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in **6**, the addition of two F^- ions per Sn would require that the metal ions become seven-coordinate, which is unlikely.[9] Moreover, the spectrum of **7** shows a normal porphyrazine Soret band B, indicating that the Sn–N bond is broken. Therefore, we tentatively suggest that the addition of F^- causes the tin atoms to undergo a linkage isomerization and move to the bidentate dithiolene site, where each tin atom could easily accommodate two additional F^- ligands in an octahedral geometry. In support of this, the Q peak of **7** is blue-shifted, split, and broadened, indicating a stabilization of the porphyrazine a_2 MO through a stronger perturbation at the pyrrole rings.

It is clear from these observations that peripheral metalation of porphyrinic macrocycles has a profound influence on the properties of these compounds. Additional investigations of these novel *star*-porphyrazines will be published in due course.

Acknowledgment. We thank Dr. Shawn Van Wallendael for preliminary observations in this work. This work has been supported by the National Science Foundation (Grant DMR-8818599 to B.M.H.) and by the Camille and Henry Dreyfus Foundation (Teacher-Scholar Award to A.G.M.B.).

Supplementary Material Available: Tables of fractional coordinates, thermal parameters, and intramolecular bond distances and angles for $6\cdot(C_7H_8)\cdot 1.25(CH_2Cl_2)$ and analytical data (microanalysis, melting point, NMR, optical spectrum, and FAB-MS) on compounds **2–4**, **3a**, and **6** (10 pages). Ordering information is given on any current masthead page.

(9) Cotton, F. A.; Wilkinson, F. *Advanced Inorganic Chemistry*, 5th ed.; J. Wiley and Sons: New York, 1989.

Transannular Diels–Alder Route to Systems Related to Dynemicin A

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The enediyne-containing antibiotics[1-4] have been the subject of many recent research efforts owing to their remarkable properties.[5] Reported herein are synthetic pathways that provide facile access to molecules equipped with many of the structural features that are characteristic of the most recently discovered member of this class, dynemicin A (**1**).

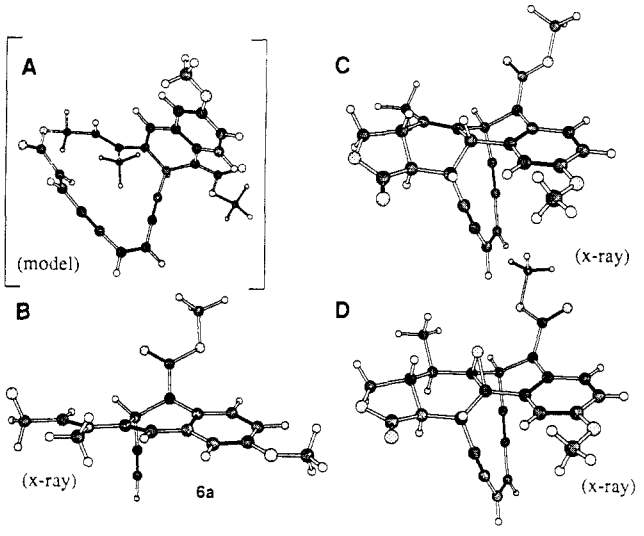
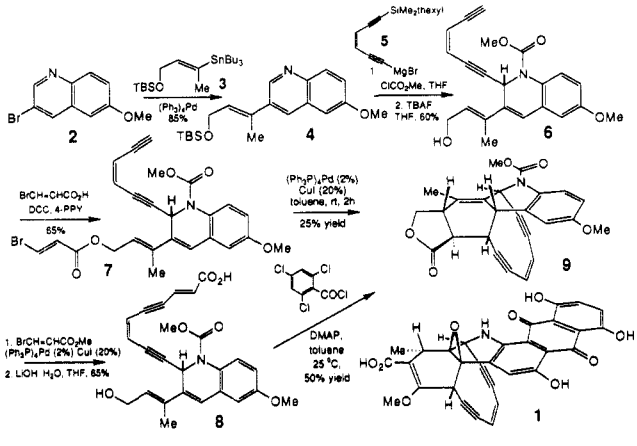


Figure 1. (A) Model of presumed macrolactone intermediate. X-ray structures of (B) trisubstituted quinoline **6a**, (C) polycyclization product **9**, and (D) epoxide **13**.

Scheme I



The bicyclic ring systems of the esperamicin and calicheamicin aglycons have been synthesized by a Diels–Alder based strategy, but not without the use of a pinacol reaction that rearranges the isomeric skeleton that was initially obtained.[6] A new Diels–Alder based strategy that reverses the previously observed regiochemistry and results in a remarkably facile polycyclization route to dynemicin-type molecules is illustrated in Scheme I. A Stille coupling reaction[7] of 3-bromo-6-methoxyquinoline[8] (**2**) and vinylstannane[9] **3** resulted in the formation of the 3-alkenylquinoline **4** (85% yield). Application of the Yamaguchi protocol[10] for the 1,2-addition of acetylide anions to pyridinium salts with quinoline **4** proved highly successful. In situ generation of the quinolinium salt of **4** with methyl chloroformate, addition of the bromomagnesium salt **5**,[11] and subsequent silyl deprotection (TBAF,

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(1) Neocarzinostatin chromophore: Koide, Y.; Ishii, F.; Hasuda, K.; Koyama, Y.; Edo, K.; Katamine, S.; Kitame, F.; Ishida, N. *J. Antibiot.* **1980**, *33*, 342.

(2) Esperamicins: (a) Golik, J.; Clardy, J.; Dubay, G.; Groenewold, G.; Kawaguchi, H.; Konishi, M.; Kirshnan, B.; Ohkuma, H.; Saitoh, K-i.; Doyle, T. W. *J. Am. Chem. Soc.* **1987**, *109*, 3461. (b) Golik, J.; Dubay, G.; Groenewold, G.; Kawaguchi, H.; Konishi, M.; Kirshnan, B.; Ohkuma, H.; Saitoh, K-i.; Doyle, T. W. *J. Am. Chem. Soc.* **1987**, *109*, 3462.

(3) Calicheamicins: (a) Lee, M. D.; Dunne, T. S.; Siegel, M. M.; Chang, C. C.; Morton, G. O.; Borders, D. B. *J. Am. Chem. Soc.* **1987**, *109*, 3464. (b) Lee, M. D.; Dunne, T. S.; Chang, C. C.; Ellestad, G. A.; Siegel, M. M.; Morton, G. O.; McGahren, W. J.; Borders, D. B. *J. Am. Chem. Soc.* **1987**, *109*, 3466. (c) Lee, M. D.; Manning, J. K.; Williams, D. R.; Kuck, N. A.; Testa, R. T.; Borders, D. B. *J. Antibiot.* **1989**, *42*, 1070.

(4) Dynemicins: (a) Konishi, M.; Ohkuma, H.; Matsumoto, K.; Tsuno, T.; Kamei, H.; Miyaki, T.; Oki, T.; Kawaguchi, H.; VanDuyne, G. D.; Clardy, J. *J. Antibiot.* **1989**, *42*, 1449. (b) Konishi, M.; Ohkuma, H.; Tsuno, T.; Oki, T.; VanDuyne, G. D.; Clardy, J. *J. Am. Chem. Soc.* **1990**, *112*, 3716.

(5) Synthesis: Wender, P. A.; McKinney, J. A.; Mukai, C. *J. Am. Chem. Soc.* **1990**, *112*, 5369 and references cited therein. Mechanism: De Voss, J. J.; Hangeland, J. J.; Townsend, C. A. *J. Am. Chem. Soc.* **1990**, *112*, 4554 and references cited therein.

(6) Schoenen, F. J.; Porco, J. A., Jr.; Schreiber, S. L.; VanDuyne, G. D.; Clardy, J. *Tetrahedron Lett.* **1989**, *30*, 3765. For a correction of the regiochemistry of the originally reported (Schreiber, S. L.; Kiessling, L. L. *J. Am. Chem. Soc.* **1988**, *110*, 631) Diels–Alder reaction, see: Schreiber, S. L.; Kiessling, L. L. *Tetrahedron Lett.* **1989**, *30*, 433.

(7) (a) McKean, D. R.; Parrinello, G.; Renaldo, A. F. (b) Stille, J. K. *J. Org. Chem.* **1987**, *52*, 422. (c) Stille, J. K. *Angew. Chem. Int. Ed. Engl.* **1986**, *25*, 508.

(8) Zymalkowski, F.; Tinapp, P. *Justus Liebigs Ann. Chem.* **1966**, *699*, 98.

(9) Prepared from 2-butyn-1-ol in two steps: (a) Bu_3SnCu, THF, MeOH, −78 °C (2 h), 52%; (b) TBSCl, imidazole, CH_2Cl_2, 95%. Cf.: Piers, E.; Chong, J. M. *J. Chem. Soc., Chem. Commun.* **1983**, 934. For a similar regiochemical outcome, see: Nozaki, K.; Wakamatsu, K.; Nonaka, T.; Tückmantel, W.; Oshima, K.; Utimoto, K. *Tetrahedron Lett.* **1986**, *27*, 2007.

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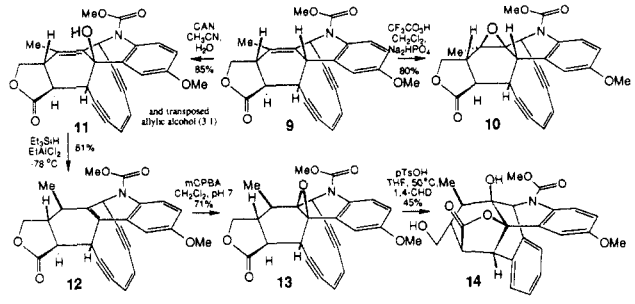
Scheme II



THF) resulted in the trisubstituted dihydroquinoline derivative **6** in 60% overall yield. An X-ray crystallographic analysis of a related heterocycle **6a** (mp 151-152 °C), prepared by a similar reaction sequence, provided evidence for the 2,3,6-trisubstitution pattern and revealed the axial orientation of the acetylene moiety, as anticipated on consideration of allylic ($A^{(1,3)}$) strain[12] that would exist with the equatorially disposed conformer (Figure 1B).[13] Such an orientation was considered desirable for subsequent cyclization reactions. Next, **6** was converted to the cyclization substrates **7** and **8** by carbon-oxygen and carbon-carbon coupling processes, respectively.

Subjection of **7** to the Sonogashira[14] coupling conditions or **8** to the Yamaguchi macrolactonization protocol[15] was hoped to afford the corresponding macrolactone (Figure 1A). Instead, both reactions provided, at room temperature, the product of an apparent transannular Diels-Alder reaction (**9**).[16] Verification of structure followed X-ray crystallographic analysis (Figure 1C) and revealed the bending of the ring acetylenes that is characteristic of the enediyne antibiotics.[13] In contrast to the transannular Diels-Alder reaction, attempted intramolecular Diels-Alder reaction of the methyl ester, *tert*-butyldimethylsilyl ether of **8** failed entirely; slow decomposition occurred instead at temperatures above 180 °C.

Having secured a simple and efficient route to the target dynemicin A model system, we next investigated preliminary functionalization reactions of **9**. An epoxide trigger to the acetylene coupling (Bergman) reaction was installed by the reaction of **9** with anhydrous trifluoroperacetic acid in CH_2Cl_2, which afforded **10** in 80% yield. Translocation of the dynemicin-type epoxide to a calicheamicin-type epoxide (as found in **10**) results in a thermally activatible substrate for the Bergman reaction; the details of this process will be reported elsewhere. In order to examine the positional epoxide isomer found in dynemicin A, isomerization of the tetrasubstituted olefin was required. This was achieved by the oxidation-reduction sequence shown in Scheme II. Benzylic hydroxylation of **9** with ceric ammonium nitrate provided a mixture of **11** and an allylic alcohol isomer (3:1 ratio) in 85% yield. Reaction of either the individual isomers or the 3:1 mixture with Et_3SiH and $EtAlCl_2$ provided a 61% yield of **12** and **9** in an 8:1 ratio. Epoxidation of **12** with mCPBA in a buffered medium resulted in the formation of the stable dynemicin-like epoxide **13**, whose structure was confirmed by X-ray diffractometry (Figure 1D), in 71% yield. Treatment of **13** with pTsOH and 1,4-cyclohexadiene in THF (50 °C, 10 h) resulted in the predominant formation of **14** (45%), which has undergone epoxide ring opening, Bergman aromatization, and translactonization.

The transannular Diels-Alder reaction appears well suited to access structures related to the enediyne family of natural products. Efforts to extend this research are now underway.

Acknowledgment. We thank the NIGMS (GM-40883 awarded to S.L.S.) and the NCI (CA-24487 awarded to J.C.) for financial support and the Division of Organic Chemistry of the American Chemical Society (sponsored by Pfizer, Inc., in support of J.A.P., Jr.) and the NIH (CA-08506, in support of F.J.S.) for fellowships. The assistance of Dr. H. Chikashita is gratefully acknowledged.

Supplementary Material Available: Spectral data (^1H NMR, ^{13}C NMR, IR, and MS) for compounds **9**, **10**, and **12-14** and crystallographic data for compounds **6a**, **9**, and **13** including experimental details, atomic coordinates and thermal parameters, bond distances and angles, and torsional angles (41 pages). Ordering information is given on any current masthead page.

(11) Prepared by the following reaction sequence: (a) *cis*-1,2-dichloroethylene, $Pd(PPh_3)_4$ (5%), (thexyldimethylsilyl)acetylene, $nPrNH_2$, CuI (15%), benzene, 75%; (b) (trimethylsilyl)acetylene, $Pd(PPh_3)_4$ (5%), $nPrNH_2$, CuI (15%), benzene, 93%; (c) $AgNO_3$, EtOH, H_2O; KCN (80%); (d) BuLi (-78 °C); $MgBr_2$-Et_2O (0 °C).

(12) Johnson, F. *Chem. Rev.* **1968**, 375.

(13) Crystallographic parameters are provided in the supplementary material.

(14) Sonogashira, K.; Tohda, Y.; Hagihara, N. *Tetrahedron Lett.* **1975**, *16*, 4467.

(15) Inanaga, J.; Hirata, K.; Saeki, H.; Katsuki, T.; Yamaguchi, M. *Bull. Chem. Soc. Jpn.* **1979**, *52*, 1989. High concentrations of DMAP were employed. For example, see: (a) Tone, H.; Nishi, T.; Oikawa, Y.; Kikota, M.; Yonemitsu, O. *Chem. Pharm. Bull.* **1989**, *37*, 1167. (b) Hikota, M.; Tone, H.; Horita, K.; Yonemitsu, O. *J. Org. Chem.* **1990**, *55*, 7.

(16) Selected examples: (a) Cram. D. J.; Knox, G. R. *J. Am. Chem. Soc.* **1961**, *83*, 2204. (b) Wasserman, H. H.; Doumaux, A. R., *J. Am. Chem. Soc.* **1962**, *84*, 4611. (c) Bérubé, G.; Deslongchamps, P. *Can. J. Chem.* **1990**, *68*, 404 and references cited therein.

Synthesis and Characterization of Hexamethyltellurium(VI)

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Peralkylated derivatives of hexavalent transition metals, compounds such as $W(CH_3)_6$ and $Re(CH_3)_6$,[1] have been known for many years; however, the analogous main-group compounds, species like $Te(CH_3)_6$ or $Se(CH_3)_6$, have not been previously reported. Within the main-group elements, $Sb(CH_3)_5$ and $As(CH_3)_5$ have been well characterized[2,3] and a very few perfluoroalkyl and aryl Te(VI) polyfluorides have been prepared,[4] but until the very recent synthesis of $Te(CH_3)_4$,[5] even peralkylated derivatives of Te(IV) were unknown. We report the synthesis, isolation, and characterization of $Te(CH_3)_6$, the first peralkylated hexavalent derivative of one of the representative elements.

Synthesis of $TeF_2(CH_3)_4$.[6] Under an inert atmosphere, XeF_2,[7] 0.359 25 g (2.1220 mmol), was placed into a 10-mL flask that was equipped with a Teflon valve. The flask was degassed, and then $Te(CH_3)_4$, 0.319 65 g (1.7026 mmol), and dry CH_3CN, 5 mL, were added. The solution was stirred at -30 °C for 2 h and then at ambient temperature for 1 h. All of the materials volatile at 0 °C were removed, which left a white solid, $TeF_2(CH_3)_4$, 0.333 05 g (1.4754 mmol), 87%.

The mass spectral and NMR data for this new compound are contained in Tables I and II. Exact mass for the *m/e* 213 ion ($^{130}TeF_2(CH_3)_3^+$): calcd 212.9739, measd 212.9741; $\Delta_m/_m$ = 0.9

(1) Shortland, A. J.; Wilkinson, G. *J. Chem. Soc., Dalton Trans.* **1973**, 872. Galyer, L.; Mertis, K.; Wilkinson, G. *J. Organomet. Chem.* **1975**, *85*, C37. Mertis, K.; Wilkinson, G. *J. Chem. Soc., Dalton Trans.* **1976**, 1488.

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(5) Gedridge, R. W.; Harris, D. C.; Higa, K. T.; Nissan, R. A. *Organometallics* **1989**, *8*, 2817.

(6) All manipulations of compounds were carried out either in a glove bag or on a vacuum line. Chemical shifts were measured vs external TMS (^1H and ^{13}C), TFA (^{19}F), or $Te(CH_3)_2$ (^{125}Te).

(7) Williamson, S. M. *Inorg. Synth.* **1968**, *11*, 147.

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