dimethyl orientation as in structure 2 provides a constitutional arrangement consistent with the long range coupling between the equatorial H_{3e} and the vinyl CH_3.[9] The J's between H_5 and the adjacent $-CH_2-$ are consistent with an equatorial Cl at C_5. Carbon chemical shifts, especially in cyclohexane ring systems, are extremely sensitive to stereochemical factors.[8,10] Hence, in methylcyclohexane the axial methyl is shielded relative to the equatorial one by 6 ppm,[10a] and the methyl shielding in *cis*- and *trans*-9-methyldecalin differ by 12 ppm.[10b] The similarity of the shift position for the equatorial methyl in methylcyclohexane (24 ppm) and the equatorial quaternary methyl in 3 (27.4 ppm) vs. that of the quaternary methyl in 2 (30.3 ppm) suggests its stereochemistry to be equatorial.[11]

Chemical conformation of the proposed structure of 2 was provided by aromatization of 2 to (*E*)-1-chloro-2-(2,4-dimethylphenyl)ethylene (4) by 1,5-diazobicyclo[5.4.0]undec-5-ene (DBU) in THF. Compound 4 was treated with O_3 to yield 2,4-dimethylbenzaldehyde (5) which was in turn prepared directly from commercial 2,4-dimethylbenzoic acid (6).[12]

We have observed by GC/MS five isomers of formula $C_{10}H_{13}Cl_3$ from various collections of *P. violaceum*. Comparative mass spectral data [especially intense fragmentation to an aromatic nucleus $(C_{10}H_{11})^+$, *m/e* 131] indicates that four of the uncharacterized $C_{10}H_{13}Cl_3$ isomers probably have a trialkyl six-membered ring with no points of geminate alkyl substitution.[13] Thus, plocamene B may be just the first representative of a host of nonisoprenoid monoterpenes from red alga. Migration of methyl from C_1 or vinyl from C_2 are the simplest possibilities to link plocamene B to the isoprenoid biosynthetic manifold. The nucleus of the former precursor, however, represents an uncommon tail-to-tail isoprenoid arrangement, and there are, as yet, no literature examples of the carbon constitution of this envisioned precursor.[14]

Acknowledgment. We thank Professor I. Abbott (Hopkins Marine Station) for guidance in alga identification. Mr. Dennis Taylor (Finnigan Corp.) kindly provided GC/MS data, and Professor R. Wing (UCR) provided the 300-MHz NMR spectra. We also thank the UCSC Committee on Research for support of this research.

Supplementary Material Available. The GC/MS traces showing halomonoterpene distribution of *P. violaceum* from two different intertidal locations north of Santa Cruz will appear following these pages in the microfilm edition of this volume of the journal. Photocopies of the supplementary material from this paper only or microfiche (105 × 148 mm, 24× reduction, negatives) containing all of the supplementary material for the papers in this issue may be obtained from the Business Office, Books and Journals Division, American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036. Remit check or money order for $4.00 for photocopy or $2.50 for microfiche, referring to code number JOC-75-2568.

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(11) It would appear that only a small chemical shift difference should be observed for a CH_3 geminate to a vinyl vs. geminate to a Cl. Compare Tables 3.7 and 3.18 of ref 8.
(12) (a) Purchased from Aldrich Chemical Co. (b) The physical properties of 4 and 5 were consistent with their structures.
(13) Based upon comparison of the individual mass spectral data from our lab; however, see also ref 5.
(14) The biosynthesis of head-to-head terpenes has recently been investigated: (a) R. M. Coates and W. H. Robinson, *J. Am. Chem. Soc.*, **94**, 5921 (1972); (b) C. D. Poulter, O. J. Muscio, C. J. Spillner, and R. G. Goodfellow, *ibid.*, **94**, 5923 (1972).

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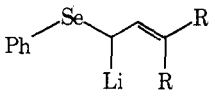
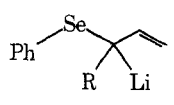
Organoselenium Chemistry. Synthetic Transformations Based on Allyl Selenide Anions[1]

Summary: Enones and allyl alcohols are formed when substituted allyl selenides, prepared by alkylation or silylation of allyl selenide anions, are oxidized.

Sir: Lithium reagents derived from allyl sulfides,[2,3a] sulfoxides,[3] sulfones,[4] phosphonates,[5] ethers,[6a,b] and amines[6c,d] have been used to perform useful synthetic transformations. We have been exploring the chemistry of α-lithio selenoxides and selenides[7,8] and report here preliminary results on the deprotonation of a variety of allyl selenides, their reaction with representative electrophiles, and some transformations of these alkylation products. Alkyllithium reagents can rarely be used for the deprotonation of selenides or selenoxides since extensive cleavage reactions often occur.[7,8] We have found lithium diisopropylamide (LDA) in tetrahydrofuran a useful base for this purpose. In sterically hindered situations lithium diethylamide is superior.

The lithium reagents 1–5 are formed using LDA in tetrahydrofuran under the conditions indicated. β-Methylallyl



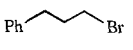
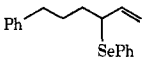
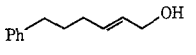
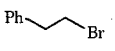
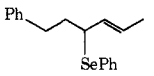
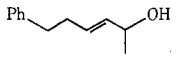
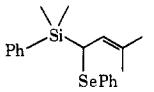
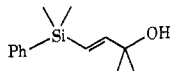
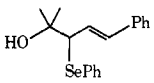
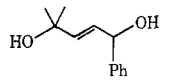
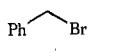
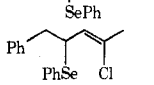
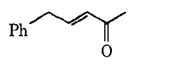
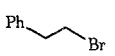
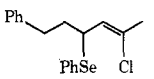
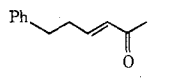
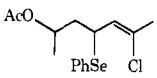
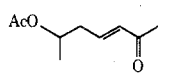
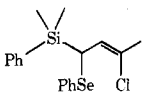
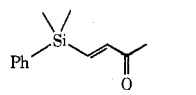


R	Conditions
1 H,H	−78°, <10 min
2 CH_3,H	−78°, 20 min
3 CH_3,CH_3	0°, 20 min
4 Ph,H	−78°, <5 min
5 CH_3,Cl	−78°, <5 min

6a, R = $Si(CH_3)_3$
b, R = CH_3

phenyl selenide can also be deprotonated and the anion behaves quite similarly to 1. Attempts to extend the procedure to α-substituted allyl anions (6) have been successful only for the α-trimethylsilyl derivative **6a**, which can be

Table I
Transformation of Phenylselenoallyllithium Reagents to Allylic Alcohols and Enones by Alkylation and Subsequent Oxidation

Anion	Electrophile	Selenide[a]	Product[b]	Yield, %[c]
1				68
2				80
3	$(CH_3)_2PhSiCl$			74
4				55
5				70
5				85
5				80[d]
5	$(CH_3)_2PhSiCl$			63

[a] The selenides from 2 and 5 were mixtures of geometric isomers. Small amounts of γ-alkylation products were also formed. [b] All compounds were adequately characterized by spectral methods. [c] Yields are for material isolated by preparative thin layer chromatography. [d] The crude reaction mixture from 5 and propylene oxide was treated with excess acetic anhydride.

formed by deprotonation of the selenide using lithium diethylamide[9] (less hindered bases such as lithium isobutylamide result in desilylation). α-Methylallyl phenyl selenide is not cleanly deprotonated to **6b** under conditions we have tried.

The anions **1–5** are powerful nucleophiles; the reactions with the electrophiles shown in Table I were carried out at −78° and were complete in <15 min. Secondary halides also react, but higher temperatures and/or longer reaction times are required. The problem of α vs. γ alkylation is similar to that found for the related sulfur systems.[2a,3a] Alkylation usually occurs predominantly α (~80% for **1**, >90% for **2** and **3**, ~50% for **4**; γ-alkylation products for **5** appear to be formed to a small extent, but these are usually rather unstable). Other electrophiles such as chlorosilanes or carbonyl compounds give more variable α/γ ratios with **1**: trimethylchlorosilane (82/18), dimethylphenylchlorosilane (41/59), acetophenone (15/85). The γ-substitution products are usually a 1:1 mixture of *E:Z* isomers.

A solution to the problem of γ alkylation for allyl sulfide anions has been found through the use of substituent groups on sulfur having chelating potential.[2b–d,3a] For example, much improved α/γ ratios were observed for the anions of 2-pyridyl allyl sulfide when compared with the phenyl analog. Unfortunately the lithium reagent prepared by deprotonation of 2-pyridyl allyl selenide[10] does not give increased α/γ ratios (70/30 for methyl iodide, 60/40 for trimethylchlorosilane). This may be because complexation with the diisopropylamine present prevents the chelation with the pyridine nitrogen.[11]

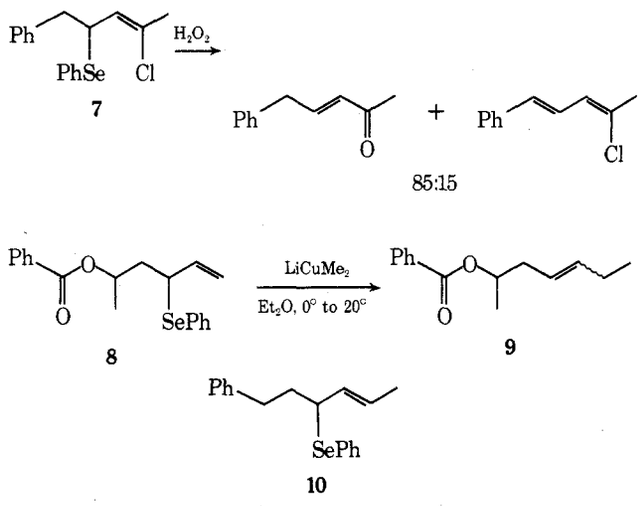
Transformations of the alkylation products of functionalized allyl anions are of several types. Allyl sulfides,[2a–f] sulfones,[4] and phosphonates[5] have been reductively cleaved; allyl vinyl sulfides[2i–j] and dithiocarbamates[2k–l] undergo [3.3] sigmatropic rearrangements; and allyl sulfoxides undergo reversible [2.3] sigmatropic rearrangements. Evans has developed the last reaction into a versatile synthesis of allylic alcohols.[3]

Table I lists a number of transformations involving [2.3] sigmatropic shifts of allyl selenoxides.[12] In all cases selenides were oxidized using the two-phase pyridine buffered hydrogen peroxide/dichloromethane procedure (15 min at 25°)[13] previously described.[14,15] This procedure is convenient and results in clean rearrangement of the intermediate selenoxide giving eventually an allylic alcohol. Excess oxidant is used so that no volatile selenium-containing compounds remain after oxidation, and no trapping agent to cleave the allyl selenenate is needed. Selenium appears as benzeneseleninic acid which is removed by extraction (and can be reduced back to diphenyl diselenide in high yield).

The anion **5** is formed rapidly even at −100°, attesting to the substantial acidifying effect of chlorine (compare with **3**). Alkylation of **5** with primary halides proceeds cleanly and in high yield at −78°. Not surprisingly, **5** is rather unstable. It is decomposed significantly after 30 min at −78° in THF so that alkylation with secondary bromides or epoxides does not occur in acceptable yields. Oxidation of the alkylation products of **5** by the usual two phase H_2O_2/CH_2Cl_2 procedure leads cleanly and in high yield to enones. The starting selenide is prepared from the readily available 1,3-dichloro-2-butene by nucleophilic displacement with PhSeNa. Transformations using **5** are similar to the α,β-unsaturated aldehyde synthesis based on 1,3-bis(methylthio)allyllithium developed by Corey, Erickson, and Noyori.[2g] Lansbury and Rhodes[16] have reported that 3-chloro-2-buten-1-yl sulfoxide and amine oxide rearrange readily to give methyl vinyl ketone.

The allyl selenoxide [2.3] shift proceeds more rapidly than selenoxide syn elimination[17] or "sila-Pummerer" rearrangement.[18] A small amount of diene (12% yield) is formed upon oxidation of **7**. Here elimination is enhanced by the phenyl substituent, and the [2.3] shift is probably slowed down by the γ substituents.

We have observed that allyl selenides such as **8** react with lithium dimethylcuprate above 0° to give product in



which methyl has replaced phenylseleno.[19] The transformation of 8 to 9 proceeds with allylic rearrangement giving a mixture of cis and trans isomers. The route from 1 to 8 to 9 results in overall 1,3 disubstitution of an allyl fragment, first by an electrophile, then by a nucleophile. Cinnamyl phenyl selenide gives unrearranged olefin (1-phenyl-1-butene, 65%) upon treatment with dimethylcuprate in ether. Alkylation products of phenyl crotyl selenide (i.e., 10) undergo reaction with dimethylcuprate sluggishly, and the reaction is likely to be limited to the less highly substituted allyl selenides such as 8. Aryl selenides with electron-attracting substituents may undergo more facile displacements by cuprate, and we are exploring this possibility.

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(1) These results were presented in part at the American Chemical Society Midwest Regional Meeting, Iowa City, Iowa, Nov 8, 1974.
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Synthesis and Stereochemistry of (±)-3′,4′-Dihydrousambarensine

Summary: A total synthesis of (±)-3′,4′-dihydrousambarensine has been carried out which confirms the structure and defines the stereochemistry of the alkaloid as **2a.**

Sir: Largely on the basis of spectral data,[1] formulas **1** and **2** were recently suggested for the *Strychnos usambarensis* alkaloids, usambarensine and 3′,4′-dihydrousambarensine. However, no stereostructures have been assigned to these substances, all unusual, indole analogs of the more familiar Ipecacuanha type, which possess isoquinoline rings as the heterocyclic entities. Using totally synthetic starting material of secure stereochemistry, namely, methyl (±)-geissoschizoate (**3a**),[2] we have carried out the first synthesis of 3′,4′-dihydrousambarensine, which not only establishes the gross structure but also defines the geometry and chirality of the natural product as indicated in **2a.**[3]

(±)-Geissoschizoic acid, prepared by saponification of methyl (±)-geissoschizoate (**3a**), was condensed with tryptamine in the presence of dicyclohexylcarbodiimide (dimethoxyethane–dimethylformamide at room temperature) to give tryptamide **4a.** Cyclization of the latter by means of $POCl_3$ in $CHCl_3$ provided, after preparative TLC, (±)-dihydrousambarensine (**2a**), indistinguishable from the natural product on the basis of TLC, uv, ir, and NMR as well as high resolution mass spectral comparisons. That no inversion occurred at the potentially epimerizable center C-3 during the synthesis of (±)-**2a** was substantiated by the result of a parallel series starting with methyl (±)-epigeissoschizoate (**3b**). After successive treatment of this ester with boron tribromide[4] and tryptamine in dichloromethane–benzene, tryptamide **4b** was obtained. On $POCl_3$–$CHCl_3$ cyclization, the amide **4b** generated base **2b,** isomeric with, but different from, natural 3′,4′-dihydrousambarensine, on the basis of TLC and ir spectral properties. In view of the foregoing, the stereochemistry of **3a** corresponds to that of synthetic (±) base **2a,** which accordingly must possess the cis relationship for C-3 and C-15 as well as for the olefinic methyl (C-18) and the C-15 center.

Obviously derived biogenetically from two tryptamine