Table I. Oxymetalation of 1,2-Cyclononadiene

X	Solvent	Catalyst	Time, hr[a]	$[\alpha]^{25}D^b$
		TlX₃		
OAc	HOAc	BF₃·Et₂O	20	0.9
OAc	HOAc	BF₃·Et₂O	72	0.5
OAc	CH₃OH	BF₃·Et₂O	20	2.8
OAc	CH₃OH	BF₃·Et₂O	72	3.3
OAc	CH₃CH₂OH	BF₃·Et₂O	20	4.0
OAc	CH₃CH₂OH	BF₃·Et₂O		
NO₃	CH₃OH		3	2.2
NO₃	CH₃OH		12	1.2
NO₃	CH₃CH₂OH		3	2.7
NO₃	CH₃CH₂OH		20	1.1
		HgX₂		
OAc	HOAc		1	1.7^c
OAc	CH₃CH₂OH	BF₃·Et₂O	5	3.5^c
		PbX₄		
OAc	HOAc			14.4^d

^{a} All reactions were carried out at 25°. ^{b} Rotation on **5a–c**. The values have been adjusted to correspond to a rotation of −22.7° for the starting allene **1**. ^{c} Values taken from ref 10 and adjusted to a rotation for **1** of −22.7°. ^{d} The initial product was 3-acetoxycyclononyne which was reduced to cis-3-acetoxycyclononene.[10]

Scheme I

4a, 5a, R = -OCCH₃
4b, 5b, R = -CH₃
4c, 5c, R = -CH₂CH₃
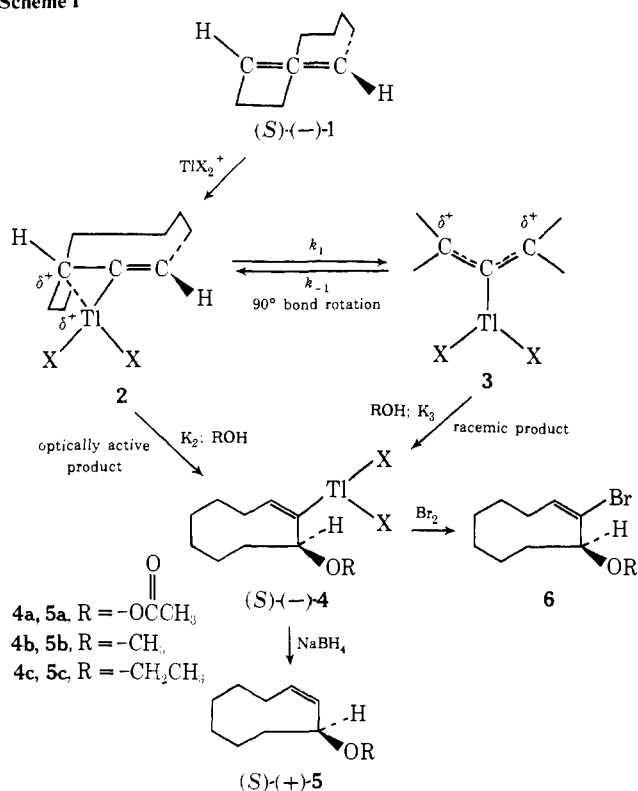
NO₃) with **1** in CH₃OH resulted in complete liberation of 1-octene and the quantitative formation of **5b**.[17]

Our results provide additional evidence that the mechanism of the oxythallation reaction closely resembles that of the oxymercuration reaction where we have provided substantial evidence[1b,9,10] for a π-complex intermediate. Although our data do not provide direct evidence for the intermediacy of a thallinium ion, we wish to propose the mechanism outlined in Scheme I involving formation of the thallinium ion **2** which may be in equilibrium with the planar resonance stabilized cation **3**. The observation that the rate of reaction of **1** with Tl(OAc)₃ is markedly increased by inclusion of the Lewis acid catalyst BF₃. Et₂O is also consistent with kinetic evidence[2a] which has established that

Tl(OAc)₂⁺ is the major electrophilic species in reactions with alkenes. Finally, these data provide the first direct evidence for the stereochemistry of addition in an oxythallation reaction with an allene.

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(11) Recrystallization of **4a** from CH₂Cl₂:pentane (1:9) afforded a white solid that had mp 170–171.5 dec and a satisfactory carbon and hydrogen analysis. Mass spectral analysis supported the structural assignment with M − OAc (445) and M − 2 (OAc) (m/e 386 and 121). The correct isotopic pattern for thallium was observed with m/e 205 and 203 in a 100:41 ratio; nmr (CDCl₃) δ 2.07 (S, 6 H) 2.17 (S, 3 H).
(12) Recrystallization of **4b** from CH₂Cl₂:Pentane 1:9 afforded a white solid mp 150–154 dec that gave satisfactory carbon and hydrogen analysis. Mass spectral analysis supported the structural assignment with M − (OAc) m/e 417 and 415. The correct isotopic pattern was observed with m/e 205 and 203 in a 100:42 ratio; nmr (CDCl₃) δ 2.07 (S, 6 H), 2.8 (m, 2.8), 4.95 (m, 1 H). The 3-ethoxy thallinium adduct **4c**, mp 128–130 dec, was too unstable to further characterize. However, NaBH₄ reduction of the crude reaction mixture afforded the known compound **5c**. The initial adducts **4a–c** must have the cis configuration about the double bond since attack from the inside of the ring is sterically precluded.[9b]
(13) W. R. Moore, H. W. Anderson, S. D. Clark, and T. M. Ozretich, J. Amer. Chem. Soc., **93**, 4832 (1971).
(14) We have previously established that dextrorotatory **5a–c** all have the S configuration.[10]
(15) It is also of interest to note that the major product of the oxyplumbation of **1** was 3-acetoxycyclononyne. This difference in product composition reflects the stability of the carbon–metal bond which decreases in the order C–Hg > C–Tl > C–Pb.
(16) The relative stereospecificity of the ethoxymercuration of **1** was also shown to be reduced when highly ionic mercuric salts were utilized in the reaction. The reduction in optical purity of **5** is due in part to the fact that **1** is completely racemized within 3 hr in CH₃OH in the presence of **4** (X = NO₃). Control experiments have established that **1** is optically stable in the presence of the thallic acetate adduct **4** (X = OAc) and in the presence of an equivalent of HNO₃ in CH₃OH. These data suggest that the dinitratothallium adduct is electrophilic enough to racemize the allene.
(17) Both alkoxy and alkene exchange reactions with oxymercurials have been reported.[18]
(18) J. E. Byrd and J. Halpern, J. Amer. Chem. Soc., **92**, 6967 (1970); R. D. Bach, R. N. Brummel, and R. F. Richter, Tetrahedron Lett., 2870 (1971); V. G. Collin, B. Muller-Hagen, and W. Pritzkow, J. Prakt. Chem., **314**, 229 (1972); V. H. J. Bergmann, G. Collin, G. Just, G. Muller-Hagen, and W. Pritzkow, ibid., **314**, 285 (1972).

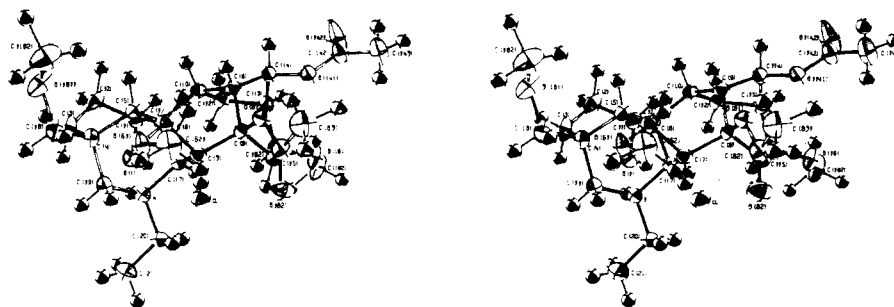**Robert D. Bach,* Joseph W. Holubka**

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**Structure and Absolute Configuration of Delphisine. A New Diterpene Alkaloid from Delphinium staphisagria**

Sir:

Delphisine, C₂₈H₄₃NO₈, mp 121–122°, $[\alpha]^{26}$ D +7.1° (c 4.00, ethanol), has been isolated from the mother liquors

Figure 1. A stereoscopic view of the molecule of delphisine hydrochloride. The molecule is shown in its correct absolute configuration. The atoms are numbered following the conventional scheme for the aconitine skeleton. The label for C(16) is omitted for clarity.

accumulated from the isolation of a large quantity of delphinine from the seeds of *Delphinium staphisagria*.[1,2] Spectral and chemical evidence have identified it as a member of the aconite group of alkaloids. The molecular structure and absolute configuration of delphisine have been established by an X-ray crystallographic study of its hydrochloride.

1, $R^1 = H$; $R^2 = COCH_3$
3, $R^1 = R^2 = H$
4, $R^1 = R^2 = COCH_3$
5, $R^1 = R^2 = CH_3$
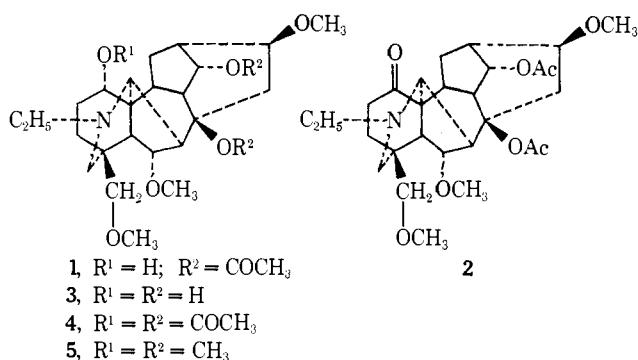
The infrared spectrum of delphisine contained a broad absorption band (3640-3000 cm^{-1}) with a small peak at 3600 and two well-defined peaks at 3420 and 3235 cm^{-1}, indicative of a hydrogen-bonded hydroxyl group, and acetate bands at 1740, 1725, and 1240 cm^{-1}. The nmr spectrum shows absorption for an N-ethyl group (3 H triplet, $J = 7$ Hz) centered at δ 1.16, two acetoxyl groups (δ 2.03 and 2.10, as 3 H singlets), and three methoxyl groups (δ 3.36 as 3 H singlet and δ 3.28 as 6 H singlet). The C-1 proton signal is a multiplet at δ 3.83, consistent with a boat conformation for ring A.

Oxidation of delphisine with Cornforth reagent (CrO$_3$–Py–H$_2$O) gave 1-ketodelphisine (**2**) (C$_{28}$H$_{41}$NO$_8$), mp 171°, ν_{max} 1745, 1725 (OAc), 1690 cm^{-1} (six-membered ketone), with no OH absorption. Delphisine was hydrolyzed by alkali to the corresponding triol **3** (C$_{24}$H$_{39}$NO$_6$) which crystallized readily from ether or acetone-hexane, mp 159-161°. In the infrared the latter showed a broad absorption band (3620-3000 cm^{-1}) with a sharp peak at 3515 cm^{-1} and a well-defined peak at 3290 cm^{-1} (no carbonyl absorption).

Delphisine yielded with acetic anhydride and pyridine, a crystalline triacetate (delphisine 1α-monoacetate) **4** (C$_{32}$H$_{45}$NO$_9$), mp 149-151°. The identical tricetate (ir, nmr, melting point, and mixture melting point) was also obtained by the hydrolysis of delphisine to triol **3**, followed by acetylation of the latter with acetic anhydride and p-toluenesulfonic acid.

By treatment with methyl iodide and sodium hydride in refluxing dioxane solution for 24 hr, delphisine was converted into 1,8,14-tri-O-methyldelphisine (**5**) (C$_{27}$H$_{45}$NO$_6$), mp 116-118°. Its ir spectrum showed no absorption in the hydroxyl region, while its nmr spectrum contained five sig-

nals in the region δ 3.31-3.45 corresponding to six methoxyl groups, and a triplet at δ 1.10 indicative of an N-ethyl group.

All simple derivatives of delphisine, with the exception of the 1,8,14-tri-O-methyldelphisine, were obtained under very mild experimental conditions. The spectral data, in each case, are consistent with the structure **1** established by crystallographic results.

Delphisine hydrochloride was prepared by treatment of an ethereal solution of the alkaloid with HCl gas. Clear tabular crystals were obtained from MeOH-Et$_2$O, mp 206-210° dec. Examination of the crystals on an Enraf-Nonius CAD-4 diffractometer (Cu Kα radiation) showed the crystals to be orthorhombic, space group $P2_12_12_1$, with cell dimensions $a = 13.866$ (1), $b = 22.27$ (1), and $c = 9.098$ (1) Å. Integrated intensities were measured for 3288 reflections to a limit of 150° 2θ, of which 2889 (87.9%) were observed at the 3σ level. The structure was solved by direct methods using the MULTAN[3] to select the best starting set of phases and using tangent refinement to determine phases for all normalized structure amplitudes greater than 1.3. Coordinates for 26 of the 38 non-hydrogen atoms were obtained directly from the $\bar{E}$-map, and the remaining atoms were located after least-squares refinement of the partial model. Further refinement, including C, N, O, and Cl atoms with anisotropic temperature factors and all hydrogen atoms with isotropic temperature factors, converged to a final R value of 0.040.[4] Ring D is in the boat conformation, flattened at C(15). Ring A is also in the boat form, stabilized by an intramolecular N-H$\cdots$O hydrogen bond. Application of Hamilton's test[5] to the R values based on both enantiomorphs has established the absolute configuration to a certainty in excess of 99.5%. The figure shows a stereo pair[6] of drawings of the delphisine hydrochloride molecule in the correct absolute configuration, which is in agreement with those previously established for lycoctonine,[7] aconitine,[8] and lappaconine.[9] Complete crystallographic details, including the atomic coordinates will be published later.[10]

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(10) NOTE ADDED IN PROOF. A referee suggested that Hamilton's test be supplemented by an examination of Friedel pairs. Intensity Measurements

were made on 56 reflections which were particularly sensitive to a change of enantiomorph $(|F_c (hkl)| > 20, |F_2 (hkl)| / |F_c (hkl)| > 1.05$ or $< 0.95)$. In all cases, the ratio of integrated intensities confirmed the original assignment of the absolute configuration.

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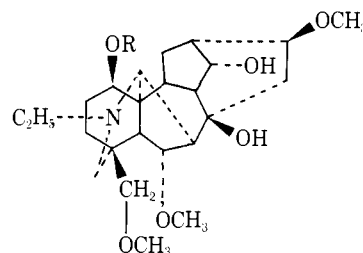
Structure of Neoline, Chasmanine, and Homochasmanine

Sir:

Neoline $(C_{24}H_{39}NO_6)$, mp 161°, was first isolated from amorphous aconitine by Freudenberg and Rogers.[1] Careful studies led Wiesner, *et al.,*[2] to assign structure **1**, with a C-1 α-hydroxyl, to the alkaloid. Marion, *et al.,*[3] subsequently correlated neoline with chasmanine, an alkaloid reported[4,5] to have structure **3**, and, on this basis, assigned structure **4**, with a C-1 β-hydroxyl, to neoline.

In the accompanying communication[6] we have described the isolation of a new alkaloid, delphisine, from the seeds of *Delphinium staphisagria* and the assignment of its structure as **5** by an X-ray crystallographic analysis of the hydrochloride. Delphisine has, by three routes, been converted to a pair of C-1 epimers, **1** and **4** Scheme I. Also mild hydrolysis of delphisine affords epimer **1**, which by exhaustive comparison, *is identical with neoline.* This correlation of neoline with delphisine demonstrates that Wiesner's original structural assignment[2] **1** for neoline is correct and that the revised structure **4**[3] is the fact in error. Also the
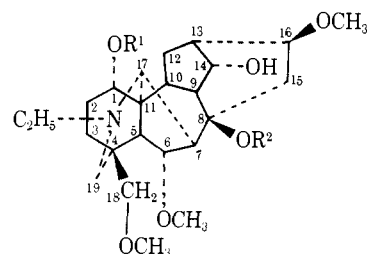
1, $R^1 = R^2 = H$
2, $R^1 = CH_3$; $R^2 = H$
9, $R^1 = R^2 = CH_3$

3, $R = CH_3$
4, $R = H$

structures of chasmanine and homochasmanine must now be revised to **2** and **9**, respectively.

Oxidation of delphisine **5** $(C_{28}H_{43}NO_8)$ with Cornforth reagent (CrO_3-Py-H_2O) afforded 1-ketodelphisine[7] (**6**), mp 171°, which was subsequently hydrolyzed with alkali to the 1-keto-8,14-diol derivative **7** $(C_{24}H_{37}NO_6)$, mp 150–152°. The latter also was prepared from delphisine **5** by the reverse procedure. Hydrolysis of **5** to the corresponding triol

Scheme I