systems. Application of this methodology to natural product synthesis are underway.

Acknowledgment. The generous financial support of the National Institutes of Health (GM 39815) and an unrestricted grant from Lederle Laboratories is acknowledged. We wish to thank Drs. Rick Sidler and Robert Waltermire for helpful discussions during the course of this investigation and Professors Kenji Mori (Tokyo University) and Chuzo Iwata (Osaka University) for providing spectral data of the pheromones.

Supplementary Material Available: Experimental procedures and spectral data for compounds 3-18 are provided (7 pages). Ordering information is given on any current masthead page.

Construction of the Tricyclic Core of the Marine Alkaloid Sarain A

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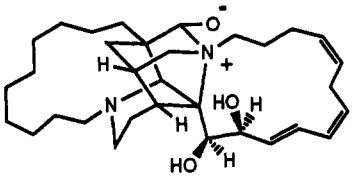
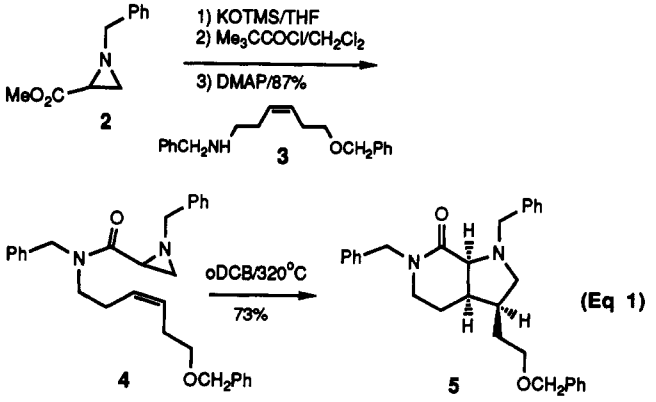
Summary: The alkaloidal nucleus of sarain A (1) has been synthesized by a short route involving a [3 + 2] azomethine ylide cycloaddition and an allylsilane/*N*-sulfonyliminium ion cyclization as key steps.

Sarain A (1) is a recently discovered polycyclic alkaloid produced by the marine sponge *Reniera sarai*.[1] The structure of sarain A was secured by X-ray crystallography on the diacetate derivative[1a] and by spectral studies on the alkaloid itself.[1b] The central alkaloidal nucleus of 1 possesses a unique structural array unprecedented in natural products. In this communication we describe the first synthetic approach to the tightly fused tricyclic core of sarain A.



1

Our synthesis began with readily available aziridine ester 2[2] which was converted to the potassium carboxylate[3] and coupled via a mixed anhydride procedure[4] with amine 3[5] to afford amide 4 (eq 1). Thermolysis of 4 in *o*-dichlorobenzene at 320 °C in a degassed sealed tube gave bicyclic lactam 5 stereospecifically via an azomethine ylide/olefin [3 + 2] dipolar cycloaddition.[2,6,7] It should be noted that the nature of the protecting groups in precursor 4 proved critical to the cycloaddition. For example, protection of the side-chain oxygen as a TBS ether led to the corresponding cycloadduct in very low yield.[8] Similarly, if the amide nitrogen of 4 is unprotected[9] (i.e., NH) or is *N*-tosyl, yields of cycloadducts were again low.



(Eq 1)

Scheme I outlines the route used to process lactam 5 into a precursor for the remaining key cyclization. A notable step here involves coupling of the acetate 7 with a mixed silyl cuprate[10a] to produce the allylsilane 8 as a 1:1 mixture of *E*/*Z* isomers. Attempts to prepare silane 8 by the more standard Seyferth-Wittig[10b] procedure directly from aldehyde 6 afforded only complex mixtures. The mixture of allylsilanes was converted in two steps to *N*-tosyl lactam 9[11] which could be cleanly reduced to α-hydroxysulfonamide 10 using DIBALH.

(1) (a) Cimino, G.; Mattia, C. A.; Mazzarella, L.; Puliti, R.; Scognamiglio, G.; Spinella, A.; Trivellone, E. *Tetrahedron* **1989**, *45*, 3863. (b) Cimino, G.; Scognamiglio, G.; Spinella, A.; Trivellone, E. *J. Nat. Prod.* **1990**, *53*, 1519.

(2) DeShong, P.; Kell, D. A.; Sidler, D. R. *J. Org. Chem.* **1985**, *50*, 2309.

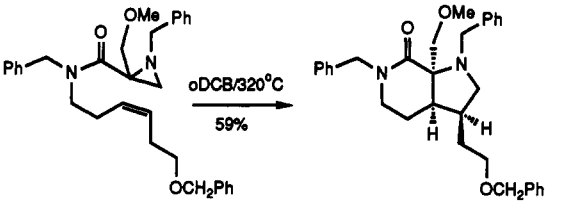
(3) Laganis, E. D.; Chenard, B. L. *Tetrahedron Lett.* **1984**, *25*, 5831.

(4) Lambert, C.; Viehe, H. G. *Tetrahedron Lett.* **1985**, *26*, 4439.

(5) (a) Sisko, J., Ph.D. Thesis, The Pennsylvania State University, 1991. (b) Compound 3 was prepared via a straightforward route from methyl 6-[(2-tetrahydropyranyl)oxy]-(*Z*)-hex-3-enoate (Carvalho, J. F.; Prestwich, G. D. *J. Org. Chem.* **1984**, *49*, 1251). Details will be provided in a full paper.

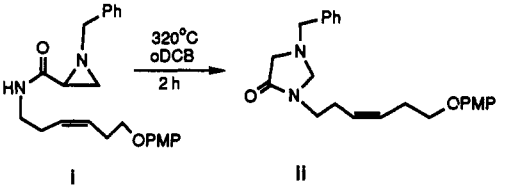
(6) Takano, S.; Iwabuchi, Y.; Ogasawara, K. *J. Am. Chem. Soc.* **1987**, *109*, 5523. Takano, S.; Iwabuchi, Y.; Ogasawara, K. *J. Chem. Soc., Chem. Commun.* **1988**, 1204. Takano, S.; Tomita, S.; Iwabuchi, Y.; Ogasawara, K. *Heterocycles* **1989**, *29*, 1473.

(7) In order to introduce a functional handle for eventual construction of the triene diol macrocyclic ring of 1, we have successfully tested the following dipolar cycloaddition (J. R. Henry):



(8) We are grateful to Professor Kunio Ogasawara for informing us of similar unpublished observations on related cycloadditions.

(9) Thermolysis of amide i gave only a small amount of the desired cycloadduct and rearrangement product ii was the major product.[5a]



i ii

(10) (a) Fleming, I.; Newton, T. W. *J. Chem. Soc., Perkin Trans. 1* **1984**, 1805. (b) Seyferth, D.; Wursthorn, K. R.; Lim, T. F. O.; Sepelak, D. J. *J. Organomet. Chem.* **1979**, *181*, 293.

(11) Cf. Somfai, P.; He, H. M.; Tanner, D. *Tetrahedron Lett.* **1991**, *32*, 283.

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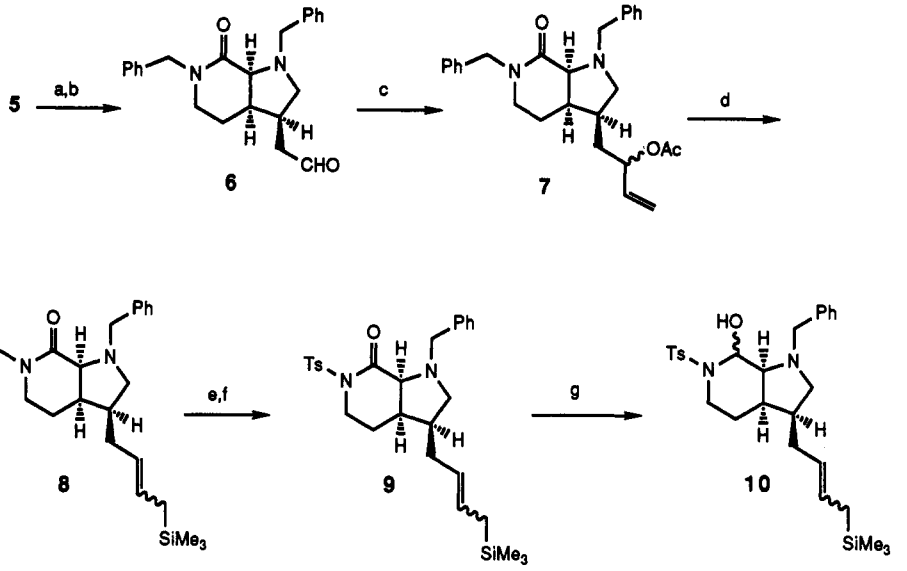
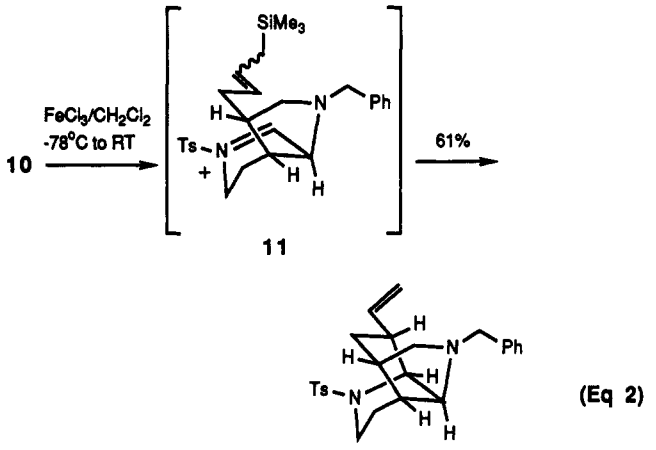
Scheme I[a]



[a] (a) $BBr_3/CH_2Cl_2/0$ °C; (b) Swern oxidation; (c) CH_2=CHMgBr/THF/0 °C to rt; $Ac_2O/NEt_3/DMAP/CH_2Cl_2$ 35% from 5; (d) $(TMS)_2(CN)Li_2Cu$/THF:HMPA (2:1)/-25 °C/50%; (e) Na/NH_3/tBuOH/THF/-78 °C/95%; (f) TsCl/LiHMDS, THF/DMAP/71%; (g) DIBALH/CH_2Cl_2/-78 °C to rt/93%.

The crucial cyclization of 10 could be effected in 61% yield by using anhydrous ferric chloride to afford tricyclic compound 12 as a single stereoisomer (eq 2). For reasons



(Eq 2)

we cannot explain, other Lewis acids (e.g., $TiCl_4$, $BF_3{\cdot}Et_2O$) gave complex product mixtures containing little, if any, 12. This cyclization probably occurs via *N*-sulfonyliminium intermediate 11, which has the allylsilane group in a quasi-equatorial position.[12] It should be noted that although allylsilane cyclizations onto *N*-acyliminium species are now well documented,[13] examples of analogous *N*-sulfonyliminium ion cyclizations are apparently unknown.[14] We are currently investigating the utilization of the approach outlined here in a total synthesis of sarain A (1).

Acknowledgment. This work was supported by the National Institutes of Health (GM-32299).

Supplementary Material Available: Experimental and spectral data for all new compounds and ^1H and ^{13}C NMR spectra and NOE data for cyclization product 12 (9 pages). Ordering information is given on any current masthead page.

(12) The stereochemistry of cyclization product 12 was established by NOE experiments, for which we thank Drs. A. Freyer and A. Benesi. (See supplementary material.)

(13) For reviews, see: Speckamp, W. N.; Hiemstra, H. *Tetrahedron* **1985**, *41*, 4367. Hiemstra, H.; Speckamp, W. N. In *The Alkaloids*; Brossi, A., Ed.; Academic Press: San Diego, 1988; Vol. 32, p 271. See also: Gramain, J.-C.; Remuson, R.; *Heterocycles* **1989**, *29*, 1263.

(14) For intermolecular additions of allylsilanes to *N*-tosyliminium species, see: Shono, T.; Matsumura, Y.; Uchida, K.; Nakatani, F. *Bull. Chem. Soc. Jpn.* **1988**, *61*, 3029. Ralbovsky, J. L.; Kinsella, M. A.; Sisko, J.; Weinreb, S. M. *Synth. Commun.* **1990**, *20*, 573. Shono, T.; Matsumura, Y.; Katoh, S.; Takeuchi, K.; Sasaki, K.; Kamada, T.; Shimizu, R. *J. Am. Chem. Soc.* **1990**, *112*, 2368.

Highly Diastereoselective S_E' Additions of Enantioenriched Allenylstannanes to (*S*)-2-(Benzyloxy)propanal

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Summary: The BF_3-promoted addition of (*S*)-allenylstannane (*S*)-6 to aldehyde 16 afforded a 68:32 mixture of diastereomeric homopropargylic alcohols 17 and 18 whereas $MgBr_2$-promoted addition gave adduct 17 as the exclusive product. The (*R*)-allenylstannane (*R*)-6, on the other hand, yielded a 30:1 mixture of syn and anti alcohol adducts 19 and 20 with $BF_3{\cdot}OEt_2$ and a 1:92 mixture favoring the anti adduct 20 under $MgBr_2$ catalysis.

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