyl and formation of the O–C bond leading to the *S* configuration. This is an unlikely pathway. If **2b** or a precursor to **2b** is the intermediate leading to **3b**, only the latter change is required which would give the *S* configuration at C-6 and C-12 of **3** and would retain the *P* twist of the biphenyl.

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Registry No.—(−)-**1**, 35053-29-3; **2a**, 35053-14-6; **2b**, 35048-36-3; **3b**, 57550-05-7.

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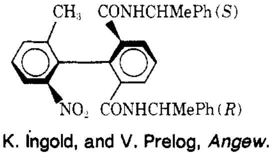

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Cyclization of Unsaturated Hydroxylamine Derivatives[1]

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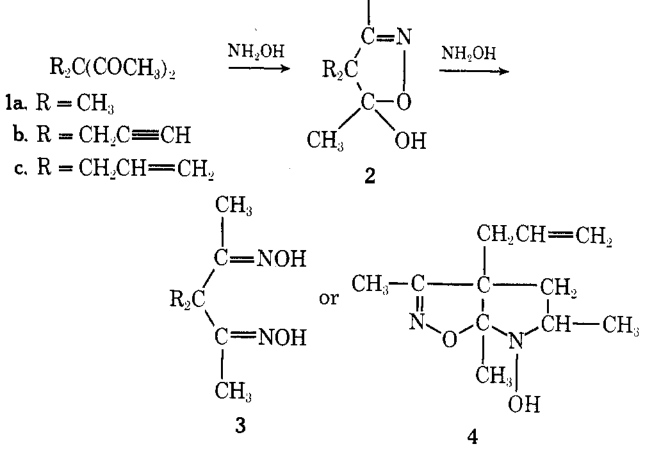
Reaction of the α-allyl β-diketones **5** with excess $HONH_2$ yielded the bicyclic pyrrolidine derivatives **7** in which a new N–C bond had been formed by cyclization of an intermediate *N*-(4-pentenyl)hydroxylamine **14**. Study of conversion of the *N*-alkenylhydroxylamine **20** to form the cyclic hydroxylamine **24a** and the electrochemical oxidation of hydroxylamines **20**, **24a**, and **31** suggested that these ring closures **14** → **15** occur by a radical chain process involving an intermediate nitroxide radical **37**.

An earlier investigation[3] of the reaction of 3,3-disubstituted 2,4-pentanediones (**1**, Scheme I) with excess hydroxylamine had provided the curious observation that although the dimethyl derivative **1a** could be converted either to the isoxazoline **2** or the dioxime **3**, the dipropargyl derivative **1b** was remarkably resistant to conversion beyond the isoxazoline stage **2**. In seeking further information relating to these observations, reaction of the diallyl derivative **1c** with excess hydroxylamine was also examined. Again, formation of an isolable dioxime **3** was unfavorable; treatment of the isoxazoline **2** (R = allyl) with hydroxylamine under vigorous conditions led to the formation of an unexpected isomeric substance subsequently shown to have the structure **4**. In this paper we describe the evidence on which the assignment of structure **4** is based and also described are our observations pertaining to the mode of formation of this substance.

Scheme I



Two 1,3-diketone substrates, **5a** and **5b** (Scheme II),