Johnson-Matthey Metal Loan Program. The 360-MHz NMR spectra were obtained at the Colorado State University Regional NMR Center, funded by the National Science Foundation (Grant CHE-78-18581).

Registry No. 1, 41414-30-6; **2**, 72233-31-9; (*E*)-PhCH=CHI, 42599-24-6; (*E*)-*n*-BuCH=CHI, 16644-98-7; (*E*)-CH_3COCH=$C(CH_3)$I, 91897-71-1; (*Z*)-CH_3COCH=$C(CH_3)$I, 91897-72-2; $(CH_3)_2$C=CHI, 20687-01-8; $(CH_3)_2$C=CHCOCl, 3350-78-5; *n*-Bu_3SnCH=CH_2, 7486-35-3; (*E*)-*n*-Bu_3SnCH=CHMe, 66680-85-1; (*Z*)-*n*-Bu_3SnCH=CHMe, 66680-84-0; (*E*)-Me_3SnCH=CHMe, 4964-07-2; (*Z*)-Me_3SnCH=CHMe, 4964-06-1; (*E*)-*n*-Bu_3SnCH=CHPh, 66680-88-4; Me_3SnCH=CH_2, 754-06-3; (*E*)-Me_3SnCH=CHPh, 7422-28-8; (*Z*)-*n*-Bu_3SnCH=$CHCO_2Bn$, 86633-18-3; *n*-Bu_3SnPh, 960-16-7; (*E*)-*n*-Bu_3SnCH=$CHCO_2Bn$, 86633-19-4; *n*-Bu_3SnC≡C-*n*-Pr, 86633-17-2; *n*-Bu_3SnCH=$C(CH_3)_2$, 66680-86-2; (*E*)-PhCH=CHCOCH=CH_2, 73291-51-7; (*E*,*E*)-PhCH=CHCOCH=CHMe, 91897-73-3; (*Z*,*E*)-PhCH=CHCOCH=CHMe, 91897-74-4; (*E*,*E*)-PhCH=CHCOCH=CHPh, 35225-79-7; (*E*)-*n*-BuCH=CHCOCH=CH_2, 84118-55-8; (*E*,*E*)-*n*-BuCH=CHCOCH=CHMe, 91897-75-5; (*Z*,*E*)-*n*-BuCH=CHCOCH=CHMe, 91897-76-6; (*E*,*E*)-*n*-BuCH=CHCOCH=CHPh, 91897-77-7; (*E*)-CH_3COCH=$C(CH_3)$COCH=CH_2, 91928-33-5; (*E*,*E*)-CH_3COCH=$C(CH_3)$COCH=CHMe, 91897-78-8; (*Z*,*E*)-CH_3COCH=$C(CH_3)$COCH=CHMe, 91897-79-9; $CH_3COCH_2COCH_3$, 123-54-6; CO, 630-08-0; PhCH=CHCH=CHPh, 886-65-7; 1-iodocyclohexene, 17497-53-9; 5,5-dimethyl-3-iodo-2-cyclohexenone, 56671-85-3; 1-(tributylstannyl)cyclopentene, 91897-90-4; 1-iodocyclopentene, 17497-52-8; 1-iodocyclooctene, 17497-54-0; 1-iodocycloheptene, 49565-03-9; 1-(cyclohexen-1-yl)-2-propen-1-one, 62672-77-9; (*E*)-1-(cyclohexen-1-yl)-2-buten-1-one, 91897-80-2; (*Z*)-1-(cyclohexen-1-yl)-2-buten-1-one, 91897-81-3; benzyl (*E*)-1-(cyclohexen-1-yl)-1-oxo-2-propene-3-carboxylate, 91897-82-4; benzyl (*Z*)-1-(cyclohexen-1-yl)-1-oxo-2-propene-3-carboxylate, 91897-83-5; 1-benzoylcyclohexene, 17040-65-2; (*E*)-1-(5,5-dimethyl-1-oxo-cyclohex-2-en-3-yl)-2-buten-1-one, 91897-84-6; 1-(cyclopenten-1-yl)-2-propen-1-one, 62672-81-5; (*E*)-1-(cyclopenten-1-yl)-2-buten-1-one, 15450-55-2; (*Z*)-1-(cyclopenten-1-yl)-2-buten-1-one, 15450-56-3; (*E*)-3-phenyl-1-(cyclopenten-1-yl)-2-propen-1-one, 91897-85-7; benzyl (*E*)-1-(cyclopenten-1-yl)-1-oxo-2-propen-3-carboxylate, 91897-86-8; 1-(cyclopenten-1-yl)-2-hexyn-1-one, 91897-87-9; 1-(cycloocten-1-yl)-2-propen-1-one, 91897-88-0; 1-(cyclohepten-1-yl)-2-propen-1-one, 91897-89-1.

Communications to the Editor

Titanium-Mediated Synthesis of *E*,*E*-Exocyclic Dienes. Application to the Preparation of Polycyclic Compounds

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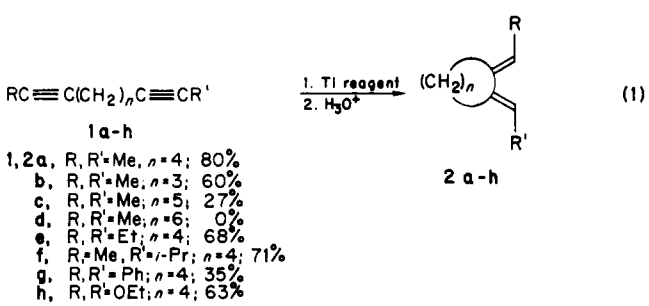
Received April 23, 1984

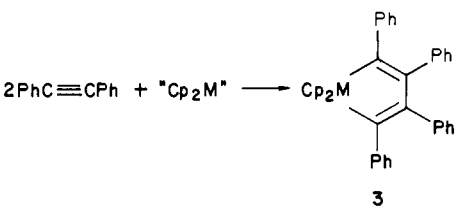
We wish to report a versatile, stereoselective cyclization of diynes **1**[1] to *E*,*E*-exocyclic dienes (**2**). It was anticipated that



(1)

an efficient synthesis of **2** would allow the rapid, stereocontrolled preparation of substituted polycyclic molecules via subsequent Diels–Alder reactions.[2] This expectation has been borne out.

There have been several reports[3,4] of the intermolecular cyclization of diphenylacetylene at low-valent metal centers (eq 2).



(2)

3

Accordingly, we screened the known cyclopentadienyl and pentamethylcyclopentadienyl chlorides of the group 4A and 5A metals in the presence of reducing agents for the intramolecular cyclization (eq 1) of **1a**.[1] In general, the reactions afforded predominantly oligomers of **1a**, resulting from intermolecular C–C bond formation. However, a system consisting of dicyclopentadienyltitanium dichloride, methyldiphenylphosphine, and sodium amalgam (molar ratio 1:1:2) at −20 °C proved uniquely effective for eq 1. Upon hydrolysis, the desired (*E*,*E*)-diethylidenecyclohexane **2a** was obtained in 80% yield.[5] A metallacyclic intermediate analogous to **3** was not isolated, but its existence was suggested by deuterolysis experiments using 20% D_2SO_4/D_2O. Under these conditions, the product **2a** was found to be 91% dideuterated in the vinyl position.

This titanium-mediated cyclization could also be applied to the synthesis of five- and seven-membered rings as illustrated by the

(1) Of the starting materials in this study, compounds **1a–d** were commercially available from Farchan Labs. The others were prepared by standard (acetylide displacement) procedures: Brandsma, L. "Preparative Acetylenic Chemistry"; Elsevier: New York, 1971.

(2) The synthesis and Diels–Alder chemistry of the parent 1,2-dimethylenecycloalkanes are well-known: Bailey, W. J.; Golden, H. R. *J. Am. Chem. Soc.* **1953**, *75*, 4780–4782. Bailey, W. J.; Sorenson, W. R. *Ibid.* **1954**, *76*, 5421–5423. Van Straten, J. W.; Van Norden, J. J.; Van Schaik, T. A. M.; Franke, G. T.; De Wolf, W. H.; Bickelhaupt, F. *Recl. Trav. Chim. Pays-Bas* **1978**, *97*, 105–106.

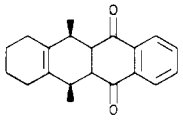
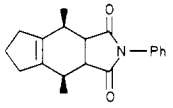
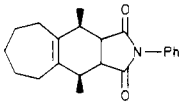
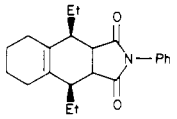
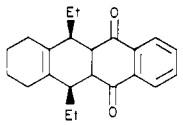
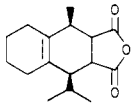
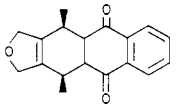
(3) Famili, A.; Farona, M. F.; Thanedar, S. *J. Chem. Soc., Chem. Commun.* **1983**, 435–436. Shur, V. B., Berkovich, E. G.; Vol'pin, M. E.; Lorenze, B.; Wahren, M. *J. Organomet. Chem.* **1982**, *228*, C36–C38. Skibbe, V.; Erker, G. *Ibid.* **1983**, *241*, 15–26. Yoshifuji, M.; Gell, K. I.; Schwartz, J. *Ibid.* **1978**, *153*, C15–C18. Fachinetti, G.; Floriani, C. *J. Chem. Soc., Chem. Commun.* **1974**, 66–67. Eisch, J. J.; Aradi, A. A.; Han, K. I. *Tetrahedron Lett.* **1983**, *24*, 2073–2076.

(4) Another related reaction is the cobalt-catalyzed cyclotrimerization reaction (Vollhardt, K. P. C. *Acc. Chem. Res.* **1977**, *10*, 1–8) for which cobaltacyclopentadiene intermediates are proposed. To our knowledge, this procedure has not been successfully applied to the synthesis of exocyclic dienes. See also: Chiusoli, G. P.; Costa, M.; Masarat, E. *J. Organomet. Chem.* **1983**, *255*, C35–C38.

(5) In a typical procedure 450 g (97.9 mmol) of 0.5% Na amalgam was added rapidly dropwise to a suspension of dicyclopentadienyltitanium dichloride (9.3 g, 37.3 mmol) and methyldiphenylphosphine (9.0 g, 45.0 mmol) in THF (400 mL) at −50 °C. The temperature of this stirred mixture under N_2 was allowed to rise to −20 to −25 °C where it was maintained 15 min. Thereupon 2,8-decadiyne (3.9 g, 29.1 mmol) in THF (100 mL) was added dropwise and the temperature was kept at −20 to −25 °C for another 3 h. The solution was quenched with 200 mL of 20% H_2SO_4 and extracted with ether (2 × 250 mL). After distillation of solvent and flash chromatography to remove remaining phosphine, the product was distilled (15 torr, 67–69 °C) to afford **2a** (3.16 g, 23.2 mmol, 80%). Anal. Calcd for $C_{10}H_{16}$: C, 88.16; H, 11.84. Found: C, 88.03; H, 11.92. ^1H NMR (C_6D_6) δ 1.59 (d, J = 7 Hz, 6 H), 1.59 (m, 4 H), 2.10 (m, 4 H), 5.38 (q, J = 7 Hz, 2 H).

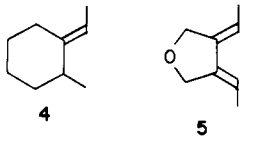
0002-7863/84/1506-6422$01.50/0

Table I. Products from Diels–Alder Reactions of *E,E*-Exocyclic Dienes[a]

diene	dienophile	product	mp, °C	yield[b]
2a	*N*-phenyl-maleimide	6	138.0–138.5	90
2a	naptho-quinone		122–123	86
2b	*N*-phenyl-malemide		98	87
2c	*N*-phenyl-malemide		77–78	82
2e	*N*-phenyl-malemide		150–151	86
2e	naptho-quinone		105.0–105.5	84
2f	maleic anhydride		96	88
5	naptho-quinone		155	91

[a] Reaction of 10% excess diene in ethyl ether overnight at room temperature. All products gave satisfactory elemental analyses. [b] Percent yield based on dienophile after recrystallization from boiling heptane.

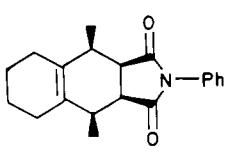
preparation of **2b** and **2c**. In contrast, **1d** did not afford the cyclooctane **2d**.[6] The reaction could accommodate larger alkyl substituents as demonstrated by preparation of **2e–g**. Two further examples indicate the versatility of this cyclization strategy. Cyclization of 1-nonen-7-yne[7] afforded **4** (55%) while **5** was obtained (72%) via cyclization of di-2-butynyl ether.[8]



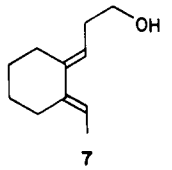
4 5

The principal limitation of this reaction appears to be its failure with terminal acetylenes. Yields are also severely diminished for (trimethylsilyl)acetylenes. However, unsubstituted tricyclic systems should be accessible via compound **2h** by using a sequence of Diels–Alder addition (as described below) followed by base-induced elimination.

Diels–Alder addition of activated dienophiles to dienes **2** proceeds at room temperature as summarized in Table I. The products were recrystallized from hot heptane and were found by NMR to consist of a single diastereomer.[9] An X-ray crystal structure on the product from **2a** and *N*-phenylmaleimide confirmed that the reaction proceeded with the expected[10,11] cis-endo stereochemistry, e.g., structure **6**.

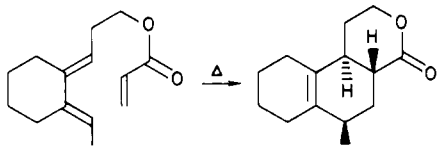


6



7

To demonstrate the use of this cyclization in combination with an intramolecular Diels–Alder reaction, we prepared compound **8** by straightforward esterification of the corresponding alcohol **7**. The alcohol was in turn prepared by O-silylation of 3,9-undecadiyn-1-ol and cyclization under our standard conditions in 79% overall yield. Heating **7** (0.5% in toluene, reflux, 24 h) produced **9** in 65% yield,[12] the remainder of the product apparently



8 9

being that derived from intermolecular Diels–Alder reaction of 2 equiv of **8**. The tentative assignment of structure **9** (i.e., the product of exo cycloaddition) is made on the basis of the NMR data and by comparison with the well-known intramolecular cycloadditions of *o*-xylylenes.[13] Nevertheless, we intend to confirm this point via the X-ray crystal structure of **9**.

Registry No. **1a**, 4116-93-2; **1b**, 31699-35-1; **1c**, 1785-53-1; **1d**, 31699-38-4; **1e**, 61827-89-2; **1f**, 92013-60-0; **1g**, 13225-62-2; **1h**, 92013-61-1; **2a**, 92013-62-2; **2b**, 92013-63-3; **2c**, 92013-64-4; **2e**, 92013-65-5; **2f**, 92013-66-6; **2g**, 92013-67-7; **2h**, 92013-68-8; **4**, 83587-55-7; **5**, 92013-69-9; **6**, 92013-70-2; **7**, 92013-71-3; **8**, 92013-72-4; **9**, 92013-74-6; $CH_2{=}CH(CH_2)_4C{\equiv}CCH_3$, 66970-18-1; $(CH_3C{\equiv}CCH_2)_2O$, 55833-53-9; $CH_3{\equiv}C(CH_2)_4C{\equiv}C(CH_2)_2OH$, 92013-73-5; Ph_2PMe, 1486-28-8; (5aα,6β,11β,11aα)-6,10-dimethyl-5a,6,7,8,9,10,11,11a-octahydronaphthacene-5,12-dione, 92013-75-7; (5aα,6β,11β,11aα)-6,10-diethyl-5a,6,7,8,9,10,11,11a-octahydronaphthacene-5,12-dione, 92013-79-1; (3aα,4β,8β,8aα)-4,8-dimethyl-1,3-dioxo-2-phenyl-2,3a,4,5,6,7,8,8a-octahydrocyclopent[*f*]isoindole, 92013-76-8; (3aα,4β,10β,10aα)-4,10-dimethyl-1,3-dioxo-2-phenyl-2,3a,4,5,6,7,8,9,10,10a-decahydrocycloheptl[*f*]isoindole, 92013-77-9; (3aα,4β,9β,9aα)-4,9-diethyl-1,3-dioxo-2-phenyl-2,3,3a,4,5,6,7,8,9,9a-decahydro-1*H*-benz[*f*]isoindole, 92013-78-0; (3aα,4β,9β,9aα)-4-iso-

(6) An attempt to prepare a 14-membered ring by cyclization of 2,16-octadecadiyne under high-dilution conditions produced a 17% yield of monomeric C_{18} products. However, the product consisted of roughly equal amounts of three isomeric compounds apparently corresponding to all possible orientations of the acetylenes prior to cyclization.

(7) In contrast, 1,7-octadiene did not react under our conditions. Apparently, at least one acetylene functionality is needed to displace the phosphine from titanium since the cyclization of 1,7-octadiene at low-valent metal centers in the absence of strongly coordinating ligands is known: McLain, S. J.; Wood, C. D.; Schrock, R. R. *J. Am. Chem. Soc.* **1979**, *101*, 4558–4570. Gell, K. I.; Schwartz, J. *J. Chem. Soc., Chem. Commun.* **1979**, 244–246. Thanedar, S.; Farona, M. F., *J. Organomet. Chem.* **1982**, *235*, 65–68. McDerrmot, J. X.; Wilson, M. E.; Whitesides, G. M. *J. Am. Chem. Soc.* **1976**, *98*, 6529–6536.

(8) The facile synthesis of **2h**, **5**, and **7** suggest that this procedure may be broadly applicable to molecules containing *saturated* heterofunctionality. (However, an attempt to extend the cyclization of **1h** to the analogous sulfur series using 3,12-dithia-4,10-tetradecadiyne instead resulted in reduction to the acyclic divinyl thioether.) In contrast, when we attempted to form a C–C bond between an acetylenic moiety and an *unsaturated* functionality (examples: 1-cyano-4-heptyne, methyl-3-butynyl carbonate) in no case were discreet monomeric products isolated.

(9) For example, the adduct of **1a** with *N*-phenylmaleimide: 360-MHz ^{1}H NMR ($CDCl_3$) δ 1.44 (d, J = 7 Hz, 6 H), 1.45–1.65 (m, 4 H), 2.04 (m, 4 H), 2.52–2.63 (m, 2 H), 3.09 (apparent dd due to magnetic inequivalence, 2 H), 7.10–7.16 (m, 2 H), 7.32–7.38 (m, 1 H), 7.40–7.47 (m, 2 H).

(10) Alder, K.; Stein, G. *Angew. Chem.* **1937**, *50*, 510–519.

(11) In contrast, Diels–Alder addition to a bicyclic system somewhat related to compounds **2** affords the products of exo addition, presumably for steric reasons: Paquette, L. A.; Schaefer, A. G.; Blount, J. F. *J. Am. Chem. Soc.* **1983**, *105*, 3642–3648.

(12) Compound **8** was purified by flash chromatography (40% ethyl acetate, 60% hexane), mp (heptane) 92.5–93.0 °C. Anal. Calcd for $C_{14}H_{20}O_2$: C, 76.33; H, 9.15. Found: C, 76.64; H, 9.09. 360-MHz ^{1}H NMR δ 0.98 (d, J = 7 Hz, 3 H), 1.46 (m, 2 H), 1.54 (m, 2 H), 1.63–2.29 (m, 10 H), 2.77 (ddd, J = 13, 5, 4 Hz, 1 H), 4.25 (td, J = 11, 3 Hz, 1 H), 4.43 (ddd, J = 11, 5, 2 Hz, 1 H).

(13) Taub, D. In "The Total Synthesis of Aromatic Steroids 1972–1981"; ApSimon, J., Ed.; Wiley: New York, 1984; Vol. 6, pp 16–37.

propyl-9-methyl-1,3-dioxo-3a,4,5,6,7,8,9,9a-octahydronaphtho[2,3-c]-furan, 92013-80-4; (4α,4aβ,10aβ,11α)-4,11-dimethyl-5,10-dioxo-1,3,4,4a,10a,11-hexahydroanthra[2,3-c]furan, 92013-81-5; N-phenylmaleimide, 941-69-5; naphthoquinone, 130-15-4; maleic anhydride, 108-31-6; dicyclopentadienyltitanium dichloride, 1271-19-8; sodium amalgam, 11110-52-4.

Leucomitomycins

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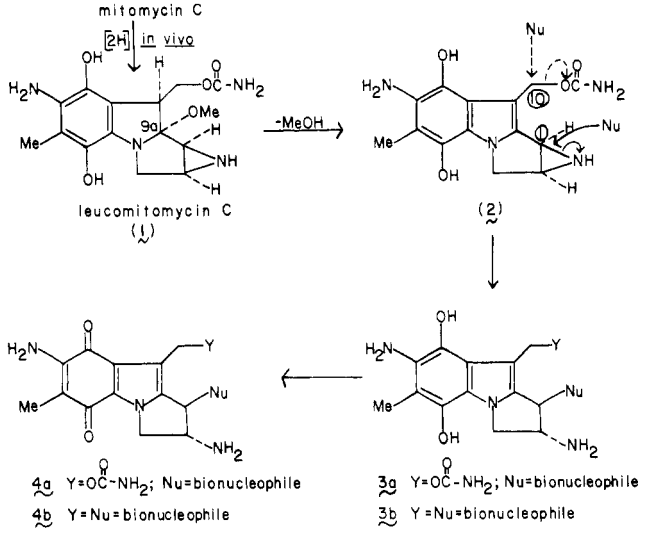
Mitomycin C, a member of a larger family of structurally related antibiotics, has become a clinically useful resource in cancer chemotherapy.[1,2] In view of its novel structure and its chemical fragility, a great deal of research has gone into establishing the mode of antitumor action of this compound.[3] The prevailing consensus is that mitomycin C undergoes in vivo reduction of its quinone ring and that the resultant hydroquinone, **1**, suffers very rapid loss of methanol to afford the indole, **2**.[4-6] In compound **2**, the benzylic aziridine carbon (C_1) becomes a potent electrophile toward various nucleic acid centered nucleophiles. Less securely supported is the proposition that the benzylic carbon (C_{10}) bearing the carbamoyloxy group can also alkylate a nucleophilic center of DNA. The alkylation product **3a** (or cross-linked product **3b**), upon reoxidation, is converted to the quinone form (**4a** or **4b**).



In a commendably rigorous investigation, Tomasz and Nakanishi[7,8] described the reduction of mitomycin C either by hydrogen over PtO_2 or by NADPH in the presence of d(GpC) and identified the site of apparent "bioelectrophilicity" to be C_1. The nucleophilic center was shown to be the "amidic" oxygen of the deoxyguanosyl system.

Pursuant to a synthetically oriented study, we became interested in an earlier step of the sequence, i.e., the loss of the 9a-oxygen function. As a consequence of the early work addressed to the structure determination of the mitomycins,[9,10] it was assumed that, upon reduction of the quinone ring to the hydroquinone level (cf. **1**), the loss of the C_{9a} hetero function, resulting in formation of the indolohydroquinone (cf. **2**), is inevitable.[11] It has been reasoned that only in the quinone series is the reactivity of the pyrrolidine nitrogen sufficiently attenuated to allow for survival of the 9a heterofunction. *The findings reported herein run sharply counter to this conventional wisdom and demonstrate that aromatization of compounds such as* ***1****, dihydro(leuco)mitomycin C and* ***6****, dihydro(leuco)mitomycin B is far from inevitable.*

We first investigated the reduction of the very rare mitomycin B (**5**).[12] The NMR spectrum of compound **5** in pyridine-d_5 at 250 MHz was recorded. The spectrum indicated the sample to be substantially homogeneous. To this solution was added 10% palladium on charcoal. Hydrogen gas was bubbled through the system. Within seconds, the purple color faded completely. The NMR spectrum of the "leuco" compound was recorded. The NMR spectrum rigorously confirms the conclusion, which would be gathered from the disappearance of the purple color, i.e., that compound **5** is no longer present.

The multiplicities in the NMR spectrum of the resultant leuco product indicate that it is not the expected "dihydro-anhydro" compound **2**. Most convincing in this regard is the fact that the proton at C_9 is clearly seen as a doublet of doublets δ 4.76, with couplings of 3.24 and 9.91 Hz to the diastereotopic protons at C_{10}. Each of these protons (H_{10} δ 5.40 and $H_{10'}$ 5.74) is, in turn, seen as a doublet of doublets: $J_{10,10'}$ = 10.37 Hz; $J_{10,9}$ = 9.91 Hz; $J_{10',9}$ = 3.24 Hz.

The NMR-based conclusion is fully in keeping with the chemical events. When a stream of oxygen is passed through the solution of leuco compound, the purple color reemerges almost instantaneously. The high-field NMR spectrum of this material indicates it to be the starting compound **5**. Under these conditions, no aziridinomitosene (**8**) or degradation products thereof could be detected. In fact, the sequence of reduction followed by oxidation leads to virtually no erosion of the homogeneity of compound **5**.

The infrared spectra of compound **5** and of the leuco compound each exhibit stretching maxima (1724 cm^{-1} for **5**; 1721 cm^{-1} for the dihydro compound) which are attributable to the carbonyl group of the carbamate. In the case of compound **5**, quinone maxima at 1649 and 1628 cm^{-1} are also present. In the case of the leuco compound, the intensities of the quinonoid peaks are

(1) Remers, W. A. In "Anticancer Agents Based on Natural Product Models"; Cassady, J. M., Duoros, J. D., Eds.; Academic Press: New York, 1980; pp 131 ff.

(2) Carter, S. K.; Crooke, S. T. "Mitomycin C—Current Status and New Developments"; Academic Press: New York, 1979.

(3) For a recently revised assignment of absolute configurations of mitomycin C, see: Shirahata, K.; Hirayama, N. *J. Am. Chem. Soc.* **1983**, *105*, 7199. In this paper the previous absolute configuration of mitomycin B (**5**) was also questioned. For the moment, we continue to draw the absolute configuration of **5** as formulated by: Yahashi, R.; Matsubara, J. *J. Antibiot.* **1976**, *29*, 104; **1978**, *31*, 6.

(4) For recent reviews, see: (a) Lown, J. W. In "Molecular Aspects of Anticancer Drug Action"; Neidle, S., Waring, M. J., Eds.; Verlag Chemie; Deerfield Beach, FL, 1983. (b) Lown, J. W. *Acc. Chem. Res.* **1982**, *15*, 381. (c) Szybalski, W.; Iyer, V. N. In "Antibiotics: Mechanism of Action"; Gottlieb, D., Shaw, P. D., Eds.; Springer-Verlag: New York, 1967; pp 211-245.

(5) For earlier papers in the original literature, see: (a) Iyer, V. N.; Szybalski, W. *Science (Washington, D.C.)* **1964**, *145*, 55. (b) Lown, J. W.; Begleiter, A.; Johnson, D.; Morgan, A. R. *Can. J. Biochem.* **1976**, *54*, 110. (c) Tomasz, M.; Lipman, R. *J. Am. Chem. Soc.* **1979**, *101*, 6063.

(6) For a comprehensive treatment of the subject of bioreductive alkylating agents, see: Moore, H. W. *Science (Washington, D.C.)* **1977**, *197*, 527.

(7) Tomasz, M.; Lipman, R.; Snyder, J. K.; Nakanishi, K. *J. Am. Chem. Soc.* **1983**, *105*, 2059.

(8) Weaver, J.; Tomasz, M. *Biochim. Biophys. Acta* **1982**, *697*, 252.

(9) (a) Patrick, J. B.; Williams, R. P.; Meyer, W. E.; Fulmor, W.; Cosulich, D. B.; Broschard, R. W.; Webb, J. S. *J. Am. Chem. Soc.* **1964**, *86*, 1889. (b) Stevens, C. L.; Taylor, K. G.; Munk, M. F.; Marshall, W. S.; Noll, K.; Shah, G. D.; Uzu, K. *J. Med. Chem.* **1964**, *8*. (c) Kinoshita, K.; Uzu, K.; Nakano, K.; Shimizu, M.; Takahashi, T.; Matsui, M. *J. Med. Chem.* **1971**, *14*, 103. (d) Hornemann, U.; Ho, Y. K.; Mackey, J. K.; Srivastava, S. C. *J. Am. Chem. Soc.* **1976**, *98*, 7069.

(10) For excellent reviews of the voluminous chemistry of the mitomycins, see: (a) Remers, W. A. In "The Chemistry of Antitumor Antibiotics"; Wiley-Interscience: New York, 1979; pp 221 ff. (b) Franck, R. W. *Fortschr. Chem. Org. Naturst.* **1979**, 381.

(11) The possibility of trapping either through reduction or through reaction with other nucleophiles, imminium species intermediates which would otherwise aromatize is implicit in the work of Matsui[9c] and Hornemann,[9d] respectively. One apparent precedent suggesting the viability of systems such as **1** and **6** is a result quoted by Franck[10b] wherein it is claimed, without supporting data, that reduction of mitomycins A or C with lithium aluminum hydride followed by reoxidation (air) affords the 10-decarbamoyl compounds with the angular methoxy group intact. Also, Patrick et al.[9a] briefly indicate that in the catalytic hydrogenation of mitomycin B, inclusion of triethylamine retards the rate of indolization. However, previous to our work no one has characterized compounds such as **1** or **6**.

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